DIM AND DIMMER:

AN EXPLORATION OF THE PRODUCTION AND DIFFUSION OF SCIENTIFIC KNOWLEDGE IN AUSTRALIA BETWEEN THE 1770s AND THE 2010s

Lynnette Hicks BSocSc (Hons) MQU

Thesis submitted in fulfilment of the requirements for the degree of Doctor of Philosophy

Department of Sociology

Macquarie University, Sydney, Australia

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Statement of Originality:

This is to certify that to the best of my knowledge, the content of this thesis is my own work. This thesis has not been submitted for any degree or other purposes. I certify that the intellectual content of this thesis is the product of my own work and that all the assistance received in preparing this thesis and sources have been acknowledged.

Lynnette Hicks

January 2016

“Our posturings, our imagined self-importance, the delusion that we have some privileged position in the Universe, are challenged by this point of pale light. Our planet is a lonely speck in the great enveloping cosmic dark. In our obscurity, in all this vastness, there is no hint that help will come from elsewhere to save us from ourselves.”

Carl Sagan (from Pale Blue Dot: A Vision of the Human Future in Space)

Dedication:

To Paul Meszaros without whom I am lost

To Ken Henson without whom this project is lost

And to my sons Clark Hicks-Jenkinson and Connor Jenkinson without whom I am incomplete

Acknowledgements:

Perhaps this journey started when I was a little kid roaming around our large suburban backyard and exploring the bush and the creek behind our house. Or perhaps it was when, as a young adult working in the advertising industry, I was captivated by Eric the opalised pliosaur from South Australia looking for a home in the Australian Museum. Either way my foundational experiences created within me a love of the natural world and a fascination for all things science.

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Abstract:

Despite growing public concerns around socio-scientific problems and the significance of these problems to everyday life, there is a dearth of sociological literature addressing the production and diffusion of the natural sciences in Australia. In particular, critical analyses of scientific knowledge production and diffusion relative to the actions of the state, the market and civil society are largely absent. This thesis sets out to mitigate this situation by contributing a critical historiography of scientific knowledge production and diffusion as it relates to Australia since white settlement. It is anticipated that this work will open up the topic for further academic research and rational debate.

This thesis explores the production and diffusion of scientific knowledge through the lens of social dynamics that have emerged in Australia between the 1770s and the 2010s. The research relies primarily on the theoretical work of Max Weber in order to identify and analyse the conception of *rationality* and its application to *social action* that is present in the policy and praxis of the natural sciences in Australia. In particular, the relationships between the state, the market and civil society are analysed using secondary data drawn from published histories, official documents and the formal policies and practices of the state and the market during this period.

A tripartite analytical model has been created specifically for this thesis and is utilised to trace scientific knowledge production and diffusion through the transformative social processes associated with *instrumentalism*, *bureaucratisation*, *developmentalism*, *environmentalism*, *postmodernism* and *neoliberalism*. Rationality is applied in three ways: as *non-instrumental* science produced to further human understandings of the natural world and to promote the development of civil society; as *pre-instrumental* science produced by the state to in order to develop markets and for other instrumental

purposes such as national defence strategies; and as *instrumental* scientific knowledge produced by the participants in the market expressly to enhance their own position in the market.

The research reveals that instrumental rationality has been an enduring concept in the policy and praxis of the natural sciences in Australia. Moreover, this thesis finds that a strong tension is often present between non-instrumental notions of scientific knowledge and those practices that are predominantly instrumental. Through each of the periods studied the state and the market have been close confederates, often working together to realise instrumental outcomes through the knowledge produced by natural science. In particular, administrative and economic ends are seen to be primary; ends associated with more normative intentions, such as the nurturing of civil society, have been regularly overlooked in favour of strictly instrumental aspirations. This continuing instrumentality has altered the relationships between the state, the market and civil society during each period studied. On the current trajectory, the policy and praxis of the natural sciences in Australia may yet begin to compromise the sovereignty of that nation state and the authority of its citizenry.

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1 Introduction

In the fragile societies of the 21st century risk and responsibility have come to rest on the shoulders of individual citizens (Beck 1992). This assumption of risk and responsibility on the part of the individual can be seen as the corollary to the social values of freedom, autonomy and self-determination that were introduced by the scholars of the enlightenment. Prior to the enlightenment the majority of individuals were positioned as property of the monarchy and were thus denied the freedom, autonomy or the responsibility of individual sovereignty.

The enlightenment scholars instead argued for a new form of sovereignty, one that could be achieved within the lifeworld through the common sharing of expert knowledge. In contemporary Australia however it appears that scientific knowledge is being increasingly colonised by market forces under the direction of the state. This thesis argues that the colonisation of the lifeword by the state and the market began early in the nation's history; that the steering mechanisms of money and power effectively guided the foundation and development of the natural sciences in Australia.

The uneven, shifting relationships between the state, the market and civil society hindered the development of a civil approach to scientific knowledge production and diffusion in Australia. Rather, scientific knowledge has been largely instrumentalised to support the political and economic goals of both the state and the market, to the detriment of civil society. This thesis explores the implications of this instrumentalisation in terms of the production and diffusion of basic (or non-instrumental)[1] science and its capacity to deal with rising local and global socio-scientific problems.

A review of the sociological literature finds an incohesive and fragmented story of the introduction and establishment of the natural sciences in Australia. Moreover, there has been limited sociological work undertaken around the changing relationships between the production and diffusion of scientific knowledge within the frameworks of the state, the market and civil society. Australia was founded, along with other colonial societies, in the wake of the industrial revolution and this has arguably had a significant effect on the way that the natural sciences are practised in Australia. This thesis begins the tasks of looking at these effects and the unique problems encountered by the practitioners of the natural sciences in Australia as a result of the nation's history.

In the light of the escalating importance and rising political salience of the natural sciences in Australia, particularly in terms of local and global socio-scientific problems, it is critical that a rational public sphere is developed as a cohesive, analytical and empirically grounded set of resources from which to draw. Much of the contemporary debate in a public sphere is driven by instrumentalised political and economic interests, crowding out the substantive story. It is hoped that this project will be the first of many to consider the production and diffusion of scientific knowledge in Australia from a value-rational perspective.

This thesis explores the production and diffusion of scientific knowledge through the lens of the political and economic dynamics that have emerged in Australia between the

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[1] A tripartite analytical model based on the concept of instrumental rationality has been prepared specifically for this project and is discussed in Section 2.4.

1770s and the 2010s. The argument underpinning this work makes use of the concept of *instrumental rationality* in order to delineate between that scientific knowledge produced to further the democratic aims of the enlightenment scholars and that scientific knowledge produced in order to develop global markets.

Instrumentalism is applied in three ways: as an ideal type of *non-instrumental* science, produced to further human understandings of the natural world;[2] as an ideal type of *pre-instrumental* science,[3] produced by the state in order to develop markets and for other instrumental purposes such as warfare; and as an ideal type of *instrumental* scientific knowledge[4] produced by the participants in the market expressly to enhance their own position in the market. A tripartite model was created specifically for this project and draws on the original work of Max Weber, Max Horkheimer and Theodor Adorno.[5] The model explores the development of natural science in Australia within the transformative social processes associated with *instrumentalism*, *bureaucratisation*, *developmentalism*, *environmentalism*, *postmodernism* and *neoliberalism* between the years 1770 and 2015.

My research finds that prior to the 1870s instrumental scientific knowledge had been an *implicit factor of production*. As the nation and its bureaucracies developed, a new type of scientific knowledge production emerged; that type of knowledge sponsored by the

[2] *Natural science* is defined in this thesis as 'dealing with or relating to nature as an object of study or research.' *Natural science* is 'the branch of knowledge that deals with the natural or physical world; a physical science as, as physics, chemistry, biology, etc.: in *pl*. these sciences collectively' (Shorter Oxford English Dictionary 2007:1895). The natural sciences are distinct from the *social sciences* which are defined as 'the scientific study of the structure and functions of society and social relationships; any discipline, as politics or economics, etc., that attempts to study human society in a systematic way' (Shorter Oxford English Dictionary 2007: 2904). This thesis aims to employ the methodologies of the social sciences in order to interrogate the development of the natural sciences within the social world.
[3] As above
[4] As above
[5] The theoretical underpinnings of the model and the model's application to the development of natural science in Australia are enlarged upon in Chapter 2.

state in order to galvanise the growth of both primary and secondary industries. This new type of pre-instrumental scientific knowledge began the process of disembedding scientific knowledge from its position as an implicit factor of production to re-emerge during the 1980s as an *explicit factor of production*.

Non-instrumental science on the other hand was driven by the notion of civil society and was less valuable to the political and economic ambitions of the firmly bound up institutions of state and market. Between the 1970s and the 1980s the new social movement of environmentalism in Australia demonstrated that non-instrumental scientific knowledge could be employed by the citizenry in order to produce change at the political level. Moreover, this public resurgence of non-instrumental science served to reinvigorate the emancipative promises of the enlightenment by providing opportunities for direct public participation in issues of socio-scientific importance.

By the late 1990s instrumental scientific knowledge had become disembedded from its implicit function within the production process and was being repositioned as an *explicit factor of production* and a discrete product for sale on the market. This marketised positioning for scientific knowledge produces a triple tension: firstly, it creates significant tension between the agreed norms of science – *communality*, *universalism*, *disinterestedness* and *organised skepticism* – and the conflicting demands of the market. Secondly, the application of market protectionism within a neoliberal state that ostensibly advocates the socio-economic value of free markets creates irrational policy conditions. Thirdly, this position creates a dialectical treatment of the enlightenment vision for rational scientific knowledge. This dialectical treatment turns on its head the enlightenment precept that rational scientific knowledge be used to ‘enlighten’ individuals and liberate them from colonising forces outside the lifeworld.

Instead, in contemporary Australia scientific experts were, and still are, leveraged by the state in order to produce scientific knowledge for the express use of the market, so effectively denying the emancipative promises of the enlightenment.

1.1 The research project

The research methodology was designed with the intention of creating a panoramic, depoliticised and heuristic approach to the problem of scientific knowledge production and diffusion in Australia since white settlement. This broad, exploratory framework was deemed necessary in the face of the limited availability of sociological literature relating to the research problem; to mitigate the disciplinary epistemology that has grown up around, and between, 'the arts' and 'the sciences'; to provide a basis for further research; and to act as a catalyst for academic and public debate.

A preliminary review of the 'science system' in Australia revealed a highly politicised system that displayed a strong tendency towards instrumentality. It was for this reason that the *evidentiary narrative* (Altheide 2008) method was chosen as the preferred research technique. While qualitative research, using primary methods such as interviews or surveys often provide a good snapshot of current understandings and behaviours, the aims of this research project necessitated a dispassionate exploration of the development of the natural sciences and the production and diffusion of scientific knowledge in Australia over time. The ideal technique needed to minimise the influence of epistemic bias and provide a long view of the scientific project in Australia. In particular, the research needed to focus on that scientific knowledge derived through the natural sciences and its progressive relationships with the institutions of state, the market and civil society. The historiographical schema was introduced into the methodology in order to trace the origins of the themes and patterns extant in the contemporary milieux.

The strongly instrumental emphasis on scientific knowledge production and diffusion in Australia necessitated a methodology that embodied the language of evidence yet attempted to draw out the meanings associated with this high level of instrumentality. The project thus required a methodology that was not embedded in the politics of disciplinary epistemology. Firstly, the Miles and Huberman (1994) research framework was employed in order to provide a cohesive pattern of data collection and analysis throughout the project. Then, in order to moderate bias, and to provide a loose epistemological scaffold around the concept of instrumentality and from which to identify patterns in the data, the concept of the *ideal type* devised by Max Weber was employed. These ideal types were constructed in order to examine levels of instrumentality in scientific knowledge production and diffusion in Australia since white settlement. This tripartite analytical model, based on three ideal types, was loosely constructed and tested on early data. The model was then applied to the data in order to examine its potential to deliver on the evidentiary narrative (Altheide 2008) technique before being fleshed out in the final stage.

The evidentiary narrative technique aims to move between epistemic disciplines rather than take a fixed position within extant epistemic communities. As Altheide argues, the evidentiary narrative helps to 'address the problem of knowledge and evidence' and

> …draws our attention to the ways in which credible information and knowledge are buffered by symbolic filters, including distinctive "epistemic communities", or collective meanings, standards, and criteria that govern sanctioned action, including talk (e.g. scripts, accounts, disclaimers) (2008: 137)…I suggest that developing our skills and sensitivity to analysis of documents can

> illuminate methodological stands and approaches for mining the incredibly rich record of evidence gained, lost, and more typically, completely overlooked (2008: 158).

This analytical methodology –Miles and Huberman's analytical framework, Weber's ideal types and Altheide's evidential narrative – proved successful in collecting, organising and analysing the data to inform a richer understanding of: the work and culture of the natural sciences; the way in which the exigencies of social world influence the production and diffusion of scientific knowledge; the tensions inherent in the relationships between the community of scientists and the state, the market and civil society; and how these tensions may influence the shifting and changing of state policy and praxis in terms of scientific knowledge.

This process employed a three stage data collection procedure. Data sources covered formal literature reviews, formal reviews of documentary evidence and informal participant observation; formal sources are detailed in Tables 1.1 and 1.2 below. Stage four entailed the analysis of the data collected. The tripartite analytical model was validated and fleshed out during this fourth stage.

Stage 1: Informal ethnography as an *action* researcher located in the Faculty of Science

This preliminary stage was conducted as a doctoral candidate in the Department of Environment and Geography in the Faculty of Science. This stage lasted two and a half years and provided valuable opportunities for close observation of scientists in their everyday realm. While the initial research focus concerned the production and diffusion of scientific knowledge from a sociological perspective, the opportunities for informal ethnography grew over time and contributed significantly to the outcomes of the final thesis.

Immersion within this unfamiliar culture also sharpened the senses and the informal research possibilities enabled through everyday work, socialising, field trips and site visits were critical to developing a richer understanding of the production and diffusion of scientific knowledge in its natural environment, the character of natural scientists and the barriers, tensions and opportunities embedded in their daily work. It also opened up a set of fresh perspectives for this classically educated sociologist.

Stage 2: A formal literature review guided by the tripartite framework of ideal types and the *evidential narrative* technique

The early part of the review was exploratory and designed to provide an overview of scientific knowledge from an historical, philosophical and sociological perspective. The review was conducted contemporaneously with Stage 1 and was applied to both peer-reviewed and grey literature. It was at this stage that a scarcity of empirical research pertaining to natural science in Australia was uncovered. In particular, sociological literature in relation to the axis of society/natural science as well as to the increasing salience of scientific knowledge and its relationship with the political, economic and social realms of Australian life was largely absent.

This finding prompted a return to the literature associated with the history of science in Australia where the early themes of instrumentalism were discovered. From these themes the first stage analytical model was constructed. This model proved to be reliable but only assumed its final level of complexity once all the empirical data had been collected, collated and analysed. Table 1.1 shows the epistemic disciplines and associated knowledge that was interrogated during the data collection process. The research process included but was not limited to this listing.

The searches were undertaken in the National Library of Australia and the Macquarie University library and the following datasets were explored: paper-based books, electronic books, pamphlets, newspapers, quantitative datasets, databases associated with sociological theory and research papers, cultural theory and research papers, economic theory and research papers and Australian history. Both peer-reviewed and grey literature (informally published material) searches were undertaken and these are reflected in the following table (Table 1.1).

Table 1.1 Epistemological groupings, search terms and formal research material

Epistemological groups	
Peer-reviewed literature	**Search areas**
History and philosophy of the natural sciences	• General histories of knowledge relevant to western conceptions of scientific knowledge • Natural history, natural philosophy • Museums of natural history • Scientific knowledge in Ancient Greece • Scientific knowledge during the European Middle Ages • Scientific knowledge during the European renaissance • The enlightenment and associated scholars including selected works of: Aristotle, Francis Bacon, Thomas Hobbes, John-Jacques Rousseau, John Locke, Immanuel Kant • Scientific knowledge during the French revolutions • The scientific revolution • Gentlemen scientists (amateur scientists) • The industrial revolution • The professionalisation of the natural sciences • The science wars (natural sciences/humanities) • Scientific knowledge in Australia • Types and typologies of scientific knowledge (basic, applied) • Science writers including but not limited to: Carl Sagan, Erwin Schrodinger, Stephen Weinberg, Edward O Wilson, James D Watson, Carl Zimmer, Rachel Carson, Stephen Pinker, Oliver Sacks, Richard Dawkins, Stephen Jay Gould, James Lovelock, Jared Diamond, James Gleick, Tim Flannery, Aristotle, Alexander von Humboldt, Carl Linnaeus, Charles Darwin, and others.
History and philosophy of museology	• General history and theory of Museums • Natural history museums, collections and social roles • Early science, scientists and cabinets of curiosity • Contemporary museums of science • Citizen-scientists and museum volunteers

Sociological theory	• **Theory and theorists**: Max Weber, Georg Simmel, Emile Durkheim, Karl Marx, Jeremy Bentham, John Stuart Mill, Fredric Nietzsche, C Wright Mills, Karl Mannheim, Michel Foucault, Pierre Bourdieu, Georg Lukács; The Frankfurt School: Max Horkheimer, Theodor Adorno, Jürgen Habermas; Daniel Bell, Ulrich Beck, Mark Poster, Anthony Giddens, Manuel Castells, Thomas Kuhn, Nico Stehr, Bruno Latour, Andrew Feenberg; and other scholars pertinent to scientific knowledge, rationalisation, instrumentalism and the processes of modernity • Sociology of scientific knowledge (SSK) • Sociology of technology and science (STS) • History and philosophy of science (HPS) • Realist theory of science (RTS) • Theories of modernity – early, high and late • Reason, rationality, rationalism • Instrumentalism and instrumentality • Developmentalism and scientific knowledge • Environmentalism and scientific knowledge • Postmodernism, the cultural turn and scientific knowledge • Post-industrial society and scientific knowledge • Network society and scientific knowledge • Neoliberalism and scientific knowledge • Public engagement with science and technology (PEST) • Public understanding of science (PUS)
Theory, history and philosophy of political economy	• **Theory and theorists:** Adam Smith, David Ricardo, Karl Marx, Max Weber • Mercantilism • Classical political economy • Neo-mercantilism • Neo-classical economics • Neoliberalism
Australia	• Social history, policy and praxis • Political history, policy and praxis • Economic history, policy and praxis • Science history, policy and praxis • Intellectual Property law, policy and praxis • Primary industries, policy and praxis • Secondary industries, policy and praxis • Museum history, policy and praxis • CSIRO, universities, research institutes • Education policy and praxis • World Wars I and II • Developmentalism and industrialism • Environmentalism and the environmental movement • Postmodernism and the cultural turn • Cultural policy and praxis • Volunteering and participation • Neoliberalism and economic rationalism
Grey literature	**Search areas**
Informally published material	In addition to the peer-reviewed material the search engines Google and Google Scholar were used to capture informal material produced by the state and corporate entities. This material was triangulated against other material before being incorporated into the evidentiary narrative. The searches were conducted in concert with the peer-reviewed search areas listed above.

Stage 3: A formal review of documents and statistics guided by the tripartite framework of ideal types and the *evidential narrative* technique

This formal documentary review and statistical analysis was conducted contemporaneously with Stage 1 of the research process. Primary data was collected from documents and statistics found on government, university and scientific organisation websites as well as in paper-based books and documents found in state and private libraries and repositories. This stage also included a review of the data relevant to the study found on corporate websites and in both corporate and state agency annual reports. Table 1.1 shows the epistemic disciplines and associated knowledge that was explored during the data collection process. The research process included but was not limited to this listing.

This search method located primary research material in the form of current and historical documents of state and the legislature, Hansard, submissions and reports to Inquiries, statistics produced by the Australian Bureau of Statistics, government websites and the majority of Annual Reports of both the Australian Museum and the Botanic Gardens in Sydney. Where appropriate, the research process has also interrogated the history and the communication material produced by corporations, universities, government instrumentalities and government departments.

Table 1.2 Documentary data, sources and search areas

Sources of primary data	**Search areas**
Australian Science Archives Project • Online resource developed by the University of Melbourne to assist in the research of Australian Science. Links to	• Industries • Corporations • Research institutions • Scientific societies • Scientists

Trove (National Library of Australia) • National, regional and metropolitan newspapers • Historical documents held in local, State, National and international libraries, museums and historical sites and archives	• Social history, policy and praxis • Political history, policy and praxis • Economic history, policy and praxis • Science history, policy and praxis • Intellectual Property law, policy and praxis • Primary industries, history, policy and praxis • Secondary industries, history, policy and praxis • Museum history, policy and praxis • CSIRO, universities, research institutes • Education policy and praxis • World Wars I and II • Developmentalism and industrialism • Environmentalism and environmental movement • Postmodernism and the cultural turn • Cultural policy and praxis • Volunteering and participation • Neoliberalism and economic rationalism
Australian Government and State Governments • Australian Bureau of Statistics • Local, State and Federal government websites • State and Federal archives • Science organisations	• As above

International Organisations
• United Nations (UN), including but not limited to:
  o United Nations Educational, Scientific and Cultural Organisation (UNESCO)
  o World Bank (WB)
  o World Intellectual Property Organization (WIPO)
  o World Health Organisation (WHO)
• Organisation for Economic Co-operation and Development (OECD)
• International Council of Museums (ICOM)
• Royal Society
• Linnaen Society
	• As above

Corporate entities
• Domestic and transnational corporations across a range of areas including but not limited to:
  o Primary industries
    ▪ Mining
    ▪ Agriculture
  o Secondary industries
  o Tertiary industries
	• As above

Scientific organisations in Australia Voluntary organisations including but not limited to: • Royal Society (by state) • Linnaen Society (by state) • Australian Association for the Advancement of Science (AAAS) • Australian Academy of Science (AAS) Industry associations including but not limited to: • Agricultural and Resource Economics Society	• As above

• NSW Farmers Association • Australian Institute of Agricultural Science and Technology • Australian Water Association • Australian Institute of Horticulture Inc. • Association of Professional Engineers, Scientists and Managers, Australia • Minerals Council of Australia • Australasian Institute of Mining and Metallurgy • Australian Biotechnology Association • Australian Institute of Environmental Health • Australian Institute of Geoscientists • Australian Meteorological and Oceanographic Society • Australian Institute of Physics • Australian Marine Sciences Association • Australian Science Communicators • Environment Institute of Australia and New Zealand • Royal Australian Chemical Institute Professional bodies including but not limited to: • Australian Institute of Marine Science (AIMS) • Australian Nuclear Science and Technology Organisation (ANSTO) • Australian Synchrotron • Geoscience Australia • Intellectual Property (IP) Australia	

Stage 4: Analysis of the data using the tripartite model and the creation of the early evidentiary narrative

The data was examined using the Miles and Huberman (1994) system of analysis. This examination was conducted using the tripartite model as an analytical lens in order to begin the preparation of the evidentiary narrative. The evidentiary narrative required many drafts and much rearrangement of the data in order to develop a cohesive and explanatory story of the trajectory of scientific knowledge and production within Australian policy settings. The tripartite analytical model was validated and fleshed out during this fourth stage. As with much qualitative research this stage this process was not smooth and did not progress in a step by step manner. Indeed, to present a lucid and candid picture of scientific knowledge production and diffusion in Australia required a sound methodology and much grappling with the data. Overall, however this project has been successful in achieving its aims. The following section provides an overview of the analytical framework and the empirical research that is used to tell the story of scientific knowledge production and diffusion in Australia between the 1770s and the 2010s.

1.2 The empirical framework of the thesis

Chapter 2 sets up the analytical framework for the thesis. This framework is drawn from the concepts of *rationalisation* as theorised by Weber and the principle of *instrumental rationality* as revealed by Horkheimer and Adorno. Chapter 2 also identifies three ideal type*s* of scientific knowledge production and diffusion: *non-instrumental science* that is practised as a means to *value-rational* ends and *instrumental science* that is produced for immediate and *purposive* use in the production of goods and services for the market or for purposes of war. A third ideal type of scientific knowledge production and diffusion has also been identified: that of *pre-instrumental science* where the state funds and/or produces scientific knowledge for express use by the market or the war effort. This third form of scientific knowledge is used as part of a suite of *protectionist* policies employed by the state for the rapid development of markets, particularly those leveraged by *special interests*.

Chapter 3 (1770s-1830s) begins the empirical analysis with a review of *instrumentalism* and its affiliation with the project of *capitalism* that underpinned the British settlement of New South Wales. The chapter analyses the first two scientific styled institutions, the Botanic Gardens and the Australian Museum in Sydney which can be said to represent two different forms of scientific knowledge that were emerging in New South Wales during the early 19th century. The Botanic Gardens demonstrates an *instrumental* form of scientific knowledge production, where knowledge was bound up with the development of global economic markets. On the other hand, the Australian Museum more closely follows the intentions of the scholars of the enlightenment, where *non-instrumental* scientific knowledge is produced in order to enhance the project of civil society.

Chapter 4 (1830s-1910s) deals with the demands of the growing nation of Australia and the establishment of bureaucracies to service those demands. Scientific knowledge, as an implicit factor of production, was critical to the growth of global markets thus the state was motivated to establish and fund scientific bureaux specifically for the advancement of the primary industries. This move on the part of the bureaucracies sought to escalate the production of scientific knowledge in order to stabilise production and increase yields; thereby, in the absence of income tax, to maximise revenue returns from tariffs. The bureaucracies, by separating scientific knowledge from its formerly *implicit* position within the factors of production to a more *explicit* form produced by the state, effectively prepared the way for the commodification of scientific knowledge in Australia.

Chapter 5 (1910s-1960s) traces the rise of *developmentalism* that occurred with the advent of Federation. This period witnessed a further transformation of scientific knowledge. During World War II and the post-war period, pre-instrumental science was leveraged by the market under the state policies of developmentalism and the endowment strategies of protectionism to further the growth of primary industries and to support the establishment of the secondary industries. Within this instrumental context the production and diffusion of non-instrument science did not flourish.

Chapter 6 (1960s-1980s) traces the distinctive social, political and economic conditions that led to the emergence of *environmentalism* in Australia. As a result of the environmental movement non-instrumental science did flourish and was elevated into the political public sphere in order to facilitate change at the level of the state.

Chapter 7 (1970s-1990s) explores the interaction between scientific knowledge, and the *cultural turn* in the social sciences. Integration into the remit of cultural policy worked to aestheticise public-facing scientific institutions in Australia and to decouple them from the expertise of scientists. This move further debilitated these institutions as producers of non-instrumental science, and opened them up to increasing irrelevance under the policies and praxes of neoliberalism.

Chapter 8 (1990s-2010s) explores how the natural sciences in Australia are faring under the policies and praxes of *neoliberalism*. The changing global conditions of the late 1970s and 1980s facilitated the introduction and development of neoliberal policies in Australia. These policies are seeing the dismantling of protectionist strategies for the primary and secondary industries and the state's facilitation of a new tertiary industry known as 'innovation'. Innovation policy, within the context of neoliberalism, moves to bind non-instrumental science directly with the market and so diminish the moderating influence of state institutions.

Just as the early industries benefited from protectionism under the rationale of developmentalism these new tertiary industries are significantly advantaged by the provision of scientific knowledge as part of a strong program of state protectionism. This protective action includes liberal and unrestricted access to scientific knowledge produced by state institutions, state funding for commercial research and development, favourable taxation treatment, supportive policy settings, a benign political public sphere and an accommodating nation state.

In the current policy milieux, pre-instrumental scientific knowledge production is being dismantled and non-instrumental scientific knowledge production and diffusion is being split into two discrete areas: environmental science (that science produced by the state and subject to efficiency and deregulation measures) and other non-instrumental science (that science predominantly produced in universities and research institutes and used as a precursor to the production of instrumental scientific knowledge).

The final knowledge product – a hybrid of non-instrumental science produced for instrumental purposes – is destined for private *knowledge hubs* operated through a *space of flows* (Castells 2005) by transnational corporations at secure points across the globe. Accordingly, nation states who participate in this neoliberal approach to scientific knowledge production and diffusion are at risk of transferring new knowledge, and accordingly sovereign power, to transnational corporations. The corporations exist independently of nation states and are thus not obliged to work within the legal framework of nation states.

Neoliberal policy settings that seek the extensive privatisation of the state's knowledge-producing assets (such as that produced by universities and research institutes) and that advocate for an all-encompassing role for the market, arguably put the sovereignty of the nation state and the security of the citizenry at risk. As the custodian of citizen sovereignty it remains the central responsibility of the state to uphold the freedom and autonomy of the individual. This autonomy includes the provision of rational scientific knowledge (and art and law) on the part of the state in order that the citizenry may claim their sovereign rights to engage in democratic decision-making. The next chapter begins the task of preparing the theoretical groundwork for the further development of the thesis.

2 Theoretical overview

Weber (1967, 1968, 1978 & 1991) identifies a form of *rationalisation* particular to the industrialised West. This unique form of *rationality* posits Weber (1967, 1968, 1978 & 1991) emanated from the *natural sciences* through the development and praxis of mathematics and experimentation, and has been instrumental in shaping western science, art and law. Weber argues that it has been an important contributor to the development of the *modern state* and the specific form of market *capitalism* extant in western nations. Weber (1967, 1968, 1978 & 1991) describes this triumph of *purposive rationality* over more normative, *value-rational* conceptions of the world, an enclosure as hard as steel from which the modern individual may find it difficult to escape. This thesis seeks to apply Weber's theoretical concepts of *instrumental (or purposive or means-ends) rational social action* and *value-rational social action*; Lukács' conception of *reification*; and the notion of *instrumental rationality* posited by Horkheimer and Adorno to the problem of the production and diffusion of scientific knowledge in Australia between the 1770s and the 2010s.

While the thesis makes use of the valuable theoretical work of Lukács, Horkheimer, Adorno and Habermas it does not seek to resolve the ongoing debates of the Frankfurt School. Horkheimer and Adorno (and indeed Weber) saw the lifeworld as subsumed by the negative authority of instrumental rationality and controlled by the misspent power of the state in collusion with capitalism. This disempowering, all-encompassing instrumental authority was described by Weber as 'the iron cage of modernity'[6] and by

[6] This visual metaphor of Weber's work was developed by Parsons in his translation of the original work. Beilharz suggests that Weber's original meaning was 'mistranslated following the image in *Pilgrim's Progress*. Weber refers to something like a casing as hard as steel, which suggests a different constellation of metaphors or images (2016 private document).

Horkheimer and Adorno as the *dialectic of enlightenment* where rationality reverts to myth; these theorists believe that there is no way out of this irrational condition of modernity. Habermas, on the other hand, has worked extensively on finding a way out of this dystopian positioning by seeking ways of incorporating a more optimistic version of rationality at the level of the lifeworld.

Habermas' theory of *communicative action* ([1981] 1987) seeks to resolve this dytopianism by reconciling the tensions between facts and values originally set up by Weber and perpetuated by Adorno and Horkheimer. Habermas ([1981] 1984) insists that while a world totally dominated by instrumentality (facts) is flawed, so too is a world consisting only of values; a lifeworld without facts is in reality a return to the conditions of 'pre-enlightenment' or a more feudal construction of the social realm.

The lifeworld needs both facts and values in order to flourish; communicative action facilitates this balance by enabling the introduction of value claims into the authority of *instrumental rationality* at the level of the lifeworld. This type of rational action enacted by the citizenry disrupts the steering media used by the state and the market by facilitating rational debate in the public sphere. Rational argument in the *political public sphere*, argues Habermas ([1981] 1987), works to pressure the state to adopt value-rational perspectives into purposive-rational strategies.[7]

In order to integrate these theoretical concepts of rationalisation into the current empirical study,[8] an analytical model has been constructed using Weber's model of

[7] The Habermasian theory of communicative rationality is seen in practice during the environmental movements in Australian during the late 1970s and 1980s. This movement is discussed more fully in Chapter 6.
[8] An opportunity exists to extend the current thesis to address the Habermasian theories of communicative action and the public sphere in terms of Australian policy settings. This further research is best conducted in a post-doctoral setting.

social action, particularly *purposive-rational social action* and *value-rational social action* as its founding principles. This work begins in the next section by exploring Weber's concepts of rationality and rationalisation as it relates to the social world.

2.1 Rationality and the rationalisation of the social world

Weber (1967, 1968, 1978 & 1991) traces the march of rationality from its original rise from the 'mathematical foundation which it first received from the Greeks' (1967: 13); through the development of the 'systematic method' of Aristotle (1967: 14); the 'rational juris-prudence of the Roman law and of the western law under its influence' (1967: 15) to the canon law of the middle ages; and the rational development of art, the modern state and the western system of capitalism.

Moreover, Weber notes that rationalisation has become endemic in 'all areas of human life from religion and law to music and architecture' and that there exists 'a historical drive' towards a world in which 'one can, in principle, master all things by calculation' (Weber [1946] 1991: 139). However, as with many socio-cultural processes, the rationalisation of the social world manifests in a diversity of ways. Notwithstanding the diversity of human life these manifestations of rationality have an historical tendency to be founded on human values rather than on specific interests. Kalberg posits,

> Their broad range of diversity depends ultimately, for Weber, on a multitude of interacting ideas, values, interests, and economic, political, sociological, and historical factors. Rationalisation processes of historic significance in societies and in entire civilizations have often originated when a constellation of factors crystallized that rewarded methodical rational ways of life….Weber argues that precisely these ways of life were based on values rather than on interests (1980: 1149).

Weber identifies four types of rationality; *practical*, *theoretical*, *formal* and *substantive* (Weber 1968; Brubaker 1984; Habermas 1984; Kalberg 1980; Levine 1981, Ritzer 2007). Practical rationality is that type used in everyday praxis where an individual seeks to solve the ordinary, day-to-day problems of life; it involves simple calculation around the best way to achieve a particular end. Theoretical rationality on the other hand may be used by scholars who apply 'logical deduction, the attribution of causality, and the arrangement of symbolic meaning' (Ritzer 2012: 42) in order to find patterns in, and add logical meanings to, an increasingly fragmented and disordered world (Kalberg 1980). Weber finds that theoretical rationality involves 'an increasingly theoretical mastery of reality by means of increasingly precise and abstract concepts' (1991: 293). Moreover, Ritzer notes that 'whereas practical rationality involves action, theoretical rationality is a cognitive process and has tended to be the province of intellectuals' (2012: 30).

The most useful types of rationality for the construction of the analytic model employed in this thesis are Weber's conceptions of *formal* and *substantive rationality* which diffuse through *purposive-rational* and *value-rational social action*[9] respectively. As an ideal type, formal rationality is that type of rationality institutionalised by large social structures such as bureaucracies, modern law and the capitalist economy, in order to affect decision-making using a means-ends or purposive type of social action. In order to optimise the chances of successful decision-making, this orientation to rationality employs *technical* criteria in the form of universally applied rules, regulations and laws (Kalberg 1980; Ritzer 2012); a *utilitarian* perspective is used to establish the most

[9] Purposive rational social action employs rational decision-making for both means and ends. Value rational social action employs rational decision-making for means, but a values orientation for ends. Social action is further defined and discussed in Section 2.2.

rational course of action in order to achieve the most rational ends; to this end, human values are eliminated from the process because they are not of a technical orientation (Weber 1968). Thus in formal rationality where rationality is enacted through purposive-rational social action, facts and values are separated from each other in the decision-making process. Notwithstanding the elimination of values from formal rationality, Weber explains that value-rational social action can be enacted through substantive rationality which is a more values[10] oriented conception of the rationalisation process; substantive rationality is positioned as a value-rational alternative to *utilitarianism.*[11] However, as Weber (1968) observes, in social milieux dominated by the formal rationality of bureaucracies, modern law and the capitalist economy, substantive rationality is often positioned as irrational.

Substantive rationality involves the harnessing of rational means to achieve a set of ends that are steered by 'clusters of values' or an appeal to ethical norms; values that involve a choice of means to achieve ends that are 'guided by some larger system of human values' (Ritzer 2012: 42). According to Weber, formal and substantive rationality are in constant tension because, as Kalberg points out, 'only substantive rationality possesses the analytical potential to master – or rationalize – reality comprehensively. It does so by consciously and methodically organizing action into patterns that are consistent with explicit value constellations' (1980:1169).

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[10] Values in this instance meaning human, social, civic or ethical values.

[11] Utilitarianism is defined as 'a form of consequentialism because it rests on the idea that it is the consequences or results of actions, laws, policies, etc. that determine whether they are good or bad, right or wrong. In general, whatever is being evaluated, we ought to choose the one that will produce the best overall results. In the language of utilitarians, we should choose the option that "maximizes utility," i.e. that action or policy that produces the largest amount of good' (Nathanson 2013: online).

Further, Kalberg (1980) proposes that Weber's[12] conception of substantive rationality is the only type of rationality that may withstand colonisation by formal rationality and thus domination of the lifeworld by systems facilitated by money and power (Kalberg 1980). In spite of the enduring efficacy of substantive rationality in terms of social outcomes, the logic of formal rationality remains firmly embedded in the systems of state and in economic policy. Weber observes that formal rationality has been particularly successful within the modern nation state where political parties act in concert with a powerful bureaucracy supported by the rule of law. The ideal type of bureaucratic administration is according to Weber 'the root of the modern Western state'; it is

> …capable of attaining the highest degree of efficiency and is in this sense formally the most rational known means of exercising authority over human beings. It is superior to any other form in precision, in stability, in the stringency of its discipline, and in its reliability. It thus makes possible a particularly high degree of calculability of results for the heads of the organization and for those acting in relation to it. It is finally superior both in intensive efficiency and in the scope of its operations, and it formally capable of application to all kinds of administrative tasks… church, state, armies, political parties, economic enterprises, interest groups, endowments, clubs and many others…The whole pattern of everyday life is cut to fit this framework (1968: 223).

Furthermore, Weber argues that bureaucratic administration within the capitalist economy draws its notion of superiority from the 'role of technical knowledge'. Technical knowledge, that knowledge used to develop modern technology and the

[12] As discussed in the opening section of the chapter Weberian theory is used in order to construct the analytical model for this thesis and Habermas has since moved to reconcile the tension between various forms of rationality in his theory of communicative action ([1981] 1984). Communicative rationality is both a solution to the tensions created between value-rational and purposive-rational actions and a type of rationality that may be used to integrated value claims into the steering mechanisms of the market and the state ([1981] 1987).

business methods used in the production of goods, has 'become completely indispensable' (1968: 225). Moreover, technical knowledge has come to dominate bureaucracies and it is only the capitalist entrepreneur who remains superior to the experts of bureaucracies.

> Bureaucratic administration means fundamentally domination through knowledge. This is the feature of it which makes it specifically rational. This consists on the one hand in technical knowledge which, by itself, is sufficient to ensure it a position of extraordinary power…Superior to bureaucracy in the knowledge of techniques and facts is only the capitalist entrepreneur, within his own sphere of interest. He is the only type who has been able to maintain at least relative immunity from subjection to the control of rational bureaucratic knowledge (Weber 1968: 225).

Weber remarks that the 'tragedy and paradox' of the modern western world is that despite the tremendous achievements of technology, humanity has misplaced its values and ideals in exchange for a life of 'soulless calculation'; that the contemporary world is instead trapped in an inescapable regime of commodities and regulations.

> No-one knows who will live in this cage in the future, or whether at the end of this tremendous development entirely new prophets will arise, or there will be a great rebirth of old ideas and ideals, or if neither, mechanizes petrification, embellished with a sort of convulsive self-importance. For the last stage of this cultural development, it might well be truly said: "Specialists without spirit, sensualists without heart; this nullity imagines that it has attained a level of civilization never before achieved (1967: 182).

This seemingly inescapable regime is produced through a self-perpetuating form of rationalisation that is value-neutral, argues Weber (1967, 1968, 1978 & 1991), and is specific to modern capitalist societies. This finding concerns Weber and he reveals an active ambivalence towards the usefulness of the specialised and value-neutral form of rationalisation that he uncovers in formal rationality (1958); this is evidenced in both his despair at the rational cell, as hard as steel, in which modern individuals increasingly find themselves imprisoned, and by his own attitudes towards the production and diffusion of scientific knowledge.

Weber suggests that while the *scientific method* is fundamental to the production of all scientific knowledge there ought to be a place for a more *value-rational* form of scientific endeavour (that being substantive rationality) which may be achieved through value-rational social action. As both Sir Francis Bacon[13] and Weber have argued, the natural sciences require three types of rationality in order to advance both the humanitarian aspects of natural science and the civilisation of the social world: the irrationality of the original idea, the rationality of the scientific method and the adoption of a values-orientation in its aims. This position is particularly evident in Weber's lecture, 'Science as a Vocation', where he proposes that a total rationalisation of natural science fails to draw upon on 'inspiration' and a Platonic sense of 'mania' (1958: 114) in order to generate value beyond mere instrumentalism.

Weber laments that the dominance of formal rationality and its praxis through purposive-rational social action has created a social world that routinises and standardises people and products and thus produces greater efficiencies and superior predictability in order to administer and manage the state and its citizenry. These efficiencies and predictabilities are essential for the conduct of a proficient and cost-effective state; a view which is endemic in industrial and post-industrial societies.

[13] Bacon's treatises on the advancement of the natural sciences through the application of the scientific method and his discussion of means and ends are examined in Section 2.4.1.2.

Contrary to notions of predictability which feature strongly in the more instrumental forms of scientific knowledge production, Weber argues that the most important scientific breakthroughs are discovered without certain ends in mind. Indeed, Weber (1958) remarks that it is the irrationality of the idea; the intuitive moment; the flash of inspiration; and the freedom to be as creative and imaginative as the artist (1958: 114) that produces the foundations for good science. This freedom to discover new ideas is as important to natural science as the efficient and predictable activities that follow. Weber posits,

> ...Inspiration plays no less a role in science than it does in the realm of art. It is a childish notion to think that a mathematician attains any scientifically valuable results by sitting at his desk with a ruler, calculating machines or other mechanical means. The mathematical imagination of a Weierstrass is naturally quite differently oriented in meaning and result than is the imagination of an artist, and differs basically in quality. But the psycho logical processes do not differ. Both are frenzy (in the sense of Plato's ' mania ') and 'inspiration'… Instead of this, an inner devotion to the task, and that alone, should lift the scientist to the height and dignity of the subject he pretends to serve. And in this it is not different with the artist (1958: 114)

This freedom to create however may be dissipated by the relentless means-ends rationality undertaken by the modern capitalist state and its association with the market. Adorno and Horkheimer, unlike Weber, believe that the natural sciences are completely lost to the highly instrumental qualities of contemporary society,

> If the only obstacles were those arising from the oblivious instrumentalization of science, thought about social questions could at least attach itself to tendencies opposed to official science. Those tendencies, too, however, are caught up in the general process of production. They have changed no less than the ideology they attacked. They suffer the fate which has always been reserved for triumphant thought. If it voluntarily leaves behind its critical element to become a mere means in

> the service of an existing order, it involuntarily tends to transform the positive cause it has espoused into something negative and destructive ([1947] 2002: xv).

Adorno's and Horkheimer's ([1947] 2002) work, as viewed from their position pre- and post-World War II couples the natural sciences with the destructive forces associated with a form of totalitarianism. This authoritarianism presents as rational in terms of formal rationality but highly irrational in terms of substantive rationality. By coupling the natural sciences to the project of totalitarian rationalisation Adorno and Horkheimer, to all intents and purposes, continue to reify means-ends rationalisation of all natural science. While instrumental rationality is a very useful concept, one that is vital to unpacking and developing a realistic understanding the dangers inherent in a corrupted instantiation of scientific knowledge, it also works towards reifying the destructive forces associated with the totalitarian project and does not move towards seeking other ways of attaching social questions to official science. By completely repudiating the potential of Baconian conceived scientific knowledge production and diffusion, the theoretical approach of Adorno and Horkheimer may not then access the creative and value-rational potentialities of the natural sciences. Nor, it would seem, does this dystopian theoretical position taken up by Adorno and Horkheimer reveal the constant and sometimes despairing struggle played out between the ideal types of non-instrumentalised and instrumentalised natural science and their practitioners.

Modern scientists are in and of themselves predisposed to supporting the traditions of natural science laid down by the scholars of the enlightenment period[14] as evidenced in the almost universal support for the norms of science by contemporary scientists

[14] Merton ([1942] 1973) has described four sets of institutional imperatives that make up the ethos of modern science. These institutional imperatives (or norms) are *communality*, *universalism*, *disinterestedness* and *organised skepticism.* These norms will be discussed more thoroughly in Chapter 8.

(Anderson et. al 2010). Moreover, 'traditionally, the most deeply held value of scientists is the extension of knowledge. To contribute to this is the highest striving of a scientist' (Etzkowitz 1998: 824) and which lies embedded in the trajectory of civil society that began with the enlightenment scholars. Despite their acceptance of the potentiality of the natural sciences to offer freedom and mastery of their own life, Adorno and Horkheimer find no contemporary salience in the project of enlightenment. Moreover, they resist the possibility of reconstructing the sociological trajectory of scientific knowledge in order that a more ethical values-oriented perspective may be developed. Rather, they argue,

> Enlightenment, understood in the widest sense as the advance of thought, has always aimed at liberating human beings from fear and installing them as masters. Yet the wholly enlightened earth is radiant with triumphant calamity. Enlightenment's program was the disenchantment of the world. It wanted to dispel myths, to overthrow fantasy with knowledge. Bacon, "the father of experimental philosophy," brought these motifs together. He despised the exponents of tradition, who substituted belief for knowledge and were as unwilling to doubt as they were reckless in supplying answers. All this, he said, stood in the way of "the happy match between the mind of man and the nature of things," with the result that humanity was unable to use its knowledge for the betterment of its condition (Horkheimer & Adorno 2002: 1).

So, as distinct from Weber, Adorno and Horkheimer couple the natural sciences with the destructive forces associated with totalitarianism, and effectively reject a way out of deeply instrumentalised scientific knowledge; they do however effectively critique the highly instrumental qualities of contemporary society (instrumental qualities that drive the totalitarian characteristics of the state and the market) and, like Weber, declare the social world lost to the 'triumph' of rationality.

As this thesis argues, the paradox revealed in the work of Weber, Horkheimer and Adorno is that under the conditions of modernity the scientific method has turned upon itself. The scientific method embodies a rational process designed to render expert knowledge of the natural world (otherwise known as: natural science). However, in the modern world this rational aim has instead turned upon itself and become a casualty of its own rationality. Instead of an emancipated civil society realised through expert scientific knowledge, the rationalisation process has delivered a weakened civil society that is itself steered by the state and market. Moreover, the positive, non-instrumental aspects of the natural sciences are often excluded from public political debate and judged poorly by the polity. As Weber posits,

> Scientific progress is a fraction, the most important fraction, of the process of intellectualization which we have been undergoing for thousands of years and which nowadays is usually judged in such an extremely negative way (Weber 1958: 116).

This ambivalence towards a perfectly instrumentalised form of scientific knowledge production and diffusion can be seen in the four part analytical model that Weber constructs in order to explain his ideal types of *social action* (1968: 26).

2.2 Weber's typology of social action

Weber argues that the processes of rationalisation function through the ideal types of social action and, just as there are differing forms of rationality, so there are differing types of social action. These differing types of social action are formed by both the coupling and the decoupling of facts and values in various formats in order to produce ideal types: *purposive-rational action (or means-ends rationality)*; *value-rational action*;

affectual action and *traditional action*.[15] This section of the thesis focuses on Weber's purposive-rational and value-rational forms of social action which, it is argued are the most useful for analysing the production and diffusion of scientific knowledge in Australia.

For Weber (1968), rational action has always formed a part of the social world; the understanding or undertaking of methodological behaviour in order to achieve particular social or individual aims did not emerge specifically during the enlightenment period. Instead, methodological behaviours have been linked to every day social actions since 'primitive' times when 'specific religious rituals were performed with the aim of receiving favors from a god' (Kalberg 1980: 1148). As Kalberg notes,

> In Weber's eyes, this pure exchange relationship as it existed in sacrifice and prayer (1968, p. 424 [258-59]; [1922] 1973, pp. 432-38) was identical in form to the modern businessman's calculation of the most efficient means to acquire profit. Likewise, the fact that the values in premodern societies diverged widely from modern values did not, for Weber, call into question the basic capacity of man to orient his actions rationally on the basis of values. On the other hand, traditional and affectual action were not uprooted and swept away to the degree that modernization movements advanced (1980: 1148).

For Weber, it was the diversity of 'interacting ideas, values, interests, and economic, political, sociological, and historical factors' that 'rewarded methodological and rational ways of life' (Kalberg 1980: 1149) and shaped the social world accordingly. These pre-

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[15] In his definition of *social action* Weber identifies four different ways that social action may work: *instrumentally rational (zweckrational)*; *value-rational (wertrational); affectual* and *traditional*. Traditional action is that which is 'determined by ingrained habituation'; affectual action (particularly emotional action) is 'determined by the actor's specific affects and feeling states'; value rational action is 'determined by a conscious belief in the value for its own sake of some ethical, aesthetic, religious, or other form of behaviour, independently of its prospects for success; and value-rational action which is 'determined by expectations as to the behavior of objects in the environment and of other human beings; these expectations are used as "conditions" or "means" for the attained of the actor's own rationally pursued and calculated ends' (1968: 24).

modern ways of life tended to be founded however on sets of values rather than the specific interests that are often present during modernity. It was predominantly under the conditions of modernity, advanced by the industrial revolution, that saw the institutions of bureaucracy, law and economics disembedded from everyday life and a means-oriented rationality driven by interests rather than values evolved. Accordingly, interests came to be tightly bound up with rational means and ends. For that reason, scientific knowledge production and diffusion became strongly associated with purposive-rational action and the production of instrumental science took precedence over the more value-rational social action that had been conceived by the scholars of the enlightenment. Weber argues to support this enlightenment conception of natural science and contends that the producers of scientific knowledge production ought instead to consider not only alternative means to achieving the desired ends but a consideration of the end in terms of 'secondary consequences' and 'the relative importance of different possible ends' (1968: 26).

Weber (1968) describes a situation where an individual, organisation or institution may use a value-rational action to choose the end result of a social goal but may employ purposive-rational action in order to achieve those ends. For instance, the production of 'pure', 'basic' or 'blue-sky' scientific knowledge may employ purposive rationality in the form of the scientific method in order to achieve a value-rational end; an end such as the exploration of the natural world in order to generate a greater understanding of nature and our place within the natural world, and to cultivate a civil society that seeks to genuinely underpin the value-oriented intentions of social equality and access to impartial scientific knowledge.

Weber argues that this form of value-rational action is employed 'independently of its prospects for success' (1968: 25) and 'may thus have various different relations to the instrumentally rational action' (1968: 26). Importantly, from the point of view of instrumentally rational action, however, 'value-rationality is always irrational' (1968: 26). Thus in terms of the rationality of the market (and indeed the modern state in Australia) it is only instrumental rationality that may be considered rational; ends focused on value-rational action are therefore positioned as irrational. This paradoxical situation can be seen played out in Australian policy settings, particularly those policies implicit in the binding, by the state, of scientific knowledge to economic interests.[16]

In order to identify and analyse these trends, this thesis adopts an analytical model based on Weber's conception of rationality and the instrumental rationality conceived by Adorno and Horkheimer. Although Weber's work has been employed by a number of important social theorists this thesis engages specifically with the work of Adorno and Horkheimer and their notion of the dialectic of enlightenment in order to flesh out the argument that instrumental rationality has become an abiding concept in the concept of modern life. Moreover, the antipathies of Adorno and Horkheimer towards the rationalities embedded within the sociological theory around the natural sciences requires examination in order to progress on the theoretical plane.

Using the concepts of substantive rationality and value-rational social action the analytical model employed in this thesis constructs the ideal type of *non-instrumental scientific knowledge*; and using formal rationality and purposive rational social action constructs the ideal type of *instrumental scientific knowledge*. The ideal type of *pre-*

[16] This argument is progressed through the remainder of the thesis.

instrumental scientific knowledge takes up a Weberian Marxist position by employing Lukács' theory of reification. The analytical model itself is shown in Figure 2.1 in Section 2.3. The following section prepares for the construction of the model by reinforcing Weber's position that these ideal types are not tied to particular social structures or specific social periods; rather they are helpful in detecting patterns and meanings within actually existing instances that may be found in the fields of history, geography, power, conflict, competition, technology and/or social dynamics.

2.3 Constructing the tripartite analytical model

The components of Weber's social action thesis are formed using ideal types; these ideal types of social action may be employed as tools with which the researcher may observe 'actual empirical regularities; that is, courses of action that are repeated by the actor or (possibly also: simultaneously) occur among numerous actors because the subjective meaning is typically meant to be the same' (Weber 1968: 29). Weber argues that these patterns of social action are originally derived from randomly occurring actions on the part of the individual; that the individual may then imitate or react to influences from the social world which are then regularised or crystalised into these *meaning*-based patterns (Kalberg 2003: online).

For instance, modern capitalist societies are particularly vulnerable to adopting *means-ends* rational action because *bureaucracies* and *market mechanisms* function to achieve particular instrumental, politically and economically focused goals. On the one hand the citizen (or indeed the individual scientist) may inherently desire to pursue a values-oriented activity over an instrumentally constructed endeavour, but the *hyper-rational* operation of bureaucracies may potentially preclude this desire.

Moreover, Weber thinks that the 'patterns' and 'regularities' identified through the application of these models of social action may be found in a range of social milieux, across varying organisational settings, and through differing historical epochs. As Kalberg explains,

> Patterns could occur at a plurality of levels of sociocultural processes, from those manifest in the dominant paths followed by entire civilizations to others that characterized long-term historical developments or short-term societal movements. Regularities of action surfaced as well within institutions, organizations, strata, classes, and groups in all societies (1980:1148) … (Weber envisions) a multiplicity of rationalisation processes that variously conflict and coalesce with one another at all societal and civilizational levels (1980:1147).

Thus Weber's models of social action are ideal for use as an interpretative device over different historical epochs rather than for specific use as fixed categories of actually existing cases. Weber notes that his models are 'basically "unhistorical' (in) character' and represent an 'ideal' or typical construction that 'captures the essence of a development, presenting it in a manner more internally consistent and systematically unified than ever occurred empirically' (Kalberg 2011: 340). Weber does not position his models as 'accurate renderings of the course of history or as themselves constituting "effective forces" but instead 'his models (unlike those of Comte, Marx or Spencer) serve a more modest task: they aim to provide the researcher with a clear and practical "means of orientation" on the one hand and an array of hypotheses regarding the course of history with respect to a particular theme on the other hand' (Kalberg 2003: online).

This section has begun the task of building a sociological model through which scientific knowledge production and diffusion in the modern world may be examined more closely. Weber's work on rationality, rationalisation and social action when brought together with the conceptual tools furnished by the scholarly works of the enlightenment; the theoreticians of the industrial revolution; and the analyses of late modernity present a powerful triumvirate with which to interrogate the production and diffusion of scientific knowledge within the modern social world.

These conceptual tools and theoretical frameworks guide this research and are helpful in detecting empirical cases and developments such as those to be found in the understanding and interpretation of social, economic and political fluctuations in relation to scientific knowledge production and diffusion in Australia between the 18th and the 21st centuries. Figure 2.1 below lays out the framework for the analytical model that has been used to develop this thesis. A theoretical discussion of each ideal type of knowledge production as presented in this model is conducted in sections 2.4.1, 2.4.2 and 2.4.3.

Figure 2.1: analytical model: three ideal types of scientific knowledge production discerned in Australia between 1770s and 2010s

Rationality and social action	Ideal type of scientific knowledge production and diffusion	Characteristics of the ideal type of scientific knowledge produced by the natural sciences

Substantive rationality realised through value-rational social action
 	
• Means are rational (scientific method)
• Ends focus on human values and ethics
	Non-instrumental scientific knowledge
	
	Theoretical influences: Aristotle, Bacon, Hobbes, Locke, Rousseau, Kant, Weber
		Non-instrumental scientific knowledge:
		
		• **A rational orientation towards the provision of socially valuable and ethical ends.**
		• Originally developed as natural philosophy (Aristotle)
		• Natural philosophers support free association and consensual decision-making (renaissance)
		• Empirical rather than epistemological (Aristotle, Bacon, Hobbes, Locke, Rousseau, Kant, Weber)
		• Science can ameliorate social and personal problems; not a 'cure' for social ills (as only God can 'cure') (Bacon)
		• Separation of reason (science) from divine knowledge (God) (Kant)
		• Rational knowledge (science) as both power and protector (Bacon, Kant)
		• Rational knowledge (science) as a means to individual freedom, ethical autonomy and self-rule; freedom of humans to pursue their own ends (Kant)
		• Rational civil society counter to feudalism; social contract and citizen sovereignty (Kant, Hobbes, Locke, Rousseau)
		• Sovereignty invested in the people over the monarch or the deity (Kant, Locke, Rousseau)
		• Civil society as social progress (Bacon, Hobbes, Locke, Rousseau, Kant)
		• Necessity of scientific 'experts' to protect individual freedoms
		    ○ Beware the 'Idols' of the Market Place (Bacon)
		    ○ Beware 'pedants' and 'populists' (Kant)
		• Importance of imaginative 'breakthroughs' in understandings of the natural world (Weber)
		• Importance of linking social values to rational action (value-rational social action) (Weber)
		• Integrates 'norms' of science (Merton)

Formal rationality realised through purposive-rational social action • Means are rational (scientific method) • Ends focus on utility	**Pre-instrumental scientific knowledge** Theoretical influences: Smith, Locke, Bentham, Weber	**Pre-instrumental scientific knowledge:** • **Rational scientific knowledge produced by the state for the express use by the market in production of goods and services** • Roots in ethics of liberalism and utilitarianism (Smith, Locke, Mill) in contrast with Baconian and Kantian perspectives of ethical, value-oriented ends. • Emerges and thrives under the conditions of modernity (Smith, Locke, Mill) esp. economics and politics of the industrial revolution • Utility and exchange value predominant; ethical value secondary • Value-rational knowledge is positioned as 'irrational' (Weber) through the focus on exchange value

		• Paradoxically high levels of protectionism for the market, state open to special 'interests' (Smith, Locke, Mill) • Highly instrumentalised to achieve political, economic and bureaucratic ends such as growing of markets and/or warfare (Smith, Locke, Mill) • Subject to high levels of bureaucratic control and regulation through ideologies of utilitarianism and *laissez faire* economics (Weber, Smith, Bentham, Mill) • Structural transformation of scientific knowledge from an implicit to explicit factor of production (Hicks)[17] • Contributor to emergence of scientific knowledge as a product in and of itself (Hicks) • Risk of destabilisation of the sovereignty of the nation state (Castells)
Formal rationality realised through purposive-rational social action • Means are rational (scientific method) • Ends focus on utility and exchange value	**Instrumental scientific knowledge** Theoretical influences: Smith, Locke, Mill, Weber, Lukács, Adorno & Horkheimer, Castells	**Instrumental scientific knowledge:** • **Rational scientific knowledge produced by the market for purposes of market advancement (i.e. competition and profit motives)** • Implicit in Lockean state and concepts of property rights/ownership (against Kant's grounding of property to freedom and autonomy) • Highly instrumentalised and used for specific ends such as market expansion and/or warfare (Weber, Lukács; Adorno & Horkheimer) • Information globalised, digitised, transnational; beginnings of the 'information age' and 'knowledge economy' (Castells) • Instrumental knowledge disembedded from the material through 'space of flows' (Castells) • Thrives under the conditions of globalisation and esp. neoliberalism (Castells) • Property rights to knowledge 'protected' by the law and managed by corporations and state sponsored 'knowledge hubs' (Locke; Bell; Stehr) • Scientific knowledge figured as both an explicit factor of production and a product in its own right (Hicks) • Transformed factors of production under neoliberalism: *land*/ICT networks; *labour*/non-instrumental scientists and off-shore workers; *capital*/state grants and tax incentives; *pre-instrumental scientific knowledge bureaux*/instrumentalised universities and research centres (Hicks). • Value-oriented ends are not present unless constructed as rhetorical marketing apparatus (Hicks) • Knowledge markets prosper under state protectionist policies echoing state cooperation with special interests, as with primary and secondary industries (Hicks) • Risk of destabilising the sovereignty of the nation state (Castells) and denying the civil rights of its citizenry • Risk of global re-feudalisation (Habermas)

[17] Note: The references to (Hicks) in this model are derived from the findings of this thesis

The following section reconstructs the three ideal types that have been introduced in this chapter and grounds these ideal types through the application of sociological theory.

2.4 Three ideal types of scientific knowledge

The previous section has set up the theoretical underpinnings of the Weberian approach to rationalisation and to scientific knowledge production and diffusion. The resulting tripartite model reveals three ideal type*s* of scientific knowledge production and diffusion:

Non-instrumental scientific knowledge: introduced into Australia by early colonists keen to establish scientific endeavour as a catalyst for the advancement of civil society.

Pre-instrumental scientific knowledge: developed in the context of the Australian colony which emerged in Australia in the 1870s as an outcome of the industrial revolution in Britain.

Instrumental scientific knowledge: appeared during the industrial revolution in Britain and was produced and diffused in Australia in an informal manner by field-based scientists. This ideal type was transformed as a result of World Wars I and II, and has again changed shape since the 1970s, compelled by the forces of globalisation and neoliberalism.

This section works through the historical and theoretical underpinnings associated with each of these ideal types.

2.4.1 Non-instrumental scientific knowledge

The initial impetus for the ideal type of non-instrumental science is values-oriented[18] rather than strictly rational or instrumental; this process of knowledge production harnesses a sense of curiosity and engages the imagination of scientists in order to generate rationally derived knowledge for the advancement of the human condition. This knowledge originates from an imaginative, values-led orientation which subsequently coalesces with the rationally constructed scientific method in order to transport it from the realm of the imagination into the rational space of the actually existing world.

Typically, non-instrumental scientific knowledge is bound up with Kantian notions of freedom, ethics, autonomy and self-rule; it ideally enables individuals to pursue their own ends by making use of this knowledge (as developed by scientific experts in the manner prescribed by Bacon) in order to manage and improve their lives. Moreover, this non-instrumental knowledge is intended to act as a protective mechanism against any possibility of the *re-feudalisation* (Habermas 1991) of the social world. These associations between knowledge, self-determination and the protection of liberty originated with Aristotle; were refined by the scholars of the enlightenment period; and have been taken up by contemporary philosophers of science, history, sociology and politics. Accordingly, they underpin the social, legal and political structures extant in the modern West. This section explores the emergence of non-instrumental scientific knowledge as an ideal type.

The ideal type of *non-instrumental scientific knowledge* (unlike the two other ideal types of scientific knowledge, i.e. *pre-instrumental* and *instrumental scientific knowledge*) is

[18] Values here are defined as human, social or ethical values rather than utility or exchanges values.

not necessarily linked to the purposive rationalities that rule modern capitalist states and markets. Rather, this ideal type relies on *substantive rationality* (Weber 1968) to realise *value-rational social action* (Weber 1968) for the direct benefit of the citizenry. That said, while non-instrumental knowledge does not work directly towards achieving economic goals or delivering solutions for national security, its imaginative potential and its propensity to deliver scientific breakthroughs may enable future instrumentality; it may be subsequently employed to inform the state on a civil matter or may lead to the undertaking of commercial activity for the direct benefit of the citizenry. The primary *intention* of this ideal type, however, is to further human understanding of the natural world and to underpin the advancement of civil society over the steering mechanisms of money and power.

The preliminary and primary impetus for this type of scientific activity is the focus on *values* over *interests*. Those values include, for the scientist, the ethics of *communality*, *universalism*, *disinterestedness,* and *organised skepticism* (Merton [1942] 1973); and for the citizen, rational knowledge produced by scientists (or as Bacon would have it, 'investigators' and 'interpreters' (Ede & Cormack 2012: 130)) offers both possibilities for emancipation and the protection of the values of individual freedom, autonomy and self-determination. What follows is an outline of the development of scientific knowledge production and diffusion from the early Greek philosophers to the natural philosophers of the enlightenment period whose notions of rationality and value underpin contemporary western democracies.

2.4.1.1 Origins of scientific knowledge production and diffusion

Since the earliest of times the observation of the natural world has been crucial to the survival of the social world (Ede & Cormack 2012). Even though human survival was contingent upon knowledge of the natural world it was not until the Ancient Greek philosopher, Thales of Miletus (c. 624 BC – c. 546 BC) – arguably the first scientist (Fara 2009) – that humans began to separate the materiality of the natural world from the realm of the supernatural. While modern western science owes an intellectual debt to the early Egyptian, Babylonian, Indian and Chinese civilisations it was from the Ancient Greeks however that the trajectory of the modern natural sciences can be traced (Van Doren 1991; Hale 1993; Findlen 1996; Burke 2000, 2012; Fara 2009; Ede & Cormack 2012).

Notwithstanding their considerable accomplishments in terms of 'technical knowledge, keen observational skills and vast resources of material and information' (Ede & Cormack 2012:3) the pre-Greek civilisations did not manage to intellectually separate the natural world from the supernatural world. It was this separation of the material from the supernatural that shaped the practice of *natural philosophy*[19] and so founded the praxis of basic (or non-instrumental) scientific knowledge[20] as it is known today (Van Doren 1991; Hale 1993; Findlen 1996; Burke 2000, 2012; Fara 2009; Kwa 2011; Ede & Cormack 2012).

Thales' account that nature functions independently of supernatural intervention and is thus governed by a set of general or universal laws opened up the natural world for human exploration, investigation and further understanding (Van Doren 1991; Burke 2000; Fara 2009; Ede & Cormack 2012). Moreover, it was Thales' materialism that was later taken up by Aristotle (384 BC – 322 BC) who subsequently maintained that

[19] 'The roots of modern science are found in the heritage of natural philosophy created by a small group of ancient Greek philosophers' (Ede & Cormack 2012: 1). Natural philosophy is defined as 'the branch of knowledge that deals with the principles governing the material universe and perception of physical phenomena; natural science' (Shorter Oxford English Dictionary 2007:2185).
[20] Or the ideal type of non-instrumental scientific knowledge

humans could only make sense of their world using what they perceived of the natural world through their senses. This early idea of *empiricism*, as it is known in the modern world, was carried through into the European Middle Ages[21] and then into the European renaissance when it was reinvigorated by naturalists, explorers, collectors and curators of the earliest natural history museums; 'curious' men such as Ulisse Aldrovandi (1522-1604) and Athanasius Kircher (1602-1680).

Findlen (1996) argues that these naturalists of the European renaissance, through their collection of natural objects of scientific worth, laid the foundations for the scientific revolution to come. Further, they re-introduced the practice of rational and dialectical discussion towards consensus that was first advanced by classical Ancient Greek philosophers such as Plato – using the Socratic method of critical thinking – and which had formed an important pillar of learning within Aristotle's Lyceum. Moreover, the private museums of the renaissance period extended Aristotle's theories that the material objects of the natural world, *naturalia*, could be interrogated – through the praxis of rational consensually oriented discussion – in order to reveal a greater understanding of the natural world.

The blend of science, philosophy and piety (Weber [1930] 1967); Merton [1942] 1973) practiced by these naturalists of the European renaissance[22] helped to generate a font of

[21] Scholars differ on the carriers of the Greek natural philosophy; some contend that Islamic Scholars were the keepers of the scientific knowledge produced by the Ancient Greeks whereas others claim that the knowledge was kept safe in Europe, only to re-emerge during the European renaissance.

[22] These private museums also acted as the fulcrum around which an early type of *scientific public sphere* was established (Fara 2009, Yeo 2001, Findlen 1996, and Habermas 1991). This early form of scientific public sphere set up prototypes for the public museums (and other public facing sites of scientific knowledge production and diffusion) that were to emerge during the late 18th century. Between the late 18th century and the late 20th century public museums of 'natural history' acted as important interlocutors in the scientific public sphere and helped to drive both the production and the diffusion of non-instrumental scientific knowledge. This role is discussed more fully in empirical chapters 3 to 8.

knowledge pertinent to human understandings of the natural world, and acted as an important pre-cursor to the trajectory of rational, consensually derived scientific knowledge production and diffusion that emerged in the West (Findlen 1996). Findlen observes that these natural history museums

> …belonged to many different worlds; they were owned by princes, clerics, doctors, apothecaries, and virtuosi. Thus they provided an axis through which all these different sectors of society intersected…The museum was not only a place in which objects were housed; it was also a setting in which relationships were formed…the museum also publicized a scientific culture formerly confined to scholastic discourse. (That despite its patrician leanings) it was the centrepiece of the humanist vision of science (1996: 10).

Notably, these early museums of the European renaissance acted as a fulcrum around which a type of scientific public sphere evolved. Traders, explorers, natural philosophers and other interested parties used both letters and newsletters to share news and discuss outcomes (Fara 2009). Moreover, the natural history museum acted as a meeting place within which the claims of the natural philosophers (otherwise known as: naturalists); the philosophical relationships between God and nature; and the empirical character of the natural world were debated and eventually agreed through a consensual process similar to that extant in the scientific realm today.

These venues acted in a similar manner to the art museums and cafes of the philosophers and artists that nurtured the alternate flank of the emergent civil society (Yeo 2001), that *public sphere* described by Habermas (1991). The current propensity to uphold the scientific norms of *communality*, *universalism*, *disinterestedness*, *originality* (or *novelty* as was added during later scholarship) and *organised skepticism* (Merton [1942] 1973) arguably began to establish during the European renaissance.

2.4.1.2 The influence of Sir Francis Bacon and the scientific revolution

Sir Francis Bacon (1561-1626), as an important forerunner to the scientific revolution, remarked about these renaissance naturalists and their museums, that 'It is not to be esteemed a small matter that by the voyages & travels of these later times, so much more of nature has been discovered than was known in any former period' (Bacon cited in Findlen 1996: 4). As Findlen affirms,

> Organising ideas around objects, naturalists increasingly saw philosophical inquiry as the product of a continuous engagement with material culture. The decision to display the fruits of collection led naturalists gradually to define knowledge as consensual, shaped in relation to the audience that entered the museum and therefore participated in the peculiar discursive practices that emerged within that context (1996: 5).

Indeed, the uncoupling of religion, philosophy and natural science, in the modern sense, arguably began with the explication of the scientific method advanced by Francis Bacon in his treatise *Novum Organum Scientiarum* ([1620] 1815).[23] Bacon's work is said to have been inspired by the writings of Aristotle in his *Organum*[24] and so reconstructs the system of logic developed by Aristotle; a system of *inductive reasoning* founded on the basis of rational inquiry. Rational inquiry or facts over magic (Kwa 2011) is a key theme in Bacon's writing as is the idea that rationally derived scientific knowledge is important not only for the glorification of God but also to more clearly understand how the natural world could provide 'relief to man's estate' or, in contemporary parlance, freely contribute to the wellbeing of all individuals.

[23] Translated as from Latin as the 'new instrument of science'
[24] Published, for instance, by Andronicus of Rhodes in 50BC

Bacon however cautions the reader against ignoble uses of scientific knowledge by declaring that knowledge is power and that that power ought to rest with individuals rather than 'Idols' such as those to be found in the 'Market Place'. In his *Meditations Sacrae* (1997 [1597: De Hæresibus]: n.p.) Bacon affirms that 'knowledge itself is power'[25] and goes on to suggest in Book 1 of *The Advancement of Learning* ([1605] 1869: n.p.) that scientific knowledge is not only valuable for demonstrating the 'glory of the Creator'[26] but could also be important for the 'relief of man's estate' or to contribute to a progressive and all-inclusive notion of social wellbeing. In his second book in *The Advancement of Learning* ([1605] 1869: n.p.) Bacon analyses and discusses an individual path to learning and provides a type of 'intellectual map' that, in his view, would best contribute the stock of knowledge in the world and by doing so further social, and individual, wellbeing ([1605] 1869: Book 1 V11: n.p.). Bacon describes his work thus,

> Wherefore I will now attempt to make a general and faithful perambulation of learning, with an inquiry what parts thereof lie fresh and waste, and not improved and converted by the industry of man, to the end that such a plot made and recorded to memory may both minister light to any public designation, and, also serve to excite voluntary endeavours ([1605] 1869: Book 2 V15: n.p.).

That said, Bacon was a realist and understood that human knowledge could easily be misused by what he termed 'Idols', or those adverse influences that could prove destructive rather than productive to knowledge production, diffusion and human

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[25] In the original Latin: *Ipsa scientia potestas est*. ([1597] 1996)

[26] Bacon was writing towards the end of the European renaissance before the scholars of the enlightenment confronted the idea that scientific knowledge was primarily to display the might and splendour of 'God, the Creator'. Instead Bacon introduced the idea that scientific knowledge would also be helpful for easing some of the problems encountered by humankind.

learning. He used this rationale to caution his readers about these undesirable and potentially destructive influences. Ede and Cormack write,

> Bacon believed that all human knowledge was flawed because of the Idols that all men carried with them. The Idols were the prejudices and preconceived ideas through which human beings observed the world. Bacon felt that that the only way for natural philosophers to disabuse themselves of these idols was to look at small, discrete bits of nature. The only way to be certain one understood these small bits was to study them in a controlled setting, isolated from the larger (uncontrolled) environment. Using this assumption, he introduced what has come to be called the inductive method. He suggested that increments of information could be gathered by armies of investigators, put together in a tabular form, and explained by a cadre of interpreters (2012: 130).

Hence Bacon had introduced the contemporary notion of experts, specialists who were obliged to rid scientific knowledge of the Idols which attempted to distort the meaning and so the understanding of the knowledge in question; Idols such as those of the Tribe[27], the Cave[28], the Theatre[29] and the Market Place.[30] Bacon considered the Idols of the Market Place 'the greatest nuisances of them all' ([1620] 1815: Aphorism 59: n.p.) thereby cautioning scientists to remain wary of the ways of 'men's commerce'. He argues,

[27] 'The Idols of the Tribe have their origin in the production of false concepts due to human nature, because the structure of human understanding is like a crooked mirror, which causes distorted reflections (of things in the external world)' (Klein 2015: online)

[28] 'The Idols of the Cave consist of conceptions or doctrines which are dear to the individual who cherishes them, without possessing any evidence of their truth. These idols are due to the preconditioned system of every individual, comprising education, custom, or accidental or contingent experiences' (Klein 2015: online).

[29] 'According to the insight that the world is a stage, the Idols of the Theatre are prejudices stemming from received or traditional philosophical systems. These systems resemble plays in so far as they render fictional worlds, which were never exposed to an experimental check or to a test by experience. The idols of the theatre thus have their origin in dogmatic philosophy or in wrong laws of demonstration' (Klein 2015: online).

[30] 'These idols are based on false conceptions which are derived from public human communication. They enter our minds quietly by a combination of words and names, so that it comes to pass that not only does reason govern words, but words react on our understanding' (Klein 2015: online).

> There are also Idols, derived as if from the mutual agreement and association of the human race, which I call Idols of the Market on account of men's commerce and partnerships. For men associate through conversation, but words are applied according to the capacity of ordinary people. Therefore, shoddy and inept application of words lays siege to the intellect in wondrous ways ([1620] 1815: Aphorism 43: n.p.).

Bacon concludes his elucidation of the Idols by declaring that they must all be 'abjured and renounced with firm and solemn resolution' so that human understanding 'may be completely freed and cleared of them' ([1620] 1815: Aphorism 68: n.p.) in order that empirical knowledge be tested with 'rigorous investigation' performed through rational experimentation. In this way, Bacon believes, scientific knowledge may as closely as possible resemble the 'truth' and not become 'adulterated' with false understandings ([1620] 1815: Aphorism 68: n.p.).

This cautionary note on the part of Bacon (that regarding Idols) arguably foretells the contemporary story of scientific knowledge production and diffusion where, through the dynamics of rationalisation and instrumentalism; the tools of public policy; and the authority of bureaucracies; the state and the market have become increasingly more tightly bound in their economic ambitions for scientific knowledge.[31] This economically ambitious position is antithetical to Bacon's explication which instead argues that scientific knowledge is not to be produced directly for the market in the pursuit of profit, but produced in order to advance the human condition and to generate a more civil society.

2.4.1.3 The Kantian effect on scientific knowledge production and diffusion

[31] The empirical work of this thesis demonstrates that the dynamics of rationalisation and instrumentalism, using the tools of public policy and the authority of bureaucracies, have increasingly shifted scientific knowledge production and diffusion in Australia from fulfilling the needs of civil society to satisfying the wants of the market.

The primary role of rational scientific knowledge, in Bacon's view, is to free ordinary people from ignorance. This theme is expanded on and enhanced by Immanuel Kant who argues that knowledge does not simply free ordinary people from ignorance; it liberates them from the control of others (from systemic controls such as those laid down by the monarchy or the church) and in so doing delivers individual autonomy and self-determination. So, for Bacon and for Kant, the possession of rational knowledge has both an emancipative aspect and a protective quality.

It is not within the scope of this thesis to discuss the wide-ranging theoretical structure of Kant's practical philosophy. Rather, Kant's work is discussed here in terms of its fit with the specific empirical work that has been undertaken in this thesis.[32] As such, a strong theme is Kant's theoretical repositioning of the natural sciences from the epistemological base of natural philosophy under the jurisdiction of the church or the monarchy, to an empirical position where rational science sits within the domain of the state. Moreover, Kant's linking of rational empirical knowledge to individual sovereignty forms a strong seam in my argument. Both of these areas are discussed below.

Prior to Kant's seminal work, the theory and practice of natural philosophy had been evolving since Aristotle and Theophrastus first collected, collated and examined material objects from the natural world and openly debated their theories with their fellow philosophers and students in the Lyceum of Athens (Van Doren 1991; Burke 2000; Fara 2009; Kwa 2011; Ede & Cormack 2012). For a range of reasons beyond the

[32] Moreover, notwithstanding the extant literature emanating from the scholars of the Sociology of Scientific Knowledge (SSK), the History and Philosophy of Science (HPS), the Sociology of Science and Technology (STS) (Antalffy 2008) or Bhaskar's Realist Theory of Science (2008) this thesis instead positions the production and diffusion of scientific knowledge as a function of the relationships between the modern state, the market and civil society.

scope of this thesis, the form of natural philosophy that emerged during the middle ages and continued into the European renaissance came to be bound up with religious practice; the motivation for the natural philosopher, often a member of the clergy or a vassal of the monarch during these periods, was to honour God by revealing the glory of His handiwork.[33]

In the latter stages of the European renaissance however scientific practice began to separate from the more philosophically inclined purview of the deity or the monarch (Van Doren 1991; Burke 2000; Fara 2009; Kwa 2011; Ede & Cormack 2012) thereby opening the way for Bacon to develop the scientific method and so reinforce the importance of empiricism in relation to the production and diffusion of scientific knowledge. Even so, Bacon's own work, while supporting the practice of empiricism, remained firmly attached to the notion of transcendent revelation achieved through a relationship with God and his earthly representatives; and so scientific knowledge remained coupled with the authority of religion and the monarchy (Van Doren 1991; Burke 2000; Fara 2009; Kwa 2011; Ede & Cormack 2012).

It was Kant who struck the defining blow and split the epistemological knowledge generated by philosophical practice from the empirical, rational knowledge produced by the natural sciences. By linking science to ideas perceived through the senses (otherwise known as: empiricism) and the validation of these ideas through experimentation and real world observations, Kant distinguished science from philosophy. Consequently, where natural science henceforth relied on rational, empirical understandings of nature, the study of philosophy relied on *a priori*

[33] For a first-class explanation of the relationships between scientific knowledge and religion during the medieval period see Kwa (2011).

knowledge, intuition or revelations from God. The possibilities for freedom from external controls (such as the church or the monarchy) and the principles of self-determination that are embedded in empirically derived rational knowledge are prominent in Kant's challenge to the individual. Kant's celebrated entreaty is for the individual to take up the challenge of freedom by seizing upon personal enlightenment as protection from these external controls.

> Enlightenment is man's leaving his self-caused immaturity. Immaturity is the incapacity to use one's intelligence without the guidance of another. Such immaturity is self-caused if it is not caused by lack of intelligence, but by lack of determination and courage to use one's intelligence without being guided by another. Sapere Aude![34] Have the courage to use your own intelligence! is therefore the [heraldic] motto [Wahlspruch] of the enlightenment (Kant [1784) 1949: 132).

In the footsteps of Bacon, scientific knowledge for Kant is 'not only a tool for individual self-betterment, but is a collective endeavour through which humanity at large is meant to realise its vocation' (Gelfert 2010: 95).

Notwithstanding Kant's linking of individual knowledge acquisition to both enlightenment and self-determination, Kant is (as is Bacon) in favour of scientific expertise that may provide both 'competence' and' sincerity' to the task of producing and diffusing scientific knowledge (Gelfert 2010: 95). To this end Kant is sceptical about the way that scientific knowledge may be conceived and delivered in the social world and he considers how moral and political philosophy ought to be employed to regulate the social use of empirical knowledge. He argues that transcendental (ethically

[34] Translation: Dare to know!

founded or beyond empirical) knowledge must be used to temper the use of reason. Wartenberg notes,

> It is a fundamental mistake to interpret Kant as an instrumentalist in regard to theoretical ideas. Indeed, Kant argues that the logical use of reason makes sense only in the light of a transcendental principle according to which the products of scientific reasoning can be viewed as providing a description of objective, though phenomenal, reality,
>
> > *How there could be a logical principle of the rational unity of rules cannot in fact be conceived unless a transcendental principle were also presupposed whereby such a systematic unity necessarily inhering in the objects was likewise assumed as a priori and necessary (A 651/B 679).*
>
> Kant here states that the logical use of reason requires some transcendental backing. His considered view is that the logical use of reason to unify our knowledge is a legitimate practice only because it is grounded by an item of transcendental knowledge (1992: 232).

Thus, as Weber argues, the transcendental values embedded in ethics and moralities are an important pre-cursor to the practise and promulgation of scientific knowledge. Gelfert (2010) takes this concept further by observing that Kant, like Bacon, is concerned about the proliferation of scientific experts who may masquerade as scientists but who are motivated by concerns other than 'truth in general' (2010: 94) or the collective good. Gelfert (2010) employs the categories of 'pedant' and 'populist' to demonstrate how Kant ideally positions the role of the scientific 'expert'. 'Where the scientific 'pedant lacks the (meta-) *competence* to communicate relevant knowledge effectively, the scientific 'populist' lacks *sincerity*, insofar as he lacks a sincere commitment to the search for truth in general' (Gelfert 2010: 94).

Gelfert (2010) argues that Kant is particularly scathing of the populists who, he says, pretend to scientific competence and authority but who are in fact similar to the 'quack and the charlatan', the 'apes of genius', who announce that 'difficult study and research are dilettantish and that they have snatched the spirit of all science in one grasp' (Kant *AA* VII: 266 cited in Gelfert 2010: 94) without actually employing the intellectual capacity necessary for scientific research. This type of pretender argues Kant is 'very disadvantageous to progress in scientific and moral education', in particular 'when he knows how to conceal his poverty of the spirit by dogmatizing from the seat of wisdom in decisive tones' over various (scientific and non-scientific) issues (Kant *AA* VII: 226 cited in Gelfert 2010: 94).

Gelfert argues that Kant's position on these so-called pretenders to science demonstrates 'a very real concern on Kant's part for applied social-epistemological problems' (2010: 95); that type of social-epistemology to be found in the figure of the scientific expert (as well as in education and in the growth of scientific knowledge). In contemporary milieux, the term experts may apply to the modern politician (as the 'populariser'), the bureaucrat (as the 'pedant'), the marketer (as the 'populist') or the science communicator (disposed towards 'popularity'). It seems therefore that both Bacon, in terms of his concerns around man-made Idols, and Kant with regard to his 'quacks', 'charlatans' or 'apes of genius', held robust concerns about scientific knowledge being used for purposes other than those that benefit all people and so advance the project of civil society.

2.4.1.4 The emergence of civil society

The development of civil society (counter to feudal society) was an important project of the enlightenment period and Kant's notion of practical philosophy, where empirical and rational ideas are applied to the social world, was, and remains, influential with social and political theorists. Kant's theories were particularly significant to the social contract theorists, those writers interested in the development of the individual within a civil society as distinct from the amorphous assemblage that had been controlled by the reigning monarch and/or the church during the feudal era and prior. During the enlightenment period, Kant's fellow empiricists Thomas Hobbes (1588-1679), John Locke (1632-1704) and Jean-Jacques Rousseau (1712-1778) were writing about politics, freedom and order and remain highly influential in defining the modern, western conceptions of state, their legal and political systems (Kersting 1992).

Indeed, it was Hobbes who, as a young man working as Bacon's secretary, coined the exact phrase '*scientia potentia est'* – translated from the Latin as *knowledge (or wisdom) is power* – meaning that access to, and use of, empirical knowledge may add to an individual's potential by increasing their understanding of the world and so advancing their life chances ([1651; 1668] Molesworth 1838-45: n.p.). Hobbes' position, which echoed that of Bacon's, was formulated in his highly influential manifesto *Leviathan* ([1651; 1668] Molesworth (1838-45): n.p.). In the Leviathan, Hobbes draws on the science of reason to establish the first instances of social contract theory; here he argues that individuals must voluntarily submit to the sovereign in exchange for protection from a return to the 'brutish world' that operated during the feudal ages and before. Hobbes asserts that unless humans freely submit to being regulated by a legitimate government (be that 'government': the monarchy, the aristocracy or a constructed democracy) they will revert to a 'state of nature', a state which is equivalent to a constant 'state of war' ([1651; 1668] Molesworth (1838-45): n.p.).

This theoretical move on the part of Hobbes establishes the notions of *sovereignty* and the *social contract* and further aligns the production and diffusion of rational scientific knowledge to ideas of individual autonomy. By voluntarily handing their individual sovereignty or natural rights to a legitimate government that is fortified by the rule of law, the citizenry remains protected from the selfish interests of others and becomes capable of adopting a more civilised approach to public life (Lloyd & Sreedhar 2014); hence Hobbes remains one of the first and enduring defenders of classic republicanism.[35]

Further, Hobbes, as a constituent member of the scientific revolution of the 17th century, continued the argument for the production and even-handed diffusion of knowledge in order that all people may benefit. In Leviathan, Hobbes' makes it clear that reason ought to be used to advance the production and diffusion of scientific knowledge for value-oriented ends,

> … The Light of humane minds is Perspicuous Words, but by exact definitions first snuffed, and purged from ambiguity; Reason is the pace; Encrease of Science, the way; and the Benefit of man-kind, the end. And on the contrary, Metaphors, and senslesse and ambiguous words, are like ignes fatui; and reasoning upon them, is wandering amongst innumerable absurdities; and their end, contention, and sedition, or contempt ([1651] Molesworth (1838-45): n.p.).

In the manner of Bacon and Hobbes, empiricists Locke and Rousseau also argue for the advancement of civil society through the adoption of a social contract that cedes individual sovereignty to the state in exchange for protection by the rule of law. Moreover, both link power to knowledge. Unlike Hobbes however, Locke and Rousseau occupy positions that do not support rule by the monarchy and are more concerned than Hobbes with notions of individual freedom and liberty.

[35] Notwithstanding his stance as a classic republican Hobbes was in favour of the reigning monarch remaining as leader of the legitimate government.

While Locke has not been described a scientist or natural philosopher, he was an original member, along with scientists Robert Boyle (1627-1691) and Isaac Newton (1643-1727), of the Royal Society[36] in London founded in 1660 (RS 2013), and was an important contributor to the study of natural philosophy.[37] Reason and the application of empirical methods such as experimental natural philosophy were strong themes in Locke's worldview and much evidence of this can be found in his writings. Moreover, a strong vein of rationalism and empirical thinking can be found in Locke's writing concerning the construction of a classically liberal civil society. Locke's vision of the ideal society powerfully develops the autonomy of its citizenry through the lens of reason and applies empiricism to validate his argument. For instance, Locke argues against the Hobbesian conception of the 'state of nature'. Hobbes argues that a rejection of the social contract will produce a return to the 'state of nature', which in Hobbesian terms, is equivalent to a 'state of war'; a state that Hobbes envisages enjoys 'no arts; no letters; no society; and which is worst of all, continual fear, and danger of violent death: and the life of man, solitary, poor, nasty, brutish and short' (Hobbes ([1651] Molesworth (1838-45) Ch. 12: n.p.).

[36] The Royal Society, as the leading scientific society of the day, was a powerful sponsor of scientific knowledge production and diffusion during the latter stages of the enlightenment and into the industrial revolution and continues to hold this position in terms of non-instrumental scientific knowledge production and diffusion. Their work, was and continues to be, influential in the development of non-instrumental science, 'The origins of the Royal Society lie in an 'invisible college' of natural philosophers who began meeting in the mid-1640s to discuss the new philosophy of promoting knowledge of the natural world through observation and experiment, which we now call science' (RS 2013: online)

[37] 'Locke retained an active interest in natural philosophy for over four decades: he wrote on the subject; he knew many of the leading English natural philosophers of his day and some continental ones as well; he was a member of the Royal Society from November 1668[2] and contributed to the *Philosophical Transactions* of the Society; he read widely in the field; he dabbled in experiments and was a keen observer of nature. As early as 1666, Robert Boyle could call him a virtuoso,[3] and by the last decade of his (p.2) life Locke had acquired such a reputation for his knowledge in natural philosophy that in August 1694 Hans Sloane, then Secretary of the Royal Society, writing to Locke to report on a whirlwind in Northamptonshire, could say: 'All philosophic occurrences are so well known to you that I am sure you might inform me, better than I, you…'' (Anstey 2011:1)

For Locke however, ‘men living together according to reason without a common superior on earth, with authority to judge between them, is properly the state of Nature’ ([1690]1924: 126) and so Locke’s appeal is based on the individual’s application of reason which in turn is upheld by the state through the rule of law. The rise of this early form of liberalism can be traced to the social conditions of the time; during the late 1700s the *bourgeois* class were applying pressure on the nascent institutions of the state to enfold property rights into the rule of law, and were demanding broad-based social models pertaining to education, money, government, law and civil society (Uzgalis 2012).

In Locke’s model of civil society, the state is mandated to uphold the individual rights of its citizenry primarily through the exercise of reason. As Orend (2005) argues, in Locke’s model the legitimate state embodies the power to implement appropriate controls in order to protect the lives of its citizens and to reinforce those citizens’ entitlement to basic civil rights; these rights, in Locke’s model, include property rights. Orend finds,

> As John Locke, and the U.S. Founding Fathers, declared: governments are instituted among people to realise the basic rights of those people. If governments do so, they are legitimate; if not, they have neither right nor reason to exist. This is vital: from the moral point of view, ***only legitimate governments have rights***, including those to go to war (2005: online).

It is not the intention of this thesis is undertake a robust discussion of civil rights or property rights and the protection of same. Rather the thesis seeks to explore the early notion of citizen rights in relation to Locke’s model of the state and civil society in order to introduce the ideal types of *pre-instrumental* and *instrumental science* and their relationships with social, political and economic expansion. A necessarily brief examination of a Lockean approach to civil and property rights follows.

Locke contends that citizens whose labour 'mixes' with and 'adds value' to the original or 'natural' form of materials that have been drawn from 'nature' (such as land or natural resources) in order to transform them and thus differentiate them from the commons of the natural world become the owners of that transformed 'property'; it is the responsibility of the state to protect that property. Locke writes,

> Though the Earth…be common to all Men, yet every Man has a Property in his own Person. This no Body has any Right to but himself. The Labour of his Body, and the Work of his Hands, we may say, are properly his. Whatsoever then he removes out of the State that Nature hath provided, and left it in, he hath mixed his Labour with, and joyned to it something that is his own, and thereby makes it his Property. It being by him removed from the common state Nature placed it in, it hath by this labour something annexed to it, that excludes the common right of other Men ([1689) 1953: 130) …The great and chief end, therefore, of men uniting into commonwealths, and putting themselves under government, is the preservation of their property ([1689) 1924: 180)

Locke is clear then that the role of the state operating through the due process of the law is to protect the property rights of its citizens. O'Byrne[38] (2012) argues that despite Locke's original thinking supporting the ideals of life, liberty and private property these

[38] O'Byrne (2012) argues that the justification of civil rights approached through the lens of philosophy has been largely unsuccessful and instead argues, in line with Habermas (1991), for civil rights to be couched within language-structure. O'Byrne maintains that despite the best efforts of philosophers to produce rational argument and rationally derived models, their theoretical work may be re-employed to legitimise projects that do not strictly support the original or intentional meaning of the work; that the original meanings of the work have been shifted by political and economically motivated 'special interests'. One such project is the ideology of neoliberalism. An antidote to this deliberate shift in meaning, and so consequences, may be the use of rational argument in the public sphere as conceived by Habermas in his theory of communicative action.

ideals have been captured by political and economic forces in order to support the ideological aims of neo-liberalism and neo-classical economics,

> Take the example of John Locke. In writing his tomes on natural law, and thus on why humans have rights and what those rights are, it is not inconceivable that Locke was acting in the best of intentions, without ideological prejudice. That his conclusions privileged life, liberty and private property may have been the product of rational, detached abstraction – but that does not change the fact that those conclusions continue to legitimise the ideology of western liberal democracy and capitalism (2012: 836).

As O'Byrne suggests, Locke's conclusions, irrespective of their original intentions, continue to dominate the construction of western capitalism and are used extensively to validate the prevailing ideology of neoliberalism and the practice of neo-classical economics. The argument goes that it is the 'social institutions such as the state, the law, and the media' that work to manipulate and reconstruct the 'language-structure' of rights 'such that it makes possible, indeed authorises, the continuing abuses of such rights' (2012: 830). O'Byrne contends that it is the 'heavily political discourse…facilitated through social institutions such as the state, the legal system or the media' that works to restructure the values associated with both civil and property rights (O'Byrne 2012: 830). He continues that this subtle restructuring of citizens' rights is prosecuted by way of a hegemonic set of self-generating ideologies that are based on self-interest over the achievement of common social ends. In effect O'Byrne (2012) upholds that the language used by Locke to set up a system of citizens' rights (supporting the democratic ideas of freedom and selfhood for all citizens) has been reshaped by political and economic forces in order to support ideological positions and special interests.

The influence of these special interests can be seen in the changing status of scientific knowledge production and diffusion during the industrial revolution. In order to support the shifting political and economic ambitions of empire the state moved to leverage scientific knowledge to facilitate a new and globalised industrial structure. This growing necessity for industrially-applied scientific knowledge generated a shift in the organisation of the natural sciences. While non-instrumental scientific knowledge production continued to exist within the purview of civil society in Britain, a further type of instrumentally directed science evolved as consequence of these new influences associated with the industrial revolution.

This nascent form of scientific knowledge production surfaced as a hybrid of non-instrumental and instrumental scientific knowledge where scientific knowledge production came to be hosted and funded by a British state keen to develop international markets through the application of scientific knowledge to manufacturing and defence. The policy and praxis of pre-instrumental scientific knowledge production in terms of its materiality in the new Colony of New South Wales is discussed in Chapters 3 through 8. Meanwhile the following section develops the theoretical underpinnings of the ideal type of pre-instrumental scientific knowledge.

2.4.2 Pre-instrumental scientific knowledge

The ideal type of pre-instrumental knowledge emerged as a highly instrumentalised form of scientific knowledge, produced and funded by the state, for utilitarian purposes such as market development or the conduct of war. This knowledge production process employs *formal rationality* (Weber 1968) which becomes manifest through *purposive-rational social action* (Weber 1968); the process is established and managed by bureaucracies in order to secure the political aims of government. Both the means and the ends are entirely rational; the means leverage the scientific method in order to focus on state approved utilitarian ends. Within this principally rational paradigm non-instrumental or value-rational scientific knowledge is thus positioned, as Weber (1968) finds, as irrational. Characteristically, this form of knowledge production and diffusion is bound up with the Lockean model of the state and the capitalist mode of production, first emerging during the industrial revolution.

Under traditional forms of production, scientific knowledge had been conceived as an implicit factor of production however this ideal type of knowledge arguably opens the way for the transitioning of scientific knowledge from its implicit position within the factors of production to becoming a factor in its own right. This transitioning of scientific knowledge from an implicit to an explicit factor of production can be seen not only in the rational workings of the early colonial bureaucracies but also in the emergence of Public Private Partnerships (PPPs)[39] in Australia during the early 19th century and in the application of utilitarian and exchange value, as distinct from social value, to scientific knowledge. This section investigates the emergence of pre-instrumental scientific knowledge as an ideal type.

2.4.2.1 The power and authority of the industrial revolution

Weber finds that the development of 'economic rationalism' (1967: 26) while being reliant on rational technique and the rule of law, 'is at the same time determined by the ability and disposition of men to adopt certain types of practical rational conduct' (1967: 26), such as the bourgeois class[40] who continue to prosper as a consequence of

[39] The first Public Private Partnership arrangements between the British state and John Macarthur, of merino wool growing fame, are investigated in Chapter 4.

[40] The traditional bourgeois class has subsequently worked to extend the concept of 'legal entity' to cover companies and so national and transnational corporations which employ a highly instrumentalised form of means and ends to achieve a financial profit as distinct from civil outcomes.

the industrial revolution. The synthesis of rationality drawn from the sciences, law and politics which emanated from the ancient Greeks and was expanded during the enlightenment period, was re-shaped during the industrial revolution in order to produce a particular type of scientific knowledge; one that was associated with the development of markets. This market-oriented scientific knowledge can be contrasted with the type of scientific knowledge advocated by Sir Francis Bacon.

As discussed in Section 2.4.1.2, Bacon emphasises a civilised (or enlightened) public-spirited role for scientific knowledge and cautions against interference by man-made Idols or special interests that, he says, may be innate in the behaviour of some individuals. In particular, the Idol of the Market Place is seen by Bacon to be antithetical to the aims of science. In a sense Bacon's concern about the behaviour of individuals in the marketplace is similar to Weber's discussion about the conduct of the bourgeoisie within capitalist settings.[41] Both authors argue that colonisation of scientific knowledge by the market, if not mediated by a democratic state (that is resolved to enhance the lives of its citizenry by way of an enriched civil society) may become problematic.[42] This line of argument is also upheld by Kant who connects the production and acquisition of knowledge with moral, value-oriented ends.[43]

Turning now to Adam Smith, a key member of the Scottish enlightenment philosophers and a founding philosopher in the study of modern economics (Sen 2013). Smith, albeit a proponent of means-ends rationality, was strongly influenced by the ideas of civil society introduced by Thomas Hobbes and John Locke during the 17th century. However, as Boyd argues, the civil society conceptualised by these philosophers is

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[41] This discussion is covered in Section 2.1.
[42] The problematic relationship between scientific knowledge and the market is discussed in Section 2.1.
[43] This Kantian perspective of knowledge is explored in Section 2.4.1.3.

'primarily as the historico-developmental antonym of barbarism or rudeness' juxtaposed to the preceding feudal era (2013: 444); that the original concept required further development in order to correspond with present understandings of the notions civil society. Boyd writes,

> Yet upon closer examination civil society proves to be a complex notion, exhibiting characteristics simultaneously public and private, voluntary and institutional, individualistic and sociable, instrumental as well as benevolent. Civil society may be conceptually distinguishable from market, state, morality, and law, but it also requires innovations in all of these arenas in order to emerge in its recognizably modern form (Boyd 2013: 443).

Amartya Sen on the other hand, applauds Smith directly for his contribution to the formation of the modern state and its role in the provision of public services such as those to be found within the contemporary conception of civil society. Sen writes,

> Smith saw the role of the state to include adequate provision of public services, such as free education, and to arrange poverty relief (2013: 585) … Going beyond his investigation of the demands of a well- functioning market system, Smith was deeply concerned about the inequality and poverty that might survive in an otherwise successful market economy. Indeed, even in dealing with regulations that restrain the markets, Smith saw the case for interventions in the interest of the poor and the underdogs of society. At one stage he gives a formula of disarming simplicity: 'When the regulation, therefore, is in favour of the workmen, it is always just and equitable, but it is sometimes otherwise when in favour of the masters' (WN I.x.c.61: 157). Underlying the plural institutional structure that Smith proposes is not only Smith's scepticism of the reach of the market, but his attempt to marry state intervention with the pursuit of the interests of the poor (2013: 585).

So, just as Smith argued for the use of rational means and ends in order to increase the wealth of individuals and nations, he also suggested that should the market fail in the provision of what are now termed *public goods* that the sovereign, or the model state, be charged with the duty of protecting the wellbeing of its citizenry.

On one hand Smith argued that freer markets lead to dynamic and efficacious methods of accumulating individual and national wealth; that, 'the new freedom would release a wave of innovative endeavour, raising the rate of growth…provid(ing) a mechanism of co-ordination, directing individual self-interest toward social benefit through the driving force of competition' (Eatwell 2003: 97); that the 'struggle for more' produced through the dynamics of competitive market action would direct 'scarce' resources to where they were needed most, and where they could be employed most profitably. Smith believed that this drive for competition would work to produce new, and cheaper, means of production; that 'competition produced change, novelty, innovation and growth; competition produced wealth' (Eatwell 2003; 97). The key principles of this way of conceptualising social and economic life leverages a division of labour or the specialisation of production tasks; the operation of an *invisible hand* which spontaneously regulates supply and demand; and through a *laissez faire* approach to the market economy.

On the other hand, as demonstrated by the work of Boyd (2013) and Sen (2013), Smith also argued for a benevolent sovereign that intervened in the social world when the market was seen to fail; such as in the provision of public goods. So, while he argued for a liberal conception of markets Smith does not suggest that governments withdraw completely from the actions of the unfettered market and thus leave their citizenry exposed and unprotected from the vagaries of market action.[44] Under these conditions

[44] This idea of protective action by the state is enshrined in social contract theory advanced by Hobbes, Rousseau and Locke and is embedded in the legal framework of the modern nation state. Social contract theory was discussed in Section 2.4.1.4.

the model state will protect its citizens against foreign invaders and injustice, and will organise for the provision of *public goods* such as education, health, roads and communications in order to advance civil society. Smith writes in the *Wealth of Nations*,

> According to the system of natural liberty, the sovereign has only three duties to attend to; three duties of great importance, indeed, but plain and intelligible to common understandings: first, the duty of protecting the society from violence and invasion of other independent societies; secondly, the duty of protecting, as far as possible, every member of the society from the injustice or oppression of every other member of it, or the duty of establishing an exact administration of justice; and, thirdly, the duty of erecting and maintaining certain public works and certain public institutions which it can never be for the interest of any individual, or small number of individuals, to erect and maintain; because the profit could never repay the expense to any individual or small number of individuals, though it may frequently do much more than repay it to a great society ([1776] 2015: 247).

It seems nonsensical therefore that in the modern *laissez faire* economy the state employs high levels of protectionism, particularly in the production of instrumentally designed scientific knowledge in order to enhance special interests and overall market performance yet denies the central proposition of the nation state; that is to protect the interests of all citizens. Certainly in Australia protection of markets, chiefly through the application of tariffs, quotas or favourable taxation treatment, and the production of pre-instrumental scientific knowledge, has been a recurring theme since colonisation.[45]

This ideal type of pre-instrumental scientific knowledge is produced by the state for the market to use in the production of goods and services that will in turn be sold back to the citizenry. Moreover, it leverages non-instrumental scientific knowledge, ostensibly produced for the purposes of civil advancement, in order to provide an essential factor

[45] This is one of the enduring themes of this thesis and will be discussed in Chapters 3 through 8.

of production to the market, often without financial penalty for the market. This early state-sponsored separation of scientific knowledge from the manufacturing process has arguably contributed to a destabilisation in the relationship between implicit knowledge and explicit knowledge. For instance, where scientific knowledge was traditionally embedded within a tangible object such as a sheaf of wheat, under the conditions of modernity and particularly late modernity, the existential link between the wheat plant and the knowledge implicit within that wheat plant is disturbed. Where the plant remains a tangible object, the scientific knowledge relating to that plant has become intangible, particularly in terms of its use in the marketplace. It may therefore be argued that pre-instrumental scientific knowledge production and diffusion contributed to the disembedding of scientific knowledge from its traditional place as an implicit factor of production to its current position as both an explicit factor of production and a product in its own right.

Further, this state provision of an independent factor of production, that of scientific knowledge, to support manufacturers and suppliers in the market both challenges the basic principles of modern liberal economics and disrupts the founding precepts of the sovereign state. By producing knowledge specifically for the market, the nation state is in effect supporting the wellbeing of special interests thus challenging the basic tenet of economic liberalism, that of minimal interference on the part of the state, and so disrupting the process of sovereign government in order to enhance the wellbeing of a select few. Moreover, the scientific knowledge produced by the state becomes re-integrated into the products manufactured by the market and thus ownership of that knowledge is handed to the market for the purposes of private profit-making. The unprocessed knowledge is therefore lost to the citizenry.

Notwithstanding the opportunity to purchase that re-integrated knowledge in the form of goods and services, and despite contributions to the production of that knowledge via the taxation system, the citizen may not have open access to that scientific knowledge for use in the enhancement of his own wellbeing; so in contravention of a core principle identified by Bacon and embedded within the basic tenets of sovereignty. Thus pre-instrumental scientific knowledge production and diffusion works to effectively disrupt both the liberal approach to economic development and the sovereignty of the citizen within the nation state. That said however, if the state, under the protective guidance of the tenets of citizen sovereignty, invites the market to use pre-instrumental scientific knowledge in order to enhance the lives of all its citizens, and the state retains ownership and control of that scientific knowledge, it would then seem that an appropriate balance may have been struck between the institutions of state, the market and civil society.

The final part of this section investigates the turn away from enlightenment thinking towards more market-oriented ends, policies and praxes that emerged during the industrial revolution. These market-oriented policies were inculcated into Australian political life through foundational policy settings originally utilised to propel the British industrial revolution; this market based position is particularly salient in terms of scientific knowledge production and diffusion in Australia.

2.4.2.2 Australia as a product of the industrial revolution

Under the conditions generated by the industrial revolution the rationalities inherent within the becoming nation state of Australia coalesced with the rationality of the market; utilitarianism drove the policies and practices of state and *laissez faire* economics underpinned the earliest trading conditions. Prior to the establishment of responsible government in all states of Australia during the 1850s[46] the colonies operated under direct control of the British state and routinely adopted British social and economic policies and rule of law. Following the formation of responsible government however utilitarian social policy and liberal economic policy pervaded the nascent government and evolving bureaucracies (Gascoigne 1994, 1998).[47]

Instrumental rationality remained the cohesive force across the emerging nation.[48] Hyper-rational principles were applied to social policy, in effect precluding the development of non-instrumental scientific knowledge in the service of civil society,[49] and yet pre-instrumental scientific knowledge was produced by the state specifically for market development (within a laissez faire policy environment). A utilitarian approach to government policy meant that the social world was to be organised in terms of rational, specifically economic, outcomes.

The architects of the theory of *utilitarianism*, Jeremy Bentham and James Mill, the father of John Stuart Mill, argued that reason could be successfully applied to the pursuit of happiness and thus be used to secure a content and unified society. Indeed, Bentham was keen to develop a science of happiness; he was in effect,

> …Trying to turn ethics into a science, (making) differences between pleasures solely quantitative. Any pleasure you might experience could be equalled by a larger quantity of another pleasure. In principle, eating enough ice cream could equal the pleasure of writing a poem, falling in love, or being elected president (Cahoone 2014: 98)

[46] With the exception of Western Australia which moved to 'responsible government' in 1890.
[47] This somewhat contradictory approach to social policy and economic policy is explored further in Chapter 4.
[48] This political preference for instrumentally rational policies and practices on the part of the Australian state forms a main theme in this thesis and is explored in Chapters 3-8.
[49] Again, this is a strongly recurring theme present in Chapters 3-8.

In Benthamite terms the ends justify the means with both ends and means couched in what Weber (1968) calls *purposive rational social action.* It is within this utilitarian framework of formal rationality, steered by purposive rational social action, that Weber argues that value rational knowledge becomes positioned as irrational (1968). Indeed, the great liberal thinker John Stuart Mill who is often linked with the sponsorship of the theory of utilitarianism (and the principles of means/ends rationality) began to have reservations about the veracity and indeed rationality of the theory during a nervous breakdown he suffered as a young man.

During this period of ill health Mill began to question the utilitarian doctrine that an action is correct if it promotes the greatest happiness for the greatest number of people. In fact, Mill came to believe that happiness is not the 'direct and conscious end of life' (Himmelfarb 1985: 15), rather that happiness cannot be pursued for its own sake, that the 'enjoyments of life…are sufficient to make it a pleasant thing, when they are taken *en passant*, without being made a principal object' (Mill 1874: 142). In his *Autobiography*, Mill petitions the reader to 'ask yourself whether you are happy, and you cease to be so. The only chance is to treat, not happiness, but some end external to it,[50]as the purpose of life' (Mill 1874: 142).

Mill finds that the teachings of both Bentham and of his own father are in conflict with his own newly forming ideas. He remarks,

> The conflicts which I had so often had to sustain in defending the theory of government laid down in Bentham's and my father's writings, and the acquaintance I had obtained with other schools of political thinking, made me aware of many things which that doctrine, professing to be

[50] Such as the happiness of others, the improvement of mankind, art, beauty, the contemplation of nature, any activity pursued for its own sake (Himmelfarb 1985: 15).

> a theory of government in general, ought to have made room for, and did not…I felt that politics could not be a science of specific experience; and that the accusations against the Benthamic theory of *being* a theory, of proceeding *a priori* by way of general reasoning instead of Baconian experiment, show complete ignorance of Bacon's principles, and of the necessary conditions of experimental investigation (1874: 156).

John Stuart Mill remained circumspect regarding scientific character of utilitarianism as prescribed by Bentham and James Mill. He came to understand that social relations were indeed more complex than the strictly scientific model accorded to politics by the Benthamites; that happiness cannot be assumed as an end in itself; and that the fruitful governance of a nation of individual citizens demanded more than one universal, instrumentally rational mode of administration.

Regardless of Mill's forewarnings about the problems associated with means-ends rationality, Australia was effectively founded on the precepts of utilitarianism and economic liberalism (Hancock 1930; Rowse 1978; Collins 1985; Davidson 1991; Beilharz 1997, 2015; Sawyer 2003; Carter [1987] 2010). These foundational settings in turn contributed to the emergence of the hybrid, pre-instrumental scientific knowledge, which worked to re-position scientific knowledge production from an *implicit* to an *explicit* factor of production; these disruptive actions on the part of the state arguably contributed to the disembedding of scientific knowledge from the tangible object to a more intangible status as a factor of production, and finally as a product in its own right. The next section looks at the ideal type of instrumental scientific knowledge that, while active since at least the days of the Ancient Egyptians and Babylonians escalated during the 20th century to become a dominant form of scientific knowledge production and diffusion under the conditions of late modernity.

2.4.3 Instrumental scientific knowledge

The ideal type of instrumental scientific knowledge has existed since the ancient Egyptian (c 5000-30 BC), Babylonian (c 2300-330 BC), Indian (c 1500 BC-500 BC) and Chinese (c 2000-220 BC) civilisations made use of mathematics, engineering and technology to study the stars, to design and build exceptional structures, to develop superior systems of irrigation and to undertake intensive programs of urbanisation. Instrumental scientific knowledge production transforms non-instrumental scientific knowledge into useful or applied knowledge. This highly instrumental form of knowledge uses rational, scientific means to achieve utilitarian ends; it leverages *formal rationality* realised through *purposive rational social action* to achieve its political, economic, social and technological goals.

Notwithstanding its apparent self-sufficiency, in the modern world this ideal type relies on non-instrumental scientific knowledge in order to activate its potential. During late modernity this type of scientific knowledge is most often produced by the market for the purposes of commercial advancement in the marketplace or, at the behest of the state, in the building of infrastructure or the protection of state owned property; its main drivers during late modernity are economic competition and the potential for financial profit. Despite the rational means used to produce both non-instrumental and instrumental scientific knowledge, their ends in the modern world remain incongruent. As the former type focuses on value-rational ends and the latter type on purposive rational ends, the enduring tension between these two ideal types of scientific knowledge has become noteworthy; this tension is particularly sharp when viewed through the lens of the ever-increasing rationality of the modern world.

The scientific community favours the continuing production of non-instrumental scientific knowledge, knowledge that in theory contributes to human potential, whereas the neoliberal state and the market are more likely to focus on instrumental knowledge produced for utilitarian purposes. Notwithstanding their ostensibly incongruent ends, both the non-instrumental and instrumental sciences are in reality mutually beneficial. Instrumental science cannot continue to evolve without the fresh understandings of the natural world that are provided by non-instrumental scientific knowledge; and the non-instrumental science cannot materially contribute to human potential without the application of instrumental science. The next section investigates the theory underpinning the ideal type of instrumental scientific knowledge.

2.4.3.1 The transformation of technical, or instrumental, scientific knowledge

As discussed in previous sections the social forces of the industrial revolution were instrumental in the contemporaneous advancement of both laissez faire economics and the praxis of utilitarianism in Australia. Lukács ([1923] 1971), following Weber, argues that the advent of these highly rational approaches adopted by the state are a result of the specific type of rationalism, one that is embedded in capitalism, escaping into the social world. Lukács ([1923] 1971) builds on Weber's theory of rationalisation to argue that under capitalism the economy is no longer subsumed within the social world; instead, commodity exchange has become the central organizing principle for all sectors of society. Drawing on Marx' work around *commodity fetishism*[51] in order to establish a form of Weberian Marxism, Lukács ([1923] 1971) posits that under the aegus of

[51] Marx describes his theory of commodity fetishism as an outcome of a shift in the relations of production due to the rise of capitalism. Under capitalism the socially motivated economic relations between people are displaced by the commodified economic relationships of the market; relationships that are based on money and commodities. As such, the subjective, intangible qualities of economic value are transformed into objective, tangible objects that are said to hold intrinsic value.

rationalisation the process of *commodification*[52] moves into social institutions such as the law, administration and journalism as well as into academic disciplines including philosophy. Reification in this context refers to 'the structural process whereby the commodity form permeates life in capitalist society' (Zuidervaat 2011: online). Lukács writes,

> Just as the capitalist system continuously produces and reproduces itself economically on higher levels, the structure of reification progressively sinks more deeply, more fatefully, and more definitively into the consciousness of Man ([1923] 1971: 93).

Lukács was especially concerned with how reification makes human beings 'seem like mere things obeying the inexorable laws of the marketplace' (Zuidervaat 1991: 76). This social dynamic of the mid to late modern period, as identified by Lukács (and later by Horkheimer and Adorno), appears to have contributed to the decisive shift of instrumental scientific knowledge from its role in nation building on the part of the state (during the early and middle phases of modernity) to the more economically focused type of scientific knowledge production that thrives in the late modern era.[53]

2.4.3.2 Scientific knowledge, power and money

As Adorno and Horkheimer have found, the global conditions that were active as a result of World Wars I and II dramatically reshaped instrumental scientific knowledge production and diffusion. Certainly the work of Adorno and Horkheimer is absolutely

[52] The process of commodification was first identified by Marx who described it as a process whereby goods and services; ideas and concepts such as those generated by the production of non-instrumental scientific knowledge; and human activities, such as caring for children or caring for the aged; are transformed into a form that is suitable for trading in the marketplace.

[53] As outlined in Section 2.4.1, the early forms of nation-building conducted by the early Egyptian, Babylonian, Indian and Chinese civilisations are more closely aligned to instrumental science than the non-instrumental trajectory of the modern natural sciences. Instrumental science, as first employed by the pre-Greek civilisations, has been more closely bound up with resolving practical issues identified by the monarchy, then, under capitalism, by state and the market, in the service of everyday life.

critical in terms of understanding the dystopian power and potential of scientific knowledge. However, as has been argued in Section 2.4.1, scientific knowledge has also a positive part to play in terms of advancing and protecting civil society.

The contemporary conditions of the neoliberal state in Australia are not in the realm of the dystopianism identified by Adorno and Horkheimer but are nevertheless a significant reason for concern. The current shifts are occurring as a result of a tightening relationship between enabling nation states and the global marketplace. This section explores the theoretical underpinnings of these shifts. It begins with the concept of instrumentalism as defined by the work of Adorno and Horkheimer following World War II. By exploring these theoretical underpinnings, it is possible to more deeply understand the developments and relationships between forms of scientific knowledge in Australia.

A detailed study of purposive-rational social action in relation to the reproduction of culture was undertaken by critical theorists Horkheimer and Adorno ([1947] 2002). Drawing on the work of Marx and Lukács, these members of the Frankfurt School coined the term *instrumental reason* to describe the hyper-rationalisation process that was present in cultural reproduction during the early part of the 20th century. Using a critique of both science and culture to ground their argument, Horkheimer and Adorno ([1947] 2002) find that the processes of rationalisation (or the bureaucratic focus on rational, utilitarian ends) has driven further into the social world to the extent that human society is now conceived as an object of technical manipulation. Moreover, as the rationalising process works to instrumentalise the social world in order to deliver rational, purposive ends, it is simultaneously reified, continuing in a rational spiral from which, according to Horkheimer and Adorno ([1947] 2002), there is no escape.

Horkheimer & Adorno ([1947] 2002) contend that the hyper-rationalisation extant in the modern capitalist world subsumes, through the process of instrumental rationality, the 'particular under the universal' (Bernstein 1991: 5) and disregards the intrinsic properties that give 'each thing its sensuous, social and historical particularity for the sake of goals and purposes of the subject'; such a rationality positions 'unlike' or unequal items as 'like' or equal items. As Bernstein remarks in the introduction to *The Culture Industry* (Adorno 1991),

> Subsumption, then, is domination in the conception realm. The purpose of subsumption is to allow for conceptual and technical mastery… without the possibility of judging particulars and rationally considering ends and goals, the reason which was to be the means to satisfying human ends becomes its own end, and thereby turns against the true aims of Enlightenment: freedom and happiness (Bernstein 1991: 5).

This critique of the culture industries can also be applied to the transformation of instrumental scientific knowledge. Instrumental science can shift: from potentialities for nation building; to a modified use by the state (and the market) to underpin contestations for power such as in war; and to facilitate action on the part of the state and the market for the purposes of capital accumulation. Moreover, the critique is also relevant to the re-shaping of non-instrumental scientific knowledge to comply with the wants of the market.

Adorno argues that capitalism has assumed control of reason, and so 'provides for this final realization of instrumental reason and self-destruction of Enlightenment' ([1947] 1991: 5). In their examination of the 'culture industries', the author declares that instrumental reason has destroyed the reflective processes so encouraged by the scholars of the enlightenment period; that this 'silencing of reflection is the substantial irrationality of enlightened reason' and, as such, 'the culture industry is the societal realization of the defeat of reflection; (that) it is the realization of subsumptive reason, the unification of the many under the one' (Bernstein 1991:11). Further, Adorno and Horkheimer point to the changes wrought by the instrumentalising processes and suggest that the rise of the bourgeoisie has been a pivotal factor in the transformation of knowledge and culture,

> …bourgeois society is ruled by equivalence. It makes dissimilar things comparable by reducing them to abstract quantities'… By sacrificing thought, which in its reified form as mathematics, machinery, organization, avenges itself on a humanity forgetful of it, enlightenment forfeited its own realization ([1947] 2002: 4).

Thus the notion of instrumental reason is eminently useful in helping to explain the transformation of instrumental scientific knowledge from a technical role associated with the development of the social world to contestations for power and to the mainstay of a globalised capitalist economy. A further, equally transformative, dynamic is identified by Castells in his theories of the *information age* and the *network society,* and his work concerning the praxis of the contemporary *knowledge economy* (1996, 1997, 1998 & 2005).

2.4.3.3 Capturing scientific knowledge for political and economic gain

Castells maintains that the social processes of the late modernity period and the advent of the globalised digital technology in the form of the world wide web, or the internet, has the potential to transform the social world. He argues that the mechanistic and hierarchical model conceived during the industrial revolution is evolving into a new model; specifically, an economy-centric model that is based on free-flowing digital networks (1996, 1997, 1998, 2002, 2005). These free-flowing digital networks, described as a *space of flows*, endlessly carry information and communication around the world; time and space become peripheral under this new globalized model. Castells writes,

> Our societies are constructed around flows: flows of capital, flows of information, flows of technology, flows of organizational interactions, flows of images, sounds and symbols. Flows are not just one element of social organization: they are the expression of the processes dominating our economic, political, and symbolic life. ... Thus, I propose the idea that there is a new spatial form characteristic of social practices that dominate and shape the network society: the space of flows. The space of flows is the material organization of time-sharing social practices that work through flows. By flows I understand purposeful, repetitive, programmable sequences of exchange and interaction between physically disjointed positions held by social actors (1996: 412)

These digital networks, according to Castells, have precipitated a new age, an *information age* which has transformed the social world from an *industrial society* to a *network society*. Castells explains how the network society has evolved since the 1980s,

> In the last quarter of the twentieth century, three independent processes came together, ushering in a new social structure predominantly based on networks: the needs of the economy for management flexibility and for the globalization of capital, production, and trade; the demands of society in which the values of individual freedom and open communication became paramount; and the extraordinary advances in computing and telecommunications made possible by the micro-electronics revolution. Under these conditions, the Internet, an obscure technology without much application beyond the secluded worlds of computer scientists, hackers, and countercultural communities, became the lever for the transition to a new form of society--the network society--and with it to a new economy (2002: 2)

According to Castells, in terms of their structure and reach these new networks are unparalleled in modernity. 'The networks of the network society are composed of a series of complex and interacting information nodes, markets, organizations, knowledge, and individuals' (Gibson 2007: 606). Castells elaborates on the framework of the network society,

> The network society, in the simplest terms, is a social structure based on networks operated by information and communication technologies based in microelectronics and digital computer networks that generate, process, and distribute information on the basis of the knowledge accumulated in the nodes of the networks. A network is a formal structure (see Monge and Contractor, 2004). It is a system of interconnected nodes. Nodes are, formally speaking, the points where the curve intersects itself. Networks are open structures that evolve by adding or removing nodes according to the changing requirements of the programs that assign performance goals to the networks. Naturally, these programs are decided socially from outside the network. But once they are inscripted in the logic of the network, the network will follow efficiently these instructions, adding, deleting, and reconfigurating, until a new program replaces or modifies the codes that command its operational system (2005: 7).

Certainly, this technologically driven scenario presents a new realm of instrumental rationality, one that could hardly have been envisioned by Adorno and Horkheimer in the early 20th century, but one which accesses a similar logic to the culture industries in terms of its reproductive capabilities and its relationship with capitalism. Moreover, these new networks of knowledge production and dissemination exhibit both utopian and dystopian capacities and reveal potentialities for both benefits and risks. As Castells argues,

> Now, it doesn't mean that networks, by definition, are wonderful. It can be networks of destruction. Networks don't have personal feelings. They kill or kiss. But the issue here is that first you start with a network which is equipped with information technology. That's the key. Then what the network does depends on the programming of the network, and this is of course a social and cultural process (2002: 4).

McLuhan's ([1962] 1967; [1964] 2013) global village features strongly in Castells' scenario as he takes up McLuhan's concept of the Gutenberg Galaxy to frame his own preliminary work around the Internet Galaxy (2002). Castells argues that the internet is transforming social life in the 21st century to the same extent that the Gutenberg printing press transformed life in the 15th century (McLuhan [1962] 1967; [1964] 2013); he says, 'Core economic, social, political, and cultural activities throughout the planet are being structured by and around the Internet, and other computer networks' (2002: 3).

On the positive front the displacement of the centralised and hierarchical systems of knowledge production and diffusion (Castells 2002) may offer greater potentials for public access to knowledge and so provide opportunities for enhanced individual autonomy. Moreover, the actions of *new social movements* (Melucci 1980; Habermas 1981; Offe 1985; Calhoun 1998; Castells 2007), powered through these digital networks, may challenge specific forms of authoritarian governance, forms which are conventionally constructed using hierarchical models and which underwrite a centralisation of power that echo the political and economic frameworks of the industrial revolution (Castells 1996, 1997, 1998, 2002 & 2005).

On the other hand, there are a range of risks that may be encountered in the network society. As Castells so readily agrees, the network society is governed by the principles of capitalism, thus the commodification of scientific knowledge is an ever present possibility. Where old knowledge may be freely available through new electronic networks, new knowledge when positioned as an explicit factor of production, becomes an economically valuable commodity and so protected by increasingly transnational Intellectual Property laws. As such, access to new scientific knowledge becomes increasingly restricted and controlled by powerful groups, organisations and transnational corporations. Membership of these exclusive *knowledge hubs* is based on both marketing potential[54] and prospective exchange value and membership remains fungible. So, under the global conditions outlined by Castells, institutions aligned with the production and diffusion of knowledge for the advancement of civil society are unlikely to be able to compete for commodified knowledge.

Traditional producers and keepers of scientific knowledge, organisations such as universities, libraries and museums become less able to maintain access to new knowledge as the new owners of scientific knowledge exercise their legislated property rights to buy, sell, own and control this neoteric knowledge. Moreover, small nation states and neoliberal governments who do not have the necessary capacity or funding, or the political will to defend scientific knowledge on behalf of their citizenry may see scientific knowledge uncoupled from its alliance with citizen sovereignty. As Castells observes, 'In fact, exclusion from these networks is one of the most damaging forms of exclusion in our economy and in our culture (2002: 3)'.

The paradox with these new forms of knowledge delivery is that the networks and flows of the system offer both possibilities for advancing civil society, possibilities previously unknown in the modern world, but they also present significant obstacles. The new silos, or knowledge hubs, are largely controlled by a market which restricts access by means of traditional capitalist hierarchies in the form of transnational organisations; value-rational ends are not part of the logic of these new purposively rational networks, and nation states (traditionally the guardian of the citizen) struggle to contain their

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[54] Paradoxically, despite the purposive-rational social action employed to develop and maintain these knowledge hubs the marketing messages used to buy and sell knowledge as a commodity are couched in value-rational terms; i.e. for the good of human society.

activities. Castells sums up the challenges faced by the state in the face of a growing network society,

> The shift to computerized global networks as the organizational form of capital, production, trade, and management has largely undermined the regulatory capacity of both national governments and existing international institutions, starting with the increasing difficulty of collecting corporate taxes and controlling monetary policy. Systemic volatility of global financial markets and vast disparities in the utilization of human resources require new forms of regulation, adapted to the new technology and to the new market economy. It will not be easy. Particularly, it will not be easy to enact effective, dynamic regulation of global financial markets…Yet, since no one has really tried, we actually do not know. It would be wise to find sensitive ways of channeling global finance before a major crisis forces us to do it under more strenuous conditions. Indeed, computer networks offer new technological tools of reasonable regulation that, powered by political will, could harness the dynamics of the market while preventing excessive disequilibrium (2002: 279).

Hence each of these major social theorists – Bacon, Kant, Hobbes, Locke, Weber, Adorno, Horkheimer, Habermas and Castells – have, in their own way, contributed important arguments around the benefits and possibilities of scientific knowledge for the advancement of human wellbeing. These theorists have also argued that scientific knowledge production and diffusion has a dystopian potentiality and that this potential for harm requires ongoing vigilance on the part of the state and the citizenry.

This chapter has set up the structural theory and analysed each ideal type within the tripartite model that has been created. Chapters Three through Eight make use of empirical research in order to ground the theoretical positions laid out in this chapter. The next chapter begins the empirical investigation by drawing on primary and secondary data pertinent to the early settlement of New South Wales and to the production and diffusion of knowledge applicable to the natural sciences.

3 1770s-1830s: The foundations of instrumentalism in Australia

Instrumentalism in the scientific milieu can be equated with commercial usefulness. As discussed in Chapter Two the project of *capitalism* delineates between scientific knowledge that is immediately useful in the economic sense and scientific knowledge, that if not actually useless, is less able to be converted quickly and easily into knowledge that may be used to grow markets. This current chapter finds that two forms of scientific knowledge were beginning to emerge as a consequence of white settlement in the colony of New South Wales during the late 18th century and the early 19th century.

Instrumental scientific knowledge, or that knowledge generated by *purposive-rational social action,* and *non-instrumental scientific knowledge* created for *value-rational* purposes, such as the enlightenment of the individual and the advancement of civil society, were both present during the early colonisation of Australia. It was instrumental scientific knowledge production and diffusion however that came to be of primary importance in the early colony and it was this ideal type of knowledge production that set the groundwork for state policy and practice into the future.

Notwithstanding the primacy of instrumental science in terms of its usefulness to both the state and the market, the production and diffusion of non-instrumental science, albeit in a weakened capacity, continued to strive for a viable position in the advancement of a tentative civil society. The dichotomy that subsequently emerged between these two forms of knowledge was not yet distinct, with each type tending to mix and merge with the other, however the pattern was being laid down during this period for a more distinct model of scientific knowledge production and diffusion that would emerge and firm during later periods.

This chapter explores how a range of factors contributed to this early instantiation of instrumentality into Australian science policy and practice. Not least of these factors was the economic imperative created by the industrial revolution, the penchant for entrepreneurial undertakings favoured by Sir Joseph Banks, and influence exercised by a powerful group of early pastoralists. These pastoralists leveraged free *land*, free *labour*, low cost *capital* and an *entrepreneurial spirit* in order to contribute to their personal and family fortunes.

Importantly, scientific knowledge was similarly a necessary, if implicit, factor of production which the state was willing to produce in order to hasten the development of global markets. The tension that developed between the powerful supporters of instrumental, purposive-rational, scientific knowledge production and the civic, value-rational, character of non-instrumental science is a central argument underpinning this chapter. The following section briefly examines the instrumental motivations of the British state in the claiming of New South Wales for the British Empire within the capitalist framework of *mercantilism* before proceeding to identify and discuss two emerging ideal types of scientific knowledge production and diffusion.

3.1 Science and empire

The continuing power of the British Empire during the 18th and 19th centuries was contingent on the employment of exploration and trade to further its economic ends. Australia was integral to that project. Indeed, the first expedition led by James Cook to explore the possible existence of a *great south land* was founded on the principles of non-instrumental science, however the members of the expedition were also closely focused on expanding the British opportunities for both trade and empire. Joseph Banks, a leading British scientist, power-broker and mercantilist was instrumental in both the launching of the expedition and in its aims to claim the land for the British Empire. Moreover, the industrial revolution was just beginning in Britain and by the end of the 18th century the newly opening factories were in need of cheap raw materials (materials such as wool for weaving and coal to fire the steam engines that drove the machines) as well as the development of new markets for finished goods.

While many factors can be associated with the rise of the industrial revolution, Heilbroner (1972) describes one pivotal process concomitant in the transformation of Britain from agricultural producer to industrialised nation. This process was the growth of wool as valuable commodity and the consequent enclosure of lands from public share-farming to private grazing land. This privatisation of formerly public lands ran from the middle of the 16th century to reach its bloody conclusion by middle of the 19th century by which time many of the bitterly protesting peasant farmers had been killed in bloody battles or thrown off the land. As British factories were still in the future, the dispossessed small farmers were mostly destitute, unable to find or secure regular work.

Stearns (2007) finds that alongside this transformation in land ownership was a period of rapid technological development that peaked during the latter part of the 18th century and the 19th century. During this intensively technological period the invention of the coal-powered steam engine in the 1760s and a growing demand for cotton cloth saw weaving methods transformed from home-based hand looms to increasingly sophisticated mechanical weaving machines. The demand for cotton grew to such an extent that by the 1790s most home-based cotton weavers had relocated to the new factories in order to access what at that time was a fairly limited source of power in order to drive their mechanical looms.

The invention and refinement of the steam engine was a huge boon to the new manufacturing industries and by the early 1800s British factories were producing not only cotton but also woollen cloth and other textiles. The demand for coal to fire the steam engines in both the textile industries and the new metal working industries was also high, ensuring that British exports grew to unparalleled levels and the mining industries boomed (Stearns 2007). As will be demonstrated in this chapter, the growing demand by British manufacturers for raw materials such as wool and coal coupled with the need to sell greater quantities of finished goods was an important driver that can be linked to the development of the colony of New South Wales during the late 18th and the 19th centuries. In the meantime, Captain James Cook was dispatched from Britain during the 1760s to explore new opportunities for expanding the empire.

With the sponsorship of the Royal Society, and under Orders from the British government to observe the Transit of Venus, the British state dispatched Captain James Cook and his crew, together with several prominent scientists, on a journey to discover and subsequently claim the great south land for the British Empire. In 1768 the barque *Endeavour* captained by Cook left Plymouth bound for the southern latitudes. Cook was known for his 'skill and daring as an explorer of the seas' and embraced a 'passion for the unknown', a passion which saw him chosen by both the Admiralty and the Royal Society to conduct this scientific expedition to the Pacific Ocean (Schultz-Byard 2012: ABC online). Accompanying Cook on the voyage was the British gentleman scientist, the botanist Joseph Banks, and the Swedish naturalist Daniel Solander. Banks was an important figure in both politics and science at the time and Solander was both his friend and colleague. As a student of Carl Linnaeus, leading Swedish natural historian and creator of the Linnaen system of scientific classification (much of which is still used today), Solander was a valuable addition to the expedition. Gascoigne writes,

> This Swedish botanist greatly strengthened Banks's links with the system and methods of Linnaeus, Solander's teacher, and its Banks's confidence that Linnaeus's system offered a guiding thread through the labyrinths of nature which helped to give his earlier investigations into natural history direction and focus (1994: 8).

Moreover, Banks' wealth had enabled him to create a significant collection of natural history specimens upon which Solander worked and which eventually become the foundations for the British Museum of Natural History (Gascoigne 1994).

The expedition had three aims; firstly, to record the Transit of Venus across the sun in April 1769 from the islands of Tahiti and to explore and chart the Pacific Ocean; secondly, to chart the coastlines of all the islands visited in the South Pacific in order to observe the local indigenous peoples, and to make detailed scientific observations of the flora, the fauna and the land forms that were encountered; and finally, to fulfil Orders from the British Admiralty to discover 'a Continent or Land of great extent' and to take possession of the country 'in the Name of the King of Great Britain'' (NLA: MS2 online).

Notwithstanding the scientific character of the mission and its patronage by scientist Banks as envoy of the Royal Society, the notions of improvement and progress were firmly embedded within the undertaking. By the late 18th century the English enlightenment had taken a turn to embrace science as 'useful' knowledge and was particularly supportive of empirically derived 'useful' knowledge; that knowledge acquired through purposive-rational social action. Banks both epitomised and drove this new direction, a course which ultimately saw scientific knowledge closely entwined with the economic aims of the British Empire. As Gascoigne notes

> In advancing such an Empire science was, where possible, to play its part and no one was of more importance in harnessing it to the chariot-wheels of British imperial power than Sir Joseph Banks (1994: 55)…Banks was one of the most enthusiastic advocates of the view that the territories under the British crown could and should have their flora and fauna improved partly for their own benefit but, more compellingly, for that of Britain (1994: 201)…improvement, indeed, could be seen as the practical application both of biblical injunctions to use nature for the benefit of humanity and the Baconian mission to utilise science for the relief of man's estate (1994: 236).[55]

Moreover, improvement was an abiding ambition of both the state and Banks personally. Indeed, Banks' approach to scientific improvement of the land and his affirmed patronage of *neo-mercantilism* formed a powerful alliance that would ultimately influence the direction of imperial expansion. For Banks and his fellow neo-mercantilists (who included powerful British landowners and politicians Sheffield, Jenkinson and Eden) the economic system of neo-mercantilism was important in order to retain control of its lands and colonies. It was through the neo-mercantilist framework and the ideologies of agrarian improvement that scientific knowledge and economic theory came to be embedded in the foundations of the colony of New South Wales. The following section explores how Australia came to take on a capitalist interpretation of enlightenment principles through the instantiation of agricultural improvement.

3.2 A capitalist interpretation of the enlightenment

[55] Francis Bacon had originally developed his ideas around scientific knowledge production and the 'scientific method' during the early English enlightenment. A close discussion of the Baconian mission is found in Chapter 3.

Banks was a contemporary of Jeremy Bentham and James Mill, both leading classical economists and the architects of the theory of *utilitarianism*, and was duly influenced by the purposive-rational thinking of these philosophers. For Banks and his contemporaries, enlightenment was closely associated with the idea of improvement, particularly agricultural improvement, through the application of scientific methods. Moreover, science was caught up with the notion of usefulness especially in terms of economic pragmatism. This conception of useful scientific knowledge was hitched to the more global aims of expanding the empire, of establishing new markets, and of importing raw materials for Britain's growing manufacturing industries. This section investigates how these goals of improving Britain and its colonies contributed to laying down the foundations of a capitalist vision of scientific knowledge in Australia.

Capitalist endeavours were destined to be the central pillar of this new society (albeit a penal colony) in New South Wales even before the first convict had stepped ashore. Indeed, by the time the First Fleet and its cargo of around 760 convicts, their guards and a few civil officers landed in Sydney Cove in 1788, the commercial disposition of the new colony was already being shaped. The British drive for economic wealth and power was deeply embedded into the *raison d'etre* of the colony. Integrated into the ontology of the nation were three primary influences: firstly, the significant political and economic authority of Joseph Banks and his ideologies supporting the principles of enlightenment within a capitalist framework, specifically neo-mercantilism; the strong demand for raw materials that were necessary to fuel the manufacturing industries of Britain; and the pressure for self-sufficiency on the part of the new colony.

For Sir Joseph Banks and his contemporaries, the spirit of the enlightenment was bounded up with the concept of improvement within a capitalist agenda. Gascoigne observes that for Banks

> …true enlightenment meant the dispelling of ignorance through observation and its application for the benefit of humankind, or more particularly, for that of his native land. On such a view exploration and discovery were particularly enlightened activities, since they made available often dearly-bought first-hand observations to the general public and the possibility of greater wealth and comfort from new products and new lands; more pragmatically, such voyages of discovery frequently offered further avenues for British commerce (1994: 32).

Banks and his contemporaries in the ruling classes of Britain believed that it was their duty to leverage scientific knowledge in order to plan and execute practical schemes designed to improve the lot of the population at large while at the same time improving the wealth and power of the British Empire. Gascoigne notes that

> This very different ideal of scientific knowledge for its own sake ran counter to the view of such a class, which held that all knowledge had a social function…Another of Banks' early biographers made the same point, writing that 'Every thought of Banks was practical: it tended every where (sic) and always to the application of the physical resources of mankind' (1994: 199).

Further, Gascoigne confirms that Banks epitomised the political and economic milieux present in Britain during the late 18th century.

> Banks, then, acts as a useful guide to the limits of the English Enlightenment. On the one hand, the Enlightenment promoted within the English Establishment a willingness to approach political and social problems in a secular spirit, to promote science – or, more broadly, useful knowledge – and to question tradition where it conflicted with observation and reason. But the hold of the English Enlightenment was not strong enough to weaken other, more traditional, beliefs of the English elite, above all their self-confidence in themselves as a class, the privilege and destiny of

> which it was to direct the affairs of the nation... [Nor did it] diminish the strength of national rivalries. Banks and his class looked to such conflicts to advance the interests of an increasingly powerful commercial Empire…In advancing such an Empire science was, where possible, to play its part and no one was of more importance in harnessing it to the chariot-wheels of British imperial power than Sir Joseph Banks (1994: 55).

The annexing of scientific knowledge to the pragmatic goals of the British empire thus worked towards transfiguring the original rationale for scientific knowledge production and diffusion that had been wrought by the early philosophers of the enlightenment period. Instead, scientific knowledge in the English interpretation was one destined primarily for leveraging political and economic goals. Thus scientific knowledge production in Britain during this period shifted from a notion of substantive rationality realised through value-rational social action to a more utilitarian vision of formal rationality executed through purposive-rational social action. This shift was to have a bearing on the type of scientific knowledge production and diffusion instantiated into New South Wales. The next section explores more deeply the influence of Joseph Banks in this transformation.

3.2.1 Science, economics and Joseph Banks

As Banks continued to rationalise enlightenment as improvement, his vision broadened to include agriculture and manufacturing and the problematic of the 'growing level of mass pauperisation' (Gascoigne 1994: 185). Among Banks' enlightened strategies was the growing need to deal with the 'mass pauperisation' that was being generated in Britain as a result of the enclosed lands movement. As the working classes were forced off the formerly 'communal' land the crime rate soared and a 'solution' was needed *post haste* (Gascoigne 1994: 185). The decision was made to open up the recently claimed land in New South Wales as a penal colony.

This outcome would serve two purposes; one, to drive down the unemployment levels and to improve society by clearing the slums; two, to set up a colony in New South Wales in order to explore the potential of the new lands to produce raw materials for the factories of Britain. The plan would both deal with the growing mass of poor and contribute to the global power of the British empire (Gascoigne 1994). Thus New South Wales was to be established under the ideologies of both social and agricultural improvement linked with the mercantilist form of capitalism. Moreover, as Hancock (1930), Rowse (1978), Collins (1985), Davidson (1991), Beilharz (1997; 2015), Sawyer (2003) and Carter ([1987] 2010) have all noted, the concept of Benthamite utilitarianism (a leading social and political theory at the time in Britain) was instantiated into the new colony along with the ideals of enlightenment positioned as improvement and the principles of neo-mercantile economics.

The coalescence of Banks views on improvement and neo-mercantilism can be seen in his heavy hand in the establishment of new frontier of New Holland.[56] While the British State was consumed with the Napoleonic Wars and was thus less than attentive to colonial matters, Banks held the position of a 'sort of Honorary Secretary of State for New Holland' (Maiden cited in Gascoigne 1998:170) … 'a role of considerable importance' (Gascoigne 1998:170). Moreover, Banks was the 'acknowledged authority on New South Wales, and on an amazing range of other subjects: colonization, exploration, currency, Botanic Gardens, merino sheep, earthquakes, plant diseases and leather tanning' (Gilbert [1966] 2014: online).

[56] Australia was known as New Holland during this era.

The mercantilist zeal on the part of Banks is apparent in the text of his letter to John King, Under-Secretary of State at the Home Office in 1789, only one year after the First Fleet had settled in Sydney Cove. In the letter, Banks complains that 'no one article has hitherto been discover'd by the importation of which the mother country can receive any degree of return for the cost of founding and hitherto maintaining the colony'…

> It is impossible to conceive that such a body of land, as large as all Europe, does not produce vast rivers, capable of being navigated into the heart of the interior; or, if properly investigated, that such a country, situate in a most fruitful climate, should not produce some native raw material of importance to a manufacturing country as England is (Banks cited in Gascoigne 1998:171).

Banks' plan for Australia was thus firmly founded on the principles of capitalism; on the capacity of the land and the people to be self-sufficient; and to service Britain with raw materials that could be transformed into products for trading with other parts of the empire. So, as New South Wales transitioned from the First Fleet into a more established penal colony, the deft hand of capitalism and its relationship with the British class system became more apparent. As distinct from the more established class system of Britain however, class in New South Wales was more closely aligned with the low-cost acquisition of land and money and the overt display of that prosperity. As Gascoigne continues,

> For Banks, science provided a means of creating greater wealth and therefore greater prestige and power for his country. But his concept of science as a servant of British national and imperial interests did not preclude the view that science could also advance the interests of human-kind more generally. In short, Banks retained some conception of Bacon's greater hope that science might act for 'the relief of man's estate'; as Lord Brougham put in his life of Banks, he 'applied himself vigorously to improving the discoveries successively made to the real use of mankind'' (Gascoigne 1998: 147).

The tensions between instrumental and non-instrumental scientific knowledge production and diffusion are clear in this understanding of Banks' conception of science. On the one hand, the scientist in Banks understood the importance of non-instrumental scientific knowledge production, but the utilitarian side of his position as a member of the British ruling class (within the highly rational and pro-industrial settings of the late 19th century) and Banks' personal stance on neo-mercantile economics seems to have taken precedence. The utilitarian focus of the British state can also be seen in the early social, political and economic life of New South Wales (Hancock (1930); Rowse (1978); Collins (1985); Davidson (1991); Beilharz 1997, 2015; Sawyer (2003); and Carter ([1987] 2010)).[57] However, where a more established class system in Britain mediated the strict economic pragmatism of utilitarianism, the class system in New South Wales became more closely aligned with the free or low-cost acquisition of land, labour and financial capital and the overt display of that prosperity. Thus the plans of the gentlemen of science to establish a strong civil society in New South Wales were often overridden in the face of the economic rationalism employed by the elite group of landed gentry, the bourgeois pastoralists. This discussion begins in the following section.

3.2.2 Science and the ruling class of New South Wales

The first ruling class in New South Wales was comprised of the capitalist pastoralists and a contrived type of gentlemen class that was made up of those who had emigrated

[57] Indeed, Beilharz (1997; 2015) argues that the Australian nation views itself, certainly within the cultural realm, in terms of its antipodean relationship to other cultures as distinct from a geographic or cultural entity in its own right. During this period the principles of utilitarianism were endemic across a rapidly industrialising Britain and British political and economic life and were laid into the foundations of the emerging Australian state; utilitarianism continues to influence social, political and economic policy, particularly in terms of scientific knowledge production. This argument forms a central theme within this thesis.

from Britain and who worked as bureaucrats for the Governor; neither of these groups would be considered members of the ruling class in Britain at that time. The wealthy urban bourgeoisie (often pardoned convicts or young traders attracted to New South Wales by the potential for making money) would join the pastoralists in the ruling classes in latter part of the 19th century (Connell & Irving 1980).

The bourgeois pastoralists and the gentlemen class represented the two different visions of scientific knowledge production, instrumental and non-instrumental respectively, that were to emerge in New South Wales prior to the 1830s. The bourgeois pastoralists required scientific knowledge to enable the successful growth of stock and crops in the harsh local conditions. In contrast the gentlemen of the colony were more concerned with evoking the spirit of enlightenment traditions; of generating scientific knowledge for its own sake; and sharing that with other scientific organisations around the world. In concert with this spirit of enlightenment these gentlemen made early attempts at establishing a civil society in the colony; but despite its voluntary character this early form of civil society was heavily reliant upon the machinations of the state which proved to be largely instrumental in character. Thus the first sign of scientific knowledge actually being produced and disseminated in New South Wales was tightly bound up with notions of wealth and a synthetic form of class distinction.

Commissioner Bigge (1823), appointed in 1819 as a special commissioner to examine the government of the Colony, describes the class structure of New South Wales during in the early 19th century and provides a general overview of the system that held until transportation of convicts was ceased in the 1830s. Bigge notes that the Aboriginal inhabitants of the land were rendered invisible but the social stratum of the white colony from the early 1820s was quite straightforward. At the lowest level of white society were the convicts, followed by the emancipists who were 'free by expiration of their terms of sentence, or remission of them by the governors of the colony' (1823: 78); next were the 'children either of free persons or convicts, and who [had] been born in the colony' (Bigge 1823: 78); a growing middle class comprised of 'persons who (had) gone out to the colony in a state of freedom, either as civil servants, settlers and merchants, or of persons, who after serving in regiments stationed there, [had] entered upon these pursuits' (Bigge 1823:78). At the very highest levels were

> …the Governor and his personal staff and a haute société, such as it was…emigrants of good social position and possessed of considerable means (who) had come to form the nucleus of a society – retired officers, and merchants, and younger sons sent out to swell the family fortunes or to work off their energies in a new and distant land' (Roberts 1975:10).

This hybridised form of ruling class comprised mainly the pastoralists, the merchants and the bureaucrats; none of these groups was consistent in its views around the role of scientific knowledge production and diffusion. Two types of scientific knowledge production and diffusion can be discerned in this early stage; non-instrumental scientific knowledge that is exemplified in the Colonial Museum and the scientific societies present in the colony at the time, and instrumental science that can be typified in the form of the Botanic Gardens.[58] The majority of pastoralists sought instrumental knowledge and practical support from the Botanic Gardens whereas the more conservative gentlemen of the colony were most interested in the non-instrumental or enlightenment inspired science. This non-instrumental science was most often conducted at the time through the auspices of the great public museums of Britain and

[58] This differentiation between instrumental and non-instrumental science can be seen more clearly in Figure 4.1.

Europe, and the Colonial Museum was part of this global network of knowledge production and diffusion. The Colonial Museum[59] was the first museum in Australia; it was as a natural history museum that was first mooted by members of the local chapter of the Royal Society. Alexander McLeay, the Colonial Secretary between 1836 and 1827, was one of the earliest gentlemen scientists in the colony and the original patron of the Colonial Museum;[60] McLeay was also the leading light in the embryonic civil society of New South Wales.[61]

On the other hand, the bourgeois pastoralists of the colony maintained strong ties with Joseph Banks and made extensive use of Kew Gardens in London and the local Botanic Gardens in order to provide a scientific adjunct to their pastoral and agricultural enterprises. This group were led by the Macarthur family of Camden who were closely aligned with the British ruling class and markedly cultivated relationships with various the Secretaries of State for War and the Colonies; the Macarthurs were instrumental in establishing the merino wool industry, amongst other agricultural projects, in Australia[62] during this period.

The intimate quality of the early colony and the daily struggle for existence within the unfamiliar social milieu together with the strange natural environment tended to preclude meaningful specialisation in either of these two forms of scientific knowledge production. In reality, non-instrumental scientific knowledge garnered from institutions, gardens, museums and societies overseas was combined with locally produced instrumental knowledge in order to produce successful outcomes for the local

[59] Also known as the Sydney Museum and the Australian Museum
[60] Also known as the Colonial Museum and the Sydney Museum
[61] Alexander Macleay and his contributions to civil society are explained in more depth in Chapter 4.
[62] These relationships are discussed in greater depth in Section 3.4.

agrarian community. Instrumentalised science featured heavily in the economic strategies employed by the British and the push for empire, however the local production of non-instrumental science, as represented by the Colonial Museum, was barely considered, and when considered actively discouraged in favour of more useful projects.

This section has explored how the notion of improvement and the capitalist agenda present in the British drive for empire manifested in the colony of New South Wales, finding that scientific knowledge production was beginning to shape itself into two distinct forms; non-instrumental science that was favoured by the conservative gentlemen of the colony in order to promote civil society; and instrumental science, that was more aligned with the economic focus of the British state and the local pastoralists.

The following section surveys how each of these scientific types developed within the constraints of the early colony. It traces the instrumental character of the Botanic Gardens and the Agricultural Society of New South Wales and the comparatively non-instrumental scientific knowledge that was being produced by the members of the Philosophical Society of Australasia and their plans for an Australian Museum.[63]

3.3 Two categories of scientific knowledge

The fixed specialisation of scientific knowledge and its division into two distinct forms, instrumental and non-instrumental, had not solidified during this period. There is a strong sense of market-centric knowledge being primary however it was not until the

[63] A museum that would be evocative of the great 'scientific' Museums of Europe: Museums such as the Amerbach Cabernet purchased by the city of Basel in Switzerland in 1661; the Ashmolean Museum established at Oxford University in England in 1677; the British Museum (Natural History) established in 1753; and the Muséum National d'Histoire Naturelle founded in Paris in 1793 following the French revolution.

emergence of a more extensive bureaucracy in the 1870s that formal centres of research were established by the state, expressly for the market, that the dichotomy between instrumental and non-instrumental became more pronounced.[64]

In the young colony of New South Wales, the instrumental and non-instrumental forms of scientific knowledge co-existed. While this co-existence was maintained in polite terms the tensions involved are aptly conveyed in the following excerpt of a letter sent from Charles Darwin (1809-1882) to John Stevens Henslow.[65] Darwin thanks Henslow for his scientific address that was delivered in the Ipswich Museum on 9 March 1848,

> I rather demur to one sentence of yours, viz "however delightful any scientific pursuit may be, yet if it shall be wholly unapplied it is of no more use than building castles in the air". Would not your hearers infer from this that the practical use of each scientific discovery ought to be immediate & obvious to make it worthy of admiration? What a beautiful instance Chloriform is of a discovery made from purely scientific researches, afterwards coming almost by chance into practical use. For myself I would, however, take higher ground, for I believe there exists, & I feel within me, an instinct for truth, or knowledge or discovery, of something same nature as the instinct of virtue, & that our having such an instinct is reason enough for scientific researches without any practical results ever ensuing from them (Darwin 1 April 1848: online).

These learned arguments between *pure* knowledge and *useful* knowledge were repeatedly played out amongst the scientific communities of Europe and Britain at this time. Banks, a leading scientific proponent for useful knowledge did not however

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[64] Government intervention in the agricultural markets and in mining ventures did not commence until after the gold rush in the 1850s. The development of instrumental science by the state and for the market and the emergence of a distinctive tripartite model are explored in Chapter 5.

[65] John Stevens Henslow (1796–1861), Charles Darwin's teacher and friend, was a clergyman, botanist, and mineralogist. He was Professor of Mineralogy at Cambridge University between 1822–7 and Professor of Botany from 1825–61 when he extended and remodelled the Cambridge botanic garden. Henslow was Curate of Little St Mary's Church in Cambridge from 1824–32; vicar of Cholsey-cum-Moulsford in Berkshire between 1832–7; and rector of Hitcham in Suffolk from1837–61 (Darwin correspondence project: online).

participate in these debates and was instead more concerned with the political applications for, and economic sustainability of, scientific knowledge within the British empire (Fara 2009). The rational instrumental character of the scientific knowledge production advocated by Banks is demonstrated in his mission, as Fara notes, to organise

> …an international network of experimental gardens that transplanted crops and permanently altered the Earth's scenery by converting far-flung lands into European agricultural lookalikes supporting sheep and cows, wheat and barley (2009:152) …the world was starting to be made uniform. As opportunistic growers transplanted crops to more profitable areas, the world began to resemble a single global garden (2009: 157).

Further, the instrumental character of these gardens, and the scientific knowledge that they delivered, would transform agriculture into a network of global markets.[66] While scientific knowledge, largely funded by the state, was at the core of the success of these agricultural markets, this instrumental knowledge was not destined for the enrichment of public understanding of the natural world. It was instead used to enrich the asset base of the capitalist owners of the factors of production: land, labour, capital, and increasingly, scientific knowledge. In contrast to non-instrumental scientific knowledge which was envisioned as shared knowledge, instrumental knowledge remained within the private realm of the agrarian landowners. So it would seem that Darwin and Banks represent the two ends of the scientific spectrum. Darwin was part of a global network of non-instrumental scientists who were keen to follow the lead of Bacon and the

[66] Integral to the success of the gardens and agriculture was the notion of acclimatisation. This 'scientific' process dealt with plants (and animals) on an experimental basis, transplanting them all over the globe to test their resilience in different environments. The instrumental science of acclimatisation will be reviewed in Chapter 4.

enlightenment philosophers, whereas Banks was a leading figure in the instrumentalising of scientific knowledge for utilitarian goals.

Where non-instrumental science was predominantly shared[67] with the scientific community and interested others through the media of meetings, newsletters, personal letters and articles, instrumental science was more tied up with the outcomes as demanded by capitalist markets, and was consequently rarely discussed or published. Notably, Banks published very little during his lifetime and as a result is often overlooked as a significant scientist of the 18th and 19th centuries (Fara 2009). Scientific knowledge was however shared at grass roots levels, at least in New South Wales, where the practicalities of making a living in a harsh unknown environment took precedence over the market-based precepts of confidentiality and competition. This sharing of knowledge continued in the mining and agricultural communities until the state began to develop centres for the production of pre-instrumental scientific knowledge during the last 1800s.[68]

In parallel with the growth of instrumental science destined for markets was a growing global network of natural philosophers who were located in universities and the natural history museums around the world. These naturalists comprised both a mix of professional scientists and taxonomists, and gentlemen with an interest in natural philosophy who conducted non-instrumental science in the tradition of the Italian renaissance, Bacon and the natural philosophers of the enlightenment.[69] The Colonial Museum in New South Wales was one of a global network of museums whose scientists

[67] A 'republic of letters', one that existed within the scientific community, was covered in Chapter 2
[68] This mutual sharing of scientific knowledge is discussed in more detail in Chapter 4.
[69] The link between the early attempts at civil society and the emergence of capitalism was covered in Chapter 2.

practiced non-instrumental science, who published extensively, and who opened their doors to both the scientific community and an interested public.

The following table (Figure 3.1) analyses the relationships between the early scientific institutions in New South Wales with the colonial administration (the state), the nascent colonial market and the early attempts at creating a civil society. The analysis shows an emerging positive relationship between instrumental science, market and the state and demonstrates the inverse relationship between non-instrumental science and the public sphere. Unlike instrumental science, non-instrumental science was not robustly supported by the state, was only marginally involved with the market in terms of the purchase of specimens, but did have a positive relationship with the scientific community and the emergent public sphere.

Figure 3.1: Relationships between scientific institutions: 1790-1830 (Hicks 2010).

Scientific institution	**Relationship with the state**	**Relationship with the market**	**Relationship with civil society**
Botanic Gardens 1816-current	CLOSE: Abundant direct support.	INSTRUMENTAL	NIL
Philosophical Society of Australasia EST. 1821-1822	NIL: Some public servants were private members of the society.	NIL	PARTIAL: Some papers published
Australian Museum 1821-current	TENUOUS: Little direct support.	SOME: Trading of fossils and specimens	EXPECTED: In development
Parramatta Observatory **1822-1847**	SOME: Built and staffed by private funds of Governor Brisbane. Taken over by state in 1826.	NIL	PARTIAL: Some papers published
Agricultural Society of NSW 1822-current	CLOSE: Abundant direct support.	INSTRUMENTAL	NIL

The next two sections explore the development of instrumental science and non-instrumental science in New South Wales in relation to the relationships between the state and the market.

3.3.1 Instrumental scientific knowledge

The Botanic Gardens exemplifies the instrumental character of scientific knowledge production and diffusion in colonial New South Wales; the utilitarian quality of the management and use of the gardens is explored in this section.

The colonial motivation for establishing the first farm in 1788 which later became the Botanic Gardens at Sydney Cove was to literally feed the colony. Consistent with this instrumental focus, the Botanic Gardens, designed to enhance the project of economic botany, was subsequently created on the site in 1816, under the patronage of Joseph Banks. As discussed earlier Banks' mercantile focus and applied approach to scientific endeavour, particularly economic botany, had a significant bearing on the governance and character of the early colony and the establishment of its first scientific institutions, particularly the Botanic Gardens.

> As a servant of the British State, whether in his capacity as virtual director of the Royal Gardens at Kew or a member of the Privy Council Committee on Trade fostering British commercial or industrial advantage, he again tended to view other nations simply as competitors or, at best, sources of calculated exchange of information (Gascoigne 1998:148).

Kew Gardens in London was Banks' proving ground. Originally owned in a private capacity by George III (after inheriting them from the Princess Dowager in 1772) the gardens were not transferred to government ownership and administration until 1841 when, as Gascoigne (1998) writes, Banks continued the role of de facto director, a position he had held on behalf of the King since 1773. Under Banks' stewardship the Kew Gardens

> …became virtually an institute for economic botany and it was there that plants that were considered to be potential sources of additional income for the British Empire could be cultivated

> and re-distributed. The example of Kew Gardens, in turn, helped to stimulate the creation of a network of colonial replicas with which Kew could exchange specimens and it was generally left to Banks to help in the organisation and staffing of such institutions (Gascoigne 1998:130).

The Botanic Gardens in Sydney operated as an annexure of Kew Gardens, created to service the global trade for economic botany and by extension, the markets for agriculture and husbandry. The Gardens were also the official nursery for the colony (Gilbert 1986). However, as the funding of the Gardens waxed and waned under different governors, the early patronage by Banks coupled with the status of the Gardens as an important resource for the local agricultural industry (including the powerful local pastoralists William Macarthur, George Macleay and John Jamison and their families) helped to maintain their high profile position in the colony (Gilbert 1986). Moreover, the Gardens were a member of a network of economic gardens robustly supported by the British government.[70] In terms of their contribution to economic botany, both locally and globally, Gilbert writes that the early Gardens acted as

> …an official nursery where vines, fruit trees, ornamental plants and other useful exotics were established and acclimatized before perhaps being distributed to the more promising gardens elsewhere, depending upon the supply and the Governor's needs…(and acted) as a nursery and clearing house where indigenous plants destined for Sir Joseph Banks, the Kew Gardens, and the gardens of English noblemen and of nurserymen could be tended pending arrival of a ship

[70] Indeed, the Museum of Economic Botany built in the Adelaide Botanic Gardens in 1881 demonstrates the importance of economic botany and the collection and interpretation of 'useful plants' to the colonies during the 1800s and provides contemporary visitors with an authentic experience of such museums. 'At one stage there were four such Museums in Australia and many more throughout the world. Adelaide's is the only one to survive – the purpose built building intact with its collection, paint scheme and furniture'. Echoing the original economic aims of these museums, the restored museum is sponsored by Santos, a transnational agricultural company (SAG 2015).

> boasting of one of Banks' 'Plant Cabbins' fitted with tubs and with tallow candles for heating when necessary (1986:16).

Certainly the instrumental character of Botanic Gardens is illuminated in Gilbert's (1986) portrayal, above, of the gardens as a 'nursery and clearing house' and his description of the specially designed 'Plant Cabbins' that were used to export live plants to be used by 'English noblemen and of nurserymen'.

As the 18th century turned into the 19th, and Banks started to age, the enormous influence that he held over the colony began to slowly dissipate. By then however the Botanic Gardens had been officially endorsed by the British government and was the recipient of a regular stream of both funding and political support.[71] The Bigge Report, as it is commonly known, into trade and agriculture in Australia in 1823 further bolstered the Gardens' authoritative status in the colony. As Bennett notes,

> Bigge's assignment to New South Wales sprang from Bathurst's decision in 1817 to examine the effectiveness of transportation as a deterrent to felons. His royal commission, issued on 5 January 1819, authorized an investigation of 'all the laws regulations and usages of the settlements', notably those affecting civil administration, management of convicts, development of the courts, the Church, trade, revenue and natural resources (Bennett [1966] 2013: online).

One of the first official signs that the Botanic Gardens were strongly supported by the British government came in the form of Commissioner Bigge's report (1823) to Lord Bathurst who was the Secretary of State for War and the Colonies from 1812 to 1827. Bigge's (1823) report focuses on colonial trade and agriculture in Australia and formalises the Gardens as an important resource of both scientific knowledge and plant

[71] Moreover, acclimatization societies had developed in the colony as part of an international network of plant breeders. These societies and their contribution to instrumental science are covered in section 4.4.2.

stock. The report also reinforces the necessity for an economic botanic garden (in addition to the erstwhile Governor's Garden that had formed part of The Domain) and strongly recommends that Charles Fraser, with whom he had travelled the colony extensively, is appointed Colonial Botanist. Bigge writes,

> I would here beg leave to solicit your Lordship's attention to the importance of the establishment of the Botanic Gardens at Sydney, that [sic] has hitherto been attached to the governor's garden at that place, and has derived assistance from the labour of the convicts assigned for its cultivation. It has been lately placed under the management of Mr C Frazer, who accompanied Mr Oxley[72] in his last expedition into the interior of New South Wales, and who also accompanied me to Van Diemen's Land, and by his care and attention the collection has been enriched with all the most curious plants that were discovered in the course of those expeditions…The value of such an establishment, both in affording means of collection and of experiment, and more particularly of diffusing throughout the colony the most valuable specimens of foreign grasses, plants, and trees, is unquestionable; and I have great satisfaction in stating that, as far as his means have allowed, these benefits have been realized under the zealous exertions of the present colonial botanist. A catalogue was furnished by him of the plants that are now cultivated in the Botanic Gardens in Sydney (Bigge 1823: online).

The use of the word 'curious'[73] to describe the plants discovered on Bigge's expeditions followed by a reinforcement of the utilitarian value that the distribution of these plants would accrue does point to the tension that was beginning to develop between instrumental and the non-instrumental science in Australia. Also of note is Bigge's praise of Fraser, the incoming Director of the Gardens. As part of Bigge's inquiry into the colony's governance, he requested that Fraser produce a more extensive catalogue

[72] John Oxley was the Surveyor-General of the Colony at the time.
[73] The term 'curious' had been used extensively since the Italian renaissance to describe the scientific specimens collected and discussed by the natural philosophers then carefully stored in museums across Britain and Europe (1996). It is also used to describe the motivation underpinning the production and diffusion of non-instrumental science.

of the plants then growing in the Botanic Gardens. This catalogue was subsequently appended to Bigge's official reports. Gilbert notes that,

> The list provided ample evidence of Fraser's own collecting expeditions and of correspondence with other institutions. By 1820 Charles Fraser clearly had the Botanic Garden, as such, well established as an institution in its own right, quite separate from the Governor's kitchen garden. It is probably significant that shortly before Bigge left the colony, the botanist's status and salary were ratified by a formal appointment: 'His Excellency the Governor has been pleased to appoint Mr Charles Fraser to act as Government Colonial Botanist in New South Wales with a Salary of Five Shillings per Diem, until His Majesty's Pleasure shall be known' (1986:38).

The Botanic Gardens were not only given honourable mention in Commission Bigge's report they thrived under Fraser's formal curatorship. Moreover, the new scientifically inclined Governor Brisbane who commenced duties in December 1821 ratified the gardens as an important source of scientific knowledge and re-acclaimed Fraser as an excellent botanist. In a dispatch to Lord Bathurst, Governor Brisbane advised that the success of the gardens was entirely due to Fraser's work,

> Mr Fraser, Botanist, highly qualified to do every justice to his appointment from zeal, talent and enthusiasm which has brought him in correspondence with all quarters of the Globe, from which he is constantly deriving benefit to the public Service by importations of new, valuable and varied productions' (Brisbane cited in Gilbert 1986: 41).

During his governorship Brisbane was also obliged to defer to Commissioner Bigge's reports and to inform Lord Bathurst of the strategies that he intended to put in place that would address Bigge's recommendations. Brisbane subsequently reported to Lord Bathurst that, 'due attention has been paid to this; the original Garden has been nearly doubled … 3,000 varieties of exotic plants, Grasses, bulbs, fruits and vegetables have been introduced within the last year' (Bathurst cited in Gilbert 1986: 41).

Governor Brisbane, a keen astronomer who came to be known as the ‘scientific governor’ of the colony, was a strong supporter of non-instrumental science; however, within the utilitarian and economically focussed milieu of New South Wales he was obliged to favour instrumental science, specifically the market for agricultural goods. Heydon ([1966] 2013: online) notes that Brisbane was appointed Governor of New South Wales in the wake of Bigge’s (1823) report on the poor levels of economic self-sufficiency being exhibited by the colonial administration. ‘Brisbane looked forward to getting the 'Colony on to its own Resources' and regarded the achievement of economy in government expenditure as one of his major successes’ (Heydon [1966] 2013: online).

Brisbane was particularly supportive of the agriculture industry, was instrumental in setting up the first agricultural training college in New South Wales and was the first patron of the New South Wales Agricultural Society that was established in 1822. The Agricultural Society was originally formed by a group of pastoralists who sought state assistance in maintaining their markets. This ‘group of leading citizens’ aimed to

> …encourage and promote the future of agriculture through improvements in breeding of animals and the growth of local produce and crops. The society’s membership read like a who’s who of the colony at the time – leading land-owners, stock-owners and merchants, Samuel Marsden, William Cox, Hannibal McArthur, John Blaxland to name a few. It was hoped a centralised body would have the affect (sic) of raising standards in agriculture throughout the fledgling colony (State Library NSW 1: online).

Moreover, the agricultural show promoted by the Agricultural Society is claimed to have been the first marketing activity in the colony, one that grew out of a Government Order first issued by Governor Macquarie in 1812 (RAHS 2013: online). The order established the first public market at Parramatta which was to be held each Thursday from 6am until noon. Furthermore, Macquarie ordered that a warehouse be built by the government in order to store the farmers' grain, as well as stalls and yards for holding stock. Following the success of the Parramatta venture the colony's agriculturalists decided to establish their own Society. At the first meeting, the then Governor, Sir Thomas Brisbane consented to become Patron and 'endowed the Society with a grant of land for experiments or the depasturing of stock imported by the Society. The Society and its show continued for 10 years, but unexpectedly collapsed in 1834' (RAHS 2013: online).

Notwithstanding Brisbane's financial assistance and the principled manner in which he promoted instrumental science in order to grow the markets for agricultural products, the resident pastoralists, 'men like George Druitt, John Jamison, Marsden, John Dunmore Lang, the Macarthurs and the Blaxlands frequently made vicious misrepresentations in London about Brisbane's administration' (Heydon [1966] 2013: online). Heydon reports that Brisbane's sensitivity, his respect for others and his merciful and forgiving character, ensured that Brisbane was 'rather out of his element when surrounded by the arrogance of the New South Wales magistracy, the disloyalty and factiousness of officials and the explosive rifts in colonial society' ([1966] 2013: online). Such was the political environment of the colony.

Despite his evident support for instrumental science, Brisbane personally favoured non-instrumental science, claiming astronomy as his chief scientific interest and privately funding Sydney's first observatory at Parramatta. Brisbane was obliged however to pay the astronomers from his own pocket, unlike the staffing arrangements at the Botanic Gardens which were fully funded by the state. This private preference for non-instrumental science likely set Brisbane up against the bourgeois pastoralists who were firmly against the state supporting any form of scientific knowledge not immediately and directly economically productive. Certainly his private interests may have become a factor in his unpopularity amongst the settlers. Heydon observes that under Brisbane, basic, or non-instrumental, science 'did not flag' and 'when he departed he left his astronomical instruments and 349 volumes of his scientific library to the colony, as he wanted his name to be associated with 'the furtherance of Science'' (Heydon [1966] 2013: online).

Notwithstanding the success of agricultural science in the colony, the colonial milieu proved to be unhelpful to the formation of a local scientific community or to the development of any form of institution devoted to the development non-instrumental science (Mozley Moyal 1976). Mozley Moyal remarks about the dearth of interest in natural history, '…and indeed there were few visitors to the colonies who failed to notice the philistine nature of society or to deplore the settler's preoccupation with commerce, flocks and wool' (1976: 106). The following section explores the comparative absence of enthusiasm in the colony for non-instrumental science; science that was not related to market outcomes.

3.3.2 Non-instrumental scientific knowledge

Basic scientific knowledge production, or non-instrumental science, can be typified by the Philosophical Society of Australasia and the institution of the Australian Museum, both located in Sydney. The Society and the Museum are seen to be central to the production and diffusion of non-instrumental scientific knowledge in the early colony and to its local and global dissemination. The scientific knowledge generated by these institutions is more resonant with the conception of scientific knowledge as a contributor to civil society than the more instrumental knowledge represented by the Botanic Gardens and favoured by the British government. This section investigates scientific knowledge using the non-instrumental form that was rapidly developing in Europe at the time but which failed to prosper in New South Wales.

The particular character of British science that had developed during the industrial revolution profoundly shaped the spirit and quality of scientific knowledge in Australia. Where British science, in general, was more linked to the utilitarian aims of empire the overarching scientific tradition that was being established in Europe tended more towards the production of state funded, collaborative science that was concerned with generating universal understandings of the natural world. For instance, Fara looks at the manner in which scientific knowledge was handled by the scientific societies of London and Paris between the mid-17th century and the end of the 18th century.

> The contrasting structures of the London and Paris Societies strongly influenced the pattern of scientific development on either side of the Channel during the Enlightenment. In France, generous prizes and a secure financial base encouraged theoretical investigations and a scientifically oriented government. But in England, research was more self-interested. Wealthy aristocrats pursued their own lines of enquiry, while enterprising entrepreneurs…focused on practical projects to generate income (Fara 2009: 151).

Moreover, during the 19th century the major industrial powers of Britain and Germany, took different trajectories in their scientific traditions. Fara writes that the British government were keen to support those scientific projects that were destined to be commercially viable whereas the German state was more concerned with combining ground-breaking science with education. This strategy would secure Germany's position as a 'scientific nation' where 'the general level of scientific knowledge was far higher… than the rest of Europe and industry was booming' (2009: 242/3). In Britain 'the government continued to give comparatively little financial support, and there was no effective technical education until well into the twentieth century' (Fara 2009: 243).

The character of British science and influence on non-instrumental science in Australia can be discerned in the trajectory of the Colonial Museum. The Colonial Museum[74] was the first institution representing basic, or non-instrumental, scientific knowledge in the colony. Despite its support from the gentlemanly classes it did not thrive to the same degree as the more instrumentally focused Botanic Gardens. Perhaps its inability to prosper was to do with the fact that apart from the trading of natural specimens the museum did not have anything to sell on the open market; perhaps it was because of the overwhelming focus on economic botany and pastoralism both domestically and by the British state; or then again perhaps because the Museum, as a symbolic of the European enlightenment, was not treated seriously by the colonial administration, the press, the pastoralists or the *emancipists* of the colony. The emancipists, many of whom were part of the emerging bourgeoisie, were on the side of instrumental science, if anything; the wealthy pastoralists were not keen to waste money on non-instrumental science; the colonial bureaucrats were under orders from the Colonial Office to support pastoralism, and the press at that time were either politicised or deeply disinterested in the concept of non-instrumental science.

Concomitant with the aims of the scholars of the enlightenment period, the founders of the Colonial Museum were members of local and global networks of amateur natural philosophers whose work focused on adding to the stocks of human knowledge

[74] Now known as the Australian Museum.

concerning the natural world. They operated in a voluntary capacity through the auspices of the Philosophical Society and its global network of natural philosophers, as well as through the patronage of the British Museum and a gamut of other museums located around the world (Etheridge 1916; Anderson 1927; Mozley Moyal 1976). These amateur scientists aimed to explore and classify the unique local flora and fauna of Australia and to collect samples of each new species and genotype. In addition to collecting and classifying the specimens, the global network exchanged letters, published papers in scientific journals, and opened their private museums up for access by fellow naturalists and any interested public. This was also the period when free public museums were commonly being established in Europe.

Discussions and debates about the natural world had been vital to the trajectory of non-instrumental science in Europe during both the renaissance and the enlightenment period, and had been sustained by means of a republic of letters and the institution of the scientific public sphere (Fara 2009, Yeo 2001, Findlen 1996, Habermas 1991). The Colonial Museum sought to follow in the footsteps of these European scholars. To this end, the museum was ostensibly designed to support the advancement of a civil society that was founded on the principles of knowledge and reason and harnessed to notions of individual autonomy. The reality of colonial life however produced tensions between the founding principles of the museum, its gentlemanly promoters, the government and the public.

As Kohlstedt argues, 'Colonial Museums structured as they were by powerful and socially conscious officials, attracted a limited audience in the 1840s, despite the lack of alternative recreation' (1980:3). To support its civic intentions, the Colonial Museum was established by a group of powerful men, members of the Philosophical Society, who were keen to continue the work originally produced by the founding scholars of the enlightenment; that is to practice scientific knowledge in order to promote opportunities for individual enlightenment. These men were imbued with a sense of civic duty as well as a personal interest in natural science and they sponsored the scientific activities of the Colonial Museum through its developmental years.

Branagan confirms that the same group of men who were involved in the various amateur societies of the colony were also active in most scientific organisations,

> …the same individuals, in varying permutations, were the activators of almost every scientific venture: governors Macquarie, Brisbane, Darling, Bourke and Denison; colonial secretaries Macleay and Deas Thomson; parsons Clarke and Turner; doctors Bennett, Jamison and Vaughan Thompson; explorers King, Sturt, Mitchell and Leichhardt (1979: 6).

Moreover, Mozley Moyal finds that these

> …doctors, civil servants and clergy, graduates of Oxford and Cambridge, members of scientific societies overseas … shared a common commitment to science and who early set themselves the task of founding clubs and societies and of recording the discoveries of Australian science (1976: 106).

Membership of the Philosophical Society required colleagues to 'contribute scientific papers, catalogue their libraries for the use of members, and accept stringent conditions as token of their good intent' (Mozley Moyal 1976: 106). The Philosophical Society was the forerunner to the extant Royal Society of New South Wales and was established by 'six prominent citizens' in 1821; Governor Brisbane was the inaugural President of the society. During its two year duration, a number of 'exploratory papers on astronomy, geology and meteorology were read' (Mozley Moyal 1976: 106) however it struggled to maintain both regular attendance of its members and its private funding arrangements.

Funding for the society was based on the private contributions of its members and tested both their attendance and their propensity for writing scientific papers. Membership required the Fellows to meet 'every Wednesday at each other's Houses in Sydney alphabetically, at 7 o'clock in the evening. Fine for non-attendance at a quarter of an hour after that time, five shillings' (Anderson 1927: 111). Anderson finds that this rule of membership was

> …rigidly (and frequently) enforced, but the most humourous (sic) entry is that referring to the meeting of 30th January, 1822, which is as follows:
>
> > "At Mr. Field's
> >
> > Present
> >
> > Mr. Field,
> >
> > The Minutes of the last Meeting were read and confirmed."' (Anderson 1927: 111)

Despite the scientific proclivities and the social standing of its membership, the society, 'conceived with vision, fell victim to the rancorous political atmosphere of Sydney and expired in August 1822' (Mozley Moyal 1976: 106). Tyler (2010) affirms that it was the political factions within the society that eventually undid it, but 'Even if there had been no personality conflicts within the Philosophical Society of Australasia it probably would not have long survived. By 1825 four of the members had left the colony, and another one died soon afterwards' (2010:33). Moreover, a number of members of now the defunct society joined the Agricultural Society of New South Wales that was formed in 1822 with Governor Brisbane as Patron (Tyler 2010). This waxing and waning of scientific societies (the Philosophical Society was not strong and underwent a number of reincarnations during the 19th century as show in Figure 3.2), and the movement of erstwhile members of the Philosophical Society to the Agricultural Society, further points to the tensions between instrumental and non-instrumental science in the early colony. Conversely, the instrumental science supported by the Agricultural Society and conducted by the Botanic Gardens continued to receive suitable levels of state funding and healthy support from the public sector.

Mozley Moyal (1976) finds that it was an absence of enthusiasm for non-instrumental science generally that inhibited its development; rather, that it was 'money and man' that drew the attention of the colony,

> In a convict-emancipist society there were few educated citizens to entertain the study of natural history and fewer still who deemed expenditure on scientific investigation a proper commitment for a greenhorn colony (Mozley Moyal 1976: 107).

By the middle of the 19th century however the elements of civil society in New South Wales had broadened to take in other types of knowledge production (including instrumental scientific knowledge), and what remained of non-instrumental science was folded into new organisations supporting science, art, literature and philosophy. This broadening effect is demonstrated in Figure 3.2 which shows the transformation of the Philosophical Society into the extant Royal Society.

Figure 3.2: The stated aims and objectives of the four societies, as well as the subsequent amendment when the Royal Society was incorporated by Act of Parliament in 1881 (Tyler 2010: 37).

Aims and Objectives Philosophical Society of Australasia (1821) 'Formed with a view to inquiring into the various branches of physical science of this vast continent and its adjacent regions; and the mineralogical and geological state of these countries form primary objects of the Society.'
Australian Philosophical Society (1850) The full title of this society described its objectives: 'The Australian Society for the Encouragement of Arts, Science, Commerce, and Agriculture.'
Philosophical Society of New South Wales (1856) 'The object of the society is to receive at its stated meetings, original papers on subjects of science, art, literature, and philosophy.'
Royal Society of New South Wales (1867) 'The object of the Society is to receive at its stated meetings original papers on subjects of Science, Art, Literature, and Philosophy, and especially on such subjects as tend to develop the resources of Australia, and to illustrate its Natural History and Productions.' **Act of Incorporation (1881)** 'For the encouragement of studies and investigations in Science, Art, Literature, and Philosophy.'

As discovered with the political machinations and funding difficulties associated with the nascent Philosophical Society, the colonial community was strongly divided on the usefulness of non-instrumental science. This can be seen in the divergence of public opinion associated with the allocation of state funding for the Colonial Museum; this divergence is demonstrated in Section 3.5. Accordingly, the Colonial Museum's success in attracting and securing funding for non-instrumental science was uneven and often relied on personal relationships both within the colony itself and with overseas museums in order to continue functioning.

The small group of amateur scientists, albeit socially and politically powerful, who promoted the importance of non-instrumental science and who established the Colonial Museum, was however isolated within a milieu that was more interested in employing science for the advancement of markets. It seems, therefore, that formal rationality enacted through the social processes of purposive-rationality took priority over a more substantive rationality achieved through the production and diffusion of value-rational scientific knowledge. Indeed, this tension between 'money and man' and scientific knowledge was to continue in New South Wales, and then in the Federation of Australia until the present day and forms a key theme within this thesis.

On balance, although there is evidence that points to the beginnings of the separation between instrumental and non-instrumental science in New South Wales, the categories were still fluid and tended to interpenetrate each other. Nevertheless, the agricultural networks propagated by the British Empire were heavily bound up with the concepts of improvement, particularly agricultural improvement, in addition to the advancement of markets. These markets served to reinforce the political and economic power of British citizens, particularly the capitalist class. Entwined with instrumental science were the capitalist prerequisites of land, labour and capital. The following section explores these factors of production in relation to the agricultural industry in New South Wales.

3.4 Factors of production: land, labour, capital…and scientific knowledge

The capitalist factors of production – land, labour and capital – were heavily subsided during this period in order to generate self-sufficiency in the colony and to supply raw materials for the burgeoning manufacturing industries in Britain. These factors of production were realised under the mercantilist model which commanded that British colonies such as New South Wales only trade with Britain, as the *mother country*, or with other British colonies. This subsidised capitalist framework served to enhance the wealth and prestige of the agrarian bourgeoisie and transformed the pastoralist/squatters into the ruling class. Class in early Australia was thus tightly bound up with agrarian pursuits focused on the production of wealth and capital.

Embedded within the factors and relations of production was the factor of scientific knowledge. Scientific knowledge was critical to both pastoralism and agricultural markets during this period. In addition to land, labour and capital, the British government provided instrumental knowledge in the form of plants, seeds and know-how in order to support the growth of primary industries and global markets. Thus the production of instrumental scientific knowledge was closely associated with the establishment of an agrarian ruling class in Australia.

In his report (1823) on agriculture and trade in early Australia, Commissioner Bigge identified an elite group of families were also the private entrepreneurs (Connell & Irving 1980) of the colony. These capitalist families made their fortunes through: *land* that had been both granted by the Governor and/or acquired through processes of illegal squatting on the land, eventually to be turned into pastoral leases; through inexpensive *labour* provided by the state in the form of convict labour; through taxation relief and low-cost financial *capital* originating in Britain; and through the provision of ready markets delivered by the state. Moreover, these entrepreneurs were offered *scientific knowledge* that had been generated by the British state through global agricultural experiments. This global scientific knowledge was curated in Kew Gardens in London for distribution to British colonies, and local knowledge was available from the Botanic Gardens in Sydney.

The system of supporting the local capitalists had begun in the earliest days of the colony when military and civil officials were granted land and convict labour in order to grow crops and raise meat for consumption by the residents of the colony. Macintyre (1999; 2004a; 2009) notes that from the year 1793 men who were involved with the defence or administrative functions of the colony were granted individual landholdings; emancipists and soldiers were granted up to twenty hectares, but the limit was uncapped for their superiors. Moreover, military and civil officials were permitted to use convict labour in order to establish their farms, and most landholders enjoyed a ready market for their agricultural produce by way of the government stores and public rations. Macintyre explains,

> Through their new dual role as public officers and private entrepreneurs, a dual economy quickly emerged: a public sector which included the government farm and its convict workers, along with others labouring on construction projects and the provision of services; a private sector of traders and farmers who benefited from the public largesse. Both sectors were dependent on the British government… (But) the British government's direction of this extraordinary arrangement was episodic and inconsistent (1999:38).

Steven (2000) argues that the economic intimacy that had been created between the government, its officers and enterprising emancipists drew young mercantilists from other parts of the British Empire. These young capitalists were attracted by the beneficial trading conditions in New South Wales; trading conditions that tended to be atypical of British colonies. Unlike the class consciousness of Britain (where wealth and class were traditionally linked) or many of its other colonial outposts that were colonised for extractive purposes, the free and convicted residents of New South Wales were treated more benevolently by the British State in the early years (Steven 2000). As the colony developed, these early farmers were supplanted by the pastoralists who, also assisted by convict labour, raised meat for sale to the colony and wool for export to Britain. These even more profitable undertakings involved the acquisition of large swathes of land.

Land was an important factor in the generation of personal wealth and prestige in the young colony. Connell and Irving note that 'the British government claimed ownership of all land for the Crown (ignoring any Aboriginal claim absolutely)' (1980: 35). While small grants of farming land were provided to emancipists and then to ex-servicemen, the colonial officers were not originally entitled to this free land. After much complaint to Britain, the officers were eventually authorised to participate in the land grant scheme. As Connell and Irving report,

> The authority arrived in the colony in 1793 and was immediately used to set up substantial farms, John Macarthur racing in the lead. Some feeble attempts were made to impose conditions on grants, but in practice farm land became a commodity, freely able to be sold or leased. (In one bizarre episode, some prime wheat land at the Hawkesbury was actually leased back to the government.) Land was granted to free settlers roughly in proportion to their wealth. By the 1820s practically all the usable land in the Sydney region had passed into private hands (1980: 35).

Understandings around the ownership of land in Australia and the legitimacy of the Crown to bestow grants of land on both officers of the Crown and to early white settlers, has been extensively reviewed and strongly debated since the *Mabo v State of Queensland (No 2) (1992)* case heard by the High Court of Australia; the Federal government response in the *Native Title Act 1993 (Cth)*; the *Wik Peoples v State of Queensland and Others (1996)* and *The Thayorre People v The State of Queensland & Others (1996)* case heard by the High Court of Australia; and the government's response to *Wik* in the *Native Title Amendment Act 1998 (Cth).* These important legal cases and consequent Acts of Parliament have brought into tension the veracity and validity of the original land grants made by the Crown during the first forty years of the Colony of New South Wales and to the pastoral leases granted in Australia after 1840. It is not the intention of this chapter to debate the merits or otherwise of various legal approaches to granting of Crown land however this is an important matter that needs to be addressed within the context of the land grants to the early capitalists and so their special access to the factors of production, particularly cost-effective land.

Despite common understandings in Australia during the late 18th and 19th centuries, the British state had been aware of, and had indeed debated, notions of native title in relation to its colonies since the establishment of the American colonies in the 17th century (Borch 2001). Borch (2001) writes that by the time Britain began to colonise New South Wales in 1788 it had the experiences of the American colonies and parts of Africa on which to draw in order to develop appropriate policies around indigenous rights; that,

> …the application of the doctrine of conquest to inhabited land thus seems well established in British law by the second half of the eighteenth century (and that) the doctrine of conquest was adapted to express the recognition of—and respect for—the existing rights of the original inhabitants; cession and purchase were both legal and political manifestations of this recognition (Borch 2001: 227).

In particular, when Joseph Banks was questioned on the possibilities of using New South Wales as a penal colony he stated that 'any District of the Country might be obtained by Cessation or Purchase' (Banks cited in Borch 2001: 230); as was also evident in James' Cook's 'instructions to take possession of certain locations 'with the consent of the natives''. In other words,

> …it may be suggested with some force that by the time of the established of New South Wales, there was no precedent in eighteenth century British policy for taking possession of inhabited land it if it was uninhabited[75] nor was there any legal doctrine in British law at the time which supported such action (Borch 2001: 230).

Borch (2001) suggests that the doctrine of *terra nullius* (translated from the Latin as 'land of no-one') was adopted from Locke's original work on agricultural property rights in which Locke wrote that individual property rights arose as a consequence of an individual adding value to the land through the application of labour. By mixing labour with natural forms of materials that had been drawn from nature (such as agricultural improvement of the land), the result may acquire additional value and thus be transformed from common property to private property; and that it is the responsibility of the state to protect that private property.[76] In developing his theories using the British colonisation of America as an exemplar, Locke trusted that it would be possible for the British to settle in America without supplanting the indigenous inhabitants. For Locke and his colleagues, agricultural improvement that did not interfere with the indigenous inhabitants provided the necessary force of law required to claim the presumably unused land.

In the official British records, it was assumed that the newly discovered land in New South Wales was 'very sparsely inhabited, most likely leading to them to conclude that this was, indeed, a practically uninhabited country' (Borch 2001: 235). This assumption

[75] As was assumed under the doctrine of *terra nullius* on which the colonies of Australia were claimed.
[76] Locke's contributions to the private property laws are discussed in more detail in Section 2.4.3.

was confirmed by Joseph Banks in his remarks to the 1785 Commons Committee, and so the government appears to have accepted that there was 'room for everybody' (235). As discussed previously,[77] the British state was heavily occupied in the conduct of war at this time and was thus not especially interested in debating the colonization of New South Wales; the word of Joseph Banks appears to have been sufficient to progress the legalities of a land claim based on the keys tenets of the Lockean agriculturalist argument (Borch 2001; Gascoigne 1994, 1998). Thus, based on the precept that the Australian land was uninhabited (or *terra nullius*) the claim was progressed, so providing the rational for acquisition on the basis of 'conquest and cession' (Borch 2001: 238). It was not until the Mabo judgement that the idea of Australia as *terra nullius* was rejected.

In short, the chain of legislation that was precipitated by the Mabo case worked to re-establish the legal framework on which white Australia had been claimed in 1788 and on which freehold land grants and pastoral leases had been issued (Ivison 1997). Where the doctrine of *terra nullius* had been used as a founding precept prior to and during the years of early colonial settlement, the case of *Mabo v State of Queensland 1992* conducted in the High Court of Australia served to alter the common law to recognize that the land had, in reality, been inhabited by indigenous people and so effectively confirmed the native title of indigenous Australians (Ivison 1997; Kildea 1997). Briefly, the main principles established in the Mabo case were: (a) the decision that the British Crown could acquire sovereignty over Australia land however it could not acquire beneficial full ownership of that land; nevertheless, the sovereignty of the Crown meant that it did have the authority to take full ownership of the land if it chose

[77] In Section 3.2.1.

to do so. If the Crown did not specifically take full ownership of the land, then the land reverted to the indigenous people (according to their own laws and customs) through the application of native title (b) Where native title continued over the land (and thus extinguished the ownership rights of the Crown), the determinations regarding the uses and rights of use of the land would be regulated through the laws and customs of the indigenous people who have proof of connection to the land (c) This native title may be extinguished if the tribe or community claiming native title loses connection with the land (d) Native title may be surrendered to the Crown but the rights and privileges conferred by that native title are not transferable to another group or tribe Kildea (1997:4). This meant that unless the Crown had specifically taken possession of these early lands, the title remained with the indigenous communities, provided they could establish connection. In order to avoid complex and costly cases in common law, these finding of the High Court were enshrined in statute law through the *Native Title Act 1993 (Cth)* (Kildea 1997). Although the Mabo case and the Native Title Act were clear in terms of freehold land, the issue of pastoral leases (post the 1840s) necessitated a further set of common law remedies and an amendment to the Native Title Act.

In December 1996, a majority of the High Court held in the *Wik Peoples V State of Queensland and Others (1996)* and *The Thayorre People V The State of Queensland and Others (1997)* that the issuing of two pastoral leases in Queensland did not necessarily extinguish native title but may extinguish pastoral leases (but not mining leases). As forty-two per cent of the Australian land mass is under pastoral lease (some States being seventy to eighty per cent of land) the *Wik* case was seen to be of tremendous importance to the issue of both native title and pastoral leases issued after 1840 (Stevenson 1996). The High Court findings in the *Wik* case produced significant tensions within the agricultural community and amongst indigenous stakeholders, thus the Federal government was compelled to revise the Native Title Act. This revised legislation, *Native Title Amendment Act 1998 (Cth),* is relevant to pastoral leases and claims for native title and takes the position that the granting of a pastoral lease does not confer exclusive possession and that native title could therefore continue to exist; that the parties should co-exist on the land. When there is an inconsistency between the native title and pastoral leases then the pastoral rights will prevail.

So, notwithstanding the legal confirmation that Aboriginal people did exist on the land in the 1780s, instrumental rationality delivered through the force of the capitalist project and its focus on securing the most cost-effective factors of production possible continues to define the nation. As Ivison concludes,

> Needless to say, accounts of the rule of law which emphasize the value of private ordering over legislative and regulatory ordering tend to work against the kinds of policies and regulatory schemes sought by Aboriginal people. A preference for deregulated markets, for example, works against correcting the impact they have on Aboriginal claims. Unrestricted rights to acquire and sell land undermine attempts by Aborigines to protect traditional lands, or recover those unjustly taken. Conversely, property rights not reducible to familiar common law categories--'native title' for example-are said to increase transactions costs **(by** complicating jurisdictional issues and land exploitation) and undermine the 'certainty' of other forms of title (by questioning their legitimacy). Finally, narrow text-based interpretive rules applied by the judiciary to legislation-a favourite tactic of public-choice-inspired theorists and judges--deliberately reduce its scope when questions of meaning inevitably arise in particular applications, and discourage more pragmatic and purposive interpretations of statutes or constitutional norms which might 'improve' or correct legislative outcomes where needed (1997: 270).

It was not simply cost-effective land that was needed by the early capitalists, convict labour was particularly crucial to the development of the land. Roberts (1975) reports that without the lure of convict labour the free settlers would have found colonial life intolerable and the idea of profit prohibitive. Once ashore in Sydney, and irrespective of their original crime, the female convicts were sent into private domestic service and the men were shipped off to the Barracks where they would be 'classified' and 'drafted for Government service or private assignment' (1975: 16).

In addition to this free or low cost provision of land, labour and ready markets, the early colonists were not taxed. Following the rebellion in the American colonies, the British State had decided against taxing new colonies such as New South Wales and instead sought to receive its returns through incremental trading opportunities and from interest generated by private investment in the new colony. Rather than collecting taxes, the governor was instead instructed to advance the economic position of the colony. An enlarged economic output would enable the colony to both self-fund and establish new commercial opportunities. These commercial prospects were to be developed from leveraging new trading opportunities and exploiting the natural environment (Macintyre 1999; 2004; 2009; Smith 2004; Connell & Irving 1980). The prevailing economic climate, being the drive towards economic self-sufficiency, necessitated the leveraging of not only land, labour and capital but also scientific knowledge as an implicit factor of production.

Scientific knowledge was an important, albeit implicit, factor of production in agriculture. The Kew Gardens and local Botanic Gardens were the clearing house of knowledge and specimens that had been tested through the scientific discipline of acclimatization. Moreover, the local plant breeders conducted experiments on local flora to determine their acceptability for global markets and on non-indigenous specimens to ascertain their suitability for local production. Economic botany was thus stimulated by this wide spread scientific practice. As Osborne writes,

> In the British Empire, small clusters of businessmen, scientists, and publicists spurred acclimatization, although the aristocracy was not entirely absent from the movement. Since the eighteenth century, botanical acclimatizations had been conducted under the patronage of the East India Company, Joseph Banks, and other notables. When Victoria came to the throne in 1837, the empire possessed eight botanical gardens. At Victoria's death in 1901, there were more than one hundred, about fifty of which were in India and the Australasian colonies (2001: 145).

By far the most successful acclimatization project was that conducted by John Macarthur in New South Wales (Osborne 2001). While Macarthur's project predated the surge of acclimatization societies, scientists and more formal undertakings in Australia that were evident following the gold rush in the 1850s[78] his project is deemed to be one of the most successful. Osborne finds 'Of all the introduced exotic organisms in Australasia, however, none would rival the Spanish merino sheep in terms of economic importance and success' (2001: 146).

Osborne notes that although Macarthur 'claimed credit for the establishment of merino sheep in New South Wales' he was 'in fact only one of a number of settlers who had obtained sheep from the Cape of Good Hope as early as 1793' (2001: 148). Osborne continues,

> Clashes with colonial governors and military superiors resulted in his return to England and subsequent resignation from the army. Promoting himself to British wool interests, he obtained eight merinos from King George III's herd and returned to New South Wales in 1805 with a letter ordering the governor to grant him four thousand hectares of land. Together with his wife

[78] The contribution of acclimatization science to the agricultural markets following the gold rush is covered more substantially in Chapter 4.

> Elisabeth and members of their extended family, Macarthur developed, publicized, and improved the Australian wool industry. After 1820, infusions of merinos came from the French herd at Rambouillet, which had been developed by Daubenton, and herds in Saxony, England, and the United States (2001: 148).

Macarthur was also an excellent entrepreneur. His skill in convincing the state to support his economic ventures was renowned, as was his capacity to develop local agricultural industries and global markets. In addition to his success with merino sheep Macarthur introduced grape vines for producing wine and olives amongst other 'exotic' fruits and vegetables. This acclimatised seed and plant stock had been afforded by the scientific work of Kew Gardens and the Botanic Gardens in Sydney and subsequently granted to Macarthur. Bigge reports that John Macarthur had fruitfully introduced the olive-tree into the colony and recommended that the government send plants from England at the earliest opportunity.

> With a view to accelerate the production of olive-oil in the colony, I should recommend that plants should be sent from England, by every convenient opportunity in the convict-ships, and that they should in the first instance be consigned to the care and management of the colonial botanist, and afterwards distributed amongst the respectable settlers who apply for them (Bigge 1823: online).

As a thoroughgoing capitalist Macarthur's chief concern however was not the sharing of his agricultural knowledge, more so the growth of his wealth and capital. Macarthur's biographer describes the man,

> A brilliant publicist and organizer, Macarthur's great service was to focus and promote English interest in colonial potential, to inspire and communicate the enticing vision of a great commercial staple. But his vision was a personal one, the necessary vehicle for a restless ambition whose dynamic energy was as likely to overset as advance it. Ultimately it was to the

persistence and loyalty of his wife and sons that Macarthur owed the greater part of that reputation derived from his practical achievements with Australian wool (Margaret Steven [1967] 2013: online).

This entrepreneurial spirit can be seen in his scheme to launch the Australian Agricultural Company, Australia's first Public/Private Partnership (PPP), in New South Wales in 1824. The scheme to organize the production of Australian wool was ratified by the British parliament, was 'richly subscribed in London' with a working capital of £1,000,000 and a 1,000,000-acre land grant at Port Stephens with harbour rights at Newcastle. This 'inspired arrangement' however 'met a hostile reception in New South Wales, where it was regarded as a naked contrivance of the Macarthurs for their own aggrandizement that 'must entail inevitable destruction of the industry of every loyal subject in the Colony' (Margaret Steven [1967] 2013: online).

Macarthur was so successful in procuring private land grants and special treatment that by the 1830s he personally held around 28,000 acres, comprising the 'greatest and most advanced mixed farm in NSW, at a time when Australian wools had almost ousted continental wools from British usage and the British manufacturers had a vast ascendancy in the world's woollen markets' (Camden Park Estate, 1965 cited in NSW Office of Environment and Heritage 2013: online). Not only were the Macarthurs instrumental in establishing the wool and olive oil industry in New South Wales, they were also influential in the founding of the wine industry. A history of the Camden Park estate reveals that

> … (The Macarthurs) were instrumental (along with Brush Farm, Ryde via Gregory Blaxland and the Sydney Botanic Gardens, via James Busby) in establishing the Australian wine industry. Camden Park became world-renowned for the quality of its wine. It played a vital role in the

> fledgling Australian wine industry through its importation and distribution of vine cuttings throughout NSW and the Barossa Valley of SA. By 1841 sons William & James were producing more than 5000 gallons and that vintage won Gold Medals in England…By 1853 Camden Park listed some 33 grape varieties for sale (Everett, (1) 2004 cited in NSW Heritage Item Camden Park 2013). Camden Park became world-renowned for the quality of its wine and by 1845 was producing around 10,000 gallons per annum as a serious vineyard and one of the most highly regarded in the colony and with quite a reputation overseas (Everett, (2) 2004 cited in NSW Office of Environment & Heritage: Camden Park 2013: online).

Notwithstanding John Macarthur's fixed position on capital accumulation through the application of scientific knowledge to his agricultural pursuits his son Sir William Macarthur was both commercially minded and generous with his knowledge.

> A keen horse-breeder, introduced the camellia, grew many fruit trees, vegetables and flowers and from 1843 published an annual catalogue of their plants. Later he built a hothouse and imported valuable orchids…As 'Maro' he published Letters on the Culture of the Vine, Fermentation, and the Management of Wine in the Cellar (Sydney, 1844) and some account of the Vineyards at Camden (London, 1849). Generous with advice and cuttings to vignerons in the Hunter Valley, Victoria and South Australia, he was president of the New South Wales Vineyard Association. In 1855 he was New South Wales commissioner at the International Exhibition in Paris, where his collection of Australian woods attracted attention…. In 1860 he became the first vice-president of the Acclimatisation Society of New South Wales…president then senior vice-president of the Agricultural Society of New South Wales (Teale 2013: online).

Sir William's generosity with sharing his scientific knowledge suggests that the fixities between the public character of non-instrumental knowledge and the private protection of instrumental knowledge were not firmly wrought at this stage in the development of science in Australia.[79] At this point in its maturity, both instrumental and non-

[79] Sir William's contribution to agricultural science in Australia is discussed more fully in Chapter 4.

instrumental forms of scientific knowledge production and diffusion could have prospered simultaneously. However, under the aegus of utilitarianism and the British directive for economic self-sufficiency, the instrumentality of scientific knowledge was emphasised in terms of its political and economic goals.

Certainly, the state subsidised capitalist framework (comprising free or low cost land, labour and capital) when combined with the entrepreneurialism of the agrarian bourgeoisie (exemplified in the form of John Macarthur) and the application of instrumentalised knowledge (in the form of Kew Gardens in London, the Botanic Gardens in Sydney and access to the global network of agrarian science) enhanced the personal wealth and prestige of the agrarian bourgeoisie and transformed the pastoralist/squatters into the ruling class.

On the other hand, scientific knowledge dedicated to the advancement of civil society was inconsistent in its development; much of this non-instrumental knowledge production and diffusion (embodied in the work of the Philosophical Society and the Colonial Museum) was not maintained by either the state or the market; instead non-instrumental scientific knowledge production and diffusion was primarily sustained through personal funding and individual commitment.

In these very early days, despite evidence that instrumental and non-instrumental science were both present and co-existed within the early colony, the more fixed forms of scientific knowledge production did not emerge until later in the 19th century.[80] The following section considers how scientific knowledge was handled in the public sphere.

3.5 Scientific knowledge in the public sphere

[80] The firming of instrumental and non-instrumental knowledge is explored in Chapter 4.

The tension between instrumental and non-instrumental knowledge is particularly evident in the discourse conducted in the public sphere. The more conservative forces of the colony, the ostensible gentleman class who were the administrators of the colony and the promoters of civil society rallied support for the establishment of a museum for the production and diffusion of non-instrumental scientific knowledge. This form of knowledge was evocative of the knowledge advocated by Bacon and the thinkers of the European enlightenment. Conversely the more liberal forces advocated the production of useful knowledge that could be used to progress the economic status of the colony. This instrumental knowledge is emblematic in the support for the Botanic Gardens and economic botany. As has been discussed in the previous section, the liberal forces were in the main the pastoralists and agricultural producers who were keen for the state to continue to maintain its support of subsidised land, labour and capital. This section looks at the formation of two distinct views regarding knowledge and how this plays out in the public sphere. It clearly demonstrates the tensions between non-instrumental and instrumental science at work in the early colony.

Where the acceptance of art and natural philosophy as important sources of knowledge had nurtured and enhanced the political public sphere in Britain and Europe, it can be argued that the notion of the museum or gallery as a producer and diffuser of knowledge had not been fully acknowledged or woven into social fabric of Australia. The humanities and the non-instrumental sciences were imported from the northern hemisphere, and to some degree, were bolted on to the Australian consciousness at a much later time.[81] Thus the public sphere for early Australia was reduced to the utilitarian matters of self-government and economic performance. Knowledge

[81] The emergence of fragile civil society is discussed more thoroughly in Chapter 4.

production, unless it supported these political and economic matters, was a private matter. This idea is clearly laid out in the newspapers of the day. Where non-instrumental science attracted little or no comment, instrumental science in the form of agriculture was a regular feature in the newspapers.

The Sydney press, as an indicator of the public mood, were mixed in opinion of the importance of art, literature, natural philosophy in the guise of basic (or non-instrumental) science, or indeed a 'Publick Museum'. The newspapers of note between 1803 and 1831 were the *Sydney Gazette and New South Wales Advertiser* (1803-1842), *The Australian*[82] (1824-1848), *The Monitor* (1826-1841) and the *Sydney Herald* (1831-current) the forerunner to the *Sydney Morning Herald* of today.

The Sydney newspapers routinely reproduced news from home (meaning Britain) and reported the undertakings of the British Museum. When it came to the establishment of a natural history museum in Sydney however the coverage was mixed. The following snippet published in the *Shipping Intelligence* section of *The Gazette* demonstrates one side of the low key debate.

> A Hint.-We would be glad to perceive, amongst some of our intelligent and public spirited Colonists, more of a desire to prosecute the public weal than at present exists. Amongst other improvement, in these times, would there be any harm in suggesting the idea of founding an Australian Museum? The earlier such an Institution is formed, the better it will be for posterity (The Gazette 29/6/1827: 4).

The *Sydney Gazette and New South Wales Advertiser* was a conservative newspaper that was published between 1803 and 1842. It was originally an official publication of the

[82] **Not** the newspaper that currently carries that name.

New South Wales government authorised by Governor King and printed by George Howe. By 1824 George Howe had taken over editorship of the *Gazette*, and it was no longer censored by the colonial government (Trove 2013: online). The editorial policy of the *Gazette* was to support the establishment of a museum in order to assist in the production of non-instrumental science and the cultivation of civil society in the colony.

In the following year a newly launched conservative journal, the *Australian Quarterly Journal*, published an article further supporting the idea of a local natural history museum. These two publications were issued and read by the small, conservative group who could be described as the gentlefolk of the colony, the same group who were keen for a flourishing civil society in New South Wales. On the other hand, the more liberally oriented readership of *The Monitor* took exception to the idea of a local museum.

> LETTER TO THE EDITOR REGARDING THE AUSTRALIAN QUARTERLY JOURNAL
>
> …Like the financial plan of my Lord Duke of Wellington, I much fear the establishment of an Australian Museum will be attended with many "practical difficulties." And as for a Museum in New South Wales" bringing scientific and learned men FROM THE REST OF THE WORLD TO THESE SHORES, that I deny; and appeal to the public for a justification of my denial; Build a Museum; fill it; and shall they not have a better in London or in Paris?
>
> Signed A LIBERAL (Anon. The Monitor 17/1/1828: 4)

Notwithstanding the disagreement from more liberal quarters, the museum as the centre of non-instrumental science in the colony was approved to go ahead by the Governor. The Colonial Office in Britain provided funding to the value of around £200 per year (to be drawn from the accounts of the colony) as well as the promise of a curator (who never materialised). *The Australian* newspaper (no relation to the contemporary version) represented the liberals of the colony, many of whom were pastoralists, including the publisher himself, William Charles Wentworth. This editorial of 1832 is clear on Wentworth's position,

> EDITORIAL IN THE AUSTRALIAN
>
> Colonial Museum, £322 4s. 5d. — Where is this Museum? Or what is it? Being unable to find out, we leave it to be elucidated by some one or another of our inquisitive readers. Can this Museum, which the public have to pay for, yet know not where it is, or what it is, be a private collection of rarities once belonging to Mr. McLeay?[83] Or what can it be? In reality we strongly suspect, the former (Anon. The Australian 16/3/1832: 2).

Moreover, the following editorial in the *Sydney Monitor*, another liberal newspaper along the lines of Wentworth's Australian, reiterates the liberal view on the establishment of the museum.

> OPEN LETTER FROM THE EDITOR OF THE SYDNEY MONITOR
>
> BY EDWARD SMITH HALL TO THE RIGHT HONORABLE LORD GODERICH, HM SECRETARY OF STATE FOR THE COLONIES
>
> Of the Colonial Museum I know nothing. It has never been published to the Colony, to my recollection as being in existence. I consider it a sort of imposition on the public...Zoology is a matter of taste, & gentlemen ought to conduct its details as they do their taste for chemistry (a much more important science), at their own private expense or by subscription. This expense was entailed upon the Colony when Governor Darling expended the public money according to the taste of his particular friends, and denying to Mr. M'Pherson, the Collector of Internal

[83] Mr McLeay is Alexander Macleay, the former Colonial Secretary who was an active member of both the Linnaen Society and the Royal Society. Macleay was a 'gentlemen' and a foundational member of the Australian Museum and invested much time in nurturing the idea of civil society in New South Wales. William Charles Wentworth, a pastoralist, was a sworn enemy of Alexander Macleay due to a disagreement over a military matter.

> Revenue, the clerks requisite for carrying on his most important duties. I never saw the Museum, and question if anything worthy of the name be to be found in the Colony. It is attributed to the influence of Mr. M'Leay, who seems disposed to gratify his particular taste for Zoology at the public expense (Edward Smith Hall. The Sydney Monitor 6/10/1832: 2).

The editorial reflects the British idea of the time that science (non-instrumental science) was a pursuit of gentlemen, a pursuit that should be conducted in their own time at their own expense and not drain the public purse. The liberals, many of whom were pastoralists or urban merchants, believed that instrumental science, such as economic botany or agricultural science that supported the development of markets was a more appropriate use of public funds. There appeared to be a limited understanding of the importance of non-instrumental science to instrumental science; that basic science fuels applied science and accordingly, the commercial applications of science.

In another example of the contested positions between instrumental and non-instrumental science, the museum and the cultivation of a civil society in Sydney, the *Sydney Gazette* was behind the campaign to install Dr John Lhotsky as the Colonial Zoologist located within the Australian Museum. Dr Lhotsky, a doctor of medicine from Vienna, arrived in Sydney with the notion of taking up the position of Colonial Zoologist that had been vacant for the previous two years. Dr Lhotsky was in receipt of a grant bestowed by the King of Bavaria to conduct botanical and zoological research in South America and Australia; he had been in Brazil for eighteen months before arriving in Sydney in 1832 (Whitley 2013). Lhotsky both applied to Governor Bourke for the position and 'sought support from the public through the press' (Strahan 1979:13). The conservative readers of the *Gazette* were supportive of this move:

> EDITORIAL IN THE SYDNEY GAZETTE

> The situation of Colonial Zoologist having become vacant now two years by the death of its occupant, we take the opportunity of expressing our earnest hope that it may be confirmed upon that talented and enterprising Natural Historian, Dr Lhotsky…As the salary is only £150 per annum, we are sure that no man of science would come out for so paltry a sum… (Anon. Sydney Gazette 18/6/1833: 2).

A responding editorial piece was swiftly published in liberal newspaper *The Monitor*. The following is the editorial retort that was published the day after the *Sydney Gazette* had demonstrated their support for Dr Lhotsky and his claim for the position of Colonial Zoologist.

> EDITORIAL IN THE SYDNEY MONITOR
>
> ZOOLOGY. The Sydney Gazette earnestly beseeches the Governor to job away the public money in appointing Dr. Lhotsky to be Zoologist. The Governor declined to give anything towards a Colonial Agent, on the plea, that he was not authorised to do so. How then can this proposal of the Sydney Gazette be attended to? The editor speaks of appointments, as if the public money were His Excellency's own patrimony; and that while churches and schools in our interior, and a Colonial Agent, are denied us for want of sufficient funds, His Excellency is at the same time at liberty to spend it in philosophical gew gaws? No. Let those who are fond of birds, fishes, beasts, and minerals, indulge their taste at their own cost, as the subscribers to our several colleges do, until we are abundantly provided with schools, churches, a Colonial Agent, roads, bridges, salaries to Members of a House of Assembly, &c. &c (Anon. The Sydney Monitor 19/6/1833: 3)

A more provocative article was published by William Charles Wentworth in his own newspaper the following month. Wentworth, as a liberal, was supportive of science in terms of pastoralism, agriculture and markets but was opposed to the idea of 'valueless' non-instrumental knowledge production.

LETTER IN THE SYDNEY MONITOR BY WILLIAM CHARLES WENTWORTH

> I must draw your attention to another item, namely 200 for a Museum; I would ask what benefit the public derive from this superfluous expense? Gentlemen, the person who filled the situation of Zoologist died some time ago; and his place has not been filled! Yet his salary has still been going on! I would ask, Gentlemen, what has become of the arrears? (Hear, hear). Can it be supposed that any person has been allowed to pocket this money? There are questions I cannot answer. One thing I do know (is) that the contents of this valuable institution (a laugh) are conveyed home and that HM Ministers are fairly stuffed with birds and rare curiosities (WC Wentworth to The Sydney Monitor 13/7/1833: 2).

A week later *The Sydney Monitor* replied, 'blasting all government involvement in science and criticising the expenditure of £764 18s 8d a year on the Botanic Gardens',

> We have the same objection to this Establishment as to that of Zoology. Zoology and Mineralogy, and Astronomy, and Botany, and the other sciences, are all very good things, but we have no great opinion of an infantile people being taxed to promote them…We might as well give salaries to painters, sculptors, and chemists, as to botanists, astronomers and museum collectors (Anon. The Sydney Monitor 20/7/1833: 3)

Two days following this heated exchange of letters, a final letter appeared the *Sydney Gazette*; one that took a more rational position, advocating for the cultivation of basic, or non-instrumental science that could be produced in the museum over the more instrumental science produced in the Botanic Gardens. The writer, while understanding and appreciating the need for economic botany and instrumental science, argues that too great a focus on economic aims may breed ignorance and illiberalism. This opinion turns the erstwhile liberalism of the economically focused pastoralists and agriculturalists on its head and claims that their opinions are narrow-minded and intolerant. The writer, notwithstanding his support for the non-instrumental sciences, does display limited understanding of the importance of basic scientific break-throughs to the production of instrumental science.

NATURAL HISTORY OF THE COLONY

To the Editor of the Sydney Gazette

SIR,

In a late number of your paper, some reference is made to the vacancy in the Natural History department of the colony; a situation, I consider, not only of importance to Australia, but to the scientific world in general; and I am only surprised that a paper bearing the title of "Monitor," should style it a gew-gaw, or that a man of Mr. Wentworth's education, should call it a trifle.

As to the real merits of Dr. Lhotsky to fill that situation, I will not speak; but from his zeal and perseverance in collecting objects of Natural History, all must allow he has the best claim to it. The expense is nothing compared to our justly stiled Botanic-cabbage-garden; and, I am sure its object is equally important. It will always be a stain on the page of British history, the neglect shown to her men of science, and I trust, that for this matter of £150 or £200. We will either be so ignorant or so illiberal, as be guided by the opinions of a few, who have neither the taste nor relish for such an interesting study. It forms an important branch of education; it can be practised and cultivated in any situation; it unfolds and explains to us many of the phenomena of nature, and elevates our thoughts from nature's works, to nature's God. Men of far greater minds and more liberal ideas than we'd ever find in this colony, have devoted their life-time to it, and secured for themselves a fame as imperishable, as that of the statesman or the warrior; and may not some of our youth at a future period, be worthy to be ranked with a Linnaeus or Buffon, a Banks or a Humboldt?

I am an advocate for economy, but not that narrow minded economy which would deny a hundred pounds to such a useful pursuit. It is a disgrace to this prosperous colony, which is as rich in the animal and vegetable kingdoms as well as in the mineralogical, that we cannot say to

> the stranger visiting our Shores come and see our museum of curiosities which are almost peculiar to our extensive continent.
>
> I remain, Sir, your obedient servant.
>
> T.D. (Anon. The Sydney Gazette 1/8/1833: 4)

The argument conducted in the public sphere of the day demonstrates both the conservative viewpoint that non-instrumental knowledge or the production and diffusion of knowledge for its own sake (that type produced and diffused in the museums at the time) is important for the development of both civil society and individual freedom. These conservative amateur scientists were the gentlemen of the colony who undertook the practice of science and promoted it in order to add to the stock of human knowledge about the natural world. Moreover, this position on science underlines the philosophy of the enlightenment thinkers who argued that knowledge of art, science and morality was critical to the emancipation, in the parlance of Habermas, of the lifeworld from the system.

On the other hand, the more liberal minded members of the colony, those pastoralists and agriculturalists who believed that improvement was found through economic gains took the more modern view that scientific knowledge was best when it was useful. Economically useful scientific knowledge was to be found in the global Botanic Gardens and could be applied to the natural world in order to generate wealth and capital for its owners.

The liberal viewpoint, that which supported the funding of instrumental scientific knowledge and diffusion within the colony eventually prevailed. Although the Philosophical Society and the Australian Museum had established more permanent footings by the end of the 19th century the support for, and development of, instrumental scientific knowledge production, proceeded apace. The tensions that had formed between these two types of scientific knowledge firmed, and a third type of scientific knowledge production and diffusion that of pre-instrumental scientific knowledge emerged during the latter part of the 19th century. This tension forms a central plank of this thesis and is taken up in later chapters using the Botanic Gardens and the Australian Museum, amongst others, as examples of each ideal type of science.

3.6 Conclusion

This chapter has argued that the political and economic intentions of the British empire during this period implanted a continuum of instrumentalism into scientific knowledge production and diffusion in Australia. While as yet indistinct the beginnings of this instrumental approach to scientific knowledge is witnessed in the attitudes and actions of the botanist Sir Joseph Banks. Banks was a neo-mercantilist and was dedicated to the project of developing prosperous trading conditions between the colonies of the British empire in order to grow the wealth and prestige of the mother country. In particular, Banks supported the instrumentalisation of economic botany and developed a global network of gardens, using Kew Gardens in London as a type of clearing house, dedicated to the acclimatisation and propagation of plants for economic returns. This economic approach to botany attracted a group of bourgeois elites who were eager to leverage opportunities proffered by the young colony. Those opportunities included the subsidised land, labour and capital made available to the early settlers in New South Wales and access to the scientific knowledge produced and distributed by the global network of botanic gardens. In these early days of the colony, scientific knowledge remained an *implicit* factor of production in tandem with land, labour, capital and entrepreneurship.

Another group of men who preferred the non-instrumental approach of the scholars of the enlightenment attempted to establish a nascent scientific community in New South Wales. This local community was comprised of the colony's conservative elites and was motivated by the ideal of civil society. Its members, who networked extensively with other global communities of natural philosophers, formed the earliest manifestations of the Philosophical Society and the Australia Museum in Sydney during the early 1800s.

While immature at this stage these two approaches to scientific knowledge production and diffusion formed the basis of the future development of the natural sciences in Australia. Despite the formation of two interest groups drawn from the one hybrid ruling class the patronage for non-instrumental forms of science was already in tension with instrumental scientific knowledge production and diffusion. For example, the Botanic Gardens and its economic aims were commended and financially supported by the state however the Australian Museum and its patron the Philosophical Society drew on private patronage and suffered uneven fortunes during this period. Thus the beginnings of the relationships between the state, the market and civil society can be seen to favour the nexus between the state and the market, often to the detriment of civil society. The next chapter reviews the period between the 1830s and the 1910s when a more formalised bureaucracy accompanied the development of responsible government and the realisation of Federation.

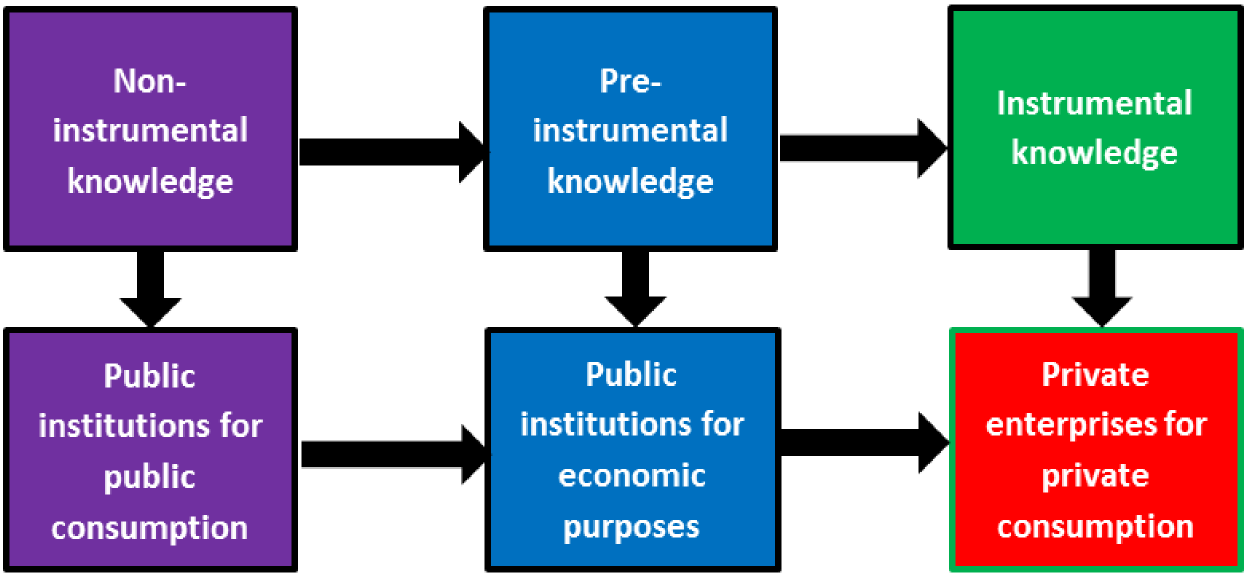
4 1830s-1910s: A deepening instrumentalism

The relationship between scientific knowledge and state support for the advancement of specific markets continued to deepen throughout this period. Until the 1870s, primary producers in the pastoral, mining and agriculture sectors, had tended to rely on the sharing of scientific knowledge with each other in order to understand more about local conditions, and to develop commodities that would serve to advance both their own position and that of the overall market. Instrumental scientific knowledge was thus an implicit factor of production that was embedded within the production process. Despite the competitive spirit of the capitalist markets these primary producers appeared comfortable about sharing this scientific knowledge. The informal sharing of scientific knowledge among producers would be altered however by the movement of the state more directly into the market.

As the colony's population expanded as a result of the 1850s gold rush and the free settler schemes undertaken by the British government, the New South Wales government and its bureaucracy came under increasing pressure to generate incremental revenue. As state revenues were sourced through a range of indirect taxes, with customs and excise duties the main source of taxation, it made sense to encourage the production of higher yields in the primary industries in order to increase penetration into global markets and so increase state revenues. Higher yields however meant a more systematised approach to production, and scientific knowledge was deemed essential to this aim. Economic concerns thus worked to transition the state into new systems of bureaucratic management, systems that involved the formal production and diffusion of instrumentalised science. This official movement by the state into the market added a third type of scientific knowledge production and diffusion. This new pre-instrumental form of scientific knowledge was funded by the state and generated by the bureaucracies in order to directly support the growth of markets, and by extension, private industries. It arguably contributed to the transformation of scientific knowledge from an implicit factor of production to an *explicit* factor in the production process.

By the end of the 19th century a tripartite system of scientific knowledge existed in New South Wales: non-instrumental knowledge produced by volunteers in order to contribute to the advancement of civil society; pre-instrumental knowledge that was generated by the bureaucracies and drew on non-instrumental knowledge in order to advance specific markets; and instrumental knowledge that drew on pre-instrumental knowledge and was created by private industries in order to improve their position in the market. Figure 4.1 demonstrates how the scientific knowledge system operated in New South Wales during this period.

Figure 4.1: Tripartite model of scientific knowledge production developed specifically for this thesis (Hicks 2015)**.**



The model shown in Figure 4.1 will be expanded and discussed in this chapter using an analysis of empirical trends present in the period. The chapter argues that a nexus between the state and the market was created through the provision of pre-instrumental scientific knowledge and set the groundwork for future policies and practices pertaining to scientific knowledge production and diffusion in Australia. This early push to formalise and regularise the primary industries delivered a partiality towards the instrumentalisation of scientific knowledge to the detriment of non-instrumental science and its role in the advancement of civil society. The following section considers the application of the principles of utilitarianism in the early colony of New South Wales.

4.1 Regularising 'a rascally community'

Benthamite inspired conceptions of utilitarianism were coming to dominate British public policy and practice at this time. However, within the Colony during the same period the ostensibly unruly, but in reality liberal, governorship of Lachlan Macquarie gave rise to the organisation of a Royal Commission into the management of the colony of New South Wales by the British Secretary of State for War and the Colonies, Lord Bathurst. This section explores the outcome of the blending of that Royal Commission with the utilitarian approach to public policy in vogue in London at the time. This instrumentally focussed approach was an important context for the development of scientific knowledge production and diffusion in the Colony at the time.

When John Thomas Bigge was dispatched from London to conduct a Royal Commission, 'with wide ranging terms of reference' (Spigelman 2009:1) into the administration of New South Wales, the British state was in the throes of recovering from the financial impact of the Napoleonic Wars. Lord Bathurst, the 'doughty aristocrat' and esteemed Secretary of State for War and the Colonies, dispatched Bigge to New South Wales to, in effect, regularise the administration of the colony and to find ways to reduce its financial drain on the British state (Macintyre 1999; 2004; 2009; Spigelman 2009). As Spigelman writes,

> Commissioner Bigge was the emissary of an imperial capital still in the process of painful social and economic adjustment after two decades of almost continual warfare, amidst the Schumpeterian gales of creative destruction arising from the Agricultural and Industrial Revolutions. With respect to the subject of his inquiry, the dominant concern of the British political nation – extremely limited in its scope by a restricted franchise – was fear of the lower orders, both in terms of criminality and also political radicalism. Bigge shared this concern and, in any event, was told to act upon it (2009: 6).

Bigge was a young and ambitious imperial bureaucrat within a utilitarian milieu; Lord Bathurst 'had unwavering faith in the old order, was "at heart a sceptic with little faith in the possibility of improvement of men or society"'; whereas Governor Macquarie, into whose administration young Bigge was inquiring, was an 'improver in the sense that he believed that individuals and social arrangements could always be made better' (Spigelman 2009: 4). Macquarie believed that former convicts, provided they reformed and became upstanding members of the community, were entitled to be returned to the same social position that had held prior to their conviction. 'There would be no permanent convict stain' (Spigelman 2009: 14) under Macquarie's watch. Bigge on the other hand had

> …imbibed the values of an aristocratic system, preoccupied with matters of status and convinced that breeding mattered more than achievement and that character mattered more than competence. A product of the minor gentry, this bachelor bureaucrat was pleased to serve what he, no doubt, called his betters and to receive such signs of approval as they deigned to confer upon him. His snobbery was derivative but firm (Spigelman 2009: 15).

Academic researchers have disagreed about the veracity Bigge's reports. Ritchie (1970) argues that Macquarie was indeed guilty of facilitating the corruption at work in the colony and offers examples of the various misdemeanours that were conducted under Macquarie's imprimatur. Parsons (1972) on the other hand argues that Bigge's reports on New South Wales are based on a false understanding of political economy; that Macquarie was correct in his use of convict labour in the service of the economic growth. Either way, as Spigelman argues,

> The Bigge Reports are the work of an imperial bureaucrat – written in convoluted and often turgid prose – but thorough, detailed, practical and full of good sense as well as unconscious prejudice. There was never any reason to expect ambition or vision from such a process or from such a man. That was why he was chosen (2009: 28).

Bigge's reports were used by Lord Bathurst to unseat the more benign administration of Macquarie and to transition the colony to a more conventional form of social order, one more suited to the social, economic and political changes that were unfolding in Britain at the time. Macintyre comments about the irregular character of the colony prior to Bigge's visit,

> Everything was topsy-turvy, and even the attempts to faithfully reproduce familiar institutions brought hybrid results. A vigorous and often rancorous society had emerged in which captivity meant freedom, and the gentlemen chafed while the outcast enjoyed the governor's favour. Then, with the arrival of Commissioner Bigge, the empire struck back (Spigelman 1999: 53).

For Lord Bathurst, New South Wales was a 'place of punishment' and he looked upon the colony as 'a rascally community' that needed fixing (Spigelman 2009: 10). This notion of fixing the colony was a product of the British enlightenment and closely associated with the ideas of improvement and usefulness (Gascoigne 1998). Moreover, the British state was moving to more thoroughly embrace the Benthamite conception of utilitarianism which aimed to deliver the *maximum utility* for all people, or in bureaucratic terms, the best decision to achieve the greatest *common good*. As Stephen notes,

> During the eighteenth century Benthamism had gone through its period of incubation. It was now to become an active agency, to gather proselytes, and to have a marked influence not only upon legislative but upon political movements (2011: 209).

As the British state adopted a more utilitarian idea of social and economic order the notion of *efficiency* was taken up by the growing bureaucracy. Bigge's reports were the first sally towards a tighter administrative control of the colony in order to establish the most effective praxis for the common good (Macintyre 1999; 2004; 2009). This idea of the common good was to play out in the ensuing decades and worked to establish the administrative, and indeed scientific, framework for New South Wales. The following section explores how the notion of utilitarianism was instrumental in informing and shaping government policy in the early colony and how that set of policies influenced the utilisation of scientific knowledge during the period.

4.1.1 Embracing utilitarianism

The beginnings of administrative reform in Britain began during the latter part of the 18th century. The pressing needs of war, the social and economic transformations wrought by the industrial revolution, and the administrative and economic reforms introduced by William Pitt the Younger[84] all served to expand and transform the British state. An outcome of this transformation was a new focus on government and bureaucracy and utilitarianism would become important to this endeavour. This section explores how the principles of utilitarianism were applied to the administration of the Colony of New South Wales and worked to establish particularly robust forms of efficiency and accountability within the flourishing bureaucracies. This utilitarian context is critical to understanding how the utilisation of scientific knowledge was shaped in Australia.

As Britain transitioned from forty years of war to relative peace, the efforts that had been expended on war could be diverted to commerce and industry and through a series of 'political and administrative reforms' the British state 'reduced its fiscal burden, increased its efficiency, and reformed oligarchical rule into a more broadly representative government' (Macintyre 1999: 55). Furthermore, as the British

[84] Chancellor of the Exchequer, 1782-1782, 1783-1801, 1804-1806, and Prime Minister, 1783-1801 and1804-1806

mercantilist[85] ideologies of 'restrictive regulation and exclusive trade' gave way to the principles of a *laissez faire* system of open markets, a new type of social order emerged (Macintyre 1999: 55), emphasising utilitarianism. Macintyre writes that 'as the logic of the market took hold, it entered into every aspect of individual and collective life' (1999: 55), and

> … a social order based on rank and station, in which relationships were personal and particular, yielded to the idea of society as an aggregation of autonomous, self-directed individuals, everyone seeking to maximise their own satisfaction or utility (1999: 55).

This transformation was largely based on the doctrine of utilitarianism and was applied to political economy as well as to social policy where it 'took hold to reconstruct the subject as an object of bureaucratic administration' (Macintyre 1999: 55). These early bureaucratic forms worked not only to reform and regularise the convict system, they effectively served to secure the political and economic dominance of the pastoralists in New South Wales.[86] By the end of the 1830s many colonists, under the radical lead of the political liberal William Charles Wentworth (himself the son of a medical doctor and a convict), began to campaign against the inequities entrenched in the colonial administration. Wentworth led a popular movement that agitated to end the transportation of convicts and to defend the equal rights of all free settlers and emancipated colonists. The movement also sought to 'replace a social hierarchy in which a rich oligopoly (the pastoralists) controlled land and labour with a more open and inclusive society' (Macintyre 1999: 75).

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[85] Mercantilism is discussed in terms of instrumental science in Chapter 2.

[86] The political and economic domination of the pastoralists was investigated in Chapter 3.

However, the tremendous increase in population resulting from the various free settler programs implemented from Britain, as well as through the 1850s gold rush, meant that the state would need to secure increased productivity from the extant primary industries to achieve a consequent rise in revenue. Officious control and departmental accountability were already endemic but the language and praxis of efficiency and productivity would soon enter the common parlance of the state. The following section examines the development of a formal bureaucracy, the introduction of responsible government and an increased emphasis on productivity that evolved in Australian public life.

4.1.2 Bureaucracy, measurement and accountability

Notions of productivity and efficiency have presided over Australian social and economic policy since before Bigge reported to Lord Bathurst in 1823. By the end of the 19th century the bureaucratic means to deliver these strategies were in place (Carew 2008). As Carew notes,

> Accountability, efficiency and effectiveness has (sic) been the mantra of Secretaries of State following European settlement. The Bigge Report supported this policy and was pursued until transportation was discontinued and responsible government instituted. Federalism and the twentieth century problems of tax sharing grants and specific purpose payments by the Commonwealth endorsed this precept. For nearly two hundred years there has been the constancy of demands for smarter and smaller government with Treasury supervising conformity in its capacity as superintendent of the public purse (2008: 367).

Indeed, Davies comments that Australians have been described as possessing a ‘talent for bureaucracy’ (1958: 3). Davies remarks that

> Of course, the pervasiveness of bureaucracy is a feature of most industrial societies, and its spread, which has been slow and steady, has its roots not only in developing technology, but also – and especially in its political application – in the modern demand for security and equality. Australia appetites have merely been in a general way larger and coarser than the average, and much more concentratedly political (1958:3).

Moreover, Carew finds that 'there has been interpolated a continuum, a theme, demonstrating the application of accountability, transparency, efficiency and economy in the financial administration of the public purse' (2008: 361). She (2008) notes that the earliest signs of the bureaucratic arrangements to come were embedded in the orders given to Governor Phillip in 1787. Inherent within Phillip's wide-ranging set of powers was a certain principle of accountability that involved not simply the gathering of numerical information but also the provision of regular reports to London on 'population, land grants, livestock, marines, the sick and the dead' as well as 'the state of the stores and the number of persons being victualled at Sydney and Norfolk Island' (Carew 2008: 365).

Laidlaw, too, confirms that information was of primary concern to the Colonial Office in London. Its permanent under-secretary (between 1836 and 1847) James Stephen and the other permanent staff were 'in charge of cataloguing an ever-increasing volume of quantitative information' (2005: 194) and were under increasing pressure, 'Every day Stephen and his staff at the Colonial Office faced an enormous challenge: how could a small metropolitan organisation effectively control a diverse, distant and increasingly dissatisfied empire?' (2005: 169). Laidlaw finds,

> While over the previous twenty years (i.e. prior to the 1830s) the emphasis had been on the collection of information as a means of alerting colonial governments to the power of the imperial state, there was now an additional emphasis on information's form, management and

> utility. The imperial government's actions between 1837 and 1842 suggest a belief that statistical information, centrally held, could be used to govern the empire more effectively…the collection and comparison of information seemed to give the Colonial Office a way of managing an empire that in other respects was straining against central control (2005: 194).

By 1822 the data collected in Australia had become regularised into the Blue Book format. The Blue Books were the official returns to the British Colonial Office between 1822 and 1857 (SR NSW 1: online) that reported the financial resources of the colony, amongst other information,[87] and were used to

[87] The full listing of data including in the Blue Books has been included here in order to demonstrate the breadth and depth of statistical data collected. The Blue Books contained data collected on areas as diverse as Civil Establishment (lists of officers in the Civil, Judicial, Police, Penal, Medical, Ecclesiastical and Educational Establishment); Convicts (population, revenue and expenditure); Exchanges, Monies, Weights and Measures including Banks (course of exchange, amount of coin and paper currency in circulation); Fees (relating to Grants of Land, Coroner's Fees and fees taken by various courts); Imports and Exports (description, quantity and value of all goods imported from and exported to Great Britain, British colonies and foreign states); Military Expenditure (works of defence, armaments; expenditure and personnel); Population (births, deaths and marriages, native populations in settled districts, from 1840 greater detail in terms of sex, faith and locality, from 1851 included abstracts of statistics on religion, education, country of birth, occupation, etc.); Revenue and Expenditure (receipts and expenditure of the colony); Shipping (imports and exports; manufactures, mines and fisheries, numbers and tonnage of vessels built and registered, accounts of convict ships arrived, and number and tonnage shipping inwards and outwards); Taxes, Duties, Fees and all other Sources of Revenue (duties, tolls, rates, fees plus wharfage rates, licenses and postage dues); Agriculture (land granted, cleared and cultivated, stock held and slaughtered, crops and produce average prices); Ecclesiastical Returns (churches, livings, etc. including names of parish, name of minister and salary, situation of church or chapel, number of persons it contains and number of persons generally attending); Education (number of schools – private or free, name of school master or mistress and salary, number of scholars, mode of instruction, whether supported by government or by voluntary contributions and examples of each school, from 1852 to 1856 includes University of Sydney staff, salaries, fees and number of students, from 1857 specific returns relating to the University of Sydney, Sydney Grammar School, Denominational Schools, Church of England schools and national schools, University of Sydney graduates, names of prize winners and names of winners of scholarships); Gaols and Prisons (total number, individual prisoners, lists of female, black or white, tried and untried plus State of Crime reports and floor plans of Sydney, Maitland, Parramatta, Windsor, Goulburn, Berrima, Bathurst and Newcastle Gaols); Grants and Sales of land (names of those grants and those sales); Local Revenues (any municipal body not accounted for in general revenue of Colony); Manufacturers, Mines and Fisheries (factories, mines and quarries, ships built and registered with their tonnage, produce from each ship); Pensions (name, amount, authority, date and former position of pensioner); Public Works (roads, bridges, etc. not of a military nature); Legislation (schedule of laws, proclamations, dates, summary and date transmitted to England); Council and Assembly (members, elected and non-elected and whether civil or military office, district represented); Security for Discharge of Duties; Printed Statistics of the Colony; Foreign Consuls; Charitable Institutions (parish and district, type e.g. hospital, asylum, etc., number of inmates and how supported); Miscellaneous Numerical Returns (annual figures for savings banks, friendly societies, freeholders, paupers, emigrants, children employed in agriculture, persons paying direct taxation, persons living in villages built since the Emancipation); Political Franchise (conditions of franchise, name of electoral division, number of elected representatives, number of registered electors, number of voters and date at last

> …rationalize the administration and expenditure across the empire. When self-government was instituted in 1856, the Blue Books were transformed into statistical registers. The Colonial Treasurers' Financial Statements, issued annually, were annual responses to the precept of ministerial accountability (Carew 2008: 365).

The Blue Books were replaced by *New South Wales Statistical Register* which was collated and prepared by the staff of the Registrar General and was first published in 1859 (SR NSW 1: online). The statistics contained within the Register would eventually be used by the Government Statistician to provide data with which the bureaucracies could conduct administrative reviews and initiate social and economic reforms. Following self-government in 1855-56 the Australian colonies were no longer required to produce statistics for the Colonial Office in London however the various colonial governments had already made provision to collect statistics relevant to their own colonies. Victoria and New South Wales were particularly effective in this regard thanks to W H Archer the government statistician in Victoria between 1853 and 1874, and H H Hayter in that role from 1874 to 1886 (Forster & Hazlehurst 1988:13).

By 1886 Timothy Coghlan was appointed the first New South Wales Government Statistician; Coghlan reported to the Colonial Secretary and was instrumental in the continuation and expansion of the already extensive set of administrative reviews (SR NSW 2: online). Maddison points to Coghlan as 'Australia's most prominent Government statistician and in the 1890s the first of Australia's public service mandarins' and 'best known as the author of Labour and Industry in Australia and for his innovative statistical work' (1999:11). Coghlan was appointed in 1886 in order to correct the 'profound dissatisfaction with the quality and presentation of the New South

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General Election); Public Debt (to support major public enterprises and works such as immigration, railways, water supply and sewerage system (SR NSW 1: online).

Wales statistics, especially as compared with those of Victoria' (Forster & Hazlehurst 1988: 27).

This emphasis on rationality, bureaucracy and accountability was also entrenched in the first examples of responsible government that emerged in New South Wales in the 1850s. In December 1852 the Legislative Council under Governor Fitz Roy was invited by the British Secretary of State to prepare a Constitution for the new State of New South Wales. The Constitution was then enacted by the British Parliament in 1855. The Constitution Act received Royal assent in July 1855 and was proclaimed in November of that year; it introduced responsible government, established the bi-cameral Parliament, set down the method of its election, procedures for business and the extent and limitation of its powers, and set down the boundaries of the colony it governed. The first Parliament under the new Constitution met on 22 May 1856 (SR NSW 3 2013: online).

The new bureaucracy commenced in October 1856 with the state departments henceforth controlled by the elected positions of Colonial Secretary, Colonial Treasurer, Secretary for Lands and Works and the two law officers, the Attorney-General and Solicitor-General. Carew reports that *reformism* was an enduring refrain during this introductory period, and that 'the themes of accountability, transparency, economic efficiency and effectiveness remained constants in [my] analysis of the political and administrative agendas for reform' (2008: 181). Moreover, the devolution of responsibility and accountability can be seen in the new administrative structures that delegated much of the bureaucratic work to the government departments. This decentralisation of administrative tasks was particularly salient amongst the departments operating within the control of the Colonial Secretary[88] and the Colonial Treasurer.[89] 'The issues concerned how to boost efficiency in departments and acquire a reliable statement of revenue collected and departmental expenditure' (Carew 2008: 200).

In the first instance the Treasury had been tasked with approving all expenditure. This meant the expenditure of not only its own bureaucracy but the bureaucracies of other ministers as well. This task proved to be totally overwhelming and slowed down the machinery of government, forcing the state to revise the structure of the bureaucracies. The revised structure devolved the responsibility and accountability for income and expenditure to individual departments and the workload of the Treasury decreased accordingly.

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[88] The new bureaucratic structure re-established 'the Colonial Secretary at its apex, with broad ranging responsibilities including the major departments administering the Postal Service, Immigration, Inspector General of Police and Police-Magistrates, Health and Welfare, Education, including the Sydney University, and Government Printing'. Of great significance was the apparent central control maintained by the Colonial Secretary over departmental administration, monitored and maintained by control of the Executive Council's agenda. Residual powers concerning the broader relations with Whitehall defence and foreign matters remained with the Governor' (Carew 2008: 195).

[89] 'The Colonial Treasurer and Secretary for Finance and Trade, an amalgamated portfolio, was responsible for finance generally: the custody, collection, and disbursement of all revenues; trade and commerce; taxation; the issue and sale of debentures; management of the public debt; the Mint and gold-receiving department; the Customs department; distillation; the issue of stamps; government stores; port and harbour regulations; navigation, including pilots, lighthouses, and telegraphs; the powder magazine.

'The Colonial Treasurer (and Minister or Secretary for Finance and Trade) was also responsible for the supervision and control of the following departments: the Collector of Customs, a difficult portfolio as the Collector had adopted a somewhat autonomous role in the colony; the Chief Inspector of Distilleries; the Colonial Storekeeper; the Port Master; the Shipping Master and the Inspector of Stamps. The Minister was also directed to correspond officially with the independent Deputy Master of the Mint, the Banks, also the Pilot, Steam Navigation and Lighthouse Boards The Colonial Treasurer (and Minister or Secretary for Finance and Trade) was also responsible for the supervision and control of the following departments: the Collector of Customs, a difficult portfolio as the Collector had adopted a somewhat autonomous role in the colony; the Chief Inspector of Distilleries; the Colonial Storekeeper; the Port Master; the Shipping Master and the Inspector of Stamps. The Minister was also directed to correspond officially with the independent Deputy Master of the Mint, the Banks, also the Pilot, Steam Navigation and Lighthouse Boards' (Carew 2008: 195).

Similarly, the bureaucratic re-structure relieved the Colonial Secretary's department of the responsibility of managing all correspondence requiring some form of action or decision by the Government; instead each department took responsibility for its own affairs and its official correspondence. 'Individual Ministers were now responsible for follow-up action and to direct the necessary instruction or reply to the department or person concerned' says Carew (2008: 196). Further, Carew's research confirms that the economic health of the new nation was to become a significant driver of government policy and the newly elevated Treasury was set to assume a more permanent role as a leading player in the future of the colony.

> This policy marked the genesis of the ascendancy of Treasury in the colony's economic affairs with its increasing control of departmental expenditure and budgeting without reference to the daily record of expenditure. The foundation had been laid for the future role and prestige of Treasury; a strong, working administrative unit, controlling the expenditure of each department by means of departmental accountants (Carew 2008: 201).

In line with this tendency towards the centralisation of government, Hirst (1988) finds that the political liberals believed that the democratic process ought to be driven through the participation of the people in strong local government; 'here the people could learn the civic virtues and become more self-reliant and less dependent on central government' that 'the liberal state, in turn, would be more secure if free institutions permeated the whole society'. The reality however was somewhat different; 'after the liberals came to power local government became weaker not stronger' (1988: 195). Hirst (1988) observes that the magistrates in each locality were initially relied upon to be the 'eyes, ears and arm' of the central government; they managed the majority of local matters including the local postmaster, the local police, census and agricultural statistics, funding and coordination of local road and bridge projects, local administration and acted as the conduit through which the various central bureaucracies could maintain control over local areas. The change of government in the 1860s, however, saw the new liberal government take the control of the police from the local magistrates, effectively reducing their power in the local community. Henceforth, the central government used the new telegraph system to direct the local police to conduct administrative tasks; ‘the police were the dogsbodies of central administration, performing tasks which did not warrant the appointment of specialised officials’. Moreover ‘departments which had a regular need to supervise operations in the country appointed their own agents. By this process too magistrates were superseded or bypassed (Hirst 1988: 254). Hirst reports that by the ‘time of self-government in 1856 there was not one elected local council in operation’ (1988: 255) and by the 1880s the colony was administered quite differently from when the liberals first took power in Sydney. Hirst reviews:

> The unpaid magistrates who had been an omnicompetent local authority had been superseded. The newly elected local bodies exercised few powers and did not operate at all in wide sections of the country. Central government’s power had increased enormously; the range of operations for which it took direct responsibility made this and other Australian governments unique. Policemen, teachers, stock inspectors, and road superintendents who service in the country were officials of departments controlled from Sydney. Rule by government official, first developed in the pastoral interior in the person of the commissioner of crown lands, had been transferred to the goldfields in the 1850s and then gradually to the whole society (1988: 264).

The ideology of utilitarianism and central control was thus worked through the emerging bureaucracy to regulate local communities and individuals. The central government, itself regulated by a Treasury steeped in notions of regulation and efficiency, thus worked to instantiate a particular form of capitalism into New South

Wales. This dynamic served to: separate economic and social relations; reinforce economic efficiency through the system of devolved responsibility, transparency and accountability; and employ the principles of instrumental rationality as the primary rationale for government policy and practice. In this Weberian view of capitalism,

> It is not the actual urge to create more money that distinguishes capitalism from other economic systems, but the fact that the increase in money occurs in rational forms, where calculability, predictability, civil legal system, and the systematic use of science and technology in production are the most important elements (Manson 2000: 90).

And so the rational application of scientific knowledge became an essential, if implicit, factor of production under this capitalist form of economic development.[90] The principles of rationality were also present in the robust forms of regularisation and bureaucratisation that were introduced into the new state, largely in support of the British government's aspirations for New South Wales to become economically self-sufficient. Moreover, consistency in revenue required consistency in yields of primary produce and exports. As greater consistency in yield demanded more localised (and less British or European) scientific knowledge production, the bureaucracies came under increasing pressure from the state and from within to create the specific means to achieve the specific economic ends. Thus the role of producing and diffusing instrumental science was largely assumed by the state. These nascent scientific institutions were tasked with developing local knowledge for the explicit use of local manufacturers arguably in order to maximise yields, standardise production and expand global markets.

[90] This principle is discussed more fully in section 4.4

The next two sections investigate the early production and diffusion of both non-instrumental and instrumental science in New South Wales before moving into the exploration of an emergent pre-instrumental science: a hybrid form of public/private knowledge produced by the government and its bureaucracy for the development and enhancement of export markets.

4.2 Non-instrumental science underpins civil society

During the 19th century scientific knowledge featured in attempts to form a civil society in the Australian colonies. Very briefly, the concept of civil society had originally formed in Britain, led by the Scottish philosophers of the enlightenment period including Thomas Hobbes and John Locke; with Hobbes influencing Locke (Sen 2013). For Hobbes, Locke, and other social 'contractarians, the terms 'society', 'civil society', and 'political society' are roughly equivalent to what we would call today government or the state' (Boyd 2012: 445). Further, these ideals of citizen sovereignty were embraced by Immanuel Kant[91] who contributed to the development of the notion of civil society by insisting on a form of individual freedom or enlightenment to be achieved through individual access to knowledge (Wartenberg 1992). It was thus originally from the enlightenment scholars that concepts such as education in the arts, the sciences and philosophy came to be bound up with the enlightenment ideals of civil society.

Macintyre (1999; 2004; 2009) argues that where civil society in Britain originally manifested as a type of benevolence attached to the class system, civil society in New South Wales during the 19th century formed as a response to the fragility of colonial life and the separation from friends and relatives at home in Britain. Where in Britain non-

[91] The Kantian conception of individual enlightenment is discussed in Section 2.4.1.3.

instrumental science was firmly bound up with ideas of civil society, in New South Wales during the late 1700s and for most of the 19th century, the colony was struggling to simply form a coherent society. Within this colonial milieu, non-instrumental science was seen as nice to have but generally considered as surplus to requirements. The practice of non-instrumental science was viewed as the preserve of the leisured classes, and thus not particularly useful to a colony made up of convicts and soldiers. As the colony transitioned, during this period, from a convict state to a free settlement the conceptual and practical tenets of civil society (under a broader set of conditions than the previous period and which combined art, literature, philosophy and science)[92] and the idea of volunteerism were picked up and carried forward by an expanding bourgeois class, looking to replicate the social world of mother England (Macintyre 1999; 2004; 2009; Connell and Irving 1980). This section reviews the emergence of civil society in New South Wales and its relationship with scientific development.

This first wave of civil society was the preserve of a small group of local gentlemen and clergymen who were steeped in the British traditions of class, who were conservative in character, deeply religious and who understood the voluntary quality of civil society. Notable amongst these local advocates for civil society were Alexander Macleay and the Reverend W B Clarke. Both of these men could be described as natural philosophers[93]

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[92] See Figure 4.2 which demonstrates how the Philosophical Society transitioned from a society focused on non-instrumental science to a broader example of civil society featuring the acquisition of knowledge concerning art, literature, philosophy and science (Tyler 2010).

[93] Natural philosophers took a more universal approach to scientific knowledge. For the natural philosophers, 'science' as the study of nature, was embedded within the study of philosophy. Francis Bacon was one of the first philosophers to try to separate 'science' from 'philosophy'; his 'scientific method' sought to use 'experimentation' in order to provide an objective, rational, 'scientific' outcome from the study of the natural world and thus provide the potential for the results to be repeated. This approach is discussed in Section 2.4.1.2.

in the traditional sense and as polymaths who believed in the democratic principles enshrined by the enlightenment philosophers.

Macleay (ADB

2013; Bravery 2005; Cherry 2012; UoS 2014) and Clarke (Mozley Moyal 1976; Mozley 2012) can also be seen to epitomise the often paradoxical conditions at work in the colony. Both men believed in the notion of civil society, in the importance of voluntary association, and in the enlightenment ideals of freedom realised through knowledge; but both were also resident in a British penal colony, the antithesis of a liberal social milieu. Moreover, Macleay and Clarke were both acclaimed non-instrumental scientists who believed in the principle of producing and disseminating knowledge for its own sake; but who were also caught up in the economic strictures of colonial nation building. Further, they were both deeply religious, had conservative dispositions and lived in the conservative milieu of Sydney society; but they also had to deal with the radical irreligious scientific ideas coming out of Britain and Europe at the time, ideas such as the theory of evolution being promulgated by Charles Darwin and colleagues. And they were both amateur scientists within in a rapidly professionalising and instrumentalising discipline.

Macleay was certainly an important contributor to both the cultivation of civil society (Serle 1949) and to the production and diffusion non-instrumental science in colonial New South Wales. In addition to his paid position as the Colonial Secretary (1826-1837), Macleay served on many public committees and inquiries, was president of the Australian Museum, the Benevolent Society and the Sydney Dispensary, and was heavily involved with the first Public Library, amongst other voluntary responsibilities.

Moreover, he was a distinguished amateur scientist who 'was said to have the finest and most extensive collection of any private individual; as a noted scientist he was a corresponding member of several European societies' (ADB 2014: online). Upon Macleay's death in 1848 (at the age of 81) 'his public contributions were recognised at a large funeral and an obituary in The Sydney Morning Herald of July 26, 1848, which read: "Mr McLeay was a man almost universally respected, and has descended to the grave full of years and full of honours; and from his consistent Christian character, we may feel assured that he has gone to his reward" (Bravery 2005: online). Moreover, Macleay's civic contributions to the production and diffusion of non-instrumental scientific knowledge remain visible in the contemporary milieu. In terms of his contributions to science and to the cultivation of civil society, biographer Cherry writes that,

> …the Macleay Museum at the University of Sydney and Macleay Street in Kings Cross remind us of the significance of Alexander Macleay, whilst the Royal Botanic Gardens, the New South Wales State Library, the Australian Museum and the Australian Club are just a few of Australia's early institutions that benefitted from his active involvement (2014: online).

Another conspicuous figure in the life of the colony, the Reverend W B Clarke was an important non-instrumental scientist. Mozley writes that 'for almost forty years Clarke was prominent in the colony's scientific life' (2012: 54). Clarke is perhaps most recognised as the 'founder of Australian geology' but he was also

> ...a man of many talents: poet, journalist, reviewer, traveller, explorer, minister, museum curator, magistrate, school teacher & headmaster, meteorologist, palaeontologist, naturalist, anthropologist, geologist, artist, writer and critic. He was also a husband, father and grandfather… W B Clarke not as a great leader or brilliant scientist, but more an indefatigable worker, playing an important role in the development of organisations such as the Australian

> Museum, the Free Public Library of Sydney, and the Royal Society of New South Wales; all the while carrying out a large body of original research - collecting, listing, describing, corresponding, reading, and writing for publication (Organ 1998: 2).

Mozley adds to the list of W B Clarke's achievements:

> In 1841-43 he was secretary and curator of the Australian Museum and trustee in 1853-73. Pressure of duties led him to decline a seat on the first senate of the University of Sydney in 1850 and a professorship in geology and mineralogy in 1856, although he was elected a fellow of St Paul's College in 1853. Clarke was a founder of the Royal Society of New South Wales in 1867 and its vice-president until 1876; its Clarke medal, struck as Australia's first scientific honour in 1878, commemorates his work (2012: 54).

Perhaps most significantly, Clarke contributed to the establishment of non-instrumental science in a social world bound up with the notion that gentlemen and clergymen 'do science' as a private leisure activity and to voluntarily contribute to civil society. As Mozley puts it,

> In a colony where science was considered a private matter and received scant government aid, Clarke was an ardent publicist for science, contributing countless editorials, articles, reviews and letters to the Sydney press and working to pierce 'the intellectual barrenness of New South Wales' (2012: 54).

The second wave of civil society emerged after the gold rush. Where the gold in New South Wales was alluvial and thus easily extracted by hand, the gold in Victoria was located in quartz veins and so required significant capital in order to finance the machinery necessary to extract it. Connell and Irving (1980) argue that this more difficult manifestation of gold contributed to the growth of Australia's first companies and so to the expansion of the bourgeois class and a new set of power relations. Once the initial gold rush was over the bourgeoisie, as the new ruling class, encouraged a different form of civil society.

During the gold rush many of the early attempts at civil society were ignored in favour of the mania that presided over the rushes. Indeed, the rush for gold created major social problems. As Macintyre notes,

> Seamen deserted their ships, shepherds abandoned their flocks, labourers quite their masters and husbands their wives to seek fortunes with pick and shovel. Small wonder that critics saw the gold rush as a levelling inundation and denounced the mania that turned settlers into wanderers, communities into mobs (sic) (1999: 89).

After the gold rush had subsided a different form of civil society emerged. In colonial Australia the citizenry was unable to draw upon the thick layers of historical and social practice that had produced the libraries, museums, galleries and gardens of Britain and Europe. Instead the accoutrements of civic life in Australia were in effect bolted on by a bourgeoisie eager to demonstrate their newfound wealth and power (Macintyre 1999; 2004; 2009; Connell & Irving 1980). This new civil society embraced art in the form of fine art, literature, music and theatrical performance; morality was provided by organised religion; and organised sport was hugely popular (Macintyre 1999; 2004; 2009; Connell & Irving 1980) particularly in Victoria where significantly more money, primarily corporate money, was made from the 1850s gold rush. Nevertheless, it was the state rather than private individuals that shaped this new civil society. Macintyre writes that

> The state persisted, nevertheless, in its promotion of a common culture. Museums, galleries, libraries, parks, botanical and zoological gardens were among the sites of rational recreation and

> self-improvement…The creation of an alternative[94] system of elementary education – secular, compulsory and free – was prompted by a desire to create a literate, numerate, orderly and industrious citizenry…similarly (the universities) were civic institutions, set up by acts of parliament, supported by public appropriations and controlled by councils largely appointed by government…Their founders hoped that a liberal education in a cloistered setting would smooth rough colonial edges and elevate public life. In practice the universities quickly developed a more utilitarian emphasis on professional training. Preparation of lawyers, doctors and engineers[95] became the chief justification of a restricted and costly higher education (1999: 117).

So, two types of civil society were emerging during this period. The first type was led by a group of private individuals who were committed to including non-instrumental science in their conception of civil society. The second type was organised and controlled by the state; it focused on 'rational recreation and social improvement' in order to 'promote a common culture' and was focused on turning out 'educated' professionals to service the burgeoning populations and the flourishing primary industries (Macintyre 1999:117).

Non-instrumental science did not feature as significant in this second type of civil society. Scientific knowledge production and diffusion was to be more closely bound up with the achievement of economic aims; so indicating an emerging differentiation between scientific knowledge and civil society. Corporate miners, agriculturalists and indeed the extant pastoralists all made use of scientific knowledge, albeit not always successfully, to support their primary production and increase their wealth.

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[94] Alternative to the extant church based system.
[95] Universities were primarily teaching organisations meant for the children of the bourgeoisie or the new 'ruling class'.

Prior to the 1870s the primary producers had relied on each other to produce and share appropriate scientific knowledge for local conditions. This mutual sharing of knowledge is discussed in section 4.3. However, by the time the nation state was transitioning to self-government and thus economic self-sufficiency, the bureaucracies were gearing up to rationalise and regularise the primary industries. This rationalisation process included the state provision of instrumental scientific knowledge and is discussed in section 4.4.

4.3 The public sharing of instrumental scientific knowledge

By the middle of the 19th century the gap in Australia between non-instrumental and instrumental scientific knowledge had widened significantly. Instrumental scientific knowledge production was flourishing in the private sector whereas non-instrumental scientific knowledge production, typically financed by the state,[96] was almost negligible. Groups of primary producers imported non-instrumental knowledge and worked hard to generate the local knowledge relevant to domestic conditions. Many of these primary producers were relaxed about sharing this knowledge amongst other producers.

These early primary industries drew on informally shared scientific knowledge in order to support individual and small group efforts, which in turn served to move the whole industry forward. For example, the acclimatisation societies that flourished in Australia during the 19th century helped families and small groups to share scientific knowledge that would benefit commercial agriculture in this new and unknown environment; the agricultural societies that formed in regional areas also benefited from shared

[96] In Britain and Europe during the late 18th and 19th centuries, the basic scientific research that was conducted in the universities and museums was mainly funded by the state. These institutions were both research and teaching centres and despite their state funding remained fairly independent of state or bureaucratic control. Many of the basic scientific breakthroughs were made during this period.

knowledge that was specific to the local geography, climate, soil types and plant stock; the alluvial miners on the goldfields also brought basic and technical knowledge to the task of extracting gold from the surface layers of the earth. Further, the early mining companies (such as BHP) drew upon the tacit knowledge (Polanyi 1966) of the partners and employees of the company in order to increase their extraction rates; likewise, Essington Lewis, the General Manager of BHP was known to travel the world collecting ideas and sharing knowledge with other mining companies.

Notwithstanding the 'competitive spirit' ostensibly embedded in the market dynamics of commercial agriculture and the mining industry, a 'culture of cooperation' (McIntyre et. al 2013: 247) was clearly evident during this period. This cooperative attitude could be seen as emblematic of the cooperative approach to the production and diffusion of scientific knowledge that was first introduced during the enlightenment era. By the last quarter of the 19th century, and despite the prevailing laissez faire ideology, the bureaucracies in New South Wales had moved to intervene in both the agricultural and the mining industries by creating specialist scientific research bureaux that were funded by the state.

This section briefly investigates how instrumental knowledge scientific knowledge was shared amongst commercial producers prior to the establishment of the formal bureaucracy. Five examples of informal knowledge sharing practice were investigated for this thesis: acclimatization societies, the wool industry, the wine industry, gold mining and the Broken Hill Proprietary Company (BHP) and are (necessarily briefly) mentioned below.

By the mid-19th century the influence of mercantilist ideology and the practice of useful and economically motivated science that had been transplanted into New South Wales by Joseph Banks and Kew Gardens during the late 1700s and early 1800s had bloomed. Acclimatization science and societies grew rapidly; 'small clusters of businessmen, scientists, and publicists spurred acclimatization, although the aristocracy was not entirely absent from the movement' (Osborne 2001: 145). One of the first attempts at acclimatisation in Australia was the introduction of the merino sheep by John Macarthur in the early 1800s.[97] Osborne notes that, 'Of all the introduced exotic organisms in Australasia, however, none would rival the Spanish merino sheep in terms of economic importance and success' (2001: 146). Following the 1850s gold rush, and notwithstanding its early success, the pastoral model on which the economy depended, required review. A dramatic increase in population, coupled with technical improvements that expanded production of wool, meant that the sheep industry needed to employ fewer men. 'It was within this context of economic transition and a search for new agricultural industries that Australia's businessmen and scientists formed acclimatization societies' (Osborne 2001: 148). These acclimatization societies met regularly and shared knowledge in order to lift the market as whole. Unhappily the members also contributed to the extant problems associated with introduced animal and plant species. (In particular, to the rabbit problem; its influence on the agricultural industry is discussed in Chapter 5).

Moreover, Rae and Brock argue that, 'fledgling industries often gained from imported experience, as histories of the gas industry, iron smelting and chemicals showed' (2013: 190). This dynamic can be seen in the forces at work in the early mining industry.

[97] Macarthur's foundational role in the sheep industry is discussed in Chapter 3.

Despite its seemingly competitive flavour, gold mining in the 1850s also exhibited a commitment to the sharing of knowledge and know-how. Many of the early miners who flocked to the Australian gold rushes of the 1850s came directly from the Californian gold fields with the idea of 'profitably applying (their) knowledge' on the Australian fields (Murray 2001: 39) and knowledge was often shared. Blainey notes that,

> The bush hotels were often the indispensable mineral academies, the clearing houses of knowledge, for those who wished to identify new minerals or learn where they might be found. Lonely little hotels had a place in the sequence of steps which led to some of the most significant finds. It is likely that Hargraves learned at an hotel about the place where in February 1851 he decided to look for gold; and he was in fact guided to that place by the publican's son. Similarly, the first important discovery of tin in Queensland was made in 1872 at the Quart Pot Hotel at Stanthorpe…Four years later the first silver-lead of the rich Broken Hill district was found near the shanty hotel at Thackaringa and the publican was the spreader of the good news and a promoter of the first vigorous mine. At the bush hotels the finder of strange minerals might show specimens to all who passed by and seek their opinion. There prospectors picked up rumours of new finds (Blainey 1982: 167).

As the alluvial gold on the New South Wales fields was exhausted the hard rock quartz fields of Victoria attracted an influx of the Irish and the Cornish miners who 'formed the nucleus of the underground workforce' (Murray 2001: 40). Blainey notes that the success of these Victorian mines led to a further diffusion of knowledge throughout the colonies,

> Victorians went on to manage new mines around the continent and spread their undeniable skills and prejudices. They spread the ideas that had transformed Victorian mining between 1860 and 1890 but all those techniques had been borrowed from abroad and adopted cautiously. And yet a remarkable change was coming. In world mining from about 1880 to World War I the

> metallurgical rather than the mining wing of the industry improved dramatically, and in that more complex and scientific arena Australia emerged as leader (2003: 78).[98]

Further, Murray finds that until the intervention of experts engaged by the bureaucracies, gold mining remained a 'plain man's business', that 'the role of experts was limited'. Men with experience drawn from California were 'invaluable' however local expertise quickly caught up. 'Geology was still an infant science, its few practitioners apt to be dismissed as fussy academic theoreticians' (2001: 40). Indeed, the metallurgical dilemma that beset the early BHP mine at Broken Hill was solved through group effort,

> …by dint of numerous experiments - 11 local companies were experimenting, and at least 40 people were contributing valuable ideas – Broken Hill's staff and employees found a new process. They did more than engineers on any other mining field in the world to develop what is called the flotation process. This remarkable innovation, improved again and again by metallurgists working in many lands, is now used in every continent to extract a variety of minerals (Blainey 2010: 27).

A potent example of the knowledge problem, and its community-based solution, can be found in the wine growers of the Hunter Valley in New South Wales. While the pre-bureaucratic state debated the necessity for education to support the nascent agricultural industry[99] the agriculturalists themselves sought overseas scientists to 'spread the gospel of scientific agriculture' (2013: 190). Rae and Brock tell the story of

[98] The metallurgical knowledge was developed by groups of miners, engineers and metallurgical scientists who were employed by BHP and was instrumental in that it was patented for exclusive ownership by that company. In particular, the Delprat-Potter flotation method of extracting zinc from the mining waste from silver and lead processing was developed through the sharing of knowledge and ideas and patented in 1904. It was to become an important contributor to the global mining industry (Blainey 2003).

[99] 'In 1893 Henry Anderson, former Director of Agriculture in New South Wales, was still arguing for development of agricultural education and eventually the establishment of a university chair (he felt that one for the country would be sufficient). Anderson called for replacement of 'brave hearts and strong arms' with practical scientists prepared to experiment and take advantage of world knowledge' (Rae & Brock 2013: 190).

James King, a chemist from Scotland who developed a scientific approach to wine-making and was willing to share his newfound knowledge in order to develop the local industry.

> King established his Irrawang vineyard in 1832 and produced his first vintage in 1836, having relocated from Sydney the previous year to join his overseers on the site. Beeston praises King's technical proficiency, which was evident in the assistance he gave to William Macarthur, Sydney's first vigneron, over a vintage that had 'stuck'—that is, fermentation had ceased despite the presence of unfermented sugar… King also shared his expertise with other growers in the Hunter River Vineyard Association (hereafter HRVA), which he and others founded in May 1847 (2013: 190).

Moreover, a study by McIntyre and colleagues (2013) finds that King's early commitment to the sharing of knowledge set the foundations for a community practice that continues to the present day. They write,

> In the absence of commercial pressures among Hunter colonists trialling wine grapes, the sharing of plant stock and knowledge occurred without any sense of competition' … Belich[100] contends that this revolution grew through networking and knowledge sharing rather than innovations by exceptional individuals or pioneers who have been the focus of earlier historians of the period…Such a culture of cooperation was identified as a feature of the wine-producing community in the Hunter Valley, New South Wales – Australia's oldest continually producing wine region – by long-time community member Audrey Wilkinson in 1960. Wilkinson commented that 'We used to get a lot of help and give a lot of help. You would never get better neighbours than around here. Indeed, the earliest experiments in wine production in the colony of New South Wales indicate that the Hunter Valley had a comparatively strong culture of cooperation from its inception in the late 1820s. Contemporary actors in the Hunter wine

[100] Belich provides a wide ranging discussion of settler colonialism encompassing New Zealand, Wakefield, India and South Africa. While the comparison with other colonial nations is important this thesis has not attempted to integrate this comparative study; this decision was due to the already large thesis and its focus on scientific knowledge production and diffusion in Australia.

> business cluster have independently echoed Wilkinson's remark by positing a history of regional cooperation among family-based firms as a central factor in the present success of the cluster (2013: 248).

Accordingly, scientific knowledge was fully recognised as a mandatory, albeit implicit, input to the manufacturing process. Notwithstanding its implicit, and therefore private character, and its inconsistency with the competitive spirit of capitalism, these primary producers were inclined to share both their tacit and newly derived scientific knowledge in order to advance their own interests and those of the market. So, for these early producers, the production and diffusion of scientific knowledge seems to have been more closely associated with the enlightenment principles of science than the rationalised capitalist adaptation that was to emerge with the establishment of the bureaucracies.[101]

These examples illustrate that where the basic, or non-instrumental, knowledge was imported and then adapted by the producers to meet local conditions, the participants in the market worked together to build the whole industry. Conversely, where the state moved into the creation of pre-instrumental or instrumental science as it did in Australia during the late 19th century then instrumental knowledge became disembedded from the production process, in effect becoming both an extrinsic factor of production and a product in its own right along with land, labour and financial capital; as such knowledge was at greater risk of commodification.

Also committed to the sharing of scientific knowledge was the Australasian Association for the Advancement of Science (ANZAAS). ANZAAS first met in Sydney in 1887

[101] The nexus between the emergent bureaucracy and the market is addressed in section 4.4.

following the encouragement of Archibald Liversidge, Professor of Chemistry at the University of Sydney. The organisation was modelled on the British Association for Advancement of Science that had been founded in 1886. The Australian association represented 'the first attempt at a national (and, with New Zealand, international) scientific and interdisciplinary cooperation' (Fenner 1995: 2). Fenner writes,

> In 1901, the year of Federation, Sir Archibald suggested that a 'supreme body to speak for science' would be a great stimulation for younger scientists. The idea was raised sporadically during the third and fourth decades of the nineteenth century, and in 1921 a national institution for science, the Australian National Research Council (ANRC) was established. However, it was not until the 1950s that the concept of a national academy of science was realized (2008: 322).

Over the ensuing years ANZAAS was nurtured by the British Association and was able to hold conferences annually in different capital cities in Australia and New Zealand, 'but ANZAAS held its last meeting in Adelaide in 1997, mainly because of the great expansion of specialist science societies that held annual conferences' (Fenner 2008: 322). For a number of reasons both ANZAAS and the ANRC struggled for funding. One of the major grants received by the ANRC (from the Rockefeller Foundation in New York valued at £55,000) was embezzled by its Treasurer in 1934 and a second grant of £10,000 from the Carnegie Corporation in the United States were used to fund

> …some 50 research expeditions were financed wholly by the Council and many grants were made to short expeditions, and ANRC founded the journal *Oceana*, largely as a medium for publication of the results of such work. Starting in 1938…ANRC sponsored the Australian Journal of Science as a journal designed to publish news, articles and views on scientific topics of general interest in Australia. With the dissolution of the ANRC the journal continued under that name and was succeeded by *Search* in 1970 (Fenner 2008: 4).

In addition to funding and publishing Australian science, the ANRC was a strong advocate for the non-instrumental science conducted in Australia's universities and pressed the 'Prime Minister for a committee to review the problem of the Australian universities, action which led to the establishment of the Murray Committee in 1956 (Fenner 2008: 4).[102]

The ANRC was dissolved in 1955 (although this was foreshadowed in 1952) and the new Australian Academy of Science (AAS) took over its role in 1956. Fenner writes that since it was originally founded, the AAS has been concerned with science policy; that policy focus has shifted over the succeeding years:

> The emphasis has changed as institutional arrangements for decision-making about science has evolved, and as the Australian economy has moved away from a highly protected domestic market, with export largely of minerals and primary produce. The new emphasis is on the removal of trade barriers, developing manufacturing industry with its supporting science and technology, and seeking new export markets with value-added products as well as mineral ores and products of the land. The economy is more and more a part of the global scene (Fenner 1995: 69).

The Australian Academy of Science, first established as ANZAAS and the ANRC, therefore actively demonstrates the tensions between instrumental and non-instrumental science that are inherent in the Australian science system. Certainly, ANZAAS[103] was formed with an eye to the development of both basic and instrumentalised science and that was reflective of both the colonial era and Archibald Liversidge, its key advocate, a technically oriented scientist. On the other hand, the

[102] The Murray Committee and its Report concerning the funding of Australia's universities is discussed in Section 5.6.1.
[103] ANZAAS will be discussed again in Chapter 6 in relation to it involvement with the first wave Environmental movement emerging in the late 1800s.

Australian National Research Council was focused mainly on the advancement of non-instrumentalised scientific knowledge, only to be superseded by the Australian Academy of Science; an organisation both tightly bound with the state, and primarily concerned with instrumentalised science and its relationship with economic development.

The next section explores the emergence of state funded and administered bureaux that produced instrumental scientific knowledge expressly for the participants in the primary industries and investigates how the bureaucracy of the late 1800s moved to rationalise primary production by introducing public/private scientific bureaux and formal agricultural education. These new scientific organisations were fully funded by the state in order to support the growth of private industry and by extension, the economic aims of the colony.

4.4 The emergence of pre-instrumental science

As the population grew and the state committed to providing the infrastructure to support the expanding population formal bureaucracies began to emerge. These bureaucracies were charged with the development of the primary industries in order to finance the commitments to infrastructure that had been undertaken by the state. As discussed in Sections 4.1.1 and 4.1.2, developing the primary industries meant applying more rational approaches to the production of goods and services. These rational approaches on the part of the bureaucracies included the provision of instrumental scientific knowledge to primary producers in an attempt to standardise both their product offerings and their yields and to increase their penetration into global markets.

During the early days of the colony the primary industries of pastoralism and a nascent agricultural sector had drawn on various types of scientific knowledge in order to bring their products to market. The sector had relied on formally imported non-instrumental and instrumental scientific knowledge; on tacit knowledge (Polanyi 1966) that was brought in through immigration; on instrumental knowledge produced by the Sydney Botanic Gardens; and/or on knowledge generated through trial and error on site. Moreover, tacit knowledge and knowledge produced through trial and error was heavily relied upon by the miners of the 1850s gold rush and during the early days of the Broken Hill Propriety Co Ltd (BHP). As discussed in the previous section knowledge sharing was common practice and did not commonly involve financial exchange; rather scientific knowledge remained an implicit factor in the production process and was included as an implicit overhead in the cost of goods.

Where these somewhat unpredictable methods of procuring knowledge had proved sufficient during the first half of the 19th century the expansion of the population, the emphasis on colonial self-sufficiency and the state's reliance on customs and excise duty rather than personal income tax[104] meant consistent yields from the primary industries became increasingly more important. Consistency in yields however required less experimentation on the part of the producer and a more instrumental focus on the production and diffusion of appropriate scientific knowledge.   Scientific knowledge was thus deemed a significant contributor to consistency and regularity in production.

Moreover, as the bureaucracies came under increasing pressure to achieve the colony's economic goals (through greater yields and consequently higher revenue) the impetus

[104] Personal income tax was not introduced into Australia until 1915.

to rationalise and regulate the primary industries increased. For devolved bureaucracies reporting to a centralised Treasury,[105] streamlining and developing the pre-existing primary industries was critical to the achievement of these economic aims. Revenue growth was thus dependent on finding new, more efficient and scientific ways of stabilising production, increasing output and growing global markets.

By the 1880s, these economic aims were primarily focused on resurrecting the stalled mining industry and developing the agricultural industries. (The secondary industries were not included in these expansionary strategies until the early 1900s.)[106] Where the acclimatization of merino sheep had seen the development of a successful local pastoral industry during the first half of the 18th century and the gold rush had provided an economic fillip, albeit temporary, by the late 1800s neither of these industries produced adequate revenue streams for the developing needs of the state (Reeves *et. al* 2010; Coghlan 1900). Reeves and colleagues note that 'gold mining itself was not generally a profitable industry for labour or capital…Wage labour in factories and on farms, and investment in government bonds, gave higher and more certain rates of return to labour and capital' (Reeves *et. al* 2010: 118) and Coghlan finds that 'the pastoral progress of the colony has been much less satisfactory than the agricultural' (1900: 5). According to Coghlan: by 1900 'no branch of industry has the progress of New South Wales been more conspicuous than in agriculture' (1900: 4).

The bureaucracies were accordingly motivated to both stimulate the waning mining industry and to find new areas of growth, such as through agriculturally based business, in order to expand local production. Pushing further into fresh, global markets was

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[105] This process of devolution was discussed in section 4.1.2.
[106] The state/market nexus between the emerging secondary industries is discussed in Chapter 5.

viewed as the principal solution to expanding the local economy and increasing revenue streams. The strategy was to establish formal research and education instrumentalities that were funded by the state and used expressly for the advancement of the mining and agricultural markets; these same agencies were tasked with regulating and expanding the industries.

This foundational model was effectively funded by the market[107] between the 1870s and 1900 in order to expand capacity and yield for global markets. The model was not altered however when Federation commenced or when personal income tax was introduced in 1915; the newly established Australian citizenry were thus called upon to continue funding the expansionary strategies of private industry. This model continued well into the 20th century.[108] The following section uses the mining industry as an example of the instrumentalisation of scientific knowledge on the part of the bureaucracies in order to meet economic goals.

4.4.1 The state, scientific knowledge and the mining industry

Prior to the 1870s mining in New South Wales had been conducted in a somewhat haphazard manner. As noted earlier, relevant knowledge was primarily sourced from sharing local knowledge with other miners; from tacit understandings introduced by miners from California, Ireland or Cornwall; through trial and error in the field; from published papers and maps produced by the volunteer geologist Rev W B Clarke; and gathered from a range of British publications meant for the small miner. The 'official knowledge' (arguably drawn from the work of Rev W B Clarke and so probably the

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[107] Through customs and excise tax rather than private income tax.

[108] Chapter 5 discusses the importance of pre-instrumental scientific knowledge as part of the ideology of developmentalism that endured until the 1960s. Chapters 6, 7 and 8 argue that this original model remained in place up to and including the 21st century. The thesis conclusion reinforces this position.

more scientifically accurate knowledge) was reproduced in the Blue Books[109] and used to 'rationalize the administration and expenditure across the empire' between 1822 and 1857 (Carew 2008: 365). Clancy confirms:

> …the maps that record the events linked to the discovery of gold come from four main sources: books and guides written by miners and visitors to the gold field: records of the British Parliament[110] and various government bodies; separately published maps for prospectors; and atlases (2002: 44).

Clancy also finds that by the end of 1852 (two years after the first gold found in New South Wales) there were over thirty privately published books on the market, eleven of which included maps, but were in the main of 'poor quality with little substance and vague and inaccurate locations' (2002: 45). These early guidebooks and their accompanying maps were in fact 'of little value' to the gold miner. Rather, as Blainey suggests, the informal sharing of knowledge between miners at the local hotel was a more likely source of genuine learning opportunities.

The commercially produced maps on the other hand were rich in business possibilities for their publishers in London. As Clancy notes,

> The maps published after the discovery of gold in Australia reflected the commercial possibilities and consequences of a rich new resource, particularly in Victoria, which witnessed the emergence of a new class of entrepreneurs servicing the gold rush. However, they also reflected the highly structured colonial system, which imposed sharp limits on the flow of information as well as on local autonomy. The former created opportunities for local map publishers; the latter

[109] As discussed in Section 4.1.2.
[110] Contained in the Blue Books

enabled well-placed publishers in London to gain an advantage over their competitors (2002: 47).

So despite the attempts by commercial operators to secure the rights to instrumental knowledge and the state's efforts to control the flow of knowledge during this period, the informal sharing of knowledge between each other remained the preeminent choice for successful small miners. Moreover, the state was presumably receiving sufficient revenue from licenses and royalties at the time to cover its expenses.

As the economic effects of the gold rush wore off however the state attempted to re-stimulate the mining industry and, arguably to re-establish control over its mineral resources, through the establishment of the Geological Survey of New South Wales in 1875. This government instrumentality was one of the first of the specifically pre-instrumental scientific bureaux and was tasked with the 'need to find and map further mineral resources' for the colony (NSW DT&I 2013: online).

Records NSW report that the first formal Geological Survey of New South Wales may have commenced with the appointment of Charles Smith Wilkinson as Geological Surveyor to the Department of Lands on 16 July 1874. The Survey under Wilkinson gradually expanded to include 'additional surveyors, field assistants, clerks and draftsmen, and campmen' (SR NSW 4 2013: online). An overview of the work that these public servants undertook is demonstrated by McElhone's request to parliament in 1877 for more details on the work of the agency. The papers afforded to McElhone specified that,

> The role of the surveyor was to survey Crown Lands and to make a report which recommended any areas which should be set aside for mining purposes. The surveyor reported annually on the work of his branch and appended detailed reports on particular areas surveyed during the year

> other major undertakings of the survey team, surveys of existing and newly developed mines, and research reports. Surveyors also reported at the request of various government agencies on the suitability of sites for dams, tunnels, underground water resources and similar purposes. The geologists frequently visited mines in other states to examine the lodes and/or the processing of the minerals. On occasion they also hosted international geologists who were escorted to some the major geological sites in New South Wales. The Surveyors were also responsible for the Mining and Geological Museum which consisted of samples collected by the surveyors in the field and donations from the public. In 1881 and 1882 the surveyor was responsible for the exhibition of the mineral resources of New South Wales which was prepared for the Melbourne International Exhibition…By 1884 assaying and analysis of samples of minerals was undertaken within the Mining and Geological Museum. A scientific library was developed to supplement the Museum (SR NSW 4 2013: online).

Moreover, the 'amateur' Rev W B Clarke proved to be an important resource in the establishment of this new scientific bureau (Clancy 2002: Mozley 2014). Mozley finds that Clarke, working mainly by himself and using his own funds, had made a personal survey of the geology of New South Wales. Clarke's voluntary work included,

> …a huge correspondence with scientists and prospectors and acting as scientific mentor to newly-recruited geological surveyors in other colonies until the Department of Mines was established in 1873. In addition to his reports and books, Clarke published some eighty scientific papers, while his geological maps formed the basis of the first geological sketch map of New South Wales, issued by the Department of Mines in 1880. His pioneering on the stratigraphy of New South Wales laid the foundations on which much later work has been based (Mozley 2014: online)

Clarke's non-instrumental scientific knowledge was thus harnessed in favour of pre-instrumental scientific knowledge to be used for commercial applications. The bureaucracies, working through the vector of instrumentalised knowledge, were thus able to rationalise the mining industry, generate mine-specific scientific knowledge and regain control over state owned minerals, ultimately earning incremental revenue through the application of royalties. The bonds between the mining companies and the state thus tightened during this period. Despite Clarke's 'pure' motivation in sharing his non-instrumental scientific knowledge with the public, and amongst others in the scientific community, moves by the bureaucracies to secure the state's mineral assets for the market effectively exploited Clarke's impulse and transformed it for commercial exploitation.

Moreover, the non-instrumental scientific knowledge (as it related to geology) that was contributed by visiting geologists from other continents as well as that knowledge produced by the Australian Museum, the Royal Society and the Linnaen Society was also taken up by the Geological Survey of New South Wales, the Technology Museum (formerly the Technical, Industrial and Sanitary Museum) and associated regional teaching museums, the University of Sydney and Sydney Technical College (formerly the Sydney Mechanics Institute) was employed in the task of educating workers for the new mining industries. Moreover, the Broken Hill Propriety Company (BHP) and the lobby group the Australasian Institute of Mining and Metallurgy (AusIMM) drew on pre-instrumental knowledge developed by these organisations in order to develop their commercial interests.

The establishment of these institutions and bureaux was not uniform. Figure 4.2 demonstrates the organisations and the flows of information and knowledge in about 1900. At its most fundamental level Figure 4.2[111] demonstrates that non-instrumental

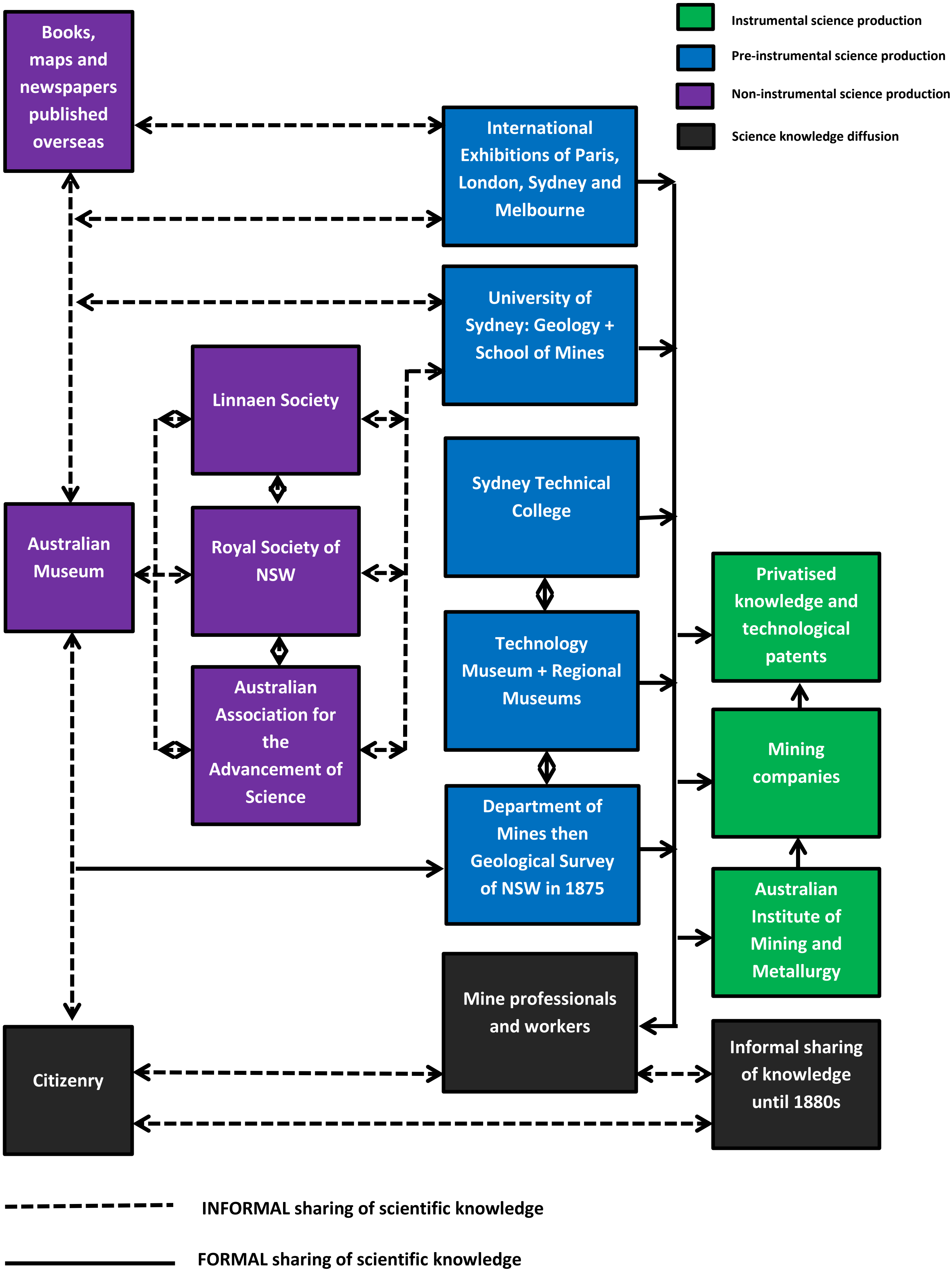
[111] The solid black lines on the diagram represent knowledge flows and the broken red lines signify information flows. The diagram has been drawn using square boxes, straight lines and expresses differentiated

knowledge was needed in order to produce pre-instrumental knowledge for the market. These new public/private styled instrumentalities developed by the bureaucracies thus worked to rationalise scientific knowledge in preparation for special use by the market. This public/private structure laid the groundwork for a system which would eventually seek to benefit the wants of the market over public utility.[112]

relationships. This is for ease of communication and interpretation. In reality the relationships between the organisations and their publics are fuzzier and more fluid.

[112] This argument is laid out in Chapters 5 to 8.

Figure 4.2 THE PRODUCTION AND DIFFUSION OF SCIENTIFIC KNOWLEDGE IN NSW: GEOLOGY AND MINING 1830-1910 (Hicks 2010)



Similarly, the agricultural industry was targeted as a growth industry by the bureaucracies. This position is discussed in the next section, which explores how the bureaucracy moved to rationalise agricultural production through the use of pre-instrumental scientific knowledge produced by public/private instrumentalities.

4.4.2 The state, scientific knowledge and the agricultural industry

As discussed earlier in this thesis many of pastoralists were both motivated to share knowledge amongst themselves in an effort to lift the whole market. Notwithstanding this propensity to share knowledge the early agriculturalists were also motivated to sell their produce locally. This can be seen in the early marketplaces[113] established by the Agricultural Society of New South Wales. As the agriculturalists grew more sophisticated in their production techniques and as pressures to export their produce increased the agriculturalists looked for ways to grow global markets in addition to those provided by other British colonies.

Along these market focused lines, the Agricultural Society of New South Wales first mooted the idea of the Sydney International Exhibition[114] as an opportunity to promote the colony's 'agricultural and mineral wealth' (Orr 2009:148). Perhaps as a component

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[113] Specifically, in Sections 3.3.1, 3.4 and 3.5

[114] 'Young colonies, embarking on the process of economic, social, cultural and political formation, were even more keenly motivated than mature nations to participate in, and sometimes host, exhibitions. Exhibitions, which operated as a key force in international information networks for government, commerce and culture, were important to Australia's colonies for two reasons. Pragmatically, they were used to attract people and capital to Australia and, more conceptually, they enhanced colonial identity in the wider world. However, perceptions of the colonies were refracted through complicated national and imperial frameworks which affected how the messages of colonial displays were received. Although Melbourne and Sydney were highly cosmopolitan centres, colonial attempts to present themselves in the most positive and optimistic light were also thwarted by the reality that their economies were still in the early stages of development' (Douglas 2008: online)…'The lifeblood of success in trade, commerce and the arts is publicity, and exhibitions are pre-eminently useful in imparting information in this most popular form ... Experience has shown that Exhibitions afford the cheapest and most effective means of advertising, without which, in some form or other, but a few people engaged in trade and commerce at the present day meet with success' (Knight 1862 cited in Douglas 2008: online).

part of the state's bureaucratic push into the primary and secondary industries during the late 1800s, this move by the Agricultural Society was forestalled by the state. Orr notes,

> Once the national and international significance of the idea was comprehended as an opportunity to raise the international profile of the colony, stimulate trade and investment, educate the population and promote cultural advancement, the colonial government and other influential sectors of the community took control (2009:148).

When the state assumed management of the Sydney International Exhibition it voted the necessary funding to construct the venue, the Garden Palace, in plain sight on Macquarie Street on the grounds of the Botanic Gardens (Orr 2009: 148).

Where the pastoralists had enjoyed a strong relationship with the state during the early part of the 19th century this connection was beginning to falter by the 1880s.[115] Fletcher argues that this was largely a result of the Sydney International Exhibition of 1879,

> For the Agricultural Society, however, the Exhibition was a disaster. The Society lost face as a result of the bitter wrangling on Council that received widespread publicity in the press. The fact that some members of the Executive had misled the government as to the capacity of the Society to shoulder costs, soured relations with ministers and cast doubt on the competence of office bearers. Stockowners were angered by the initial decision to become involved in an International Exhibition which they thought favoured city at the expense of country interests. For a time it looked as though pastoralists might break away from the Society and form an organisation of their own. This step was averted but tension still remained and in country circles there were suspicions that took some time to die down. Added to all this, the Society was unable to hold a

[115] The next bureaucratic foray into reigning in the pastoralists was with the establishment of the CSIR in 1926 by Prime Minister Bruce Stanley. This move is discussed more fully in Chapter 5.

show of its own in 1880 because of competition from the International Exhibition and as a result the financial situation deteriorated (1986: 8).

In concert with the varying fortunes of the Agricultural Society the state was gradually regularising the ownership of land and was moving towards regulating the agricultural industries. The introduction of a more equal treatment in terms of land ownership was the first strike towards this goal and was conducted by the increasingly bureaucratic machinery of government. Land settlement in the early part of the century had been the responsibility of the Colonial Surveyor's office. By 1856[116] those duties had been transferred to newly formed New South Wales Department of Lands and Public Works. This large department was subsequently divided to form the Department of Public Works and the Department of Lands. Much of the work of the Department of Lands in the middle of the century involved adjudicating between the extant pastoralists, predominantly squatters, who were loath to give up their 'free' land,[117] and the free settlers, or selectors, were determined to purchase land in order to farm.

The landholdings available to the selectors were smaller than those holdings obtained by the squatters and were deemed to be insufficient to effectively farm sheep. Thus there was often conflict between the pastoralists who held vast reserves of 'rich grazing lands' and the selectors whose holdings were less than ideal for traditional farming models imported from Britain and Europe (SR NSW 5 2014: online). Moreover, 'dirty tricks' campaigns were run by the pastoralists in order to dissuade selectors from moving onto the land; 'dummying'[118] and other nefarious practices were rife. In 1859

[116] With the introduction of the 'responsible government' policy to New South Wales
[117] This activity on the part of the pastoralists was explored in Chapter 3.
[118] Dummying involved an agent for the pastoralist choosing land to comply with the residential conditions 'only to sell it by pre-arrangement to another party and 'peacocking', taking the best part of the run to block the access to water' (SR NSW 5 2014: online).

the state moved to create the New South Wales Department of Lands. This new department was charged with

> …the administration of the alienation and occupation of all Crown Lands. This power flowed from two Acts, the Crown Lands Alienation Act 1861 which dealt with the sale of land, and the Crown Lands Occupation Act 1861 which allowed the leasing of Crown Land. The 1861 legislation repealed the Order in Council of 1847 and abolished the old land distinctions of the Colony - 'settled districts' (19 counties plus specified established areas), 'intermediate districts' and 'unsettled districts'. The new land differentiation involved town land, suburban land, first class settled districts and second class settled districts (SR NSW 7 2016: online).

By the 1870s the smallholdings of the selectors were often failing and the mining industry was all but defunct. In order swell diminishing state revenue, the bureaucracies resolved to expand the agricultural industry (and to reinvigorate the ailing mining industry).[119] To this effect the New South Wales Department of Mines and Agriculture was formed in 1891. The subordinate Department of Agriculture was under the control of the Secretary for Mines and an independent Department was not established until the Department of Agriculture Act in 1907 (Act No.6, 1907). The Office of the Minister of Agriculture was created in 1908 and was immediately responsible for the expansion of the State's agricultural industry.

The Department was authorised to manage the rural industry in general and to administer policy and programs under the Acts of Parliament relating to rural industries. The main functions of the new department were scientific 'research, education, advice, and regulation' (SR NSW 5 2014: online). As an important source of local and export revenues the agricultural industry was destined to be as bound up with

[119] The bureaucratic efforts to rationalise and grow the mining industry were discussed in section 4.4.1.

the bureaucracies as the mining industry, if not more so. Indeed, the first 'experimental farm' had been established by James Ruse in 1789 at the request of Governor Phillip. Ruse's farm at Harris Park (near Parramatta) used a system of trial-and-error to determine whether a colonial farm could support a settler and his family or 'produce surplus products for sale, or even what sorts of crops and herds would thrive or die in the strange climate and soil conditions'… (This first experimental farm) …'paved the way for ongoing agricultural experimentation and education in New South Wales and Australia' (SL NSW 3 2013: online).

During the 1890s and the early 20th century more experimental farms, modelled on this 'first farm', were created across New South Wales. These scientific institutions (a combination of working farm, demonstration farm, research station and educational college) were originally located in Wagga, Bathurst, Cowra, Yanco, Wollongbar, Grafton and Glenn Innes (SL NSW 3 2013: online). This 'new emphasis [on] … the science of agriculture created a need for formal education' (SL NSW 3 2013: online). In response, the State government established the Hawkesbury Agricultural College in 1891. It was the first college of its kind and offered theoretical knowledge as well as practical lessons held on the college's working Experimental Farm (HAC Prospectus 1893).

In a further move to centralise and regularise agricultural production the state established the Bureau of Microbiology which assumed the responsibility for bacteriology which had previously been held by the 'various botanical, zoological and dairy experts employed by the Department' (SR NSW 6 2014: online). Additionally, a wide range of new regulatory authorities were introduced by the Department of

Agriculture[120] between the 1860s and the 1900s. The Department of Mines and Agriculture Department also controlled the Botanic Gardens and all its subsidiaries.

During this period the Botanic Gardens shifted from its position as branch of Kew Gardens in London and as a private nursery for the pastoralists,[121] to a more important and independent scientific institution. This shift saw the Gardens develop a stronger alliance with the agriculturalists, particularly with the grape vine and sugar cane growers. The introduction of Experimental Farms eventually took the pressure off the Gardens and redirected some of the instrumental science that had been performed by the Gardens to the Farms.

By 1908 when the New South Wales Department of Agriculture was established as a bureaucratic entity in its own right the focus was very much on the nascent agricultural industry rather than on pastoralism or the associated science of animal husbandry. McLean (1982) finds that the primary responsibilities of the Department of Agriculture, while ostensibly pertaining to all rural matters, did in fact specifically concern itself with the administration, research and education of the agricultural industry. Indeed, as McLean remarks, it seems that the pastoralists continued to be out of favour with the bureaucracies,

> The agricultural colleges and experiment farms were established to serve the agricultural industry (narrowly defined) rather than the rural sector in general. They certainly were not oriented to the concerns of the pastoral industry. This industry bias is clear from an inspection of

[120] The primary areas regulated by the Department were Agricultural Pest Management from 1860; Agricultural Education and Training from 1891; Water Conservation from 1896; Agricultural Research from 1890; Animal Industry Regulation from 1861; Dairy Industry Regulation from 1901; Fishery Regulation from 1874; Forestry Management from 1871; Plant Industry Regulation from around 1900 (SR NSW 6 2014). Further, the Department of Agriculture was involved in the 'production and marketing of crops … as well as the emergence of an Exports Board/Branch'

[121] The relationship between the early pastoralists and the Botanic Gardens was discussed in Chapter 3.

> the syllabuses of the colleges and of the research programmes they initially embarked on. Similarly, as the departments of agriculture acquired functions of information dissemination, statistical collection and, later, regulation, they appear to have offered little of relevance to the wool-grower, and rather more to the grain farmer, dairy producer or orchardist (1982: 296).

Indeed, it seems that the decision to support the agricultural industry was the result of an explicit resolution on the part of the state and was not a result of individual or group pressure. Rather it was the 'threatened revenue loss' that seemed to motivate the state to take bureaucratic control of agricultural production (McLean 1982: 295). McLean's research finds that,

> …it is difficult to make a case that government action in establishing agriculture research stations occurred in response to pressures from individuals and groups who perceived that they would obtain immediate and certain economic benefits (1982: 295) … Neither ***a priori*** reasoning, nor an examination of the historical evidence, support an interpretation of government action based on the private interest hypothesis (1982: 306) … Rather, given the importance of agriculture in colonial economic development, the demand for government action arose when the process of rural settlement was threatened by problems of poor management, climatic variability, pests, and out-migration, encouraging politicians to cast around for solutions. The threatened revenue loss from land sold on credit sharpened this incentive (1982: 306).

McLean continues that market failure produced the impetus on the part of the bureaucracies to increase the flow of 'research and educational services' in order to support a special kind of 'public interest' hypothesis,

> The colonial governments were in some sense landlords, and had a direct fiscal interest in maintaining the private profitability of agriculture as well as the momentum of agricultural development and settlement - the latter being a basic social and political objective. The timing of legislative action on the part of different colonies may largely be accounted for in terms of actual or potential threats to colonial economies from problems in the agricultural industry, problems

which, some contemporaries believe would be alleviated by public provision of research, information and education to farmers (1982: 307).

In another bureaucratic move to rationalise and centralise control over the agricultural industry, the Council for Scientific and Industrial Research (CSIR), the forerunner of the Commonwealth Scientific and Industrial Research Organisation (the CSIRO) was established in 1926 by the newly federated national government.[122] The remit of this new scientific organisation was to complement the scientific work being done by the State-based Departments of Agriculture and the nascent universities.

The concept of a new national bureau of science was sold to the State governments by the Federal government through offers of incremental funding and other forms of assistance; Schedvin finds however that nationalising scientific knowledge production would in reality create 'a new problem in in the distribution of power and responsibility between the Commonwealth and the states' (1987: 1). Thus centralised authority and bureaucratic control in terms of scientific knowledge production had, within the fifty years or so between the 1870s and the 1920s, shifted from the producers themselves through the vector of State bureaucracy to culminate in a national scientific bureau funded and controlled by the Federal government.

As at 1900 in New South Wales however the official production of non-instrumental scientific knowledge as it related to basic biology and chemistry was practically non-existent. The Linnaen Society and the Royal Society of New South Wales produced and published some non-instrumental scientific knowledge as it related to the basic sciences of biology and chemistry; this knowledge, as with the knowledge produced by the

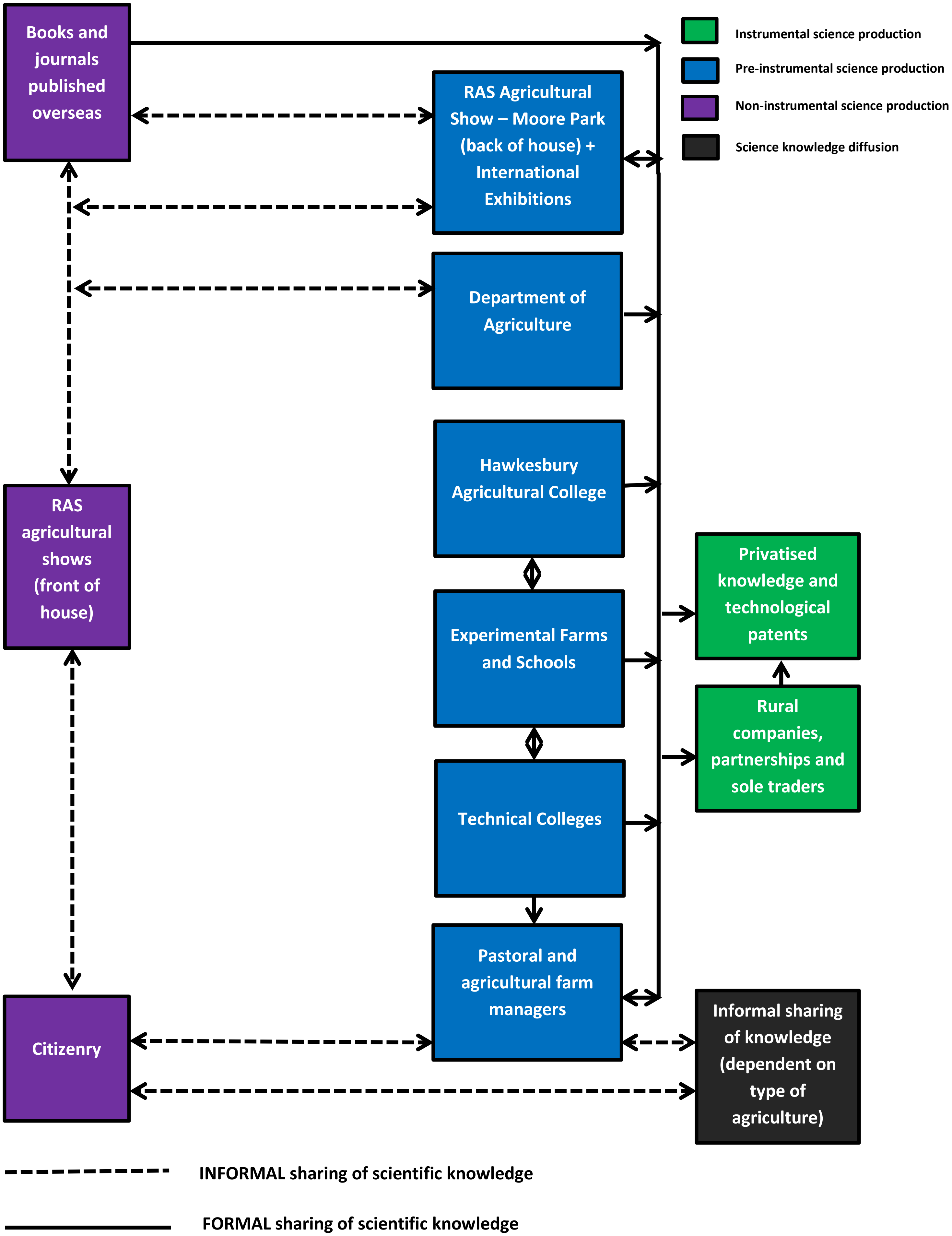
[122] The CSIR and the CSIRO and the relationships between the States and the Federal governments are explored more thoroughly in Chapter 5.

Agricultural Society up to the 1880s, was shared with the scientific community. However, the bulk of the scientific work at that time was conducted by the Department of Agriculture in the form of the pre-instrumental Experimental Farms and Schools, the Hawkesbury Agricultural College, the Botanic Gardens and the Technical Colleges (as shown in Figure 4.3). The Sydney International Exhibition of 1879 served as more of a marketing apparatus than a scientific organisation, as did the Technical Museum and its museological subsidiaries across the state.

The diagram below (Figure 4.3) allocates each organisation to one of three categories. These three categories – non-instrumental, pre-instrumental and instrumental – indicate the status of the organisation in terms of information and knowledge production and diffusion. The establishment of these institutions and bureaux, as with the mining industry, was not uniform. Nonetheless, the snapshot presented in Figure 4.3 demonstrates the trajectory of scientific knowledge production over the previous century.

At the beginning of the 1800s scientific knowledge pertaining to pastoralism and small agricultural industries was generated by the market actors themselves and was confidently shared. However, by the end of the century the state had moved to bureaucratise the agricultural industry and rationalise its production. This had the effect of introducing a third form of scientific knowledge production, that pre-instrumental type of knowledge that was produced by the state for the express goal of growing global markets. Thus by the end of the 19th century the vision of scientific knowledge based on the principles of the enlightenment that had existed in the early part of the century had been obscured by the actions of the state and its bureaucracies.

Figure 4.3 THE PRODUCTION AND DIFFUSION OF SCIENTIFIC KNOWLEDGE IN NSW: PASTORALISM AND AGRICULTURE 1830-1910 (Hicks 2010)



The tripartite model discussed in this chapter has laid the foundations for the production and diffusion of scientific knowledge from the 1870s to the present day. The transitional years between the 1910s and the present are discussed over the following four chapters with a final analysis in the thesis Conclusion.

4.5 Conclusion

This chapter has investigated the formalisation of scientific knowledge production and diffusion during the foundational years of the Australian nation. A review of the markets for agriculture and mining together with an exploration of the non-instrumental forms of natural science during the period reveals three central shifts in the production and diffusion of scientific knowledge. The first shift occurred largely as a result of the movements of the bureaucracies into the market. As bureaucracies were formalised the resultant system of scientific knowledge production supplanted the general sharing of knowledge amongst agriculturalists and small miners in the field. The primary aim of this formal system was arguably to regularise and streamline the yields of the nascent agricultural and mining industries in order to provide greater reliability and superior economic outcomes.

Secondly, this action on the part of the state not only altered the relations of production in the colony it arguably precipitated a disembedding of knowledge from its position as an *implicit* factor of production (and so regarded as cost of doing business) to that of an *explicit* factor of production (along with land, labour and capital). This newly explicit scientific knowledge was provided at minimal or no cost to private operators in the market in order to develop local markets and integrate into global markets. Moreover, this state move, in combination with the early forms of *property rights*, opened the way for scientific knowledge to develop as a marketable product in its own right.

The third finding concerns a more concerted and more powerful movement away from the production and diffusion of *value-rational* scientific knowledge towards scientific knowledge produced predominantly for *purposive-rational* ends. Moreover, the institution of civil society had broadened to include art, literature and philosophy. This broadening effect, in conjunction with a continued focus on pre-instrumental science, tended to dilute the public funding available for the production and diffusion of non-instrumental scientific knowledge, particularly that knowledge created in the Australian Museum. As discussed in the next chapter, the newly established University of Sydney also struggled to produce and diffuse non-instrumental science within the highly instrumentalised colony.

As the 19th century moved on and passed World Wars I and II the state continued to prioritise pre-instrumental forms of scientific knowledge production on the basis of nation building. Moreover, the notion of trade secrecy more robustly informed its processes and procedures[123] and competition became more widely instantiated. The events and outcomes of this further shift away from non-instrumental science towards a heavily instrumentalised form of scientific knowledge production are investigated in the following chapter.

[123] This pattern is clearly defined in the first half of the 20th century and is discussed in Chapter 5.

5 1910s-1950s: The intensification of developmentalism

The advent of Federation, the rise of developmentalism in Australia and the social and economic restructuring created by World Wars I (1914-1918) and II (1939-1945) worked to reshape scientific knowledge production and diffusion as effectively as the primary industries of agriculture and mining had done during the second half of the 19th century. As the mercantile bourgeoisie had successfully diffused the power of the pastoral elites and democratised Australian society in the late 19th century, so the incoming industrial ruling class was to reshape the dynamics between the state, the market and the public in the first half of the 20th century. Three salient ideas emerge from the investigation of the period 1910s to 1950s. These ideas indicate that state action advanced the case of both pre-instrumental and instrumental scientific knowledge during the period but, despite a temporary stimulus for the universities during the 1950s and 1960s, unfavourable conditions continued for the production and diffusion of non-instrumental science.

Firstly, economic and public policy aimed at developing Australia as an industrial nation greatly enhanced the pre-instrumental quality of scientific knowledge production during this period. To help achieve the nation's defence and development goals, the state leveraged purposive-rational action by way of state protection for both primary and secondary industries. This protectionism was embedded in both the instantiation of the domestic defence model (Castles 1988) that was first applied during the 1910s and in the substantial increase in the production and diffusion of pre-instrumental scientific knowledge between the 1920s and 1950s.

Secondly, the force of these protectionist models arguably served to alter the character of instrumental science, particularly following World War II. Prior to World War II instrumental knowledge had been collectively developed on site and had been spontaneously shared (despite the Intellectual Property legislation already in place) amongst primary and secondary producers. Moreover, this sharing behaviour appears to have occurred across all levels of expertise; between the workers at the coalface, the scientists in the lab and the managers in the office.

Conversely, the war effort, an emerging globalisation, and the rise of secondary industry in Australia saw instrumentalised scientific knowledge take on a more secretive, and more competitive, countenance. As the production of scientific knowledge became even more instrumentalised under the regimes of war and industrialisation, the realm of the scientific expert was relocated from the front lines of nation building strategies to the restricted and more secretive sphere of the laboratory. These national laboratories were state-funded and industry controlled, and produced large volumes of pre-instrumental scientific knowledge during World War II and through the post-war economic long boom.

Thirdly, the political focus on pre-instrumental science further diluted the political will around the production and diffusion of non-instrumental science and the state continued the close association between itself and the market. This position resulted in poor outcomes for the Australian Museum[124] as well as for scientific knowledge production in Australia's universities as these institutions continued to struggle in their attempts to establish themselves as producers and purveyors of non-instrumental scientific knowledge.

[124] An exemplar of non-instrumental science that is used in this thesis

This chapter begins the task of unravelling the dynamics that led to these transformations and sets up the groundwork for the chapters pertaining to scientific knowledge within the frameworks of environmentalism, postmodernism and neoliberalism, to come.

5.1 A nationalised instrumentalism

Federation produced a new tier of government in Australia which effectively generated a dividend for both the state production of pre-instrumental science and for the significant growth of secondary industry. For the pre-existing agricultural and mining industries, plus the small group of powerful manufacturers that were to emerge during World War I and consolidate during World War II, the nationalisation of public and economic policy delivered a crucible for the substantial growth of wealth, capital and government focus. This 'golden age' of industrialism and the associated economic 'long boom' remained in place until 'the crises of the 1970s and 1980s challenged its fundamental institutions and policies' (Broomhill 2008:16).

National government policies to develop secondary industries and to further develop pastoralism were particularly potent during this period, and scientific knowledge production was seen as integral to this aim. In particular, the spectre and actuality of war produced exceptional results for both the growth of pre-instrumental science and for the establishment of a vigorous suite of secondary industries. Federation had enabled a centralisation of economic and defence policy which facilitated nation building strategies that were central to the aims of developmentalism during this period.

Between Federation and the 1950s, science policy in Australia was increasingly centralised and primarily shaped by the protectionist strategies that were applied to manufacturing industries in order to respond to the significant scientific demands of the two World Wars and to enhance their potential for nation building (Encel 1971). These global and domestic forces necessitated an escalation of nationally funded pre-instrumental science, the structure of which was already in place with the Council for Scientific and Industrial Research (CSIR) that had been founded in 1926 and which facilitated knowledge for both the war effort and the state's ambitions for nation-building.

The Federal government's moves to centralise and nationalise scientific knowledge can also be seen in other national scientific projects. These projects, developed in the pursuit of nation building, include the National Botanic Gardens in 1945; the Woomera rocket range in South Australia which was established in 1947 as a joint facility for testing British and Australian short and long-range missiles; the establishment of the Australian National Antarctic Research Expedition (ANARE) in 1947 after which scientific stations were set up on Heard and Macquarie Islands; and a new national bureaux for the exploration of mineral resources in 1946, amongst others. In another move to centralise science policy and praxis, and despite the extant bureaux in each State, the Federal Labor government under Ben Chifley (1945-1949) moved to establish a national Bureau of Mineral Resources, Geology and Geophysics (BMR) in 1946.

Conversely, Australia's universities and the Australian Museum, as instances of the conventional producers and diffusers of non-instrumental scientific knowledge, and at that stage funded by State governments, did not fare so well.[125] The following section traces the interplay between the Federal government and scientific knowledge production through the lens of the domestic defence model.

5.2 Federation and the domestic defence model

The effect of Federation on the political, economic and scientific milieux of the newly formed nation was significant. As the pastoralists experienced diminishing power in relations with the state the large mining companies and the secondary manufacturers increased their national influence with the newly federated national government. Where the rural-based industries continued to subscribe to the tenets of economic free trade, the emergent manufacturing industry advocated for protectionist policies to safeguard the growth of local markets (Connell & Irving 1980). These protectionist strategies, employed immediately after Federation, have been described by Castles (1988) as the domestic defence model. The model served to buttress Australia's already heavy reliance on British capital and technology and hampered local efforts (apart from state sanctioned producers of wool, mining and steel manufacture) to expand by way of corporate research and development.

As discussed in previous chapters, country Australia was central to economic, social and political stability, and to the successful settlement of Australia during the 19th century and the early 20th century. The primary industries continued to produce Australia's main export income (until the massive growth of the secondary industries immediately prior to and following the World War II);[126] and the state and the market remained

[125] The decline in the quality of university research and the struggles for relevance by the Australian Museum during this period is explored more fully in Sections 5.2.1 and 5.2.2

[126] This broadening of state focus from primary to include secondary industry is discussed in more detail later in this chapter.

tightly bound in the endeavour to grow robust global markets for the primary industries.[127]

Castles' (1989) work emphasises the significance of the tight bonds between the state and the market during the early development of the nation. Castles' (1989) domestic defence model comprises three major components: state regulation of imports through tariff/import controls; significant state regulation and intervention in the labour market; and heavy government regulation of migrant intakes. Each of these components involved 'strong regulative intervention in the economy, but rather little in the way of state ownership on the British model' (Castles 1990:494). Comparative to other nations, the Australian model 'had high levels of income equality, but low levels of welfare state development. In many respects, wages policy was a substitute for welfare state on European models' (Stokes 2004: 17). Castles argues that the policy mix instituted in the domestic defence model used

> …tariff policy and/or import controls…to protect domestic manufacturing from overseas competition. Second, quasi-judicial powers of compulsory conciliation and arbitration of industrial disputes were used to regulate the labour market with the aims of simultaneously achieving a social policy minimum (a 'fair' wage sufficient to support a bread-winner and family) and of adjusting wage levels to take account of fluctuations caused by dependence on highly unstable primary commodity markets. Third, migrant intake was regulated in order to adjust labour supply in the hope of minimizing unemployment and protecting the wage levels decided on through the arbitration system (1990: 494).

Castles notes that this strategy relied heavily on the power of the state as well as the 'quasi-judicial organs of state' and differs significantly from the more democratic

[127] The bonds between the state and the market were discussed in Chapter 4 and will be enlarged upon in the present chapter in order to take in the significance of scientific knowledge to national goals.

approach where consensus is achieved through 'strongly organized political interests' (Castles 1990: 494). This strategy suggests that the state was continuing its tightly bonded relationship with the market, albeit with the welfare of the citizenry in firm sight.[128]

Between and during World War I and II the bureaucracies and primary and secondary industries became more entwined and the formerly vibrant democratic public sphere began to disperse (Hirst 2004). In effect, the ever tightening bonds between the state and the market and the state push for forging national identity through the precepts of nationalism (Calhoun 1997) during the first half of the 1900s worked to stifle both the entrepreneurial spirit of the citizenry and their political will for democratic action (Hirst 2004). A weakened public sphere and an increasingly powerful industrial base was particularly evident in Australia between World War I and the 1950s. This position would shift in the 1970s with the emergence of new social movements that would pressure the state for change in favour of the citizenry. These movements in relation to scientific knowledge are discussed in Chapter 8.

Notably, the historical accounts of the domestic defence model do not include the production and diffusion of scientific knowledge production nor its importance in state/market relations. On the contrary, while the production of scientific knowledge had significantly contributed to the socio-economic life of the nation, the importance of knowledge to industry lies dormant within these historical accounts of early economic development. There are arguably three reasons for this. Firstly, access to British research and technology had been implicit in economic policy and the growth of

[128] The bonds between the state and the market would continue to tighten, reaching a peak in the neoliberal years. Under neoliberalism however the protective action in favour of the citizenry would decline.

favoured players in the market since white settlement;[129] secondly, the domestic defence model (Castles 1988, 1990) focuses on national development. Until World War I however the majority of scientific knowledge production was located under the control of the State governments; and thirdly, scientific knowledge production, albeit a critical component of economic growth, appears to have been viewed by both the primary and the large secondary industries as an implicit contribution from the Australian state to the growth of global markets.

Cochrane (1980) argues that the protectionist policies afforded to local primary and secondary industries actually worked to maintain an extant dependency on Britain for both technological development and capital investment. This reliance was exacerbated by the growth of a manufacturing industry dependent on the principles of import substitution (Macintyre & Marginson 2000). As Macintyre and Marginson argue (2000) it was the fallout from this protective economic structure where investment – both in terms of research and capital – worked to restrict the development of industries not supported by the British and Australian governments that was to set the foundations for future knowledge production.

During the latter part of the 19th century and early 20th century, Australian enterprise (over and above the large pastoral and agricultural concerns and the emergent mining corporations) had typically been made up of small manufacturers 'operating under primitive and inefficient conditions' with much of the production 'concentrated in clothing and textiles, food and drink, metal works and machinery, wood working, vehicles and fittings (including saddlery and harnesses), printing and and the treatment

[129] This effect was discussed in chapters 3 and 4.

of agricultural and pastoral produce' (Cochrane 1980: 2). The larger organisations were able to network directly with the British state, British companies and financial institution (Laidlaw 2005) however the smaller operations were constrained by a both a limited interest on the part of the financial organisations and the accessibility of British technology. This heavy ongoing reliance on British technology and capital (particularly between 1870 and 1939) together with a strong state focus on growing the key industries of wool and mining and steel manufacture, meant that the smaller manufacturers were limited in their opportunities for growth. Cochrane finds that

> …the absence of an advanced capital goods industry in Australia was a major feature of dependence. Imperial economic relations contained a tradition of reliance on British technology and thereby retarded the emergence of a fully mature industrial base in Australia…As a director of the British Engineers Association noted in 1922: 'It was much more pleasing... to sell Australia manufactured goods, rather than tools or equipment for the making of those in Australia'' (1980: 5).

So, between the continued dominance of the British state in Australia's economy; in the restricted access to capital and technology for smaller manufacturers; and in the Australian government's institution of the domestic defence model, the technological advancement that would drive industrial development apart from the primary industries and select secondary industries (those supported by the state) was hindered. As discussed previously, the expectation that the state would be responsible for the production and diffusion of pre-instrumental scientific knowledge aimed at growing *specific* markets was embedded in the nation's colonial history. These settings are explored further in the following sections.

5.3 Science and the primary industries

The primary industries had been amply supplied with pre-instrumental scientific knowledge since the early days of the colony. The States continued to fund scientific bureaux such as the Geological Survey and the Experimental Farms through their Departments of Mining and Agriculture. Moreover, the numbers of universities had expanded to six by the 1950s and were to be found in the majority of the states. The following section takes as a potent example the establishment of Australia's first university, the University of Sydney, and considers the tensions created between those people seeking a site of learning such as that enshrined in the Oxbridge model and those seeking graduates with technical skills who could be directly useful in building the nation.

5.3.1 Universities and industry

The traditional producers of non-instrumental knowledge production, Australia's six universities, had been restrained since the 1850s by both severe funding issues and an obligation to train graduates for instrumental careers such as law and medicine and the useful sciences that were pertinent to the mining and engineering industries. Up until the introduction of higher degree research in the 1950s, pre-instrumental knowledge had been produced by drawing on existing non-instrumental knowledge from sources that had been published overseas; through the receipt of knowledge directly from graduates of British, European and American universities; and from researchers who had returned to Australia after visiting and/or studying at these foreign universities.

There are a number of important studies around the history of Australia's universities, each focussing on one university (Blainey 1957; Alexander 1963; Duncan & Leonard 1973; Thomis 1985; Davis 1990; Turney, Bygott and Chippendale 1991; Foster & Varghese 1996; Poynter & Rasmussen 1996; Horne & Sherington 2012). There is in addition an important book on *Why Universities Matter* (Coady 2000: 1), a comparative history of Australian universities (Gardner 1979), and views around how the production and diffusion of non-instrumental knowledge continues to be eroded (Klein 2000) under economically rationalist government policy (Pusey 1991; 2010), managerialism and the principles of the market (Marginson 2003). These latter resources demonstrate how state policy and praxis continues to encourage the instantiation of instrumental rationality into the university structure in Australia. While it would be a most useful endeavour to integrate these critical elements into this thesis, space and time limit this undertaking. The discussion of Australia's universities in this chapter will thus firstly scope the philosophy associated with the founding of Australia's first university, Sydney University, then engage with the growth and development of universities in Australia in relation to the instrumentality of knowledge. Section 5.6.1 looks at the crisis of funding and research capacity occurring in Australian universities during this period.

Sydney University was the first university to be established in Australia. It was founded in 1850 at the behest of a growing middle class who were demanding a more secular system of education; one that was provided not by the church but by the state (Horne & Sherington 2012). The university was formed from the vestiges of the Sydney College (formerly the Sydney Public Free Grammar School founded in 1825). Sydney College opened in 1830 but closed in 1850 only to re-open in 1857 as Sydney Grammar School. During the intervening seven years the new Sydney University had used the vacated premises of Sydney College. The university was moved to larger premises in 1857 and Sydney Grammar was established in 1857 as the feeder school for the university (Horne & Sherington 2012).

> Sydney Grammar School was founded by Act of Parliament in 1854, after Sir Henry Parkes, the Father of Australian Federation, tabled a petition from a group of citizens concerned that the fledgling University of Sydney should have a 'nursery' to provide it with well-prepared undergraduates (Sydney Grammar 2014: online).

As previously discussed,[130] the colony's ruling class was a hybrid of the bourgeois pastoralists and merchants and the more conservative promoters of civil society. This hybridised group sought the provision of a state funded, secular, university, one which would offer a liberal education in the arts and the sciences in the footsteps of Oxford and Cambridge, as well as educating professionals such as doctors and lawyers, and generating and teaching useful knowledge to be deployed in the mining industry and in engineering projects (Horne & Sherington 2012). Macintyre and Marginson find that the University of Sydney, founded in 1850, and the University of Melbourne, founded in 1853,

> …originated as statements of colonial aspiration, marking the advent of self-government with an institution of liberal education that would 'reclaim the character, create the taste, form the manners and confirm the loyalty of a restless agglomeration of individuals (Macintyre 1881: 146) and fit them 'to discharge the duties and offices belonging to the higher grades of society' (Turney et al 1991: 4). To this end both began the classical curriculum that would provide 'mental culture and improvement' (Turney et al 1991: 4). They survived, since the initial enrolments were so meagre, by offering professional degrees, first in medicine and law, then science, engineering, and later agriculture, commerce, architecture, education and other fields (2000: 54).

[130] In Chapter 4

Moreover, Turney, Bygott and Chippendale (1991: 4) remark that professional degrees were highly sought after by bourgeois parents who were demanding a practical, professionally based higher education for their offspring. An education,

> …by which men may be fitted to discharge the duties and offices belonging to the higher grades in society; to enable her citizens to become enlightened statesmen, useful magistrates, learned and able lawyers and judicious physicians (1991:4).

Macintyre and Marginson find that there was little demand in Australia for 19th century universities that were considered 'feeble imitations of Oxford and Cambridge', particularly when the 'lay governing bodies' were

> … dominated by professional elites within a society that placed high value on practical qualities in the pursuit of wealth. The economy was based on the export of primary commodities and reliant on the importation of capital, labour technology, which were adapted to local needs. Local industries grew by import replacement of a limited range of manufactures together with construction and service activities. The high standard of living and the keen demand for skilled labour provided little incentive to undertake extensive career preparation. The great majority left school in their early teens and acquired occupational skills in employment by pupillage, apprenticeship or informal instruction. Secondary education was meagre, and schools of mines, technical colleges provided specialised training (2000: 55).

Thus the foundations of Australia's higher education system were laid down amidst the active tensions that prevailed between what Weber has termed value-rational and purposive rational social action. The tensions continued to evolve between instrumental and non-instrumental knowledge production and diffusion and can be seen in the courses taught by the University of Sydney the late 19th century. In its early years the university taught only undergraduate Arts courses in Classics, Mathematics, Chemistry and Experimental Physics (Horne & Sherington 2012), that form of non-instrumental knowledge which contributed the flourishing of a robust civil society. Foreshadowing the shift to a more instrumentalised focus on education, the university add the discipline of Geology in 1870 in order to support the demand for high level instruction in economic geology and mining. By the 1880s highly instrumentalised degrees were being introduced in order to meet the demand for engineers in the mining industry. In 1882 the Senate voted to establish an engineering school and to 'award Certificates in Engineering, in Civil Engineering and Architecture, Mechanical, and Mining Engineering' (UoS Engineering 2014: online). Moreover, the Faculty of Science that was established in 1883 caused the Senate to alter the by-laws in order to add two degrees of engineering, the Bachelor of Engineering and the Master of Engineering, specifying three branches: 'Civil Engineering and Architecture; Mechanical Engineering and Machine Construction; and Mining Engineering, Metallurgy, Assaying and Mining Law' (UoS Engineering 2014: online).

This enshrining of instrumentalism into the foundations of the University of Sydney demonstrates the importance of the market mechanism to the bourgeois ideologies operating at the time. However, this academic mission to pursue instrumentally oriented knowledge production and diffusion was not without its problems. The 'Homeric battles with the forces of Arts' at the University of Sydney are well documented (Mellor 1974: online) and serve to highlight the tensions between the academics who favoured the diffusion of non-instrumental knowledge over the highly instrumentalised courses being demanded by the market and the state. Notwithstanding the 'forces of Arts' the university was financially encouraged (through student fees and state endowments) to remained focused on teaching in order to meet economic demand rather than contribute to a growing civil society (Macintyre & Marginson 2000; Horne & Sherington 2012;).

This pattern of instrumentality continued with the establishment of the University of Technology (now the University of New South Wales) which was incorporated by an Act of Parliament in 1949. Its 'character and idea' (O'Farrell 1999: online) originated in the form of the Mechanics Institute which opened its doors in Sydney in 1843 and which led to establishment of the Sydney Technical College in 1878. The instrumental character of these organisations is discussed in Section 4.4. O'Farrell substantiates this argument when he finds that

> …the University's international context is that of the Australian recognition of that scientific and technological impulse in tertiary education that produced the Massachusetts Institute of Technology and the Berlin University of Technology. It acknowledged at university level that profound development in human knowledge and concern that had impelled the nineteenth century industrial and scientific revolution (1999: online).

O'Farrell comments that the establishment of the university was also a way of keeping 'abreast of the diversity of challenges associated with the Second World War, a demand recognised by the NSW Government in establishing the University' (1999: online). This same model was upheld until the 1950s and Australia's six universities remained predominantly teaching institutions until the Menzies era (1949-1966) when the potential of the universities to contribute to stocks of non-instrumental knowledge was investigated by The Murray Report (1957).[131]

[131] The Murray Report and its ramifications are discussed more fully later in this chapter.

The Australian National University (ANU), established in 1946, was created to remediate the focus on teaching that had been institutionalised into Australia's universities. As part of its strategy for post-war reconstruction, the Chifley Labor government (1945-1949) undertook to establish a national research university in Canberra, the ANU. The national university 'established by an Act of Commonwealth Parliament was financed solely' by the Federal government and did not rely on state endowments or tuition fees (Murray 1957: 47). At the time, ANU was

> …concerned only with research and research and post-graduate studies in the special fields of its four divisions:-Medical Sciences, Physical Sciences, Social Sciences and Pacific Studies; it is not concerned with under-graduate teaching. Some of its staff, however, visit (sic) other universities (Murray 1957: 26) …The establishment of the Australian National University has made a notable addition to the facilities for post-graduate training and research in physical, medical and social sciences and in Pacific studies. Nowhere else in Australia are there any facilities for post-graduate training in such fields, to take a few examples, as astronomy, geophysics and demography (Murray 1957: 47).

At the time of The Murray Report in 1957 the ANU had 67 students enrolled and during the previous year had graduated only one student (out of 129 nationally) in a Higher Degree, that degree from the Faculty of Science. Additionally, the facilities, including the library, were in poor condition and the university was inadequately funded generally (Murray 1957).

Moreover, the overall the production and diffusion of non-instrumental science was poorly serviced in Australia. Scientific organisations such as the Australian Academy of Science, the Royal Society and the Linnaean Society[132] continued to support the

[132] This heavily instrumentalised scientific milieu also impacted the Australian Museum, the details of which are covered in Section 5.6.2.

production and diffusion of non-instrumental science but were hampered in their efforts by their inability to practice. Their members were caught between their aspirations to conduct non-instrumental research and their obligations to teach or produce instrumentalised science to grow the economy. On the other hand, pre-instrumental scientific knowledge production was given a significant boost through the establishment of the Council for Scientific and Industrial Research (CSIR) in 1926.

The following section explores the early days of the CSIR which was originally founded to support the further development of the pastoral industries, and so the economy. A subsequent expansion of the CSIR was to provide pre-instrumental scientific knowledge for the emerging secondary industries and to facilitate their role in Australia's contribution to the Second World War.

5.3.2 Council for Scientific and Industrial Research (CSIR) and growing markets

Notwithstanding the States' role in generating research for the primary industries the Federal government under the leadership of businessman and conservative Nationalist Party Prime Minister Stanley Bruce (1923-1929) founded the CSIR,[133] the forerunner to the Commonwealth Scientific and Industrial Research Organisation (CSIRO). While it was created ostensibly to offer an adjunct to State-based efforts, in reality the CSIR would expand its remit from the primary industries to the secondary industries and become an important producer of pre-instrumental scientific knowledge for Australia's part in World War II. The CSIRO would go on to become one of the largest and most respected pre-instrumental scientific organisations in the world.

[133] Predecessors of the CSIR were the Advisory Council of Science and Industry founded in 1916, and the Institute of Science and Industry which was established in 1920. The nexus between pre-instrumental science and primary and secondary industry is accordingly deep-rooted in the CSIRO.

In the meantime, however, Schedvin finds that the emphasis on 'agricultural instruction and technology' on the part of the State Departments of Agriculture 'far exceeded the increase in employment of research scientists' (1987: 8). Thus in line with the educational and pre-instrumental character of the universities at that time, the state's technical schools also focused their attentions on training rather than research. Schedvin observes

> This was understandable in view of the comparatively short time horizon of most governments, and at first it did not seem to matter greatly. In the years before World War I there appeared to be an adequate stock of knowledge, and the need was for the application of knowledge as quickly as possible. In the 1920s the situation changed. The technology of the average farmer still needed improvement, but the unsolved scientific problems[134] loomed larger than before (1987: 8).

Prior to Federation the States had supported the scientific needs of their resident farmers, and the requirements of the local mining licensees, and this continued after the national government had taken power. By the 1920s however population growth; the proliferation of small family farms; the increasing need for training; and for technological problem solving meant greater workloads on the part of the State scientific bureaux. Moreover, as Schedvin finds, 'in general the losses sustained from pests and diseases were highlighted because profits were being squeezed between rising costs at home and the limited scope for expansion of overseas markets' (1987: 9).

[134] Schedvin notes that by the 1920s 'pleuro-pneumonia, buffalo fly and tick fever cast a shadow of the beef industry in northern Australia; the sheep industry was afflicted by rabbit infestation, internal parasites and blowfly strike; in the wheat industry the application of superphosphate seemed to have reached the limit of its capacity to improve wheat yields, and the breeding of new strains was still necessary to escape the worst effects of rust; in the irrigation areas of the Murray the problem of rising salt was of growing significance; and in South Australia the mysterious 'coast disease' which affected sheep remained unresolved as it had done since the first settlement of the region. Few if any of these problems were new in the 1920s; but in some cases such as blowfly strike and rabbit infestation the problems were greater than before the war' (1987: 8, 9).

Each State was thus heavily occupied in scientific and economic problem-solving for the small farmer in their own constituency.

On the other hand, the pastoral industry in each state had been 'bypassed almost completely by the enlarged agricultural departments' (Schedvin 1987: 9) primarily because the pastoralists were reluctant for the bureaucracies to intervene in their industry.[135] Schedvin's (1987) work concurs with the discussion in the previous chapter suggesting that the early agriculturists had developed their own extensive tacit knowledge banks and that instrumental knowledge was frequently shared among each other in an effort to lift the whole industry. As the bureaucracies enlarged and the state's involvement in the primary industries grew, the pastoralists became increasingly reluctant to become bound up with what they saw as bureaucratic intervention, and ultimately state management of the sector. The establishment of a national and independent scientific organisation, the Commonwealth Institute of Science and Industry (CSIR), was calculated to alter the mindset of the pastoralists; and to encourage them to *scientise* their production in order to increase their participation in economic nation-building.

So, as the State departments of agriculture concerned themselves with the problems of the small farmer ('fertilizers, agricultural machinery, new seed varieties, crop rotation, orcharding, fruit drying, bee keeping, milking machines' (Schedvin 1987: 10)) the CSIR was conceived in order to produce pre-instrumental scientific knowledge for the pastoral industries. On the whole, the Bruce government was concerned that the State departments and their scientific bureaux were inadequate for the economic task ahead.

[135] The relationship between the pastoralists and the state was discussed in Chapter 4.

Indeed, Schedvin argues that 'In part CSIR's creation was a response to the scientific inadequacies of the state departments' (1987: 9). In an effort to 'sell' the States on the benefits of a national scientific bureau however, the Bruce government

> … Insisted that it had no intention of establishing a large and expensive authority which would duplicate the work of the state institutions. Rather, the purpose was to complement on a modest scale the work of the departments of agriculture and the universities according to the principles of co-operative federalism (Schedvin 1987: 1).

This 'challenge to the states' was thus surreptitiously transformed into a benefit or opportunity and 'disguised in a manner which has become part of the ritual of Australian federal politics' (Schedvin 1987: 1). Moreover,

> It was these circumstances which provided the CSIR with the opportunity to link scientific research with several of the important primary industries on a national scale without intruding into the established spheres of interest of the state departments of agriculture (Schedvin 1987: 10).

This new knowledge would be formulated in order to support the larger commercial opportunities possible with animal production. These opportunities, argues Schedvin, were made manifest following World War I when the 'technical and economic problems of animal production accumulated rapidly, and profitability in the longer term seemed to be threatened' (1987: 10). The preliminary research projects undertaken by the CSIR involved not only those particular to animal production, but covered soils research, animal nutrition, veterinary research, economic botany, prickly pear and economic entomology, forest products, food research and fisheries research (Schedvin 1987).

Not only was the CSIR charged with expanding scientific knowledge associated with the agricultural industries, its role in the development of the secondary industries under the spectre of World War II would cement is place on the national stage. The following section considers the role of the CSIR in the economic growth of the secondary industries.

5.4 Expanding the economic role for science

The idea for a national laboratory had been mooted since before World War I and in 1916 the Advisory Council of Science and Industry was created. By 1920 it had evolved into the Institute for Science and Industry. These early years had been hampered by 'the absence of an accepted role for national science during [World War I] and the early post-war years' and as a result the organisation struggled for funding 'beyond a token amount' from the federal government (Schedvin 1987: 17).

Schedvin finds that 'finance…depended on the identification of a major economic role' (1987: 17) for science, one which would emerge in the 1920s under pressure from the major industrialists and with the full support of the Bruce government. Bruce, a seasoned businessman, 'stressed the need for business methods in government' and believed that science was critical to the project of economic development. Indeed, he later declared that among his greatest achievements was the establishment of the CSIR and his acceptance as a Fellow by the Royal Society in London (Radi 2014: online). With the CSIR in place the Federal government was ready to begin the task of nation-building on a large scale. Science was seen as integral to the development of industrial and economic power. In the meantime, however, the shadow of war was set to increase the importance of pre-instrumental science and to motivate the urgent development of secondary industries.

Where the *scientisation* of the primary industries in order to expand global markets had engaged the bureaucracies during the last quarter of the 19th century, the rise of industrialism, and the preparations for war were intimately entwined in the story of Australian science during the first half of the 20th century. Much of the industrial/military engagement with science was generated by the ill-preparedness for World War I so soon after Federation. The newly Federated government and the nascent manufacturing industries had been taken off guard by the First World War (Mellor 1958). Mellor finds,

> In the war of 1914-18 Australia was not sufficiently industrialised to do more than provide her armies with food and clothing, and rifles and ammunition. The war threw into sharp relief her dependence on outside sources for guns, gun ammunition and high explosives. Government and defence authorities alike took the view that it was high time Australia made these items herself (1958: 5).

Moreover, World War I had demonstrated to the Federal government that pastoralism, agriculture and mining were insufficient exports on which to base a growing economy or indeed to keep it primed for the shadowy possibilities of war. Mellor (1958) argues that the state needed to balance the general call for disarmament after the horrors of World War I with the prospect of an adequate industrial/military alignment in the event of future military action.

An ambitious industrial chemist Arthur Leighton, who was later to become an important bureaucrat in the Department of Defence, was despatched by the Federal government in 1915 to undertake a study tour of India and Britain. On this study tour Leighton formed the opinion that Australia needed to maintain and build its secondary industries to be ready in case of further warfare. Despite the state's inclination towards disarmament and the strong public call for demilitarisation following World War I, Leighton became a strong supporter of developing a secondary industry that could be quickly re-armed as required (Mellor 1958). Leighton's speech in 1920 demonstrates his stance,

> An industrially developed nation cannot be disarmed. Exact knowledge of munition production, a nucleus of skilled workers, supplies and then within a few months a nation is transformed . . . . The power to retain a strong position in the world depends ultimately, not on the possession at any moment of ships, engines and munitions of war, but on the extent and variety of the nation's industries and the possession of knowledge to apply the resources of the industries quickly and effectively to the problems of war (Leighton 1920 cited in Mellor 1958: 7).

Leighton also recommended that the government's munitions factories continue to supply 'the country's small peacetime demand for munitions, which it was hoped would be sufficient to keep them, operating on an economic basis' (Mellor 1958: 7). Mellor highlights the importance of private industry to this strategy,

> At the same time the factories would acquire equipment, and with the help of adequately equipped scientific laboratories would develop methods of manufacture and train men so that when war came it would be possible to transfer to commercial industry the burden of the mass production of the great bulk of munitions. In this sense the government factories and commercial industry were to be complementary. Government factories would of course depend on private industry for their raw materials, principally metals, alloys and the heavy chemicals needed for explosives (1958: 7).

While industrialisation had not been sufficiently advanced to cater for the immediate demands of World War I the pre-emptive industrial/military strategy that was put in place after that war was both an opportunity for the Department of Defence to build its research capacity and a significant spur for the nascent industrialists. In the background was the emerging strength of the newly established CSIR which was later to enter into a power struggle with the Department of Defence.[136] On the other hand, the new industrial/military strategy aided secondary industry to continue its development through the Great Depression and into the years before and after World War II (Connell & Irving 1980; Cochrane 1980).

Mellor writes that many of Australia's founding secondary industries had developed from the mining industry in the early 1900s and continued to grow during World War I:

> Australian metal-extraction industries were by now fairly well established: steel at the Broken Hill Proprietary Company Ltd, Newcastle, New South Wales; zinc at the Electrolytic Zinc Company of Australasia Ltd at Risdon, Tasmania; copper at the Electrolytic Refining and Smelting Company of Australia Pty Ltd, Port Kembla, New South Wales; and lead at Broken Hill Associated Smelters Pty Ltd, Port Pirie, South Australia. All of them either owed their existence to or had been greatly stimulated by the war of 1914-18 (1958: 7).

The major mining conglomerates, Collins House and Broken Hill Proprietary Company (BHP), led the transformation of the mining industry into the metals industry and as such were heavily influential in the growth and maintenance of Australia's secondary industries[137] (Connell & Irving 1980). Cochrane reiterates that it was 'monopoly mining capital, among the most powerful of fractions in Australian political life [that] developed a vested interest in the growth of local manufacturing between the wars' (Cochrane 1980: 12). Additionally, that it was the 'parlous situation of the British iron and steel industry… [and the economic] protection guaranteed by the Australian government'

[136] This power struggle and its outcomes are discussed in Section 5.4.1.
[137] The influence of BHP and Collins House in the industrialization of Australia is continued throughout this chapter.

that encouraged British capital 'into the development of an iron and steel industry in Australia' between the wars (1980: 94). Cochrane writes,

> While Broken Hill Proprietary dominated mining and metallurgy from 1915, several other firms transferred production from England soon after the war. These moved into the manufacture of metal products, mainly capital goods for consumption by smaller, Australian-owned manufacturers and other producers. BHP encouraged this pattern. Its strategy in 1920 laid stress on economy of scale in steel production; it accepted the proposition that other companies, ideally with BHP associations, would pioneer the metal products sector (1980: 94).

The scale of BHP's operations to some extent protected the organisation from the more deleterious effects of the Great Depression (Cochrane 1980) and a number of domestic factors worked to ameliorate the impacts of the economic downturn for BHP. These factors included the 'continuous decline in labour costs… increased (state) protection, a temporary extension of the working day, some increase in the export of iron ore, and, notably, by a reduction in coal costs following the defeat of the marathon miners' strike in northern New South Wales' (Cochrane 1980: 95).

Indeed, not only did BHP weather the downturn successfully, it continued its expansionary phase with the takeover of Australian Iron and Steel (Hoskins) in 1935. The other major mining conglomerate, Collins House, also benefited from domestic conditions and it too expanded into metal manufacturing prior to World War II. Cochrane notes that 'for Collins House, the Second World War cut short the drift to bad times that was looming. Government controls did not permit runaway prices as in the First World War, but good war contracts stamped out a stable, lucrative future' (Cochrane 1980: 87).

In many ways the success of the secondary industries was also down to the provision of pre-instrumental scientific knowledge. The following section considers the tense relationship between two national producers of this knowledge, the Department of Defence and the CSIR, before moving on to discuss the role of the victorious CSIR in the industrial/military alliance.

5.4.1 Pre-war tensions between the Department of Defence and the CSIR

During this inter-war period two groups of bureaucrats worked to extend their power base in terms of pre-instrumental scientific knowledge production and diffusion. The Department of Defence led by scientist and career bureaucrat Leighton[138] and the newly formed CSIR (which had the support of the Prime Minister Stanley Bruce) vied for the position of leading national producer of pre-instrumental scientific knowledge in Australia. Fundamental to industrialisation was the need for instrumentalised scientific knowledge and both the Department of Defence and the CSIR competed for funding and power. The Department of Defence saw the need for science in order to prepare for the possibility of a Second World War; the CSIR was keen to complement their role in the primary industries and secure their position by producing the science to underpin the emerging secondary industries.

After World War I and prior to World War II, at the urging of Leighton, the Federal government had laid the foundations for military/industrial oriented pre-instrumental science with the establishment of the Munitions Supply Laboratory (MSL) at Maribyrnong in Melbourne. The MSL was created by the wartime Prime Minister Hughes in 1920. The main work of the MSL between the wars

[138] As discussed in Section 5.4.

> …embraced metallurgical and chemical analyses and the physical testing of metals and alloys used in munitions manufacture, investigations of the physical and chemical properties of explosives, and the checking of and maintenance of measuring instruments and gauges used in the inspection process during manufacture. The matter of standards was of central importance in the manufacture of items originally designed and developed overseas and officers of the Laboratories were directly concerned with translating modifications advised by the British War Office to local procedures. The need to establish operating rules for industry by way of legally recognised standards of methods of measurement was recognised by the separate States of Australia as a result of wartime experience (Farrands & Wisdom 2000: 905).

As an agency of the Department of Defence the MSL was not required to prove its economic worth and continued with its mission to prepare the nation for the possibility of war. On the other hand, for the CSIR, established by Prime Minister Bruce and a committee of 'seven professors and four men of industry', the demonstration of economic worth was critical to its continued existence. As Schedvin observes,

> [Bruce] told the small gathering that the time was opportune for the harnessing of science and industry. Continued economic development and immigration needed the aid of science as did the growth of Imperial co-operation, on which the Prime Minister had pledged so much. But the Council was on trial until it had demonstrated its economic value to the nation (1987: 43).

Bruce's concerns highlighted the importance of science to the market and this, in the absence of other ways of lifting the project of science in Australia, was accepted by the committee members. Schedvin posits that the scientists in attendance felt that 'the thin rivulet of Australian science might soon flow with greater abundance and strength' (1987: 43).

The CSIR initially proved its economic worth in terms of solving some of the complex scientific problems that had beset the pastoralists since white settlement.[139] By the early 1930s however commodity prices had fallen dramatically and the Federal government began to question the capacity of the primary industries to service economic development and population growth. As mentioned previously, economic recovery after the Great Depression (officially 1929-1932) had been led by the manufacturing industries, particularly by the expansion in iron and steel production. Accordingly, the Federal government canvassed the idea of industrialisation as 'the road that offered superior 'economic security, independence and 'maturity'' for the nation (Schedvin 1987: 185) and sat well with the bureaucrats seeking to advance the military/industrial alliance.

The first step in enlarging the industrial base was managed by a 'syndicate of industrialists' who set out to establish in 1935, 'with the government's blessing' both the Commonwealth Aircraft Corporation (CAC) and the beginnings of a motor vehicle industry (Farrands & Wisdom 1988: 908). These new industries with an outward civilian focus also contained a tacit military purpose that required extensive scientific support from the state (Schedvin 1987). Key players from the industrial sector involved in these development initiatives included Essington Lewis on behalf of BHP, Sir Lennon Raws for Imperial Chemical Industries (ICI), W S Robinson (BHAS), and L J Hartnett for General Motors (Holdens) (Farrands & Wisdom 1988: 908).

This level of industrial development required a substantial concentration of scientific knowledge production that the industrialists were not able, and not willing, to fund.

[139] The agricultural problems that were tackled by the CSIR were discussed in Section 5.3.2.

Instead, the industrialists petitioned the government to expand the CSIR's remit to cover not only primary industry but secondary industry as well (Farrands & Wisdom 1988). Notwithstanding an initial reluctance to subsidise these secondary industries, the government acceded and by the mid-1930s the CSIR was asked to more closely scope the pre-instrumental science sought by these new secondary industries.[140] Three research areas were specifically selected,

> The first basic requirement was to provide industry with those standards of measurement necessary for mass production; secondly, surveys of availability of strategic raw materials such as chromium, nickel, tungsten, manganese, tin, aluminium, etc. and investigations of methods of treatment of ores were needed. Thirdly, and more specifically, the new aircraft industry, and probably a developing automotive industry required scientific support (Farrands and Wisdom 1988: 908).

This new role for the CSIR began with much politicking between the Department of Defence and in particular the Director General of Munitions Supply who was by then Arthur Leighton) and the new Executive Committee of the CSIR chaired by Sir George Julius. Leighton claimed that his Department had 'already dealt with many requests from secondary industry for assistance and he had reservations about the need for this new development by CSIR' (Currie & Graham 1971: 16). This ongoing tension was eventually resolved at Ministerial level and an alternative representative of the Department of Defence was assigned to liaise between the CSIR and the Department. These tensions continued to underpin relationships between the bureaucracies and the CSIR however the CSIR (and its successor, the CSIRO) maintained its position as the pre-

[140] This scoping exercise was discussed in the previous section.

eminent scientific research organisation in Australia until the 1980s when the neoliberal state moved to restructure the economy and the *science system*.[141]

The following section explores the circumstances in which the state and the secondary industries joined forces to establish an industrial/military alliance prior to and during World War II before exploring the tightening relationships between the state and the market during World War II.

5.4.2 Forming the industrial/military alliance

Notwithstanding these bureaucratic tensions, a CSIR team led by George Julius (and which included a ministerially appointed representative from the Department of Defence) was charged with enacting the Secondary Industries Testing and Research Committee (SITRC) in order to investigate means by which the CSIR could contribute to the development of the new secondary industries. Senator the Hon. A J McLachlan, Minister in charge of CSIR addressed the full Council on 5 April 1937 and confirmed the government's enthusiasm for engaging the CSIR in producing pre-instrumental scientific knowledge designed to support the secondary industries:

In detail the SITRC delivered five recommendations (cited in Schedvin 1987: 189):

(i) that a laboratory should be established forthwith for the maintenance of fundamental physical standards, to be supported by testing authorities in each of the states for gauging, calibration, testing and certification;

(ii) that the Commonwealth exercise its legal authority over weights and measures under section 51 (xv) of the Constitution, and introduce legislation adopting the British legal standard of measurement as the legal standard in Australia;

(iii) that an aircraft and engines research laboratory be established in Melbourne;

[141] This restructure of the economic system under the neoliberal state is discussed in Chapter 8.

(iv) that the Information Service be expanded to include the needs of secondary industry;

(v) that further consideration be given by CSIR to the establishment of a secondary industries research service with sections such as metallurgy, chemistry, physics and engineering.

Currie and Graham note that the role of the CSIR in 'standards, in engines research and an information service led naturally to the general acceptance of the principle that CSIR had an important role to play in research in secondary industry generally' (1971: 27). The CSIR was henceforth in the business of underwriting both primary and secondary industries with the production of pre-instrumental science. As the prospect of war in Europe and possibly Asia threatened, the CSIR would take on an even greater responsibility.

The political power of the CSIR was more firmly established with the rapid development of the secondary industries under the shadow of war. During the lead up to World War II 'the remaining barriers between scientists and the war effort were removed' as Australia geared up for the possibility of military action. Most pre-war research was either 'suspended or modified'; any non-instrumental scientific research was 'abandoned' (Schedvin 1987: 281). Two factors were particularly influential to shifting the state's position on rearmament. The first of these factors was the growing industrial strength of Japan and increasing national concern about the Japanese influence in the Pacific. Secondly 'anxious pleadings' (Farrands & Wisdom 1988: 908) on behalf of the industrial sector, in the main from Essington Lewis, the head of BHP, who had personally witnessed 'growing militarism in Japan' (Farrands & Wisdom 1988: 908) and who was recommending the rapid escalation of the secondary industries in order to be prepared for any possibility of war.

Under the spectre of war, the recommendations of the CSIR to expand into secondary industry were accepted by the Federal government and subsequently funded. So in 1938 the new research Divisions of National Standards, Industrial Chemistry and Aeronautics were founded within the extant CSIR (Farrands & Wisdom 1988). These new divisions were created in order to provide pre-instrumental and instrumental scientific research for both private industry and for the state's preparations for war, should it arise. Positioning these divisions into civilian (CSIR) rather than military organisations (Department of Defence) ensured that the scientific outcomes would flow directly to market actors without encountering the security issues associated with accessing military knowledge.

Federal public servants were concurrently making forward looking plans that would combine public and private manufacturing in order to develop 'a nationwide infrastructure of defence production, with its attendant technological support in materials testing and provision of manufacturing standards' (Farrands & Wisdom 1988: 908). This infrastructure was completed in 1939 with the creation of the Department of Munitions. Farrands and Wisdom write,

> The appointments of Essington Lewis, Chief General Manager of the Broken Hill Proprietary Company, as Director General of Munitions, and Laurence Hartnett of General Motors (Holdens) as Director of Ordnance Production, were a fundamentally important step in helping to put the nation's industrial strength on a war footing…. Leighton's basic objectives were about to be realised. A peacetime munitions supply establishment, based on government support could develop expertise and disseminate its knowledge to industry in wartime (1988: 908).

The Federal government and the large industrialists were accordingly tightly interlocked. World War II would serve to further merge the state with the market as the industrialists took on the practical management of the manufacturing industries and the associated production of pre-instrumental knowledge. The following section explores the relationships between the state, pre-instrumental science and the secondary industries before moving on to explore science within a post-war context.

5.4.3 The interpenetration of the state, science and secondary industry

During World War II the state, science and secondary industries interpenetrated each other in order to research and produce the necessities for the war effort. Not least of this interpenetration was the appointment of Essington Lewis to one of the most important positions in the country. Lewis had been a key driver in the growth of industrialisation, particularly during the 1930s; he was able to move easily from corporate side to state side (as Director-General of Munitions and Director-General of Aircraft Production) and back again as the need arose (Connell & Irving 1980; Mellor 1958; Blainey & Smith 2014). Lewis was also a powerful businessman who had previously succeeded in negotiating with the Federal government to provide the funding for pre-instrumental scientific knowledge necessary to support the growth of the secondary industries. Connell and Irving note,

> Lewis, a tough and taciturn man who had trained as an engineer, became the most powerful businessman in the country and arguably the most important figure in twentieth-century Australian history. He personified a new drive for technology and precision in combination with reactionary social attitudes, hostility to unions and a determination to promote accumulation and growth regardless of social cost. In that, he was impressively successful (1980: 271).

Mellor writes that during the late 1930s leaders of industry had negotiated to convert their factories over to the production of munitions[142] in the case of war. This interlocking relationship between the state and the market was in order to 'enable the fullest use to be made of commercial industry' in the war effort (1958: 36). Lewis, by being appointed Director-General of Munitions was 'entrusted with the widest powers – perhaps the most responsible position of its kind ever allotted to an Australian' (1958: 36). Lewis continued to be employed by BHP during this period.

Indeed, Lewis' appointment precipitated a broadcast to the nation on 16 June 1940 by Robert Menzies (1939-1941 and 1949-1966), the conservative Prime Minister at the time. A large part of Menzies' broadcast has been reproduced here in order to demonstrate the enormous power that had been handed over to Lewis, BHP, and the other industrialists in pursuit of the war effort.

> In order to give Mr Essington Lewis the greatest possible degree of authority, subject only to the policy and approval of the War Cabinet and to ministerial direction from myself, there will be established a Department of Munitions, with myself as Minister and Mr Lewis as Director-General. Mr Lewis will have access to the War Cabinet, in the same way as the Chiefs of Staff, on matters which relate to his work. This new Department of Munitions will deal with all ordnance, small arms, explosives and ammunition, together with such ancillary matters as gas masks, and will have a supervisory jurisdiction over aircraft supply. It will also include related materials.
>
> The Director-General will be given a complete power of delegating authority. He will be a member of the Defence Committee. Through his Minister he will have the right of initiating

[142] 'In its widest sense, the term munitions embraced many items similar to or identical with those used in civil life: clothing, food, housing, transport and communication; in fact, stores of this kind might be required by the Services in greater quantities than munitions in the narrower sense of the word, such as, small arms, guns and ammunition. Since practically every major industry was thus involved in the provision of supplies for defence, the Munitions Supply Laboratories were equipped with a correspondingly wide range of facilities for the examination of materials and products of the most diverse character' (Mellor 1958:10).

> matters for consideration by the War Cabinet. The new department will, as far as possible, use the existing machinery of the Supply Department, including the Contracts Board. Instead of securing specific approvals from time to time, one of the earliest duties of the new Director-General will be to confer with the other members of the Defence Committee in an endeavour to formulate a series of objectives which it is desirable to achieve during some prescribed period. If these objectives are then approved by the War Cabinet, the mandate to the Director-General will be a perfectly simple one. It will be: Go ahead in your own way and achieve these objectives in the shortest possible time.
>
> We will take power by regulation, to the extent to which it does not already exist, to requisition all private resources of plant and equipment. The Director-General will be authorised to make purchases direct without tenders or circumlocution. A standing order will be issued by the Government that no factory may provide for any new tooling-up without authority . . . . The Director-General will not be limited by Public Service regulations or otherwise in regard to the employment of personnel (Menzies cited in Mellor 1958: 36).

Mellor describes Lewis' new post as 'extraordinary … virtually an industrial dictator' and explains how Lewis brought with him a team from BHP who, like himself, remained salaried employees of BHP or its subsidiaries throughout the war. 'No remuneration was sought from the Commonwealth, the companies concerned regarding this arrangement as part of their contribution to winning the war' (Mellor 1958: 36). Instead the state provided invaluable scientific knowledge generated by the BMR, the CSIR, and the MSL for the aircraft and motor vehicle industries, amongst others, as well as a ready market for the goods produced by the secondary industries. Moreover, the state at war was an important market for the manufacturing industries, and the new industrialists benefited from wartime budgets in terms of scientific knowledge production as well as industrial growth and guaranteed profits. Connell and Irving report that

> During the Second World War, most of the manufacturing complex that went over to war production worked on a 'cost-plus' basis (that is guaranteed profit) basis for the federal government, and that government reciprocally stepped in to organise war production and regulate profits – appointing as director of the national industrial effort one Essington Lewis (1980:277).

Furthermore, in order to fund this war economy 'the government assumed far-reaching controls of industry and employment. Wages, prices and rents were fixed, essential items rationed, labour directed into essential industries' (Macintyre 1999: 193). The war effort was largely financed through the tax system; caps on household consumption and a reduction in government investment were also introduced in order to maximise war production (Macintyre 1999; 2004; 2009). As with the mining industry, it seems that the citizenry inadvertently funded the profit-making activities of the industrialists through the provision of pre-instrumental knowledge derived from the CSIR, the BMR and the MSL. Notwithstanding their own significant financial contribution, the citizenry remained unable to access this newfound knowledge primarily due to the confidentiality intrinsic to its commercial and military status.

The industrialists were not the only group to benefit from the exigencies of World War II. The crucible of pre-instrumental science, the CSIR, grew enormously during the war and into the 1960s. Schedvin reports that the CSIR transformed during the 1940s; that at the beginning of the decade the organisation had been 'small with tight control of policy at the centre and a pronounced concentration on agricultural and biological sciences' (1987: 282). By the end of the 1940s the CSIR had increased staffing levels 'five-fold' and total expenditure more than 'six-fold'.

> With the number of staff (scientific as well as non-scientific) in excess of 2000 in 1949, CSIR was now one of the world's largest scientific organisations, covering a broad spectrum of physical as well as biological sciences (Schedvin 1987: 282).

The rapid growth of the CSIR during the 1940s can be attributed to wartime expansion; the negotiating skills of the Chairman David Rivett; and the radical change in 'the relationship between science and state brought about by the war' (Schedvin 1987: 284). Rivett had been on the Executive Committee of the CSIR since inception and was appointed Chairman in 1946. His skill at negotiating with public servants over budgets is demonstrated in the following passage defending the continuation of civilian research during wartime,

> We could … cut out work on soils, animal health, pastures, bugs and other matters not directly associated with efforts to kill Germans: but it would all recoil severely against us in the post-war period when such activities will return their cost many times over (Rivett 1941 cited in Schedvin 1987: 284).

Rivett was also known for his views on the importance of non-instrumental knowledge, his commitment to basic science (albeit within a politically charged organisation focussed on science for industry and warfare), and his defence of the enlightenment ideals of scientific freedom and the democratic access to scientific knowledge. Rivett's distaste for secrecy in science troubled him during the war and post-war years; he was publicly critical of the outcomes of this secrecy and often advocated a return to 'internationalist principles' at the earliest opportunity following the war (Schedvin 1987). A scandal regarding the alleged paucity of security arrangements in the CSIR erupted around Rivett towards the end of his tenure as Chairman of the CSIR.

Deery (2000) finds that the 'thorny issue' of scientific secrecy and political freedom within the CSIR came to a head when Rivett declared his position in a political forum. When he took umbrage at the necessity for military secrecy the result was a sustained attack on both the man and the CSIR. Deery reports that while the 'steadily increasing attacks in the press and Parliament, and defensive counter-attacks by the CSIR' (2000: 14) continued, Rivett remained a strong advocate for scientific freedom. His position is amply demonstrated in the following passages quoted by Deery.

> As to all this business about classified information, security, secrecy and the rest of it I just loathe it. Of course we shall be prepared to give whatever guarantees may be required if that is the only way we can engage in research work of any value. I have however the utmost distrust of secrecy practices particularly when they are influenced by military people (Rivett 1948 cited in Deery 2000:14).

Similarly, in a vitriolic letter in early 1949, he wrote:

> These politicians and Civil Service bureaucrats know nothing about scientific work or the conditions under which alone it can flourish. "Science" to them means atomic bombs and rocket ranges...Hence the freedom under which CSIR developed seems to them to be something demanding suppression (Rivett 1949 cited in Deery 2000:14).

It seems that the secrecy debate that was conducted both brutishly and very publicly was centred on ill-conceived notions on the part of the government (and the citizenry) of the function of basic or non-instrumental science. As Mellor writes,

> Much of the argument in the debate was obscured by astonishing and (to scientists) disconcerting confusion over secrecy as applied to fundamental science (a suicidal policy) and

> secrecy as applied to defence science (the application of scientific principles to the problems of war)—an entirely different matter (1958: 684).

In the context of the beginning of the Cold War this was a particularly potent issue. Following the international scandal, the Federal government moved to re-organise the CSIR in order to increase security and preclude unauthorised access to scientific knowledge (Schedvin 2013: online; Deery 2000). This was a double-edged sword for Rivett. While the CSIR had been enormously successful under his leadership and he had personally contributed extensively to that success, Rivett found that the increasing focus on secrecy in science, the consequent reorganisation of the CSIR, and the transformed political environment were not conducive to his vision of scientific progress; Rivett thus resigned in 1949.

Before and during World War II the scientific milieux in Australia had been transformed. The relationship between science and democratic freedom had altered radically and scientific knowledge had raised its salience within government circles. Whereas during the 19th century and into the first quarter of the 20th century both primary[143] and secondary[144] producers had willingly shared instrumental scientific knowledge in order to benefit the whole industry and indeed the nation, this practice had been radically altered by the 1950s. The erstwhile positive relationship in Australia between science and democracy had been first modified by the establishment of the scientific bureaucracies in the late 1800s and went on to become radically reworked by

[143] As explored in Chapter 4, the sharing of instrumental scientific knowledge was commonplace in the pastoral, agricultural and mining industries during this period.

[144] Secondary manufacturers regularly shared instrumental scientific knowledge (as well as the product of their knowledge) at the International Exhibitions of the late 1800s; exhibitions were held in Sydney in 1879 and Melbourne in 1880 as well as in most continents around the world. As discussed in this chapter, Essington Lewis of BHP regularly travelled the world sharing and receiving knowledge from overseas manufacturers.

the processes of war. World War II and the Cold War ably demonstrated and indeed amplified the capacities of scientific knowledge to enhance a nation's power.

So rather than taking an active disinterest in things scientific, politicians instead were insisting on higher budgets for science and asserting that scientific knowledge production was one of 'the best investments a nation could make' (Schedvin 1987: 284). Schedvin notes, 'Science was now equated to state power, also with the means of increasing control of the human condition' (1987: 284). This political elevation of pre-instrumental science for both industrial development and for secret military purposes continued to develop during the Cold War period of the 1950s and 60s and beyond and is investigated in the following section.

5.4.4 Science and post-war reparation

After World War II the ideology of developmentalism was renewed as industrial development and pre-instrumental science was expanded. During the war non-instrumental science had slowed considerably with much of the research undertaken for the instrumental purposes of warfare. Moreover, before the war much of the pre-instrumental scientific knowledge production had been undertaken by the state in order to grow specific markets however after the war it became more common for industrialists to either import their scientific requirements or set up their own laboratories in order to conduct instrumental science for market-based products.

This post-war period witnessed the first signs of both globalised capital flows and disembedded knowledge flows as both capital and knowledge were freed from the manufacturing process; and the western world began to shift from a material economy to a monetary economy (Stehr 1994). Concomitant with this shift was the beginnings of a move by the Organisation for Economic Cooperation and Development (OECD) to streamline and centralise science policy in its member countries in order to integrate them into the emerging global economy. This strategy on the part of the OECD is discussed more thoroughly in Chapter 8.

Post World War II the CSIR had become a sizeable research organisation and had expanded into defence, physical, biological and industrial science which had 'produced diversity of corporate objectives compared with the simplicity of the 1930s' (Schedvin 1987: 322). Schedvin finds that 'the transformation of the CSIR into the CSIRO[145] was forced by the need to clarify the organization's role in defence science, but governance and management were also due for an overhaul' (1987: 322). John Dedman, the Minister in charge of the CSIR at the time declared that if the organisation was to become more important in social and economic terms it would need to become 'an integral unit of industrial society'. For Dedman, the application of rationality achieved through science was the only way to 'curb the madness of political rivalry and the social division created by economic instability' (Schedvin 1987: 323). Despite his rhetoric casting the organisation as a 'great scientific institution' Dedman's vision for the CSIR was as an instrument for economic stimulus,

> CSIR must be more than a great scientific institution – it must…play an important part in public education, in foreseeing the problems which will cry out for solution in ten years' time, and in bringing together the official or industrialist who has a problem to be solved – perhaps a problem of which he is not aware – and the scientist can solve it (Dedman cited in Schedvin 1987: 324).

So despite the national vision for science that had evolved in the post-World War II era, the state's task for the CSIRO remained pre-instrumental and development focused.

[145] Commonwealth Scientific and Industrial Research Organisation

Sensing a showdown around the vision for non-instrumental science that was held by the CSIR and that for pre-instrumental science held by the state the Executive Committee declared,

> Such wartime triumphs of applied science as radar, penicillin and the atom bomb, were all based on fundamental research conducted in civil laboratories before the war…Fundamental research leads to new knowledge, provides scientific capital and creates the fund from which practical applications of knowledge, both in the civil and military fields, must be drawn (CSIR EC cited in Schedvin 1987: 336).

These disparate visions could not be reconciled however and in the final analysis the CSIR was re-organised along conventional bureaucratic lines and management was transferred to the Public Service Board under the new name, CSIRO. The proximity of the transformed organisation to the state meant that it was more 'manageable' and would become 'an instrument of economic growth and as an integral unit of industrial society' (Schedvin 1987: 348).

Such was the importance of the CSIRO post-war that to refer to *science policy* in Australia was to refer directly to the CSIRO. As Homeshaw posits, 'Much of the analysis of science policy in Australia has focused on CSIRO. CSIRO funding is taken to be the bellwether of the state of Australian research' (1995: 525). The CSIRO was not only the barometer of science policy in Australia, it was intimately involved with co-operative instrumental research projects conducted between the large mining and manufacturing companies, the BMR, private research brokers and laboratories such as the Australian Mineral Industries Research Association (AMIRA) and the Australian Mineral Development Laboratories (AMDEL)[146] amongst others. As the century wore on and the

[146] Currently owned by international corporation Bureau Veritas

demand for scientific knowledge became more central to the global economy,[147] many of the newly globalising companies found that they could not necessarily rely on pre-instrumental science delivered by nation states. Hence trans-national corporations began to produce instrumental science within their own laboratories and relating to their own spheres of commercial activity.

Furthermore, the newly globalising capitalist economies were shifting from a material basis to a monetary footing (Stehr 1994) or from industrial society to post-industrial society (Bell 1976) and towards the network society[148] (Castells 1996). Integral to this shift is the emergence of commodity chains (Hopkins & Wallerstein 1986), meaning that the production functions of research and development, raw materials extraction, manufacturing, sales and marketing of products becomes increasingly physically disengaged from one another. As the research and product development functions are decoupled from the manufacturing process, scientific knowledge itself manifests as an explicit factor of production – a product in its own right – and as such attracts an exchange value that is independent from the utility value or price of the commodity.

The period of developmentalism discussed in this section was influential in expanding the role of instrumental science both in Australia and globally, and presaged the transformation of scientific knowledge into an explicit factor of production. The following section explores this transformation in the role and reach of scientific knowledge production and diffusion as it relates to Australia.

5.5 The expansion of instrumental science

[147] The OECD was a key figure in this centralisation dynamic. The contribution of the OECD to the emerging global knowledge economies is discussed in Chapter 8.
[148] The emergence and global impact of the network society is discussed in Chapter 8.

Development as an ideology is clearly present in the expansion of instrumental science in the mining and manufacturing industries during the 1950s and early '60s. Prior to the 1950s, commercially-oriented research had most often been provided by government bureaux or conducted by employees in the field or the workshop. As discussed in this and previous chapters the instrumental knowledge produced by the 19th century pastoralists, agriculturalists, gold miners and mining companies drew on collective expertise, from those at the coalface to those in the managerial suites; insights and expertise were also shared from and with other companies working in the same field. Between the 1930s and the 1960s however this collective approach to solving commercially-oriented scientific problems was being replaced by corporate laboratories, expert scientists, and a heavy emphasis on trade secrecy.

These changes were symptomatic of the significant fragmentation underway in the global economy; the decoupling of pre-instrumental and instrumental scientific knowledge from the manufacturing process; the shift in scientific knowledge from an intrinsic to an extrinsic factor of production thus transforming scientific knowledge from simply having use value to more explicit exchange value properties. As scientific knowledge transformed to attract both a use and an exchange value, its instrumental character became more pronounced, and the role of scientific experts became more important. Moreover, when the exigencies of secrecy that had developed during World War II (and then the Cold War) coalesced with the competitive character of the marketplace, scientific knowledge began to turn against the undertakings of the enlightenment scholars; to instead produce a dialectical relationship to the emancipative promises of the enlightenment. This concept and how it played out in Australia's secondary industries is traced below.

5.5.1 From the plant to the laboratory

The earliest forms of instrumental research in Australia tended to be conducted at 'plant level rather than in the laboratory' and were particularly significant to the development of the mining and manufacturing industries (O'Malley 1988: 744). Examples of these early scientific discoveries include the Potter-Delprat flotation method invented concurrently by Melbourne brewer Charles Potter and Guillaume Delprat's mining team at Broken Hill in order to extract zinc from waste mineral (Clark et al 2006); the pyritic smelting of copper at Mount Lyell invented by Robert Sticht and his team (Rae 2006: online); the process of continuous lead refining at Port Pirie by George Williams and fellow miners (Branagan 2013: online); and the electrolytic zinc extraction at Risdon under Howard Gepp's management (Rae 2006: online).

Although instrumental in character each process was developed on the mine site as a result of collective experimentation by managers and workers.[149] Conversely, by the late 1950s and beyond many of these early onsite collective problem-solving experiments were dispensed with in favour of scientific experts working in research laboratories. The Australian Mineral Industries Research Association (AMIRA) is one such example. AMIRA was established in 1959 in order to provide a private research service for the Australian minerals industry. Attending the inaugural meeting of AMIRA, held at the head office of the AusIMM, were 'Ian McLennan, Chief Executive of BHP (now BHP Billiton), Maurice Mawby (Consolidated Zinc, now part of Rio Tinto), George Fisher (Mount Isa Mines, now absorbed into Xstrata) and G. Lindesay Clark (WMC, now absorbed into BHP Billiton)' (AMIRA 2019: online). The news release announcing the fifty year anniversary advised that,

[149] Examples of this are explored in Chapter 4.

> All of this group were Australian and all were eventually awarded knighthoods for their services to the industry – and rightly so: each played a role in expanding the activities of the companies they headed and in several cases paved the way for the emergence of their companies as global players. The Association they founded has, through nearly a thousand research projects, returned to industry dividends on their research investment of more than a billion dollars (AMIRA 2009: online).

This transfer of scientific knowledge production from a broadly collective activity at the site of the real world problem to a more distant environment occupied by experts in specialist laboratories (who are represented by knowledge brokers) demonstrated a shift of instrumental knowledge from a collective endeavour to one controlled by market forces. For instance, the scientific process that was discovered in order to extract the valuable zinc from the slag heaps at Broken Hill in the early 1910s came about through the combined efforts of many (Blainey 2010). Indeed, Blainey comments that BHP, despite being the largest industrial company in Australia, did not need a research laboratory until the mid-1950s. Instead Essington Lewis would

> …travel the world in mail steamers every few years to examine steelworks and allied plants, coke ovens and coal mines, just to find out the latest information and new techniques. He would come home after his tour of Europe and North America, his notebooks full of information. As BHP was not an international competitor, no overseas company seemed to resent it pirating or borrowing new techniques. Moreover, Lewis freely divulged information about BHP's practices and also the prospects of Australia's steel markets (Blainey 2010: 30).

By 1957 however to the economic and political function of knowledge production and diffusion was transforming. Bell (1973) argues that the symbolic onset of post-industrial society and the escalation of knowledge as a commodity began at the end of World War II; Richta and colleagues (1969) date the shift from the 1950s. Stehr after

Giddens (1990) posits that 'a new consciousness about time and social change' (1994: 8) began to emerge in the 1950s when the material economy (such as Australia's manufacturing economy) gradually moved to include knowledge which increasingly attracted a value (Stehr 1994: 10; Gibbons *et al* 1994). Castells (1996) maintains that the highly networked digital economy that emerged during the 1970s produced a *network society* whereby money and information traversed the globe through a *space of flows.*[150]

By the late 1950s scientific knowledge was not as easily shared[151] as it had been at the turn of the century. To continue to lead Australian industry, BHP needed to establish a formal research arm; the Central Research Laboratories (CRL) located at Shortland near Newcastle in New South Wales were the first of the private laboratories set up by BHP. The laboratory's principal functions 'involved R&D into raw materials and processes, technical consultation with BHP's operating centres and provision of centralised analytical, testing and information services' (SSCSE 1979: 942). Moreover, the Melbourne Research Laboratories set up by the company in 1969 functioned to 'maintain or expand the Companies' current markets, create new markets, provide technical information to the Company's customers and provide a consultancy to the Company's operating centres' (SSCSE 1979: 944).

There are significant differences between the type of scientific research conducted by BHP on the mine site in 1910; the type accessed through the informal sharing of knowledge by Lewis and his contemporaries; and the type of private market-specific knowledge that was emerging in the 1950s and '60s. This change in the way that

[150] Castells' ideas are explored in theoretical terms in Chapter 2 and again in an empirical context in Chapter 8.
[151] For reasons discussed during this and previous chapters.

knowledge was procured by BHP demonstrates the shift in global relationships to knowledge production and the transformation of developed markets from material or industrial footings, to economic or knowledge-based operations.

These shifts in knowledge production and diffusion also reveal a change in the way that companies related to each other. The push for the development of the manufacturing industry as a whole in Australia during the early 20th century had motivated co-operative relationships between the participants in the market in order to put collective pressure on the state. By the end of the 1970s however the rise of scientific knowledge as an important commodity, concurrent with the introduction of neoliberalism as the guiding principle of economic policy, pushed the individual corporations into competition against each other.[152] Instrumental knowledge was to outflank both pre-instrumental and non-instrumental knowledge by the turn of the 21st century. In the meantime, as pre-instrumental and instrumental scientific knowledge boomed at the behest of the prosperous manufacturing companies during the first half of the 20th century, non-instrumental science was not so expansive.

5.6 Non-instrumental science at the periphery

Even with the high levels of state support for pre-instrumental science that had been demonstrated during the 19th and early 20th centuries, the political will for the production of non-instrumental scientific knowledge in Australia remained feeble, and the provision insubstantial. Conventional producers of non-instrumental science including the universities, the natural history museums, the botanic gardens and so

[152] This shift is discussed in greater depth in Chapter 8.

forth, had not fared well during an era characterised by industrial development and the machinations of war.

As pre-instrumental science flourished on the national stage, the State-based universities continued their decline. Most universities in Australia had been founded on the basis of teaching undergraduate students and, particularly before World War II, did not have the financial or academic resources to either educate post-graduate students or to conduct non-instrumental science. Similarly, the Australian Museum in New South Wales was relegated to conducting exhibitions and teaching natural history to school students rather than conducting non-instrumental scientific research. The status of both the Australian universities and the Australian Museum in terms of the on-going production of non-instrumental scientific knowledge during this period is explored in the remainder of this chapter.

5.6.1 Universities in crisis

In the first half of the 20th century Australia's universities were simply teaching institutions; rarely did they contribute to the production of non-instrumental science. Ostensibly the producers of non-instrumental scientific knowledge the universities were in reality more oriented to acting as certifying agencies (Conant 1951). As discussed previously, the universities had been encouraged by bourgeois colonial governments and successive State governments to concentrate their efforts on educating 'the middle classes' in the humanities, the law and medicine. Any scientific research that was conducted had been of a predominantly pre-instrumental character. Schedvin notes

> The neglect of research was not new. Australian universities had been established as teaching institutions in the liberal tradition;[153] writing and research were regarded as the private occupations of the exceptionally energetic or the eccentric (1987: 12).

Macintyre finds that by the 1930s the 'six dilapidated universities' were still teaching fewer than 12,000 undergraduates and 'the gulf between these intellectuals and the mistrustful, practical men who exercised authority had never been wider' (2009: 187). The funding situation did not improve when the Federal government chose to steer research funds towards the newly established CSIR rather than towards the universities. As discussed previously, the new industrial/military strategy began to emerge after World War I and by 1937 the CSIR was commissioned to develop the Secondary Industries Testing and Research Committee (SITRC). The aim of this new committee was to investigate the means by which the CSIR could contribute to the development of the new secondary industries (Connell & Irving 1980; Cochrane 1980). Thus as the Commonwealth research funding was steered towards the CSIR, Australia's six universities slipped further into financial crisis. Tomkins writes 'Australian universities have never had an easy road…In their efforts to win a sympathetic audience the universities have had to cope with the skepticism (sic) of the Australian man-in-the-street, a pragmatist inclined to view the "intellectual" with suspicion' (1958: 361).

University finances were problematic. The universities were largely financed from a mixture of student fees, donations and bequests as well as the occasional fixed grant received from State governments; universities' finances were thus linked with the prevailing economic conditions. This way of financing the universities was strained to

[153] This thesis argues in Section 5.3.1 that the universities had been established as teachers in the liberal tradition, as teaching institutions for doctors and lawyers, and as producers and diffusers of pre-instrumental science.

breaking point in the first years of the 20^{th} century as increasing numbers of children of the bourgeoisie sought a professional education. Furthermore, after World War I the government provided financial assistance to enable ex-servicemen to enrol at the universities; the demand for practical education increased substantially. New degrees in engineering, dentistry, education, economics and commerce were added to the extant degrees of medicine, law and mining.

The growth in student numbers and the additional academic disciplines served to severely strain the budgets of the universities. Government grants were commonly late and often inadequate, and student fees did not cover the increasing costs associated with a larger student load (Schedvin 1987). Schedvin finds that

> As a consequence, the period between the wars was one of extreme parsimony, of deterioration in buildings and equipment, of growing classroom pressure on teaching staff, and of research undertaken in primitive physical conditions and in spare moments between lectures and demonstrations (1987: 12).

During World War II the universities went into further decline as staff and students were redirected to the war effort (Schedvin 1987). Mellor finds that the primary research agencies during the war, the CSIR and MSL, significantly overshadowed any scientific research produced by the universities and in some cases research was duplicated,

> Instances of two or more laboratories working on the same problem but unaware of each other's efforts were not uncommon. University scientists were working on problems in the belief that they were making a useful contribution to the war effort when in fact the same problem had already been solved in some government laboratory (Mellor 1958: 57).

Mellor (1958) argues that this was due to the inundation of undergraduate students after World Wars I and II, the ongoing shortage of funds and the absence of postgraduate students, particularly those undertaking the degree of Doctor of Philosophy. It was not until the 1950s that Australian universities began to enrol PhD students; prior to that, higher research students had been forced to go overseas to complete their education. Moreover, the staff to student ratios in Australian universities was particularly high at 1 to 20 in comparison with other countries (1 to10 in Britain and as low as 1 to 4 in some American institutions). Mellor notes,

> … (This) indicates how unsuitable conditions were for scientific research. As a general rule, the smaller the ratio, the better the conditions. In proportion to her population, Australia was sending more students overseas for advanced scientific training than probably any other country (1958: 678).

It was only after Robert Menzies became Prime Minister for the second time in 1949 that the plight of the nation's universities was addressed. Mellor reports that

> …The Federal Government was spending more on applied science than on pure science. The C.S.I.R.O., for example, received approximately £3,000,000 a year, whereas the total university expenditures on scientific research financed from Commonwealth funds was only of the order of £100,000. Considerations such as these provided powerful arguments in favour of a national university devoted to postgraduate studies (1958: 678).

As discussed previously the Australian National University had been established by the Chifley government in 1946 as part of the post-war reconstruction effort. However, ANU laboured under the same financial difficulties as the State run universities and was particularly impoverished in terms of the production of non-instrumental scientific knowledge (Murray 1957).

Concerned about the parlous state of Australia's universities, conservative Prime Minister Robert Menzies appointed a 'Committee on Australian Universities' in 1956. The Committee was led by Sir Keith Murray in order to conduct an official inquiry into the status of Australia's by then eleven universities and to consider the potentiality for a national research university to be founded in Canberra. The Terms of Reference included 'enrolments, attrition, guidance, and scholarships; honours and postgraduate programs; staff problems; facilities and equipment; scientific and technical education; university policy-making and administration; and financial needs' of the universities (Tomkins 1958: 363). Moreover, the Terms of Reference reflected the importance placed on technical or pre-instrumental science within Australia at the time. As Murray (1957) writes,

> In our discussions with the universities, and others, and in drafting this report we have, however, kept very much in the forefront of our minds the four major topics to which the Prime Minister turned our attention when he invited us to "indicate ways in which the universities might be organized so as to ensure that their long-term pattern of development is in the best interests of the nation, and in particular to inquire into such matters as-
>
> 1. The role of the university in the Australian community;
> 2. The extension and co-ordination of university facilities;
> 3. Technological education at university level; and
> 4. The financial needs of universities and appropriate means of providing for these needs." (Murray 1957: 5).

The Report of the Committee on Australian Universities (1957), known informally as the Murray Report, provided in turn an extensive review of Australia's universities. The main findings indicated that by limiting the universities to teaching only, the nation was facing an intellectual crisis.

> …education of the graduate is only one of the two central aims of a university; the other is research, the discovery of new knowledge for its own sake. Finally, the universities are or should be the guardians of intellectual standards and of intellectual integrity in the community (Murray 1957: 120).

The Murray Report (1957) confirmed that the sciences in particular had been neglected and required urgent review; the status of Australia as a prosperous, industrial nation was in jeopardy if the Federal government did not immediately begin massive funding initiatives. The Federal government's plans to expand the number of universities, particularly addressing the paucity in technical education, were rejected by the Committee.

> Provision for the sciences and particularly the technologies presents one of the most urgent problems facing the Australian universities. The universities are faced with problems of such magnitude in improving their existing departments of pure and applied science that the establishment of new departments in the immediate future should be undertaken only under exceptional circumstances (1957: 123).

Notwithstanding the emphasis on technological education the Report (1957) is firm in its aspiration to provide a balance between non-instrumental and pre-instrumental science. Indeed, Chapter One of the report, entitled 'The role of the universities in the community' takes care to establish the importance of non-instrumental science as a precursor to pre-instrumental science. Point eight of Chapter One has been reproduced here in its majority as it speaks to a foundational argument for non-instrumental science in Australia.

> But education is only one of the two central aims of a university. The other is research. Research is of various kinds and is conducted under various kinds of organization. But there is one kind of research which is in general best done in universities and the greater part of which in recent generations has in fact been done in universities. It is obvious that most of the basic secrets of

> nature have been unravelled by men who were moved simply by intellectual curiosity, who wanted to discover new knowledge for its own sake. The application of the new knowledge usually comes later, often a good deal later; it is also usually achieved by other men, with different gifts and different interests. In general, especially nowadays, the work of applying new knowledge is roughly predictable – it is possible often to foresee how long it will take to solve a particular problem in this field – and it can be organized. So far as the fundamental insights are concerned in scientific speculation and inquiry the wind bloweth where it listeth. Advances in knowledge have come because free inquirers have been pursuing their own ideas and insights, devotedly and with great persistence, in pursuit of enlightenment for its own sake… (Murray 1957: 9).

By addressing the scarcity of specialist research areas and dearth of postgraduate students, the Report (1957) also questioned the functions of the CSIRO, the Australian Atomic Energy Commission and the newly founded Australian National University (ANU) finding that

> …before measures are taken to establish additional highly specialized scientific departments, particularly those which would be concerned primarily with advanced and post-graduate training, consideration should be given to the possibility of collaboration with such research organizations as the Australian National University, C.S.I.R.O., and the Australian Atomic Energy Commission (Murray 1957:70).

Further, the Report (1957) recommended that the Bureau of Mineral Resources and the Defence Scientific Services of the Department of Supply Report (1957) could provide opportunities for scientific cooperation. Until the late 1950s these scientific bureaux had operated independently of each other (Schedvin 1987).

In many ways the CSIR was disparaging in their view of the universities (Schedvin 1987),[154] suggesting that in the main the universities were not sufficiently well resourced or indeed proficient to collaborate with the CSIR in scientific projects. Postwar the situation deteriorated even further and as the CSIR budgets grew, university funding became increasingly dire. In an effort to address the conditions of hardship which continued to plague the universities, the Murray Report (1957) recommended the establishment of an independent and permanent funding body attached to the Prime Minister's Department. This funding body would provide the Federal government with rational and ongoing advice on the funding requirements of the universities. This forerunner to the contemporary Australian Research Council (ARC) was the Australian Research Grants Committee (ARGC) established in 1957. The Report (1957) also proposed that universities offer a greater number of research scholarships drawn from their increased funding arrangements in conjunction with the scholarships already offered by the CSIRO and the Australian Atomic Energy Commission.

The Murray Report (1957) was central to the transformation of the universities from teaching organisations to vital contributors to the nation's production of non-instrumental scientific knowledge. This new synthesis of teaching and research recommended by the Murray Report (1957) was foundational to the contemporary university structure and was highly supportive of non-instrumental science.

Notwithstanding the liberal spirit found in the Murray Report (1957), Menzies and his government were not so convinced. Forsyth (2012; 2013) reports that the

[154] One of the few areas of research where there was genuine collaboration between the CSIR, the Australian universities and the international science community was the top secret development of radar during World War II (Schedvin 1987).

centralisation of university funding within the Prime Ministers Department was not as benign as first suggested.

> Confidential cabinet documents held in the National Archives, however, tell a different story. Much as Menzies was sympathetic to the universities, he was also compelled to ensure that Federal funding resulted in national benefits. While those in the universities considered the Australian Universities Commission to be a buffer body like its UK counterpart, Menzies instead saw it as the vehicle for assuring fulfilment of government goals. To Cabinet, he argued: Money is the weapon by which oversight of universities will be secured, but the intention is more than monetary. It is hoped that the Commission will devote itself to thought about the development of universities in the widest sense. It will advise precisely on the buildings which the Commonwealth should support at each university…as well as expenditure on other matters such as laboratory equipment or libraries (Forsyth 2013: online)

Murray's vision for the production of knowledge in Australia demonstrates that balance may be achieved between the non-instrumental sciences conducted by the universities; the pre-instrumental science conducted by state supported scientific bureaux; and the instrumental science, specifically for the market, developed by corporations themselves. However, as Forsyth's (2012; 2013) work suggests, this vision may become clouded when mixed with money and power.

While Murray's report recommended that the universities were provisioned for the evolution from an industrial society to a knowledge society, the longstanding producer of non-instrumental scientific knowledge in Australia, the Australian Museum, continued to be overlooked. This official indifference towards the museum, both as an important research institution in its own right and as the only scientific organisation with direct access to the public sphere at that time, is examined in the next section.

5.6.2 The modernisation of public-facing science

Institutions geared towards producing scientific knowledge not required for industrial development or for the war effort, the Australian Museum and the Botanic Gardens, managed to maintain their production and diffusion of non-instrumental science during this period, albeit barely. This section explores the modernisation of Australian Museum and the rise of popular science in an era of experts. The Australian Museum, as Australia's first museum, and a dedicated natural history museum, is used as model in order to understand the shifts and changes faced by scientific organisations dedicated to the advancement of scientific knowledge as a function of civil society. Note that the Australian Museum is a State-based museum and that most colonies, and States, had similar organisations.

The Australian Museum, between the years 1921 and 1954 has been described by its historian as 'drifting' (Strahan 1979: 61). In the context of war, economic depression, increasing demands of the primary and secondary industries, and the drive for economic and industrial development, the non-instrumental scientific knowledge produced by the Australian Museum seemed, to many government officials, antiquated and of limited importance.

Attempts were made to modernise the museum in the 1930s by following the American model exhibited in the Smithsonian Institution and Californian Academy of Science Museum. This model sought to produce more interesting and more exotic displays in the public galleries and leave the practice of non-instrumental science well and truly behind the scenes. The move effectively separated scientific knowledge production from its publics and set up the paradigm of science communication; the realm of communication experts rather than scientific experts.

Science communication and *museum studies* are closely aligned in the literature; both advocate the use of theatrical approaches to produce a type of social constructivist learning (Guba & Lincoln 1994) amongst their publics. This conflation of art with scientific knowledge has been enthusiastically embraced by museum curators and marketers since at least the 1930s (Markham & Richards 1933). Science communication is a journalistic style of knowledge diffusion, often separated from the main source of non-instrumental scientific knowledge in terms of time and space, and set up as an interesting, though often conceived as an irrelevant adjunct to daily life. In contrast, the instrumental scientific knowledge produced and diffused by marketers of, for example, health and beauty products, is positioned as critical to everyday life and treated accordingly by a consuming public. Science communication, similar to the rhetorical communication produced by marketing companies, works to separate scientific knowledge out of everyday life by inserting a sphere of entertainment[155] into the spaces between knowledge production and its diffusion.

Certainly a key driver of science communication[156] is the notion of entertainment and even spectacle (Olsen 2009). Contributing to this sense of performance is the use of the *deficit model*[157] which assumes as its starting place a deficit of scientific literacy on the part of the public (Gregory & Miller 1998). This employment of entertainment and spectacle in the delivery of science communication and the assumption of deficit on the part of the audience arguably stems from the shift of museums as scientific institutions and halls of learning (as they were between the 1500s and the early 20th century)

[155] Or 'infotainment' as it is often called.
[156] Science communication draws on a journalistic heritage as distinct from the 'public understanding of science' (PUS) or the 'public engagement with science (PES) programs which tend to proceed from a scientific base and work towards an overarching understanding/engagement with scientific knowledge as a category.
[157] The deficit model of science communication is explored more thoroughly in Chapter 7.

(Findlen 1996) to sites for culture and domains of infotainment or scientific theme parks (Bennett 1995; Prior 2006; Conn 2006) in the contemporary milieu.[158]

Museum scholars have drawn parallels between the developments of museums as places of serious scholarship to their current manifestation as cultural pleasure palaces (Bennett 1995). These developments can be seen empirically in the complex interplay of capitalist praxes enacted through the International Exhibitions (or World Fairs) of the late 19th century (Rydell 2006) and the advent of department stores during the latter part of the 19th and the early part of the 20th century arguably contributed to the modernisation of museums. A complex interplay of capitalist praxes enacted through the International Exhibitions (or World Fairs) of the late 19th century (Rydell 2006) and the advent of department stores during the latter part of the 19th and the early part of the 20th century arguably contributed to the modernisation of museums. Rydell writes that the world fairs[159] were

> …showcases of scientific and technological innovation. From air conditioning through escalators to x-rays, world fair introduced mass publics to the building blocks of modern civilisation. But more than this, exposition authorities sought to use the power of display to convince the public of the necessary connection between scientific and technological innovation and national progress. Not surprisingly, given the transitory nature of expositions, not a few builders of world fairs sought to sustain the educational – and ideological – value of their work by housing world fairs in museums (2006: 143).

[158] The Australian aestheticisation of public-facing scientific knowledge producers is discussed in Chapter 7.
[159] The influences of these world fairs or international exhibitions on Australian science was discussed in Chapter 3.

Moreover, the evolution of the museum as the site of the spectacular (and paradoxically the modern) was concomitant with the emergence of not only the world fairs but also the department store. Leach (1984) writes

> By the turn of the century, shopping had developed into an almost full-time secular and public business. It was also an adventure bursting with new meanings… (1984: 333). The department store borrowed from other mass consumer and public institutions, as they did from it. By 1920 the department store was a zoo (Bloomingdale's and Wanamaker's in New York had enormous pet stores), a botanical garden (floral shops, miniature conservatories, roof gardens), a restaurant (some of the major stores had lavish restaurants bigger than any other in their cities), a barber shop, a butcher shop, a museum (gift and art shops, art exhibits), a world's fair, a library, a post office, a beauty parlor (Leach 1984: 326).

Prior (discussing art museums) argues that in the contemporary milieu museums, shopping malls and cinemas have become conflated,

> The erosion of boundaries between the aesthetic and the economic, between art and popular culture, are the results of processes of cultural commodification…which have themselves (sic) placed museums alongside shopping malls and cinemas within the realms of consumption and entertainment (2006: 519).

In Australia, the twin influences on the modernisation of museums were firstly, the Report on the Museums & Art Galleries of Australia (Markham & Richards 1933) conducted by the Museums Association in London and funded by the Carnegie Corporation in New York, and secondly, businessman Ernest Wunderlich, the Trustee and President of the museum and co-owner of Wunderlich Patent Ceiling & Roofing Co (Walsh 2013: online). Both of these influencers called for a radical shift in display techniques and changes to the way non-instrumental science was communicated to the public. Wunderlich's modernisation strategies called for the museum to lead a campaign to popularise science.

This popularisation strategy included the launch of a popular science magazine produced specifically for non-scientists and known as the *Australian Museum Magazine* plus a greater emphasis on exhibition displays amongst other business-like activities; the famous diorama display technique was introduced into the Australian Museum by Wunderlich. These activities may have been popular with the public but were deeply unpopular with the museum's scientists. Strahan (1979) reports that eleven days the *Daily Telegraph* published letters and articles about the 'Museum Turmoil' summarised in the following extract

> …the Australian Museum, the leading institution of its kind in Australia, is the centre of considerable turmoil…In the general contention of the Trustees it is understood that a basic principle is involved – whether the museum should be primarily for 'show purposes' or whether its chief purpose should be education through scientific research (DT 8 July 1926 cited in Strahan: 66).

The final article in the *Daily Telegraph* noted that 'The modernists have won a partial victory. But they have won it at a cost. Some complain that the institution has been "Americanised". Others are certain that it had not been Americanised enough' (DT 19 July 1926 cited in Strahan 1979: 66). The Americanisation or modernisation of the Australian Museum continued into the 1930s and '40s when the Carnegie Institution sent representatives from New York to evaluate the educational institutions in Australia.

Following the publication of a 'damning report' (Fox 2010: 1) on the nation's museums and galleries, the Carnegie Institution undertook to deliver the appropriate training to transform the Australian Museum and to provide the seed funding required to modernise the institution (Fox 2010). The Markham and Richards Report (1933) found that the nation's 'educational instrumentalities (including libraries and museums) were in… a parlous state' (Fox 2010: 1). Moreover, one Carnegie visitor to Australia, Mr Frank Tose, of the California Academy of Science publicly described Australia's Museums as 'morgues' (Anon. Argus, 13 August 1937: 10). The Australian Museum in particular was pronounced as 'overcrowded (with) unsuitable buildings, deteriorating collections, meagre staff salaries and minuscule research funding' (Markham & Richards 1933 cited in Mulvaney 1993: 17). The same Mr Tose also declared the Australian Museum 'cold and uninviting' and sought instead to 'lighten and enlighten all who venture into the somewhat depressing atmosphere' (Anon. Argus, 13 August 1937: 10).

Tose subsequently went to work with the museum's preparators, teaching them how to showcase the Australian fauna in its natural 'habitat' and how 'to hold, as't were, the mirror up to nature' (Anderson in AMM 1/10/37). The new displays continued with the diorama displays in order communicate the notion of 'habitat' and to simplify the research for public visitors. The *Australian Museum Magazine* of 1 October 1937 (Anderson 1937) carries a glowing article about the 'debt of gratitude' owed to Tose for the instruction received in the modernising of the public displays in the museum.

Paradoxically, Wunderlich's preference for promoting popular science over expert science and the Carnegie Institution's simplification of research into three-dimensional displays for public consumption prepared the way for the success that the museum had in addressing environment issues of the 1960s and beyond. As scientific knowledge was increasingly produced by experts for experts and for economic return, the Australian Museum under the subsequent directorships of John Evans (1955-1966) and

Frank Talbot (1967-1975) contributed to a counter-movement that encouraged the growth of a political public sphere and promoted government engagement with non-instrumental earth and environmental science. The next chapter explores the influences of a growing environmentalism on the extant development agendas.

5.7 Conclusion

As the nation transitioned from individual colonies to a federal system of government, a centralised layer of scientific knowledge production and diffusion was added to that already provided by the States. While the States retained their pre-instrumental knowledge production facilities this new, centralised layer came to be bound up with expansionary goals of both the state and the market. Under the remit of developmentalism the state and the market collectively undertook firstly, to ready the nation for the eventuality of war and secondly, to integrate Australia into the marketplace as a globally competitive, industrialised nation.[160]

Each of these centralised policy areas initially rested within the discourse of nation-building and post-war reparation; and pre-instrumental science was seen to be critical to each of these projects. It is noteworthy however that the character and use of pre-instrumental science tended to shift in line with the wants of the preeminent capitalists of each period. As clearly demonstrated in this chapter, a major shift in power occurred between the older rural capitalists and the new industrialists and this shift was accompanied by a modification in the focus of pre-instrumental scientific knowledge production and diffusion. This shift in power and focus combined with effort to effectively compete on the global stage, both in terms of the war effort and in the

[160] This aim is discussed further in Chapter 8 particularly in terms of the OECD's involvement in centralising science policy amongst its member states.

development of the primary and secondary industries, saw the national state introduce high levels of protectionism.[161] This protective action on the part of the state included a range of strategies, not least of which was a substantial increase in the production and diffusion of pre-instrumental scientific knowledge.

Between and during the wars, pre-instrumental scientific knowledge had increasingly become the domain of experts who worked behind the closed doors of the laboratory to enact the often secretive political and economic goals of the state and the market. This period saw the transformation of instrumental scientific knowledge from the spontaneous sharing of field-based knowledge across all levels of expertise into a highly instrumentalised type of knowledge production; this newly instrumentalised knowledge production was performed by highly specialised scientists under the conditions of rivalry and confidentiality initiated by the war effort.

After the war the clandestine character of scientific knowledge and the obligation to compete with other nations were exacerbated by Australia's determination to industrialise. The strategies of developmentalism continued the reworking of scientific knowledge from an implicit to an explicit factor of production. Where utility value had been primary, scientific knowledge was being transformed to attract both a utility value and, increasingly, an exchange value. These shifts signalled the earliest moves from industrial society to a post-industrial, globally networked society. Further, these shifts diluted the political will for non-instrumental science as the Australian Museum and the nation's universities struggled for relevance and funding in this economy-centric period. Notwithstanding the difficulties encountered by the producers and diffusers of non-

[161] Castles' domestic defence model (1989)

instrumental science during the first half of the 20th century, the new social movement of environmentalism reignited the political will to engage with the more substantive aims of non-instrumental science through politically enabled value-rational social action. The following chapter explores the rise of environmentalism through the lens of non-instrumental science.

6 1960s-1980s: Science and environmentalism

The distinctive set of social, economic and scientific conditions that emerged in Australia during the late 1960s and 1970s demonstrated that non-instrumental scientific knowledge production could work alongside the new social movement of environmentalism to advance the rational, democratic aims of enlightenment scholars and to reposition non-instrumental scientific knowledge into a *post-materialist* civil society. As discussed in previous chapters, the non-instrumental science that had been inspired by the enlightenment to facilitate a strengthening of civil society had, in pre-1970s Australia, given way to pre-instrumental science created by the state for the purposes of developing primary and secondary markets and for the provision of the war effort.[162]

Where the scientific community had been signalling environmental concerns since the 1880s it was not until the second wave environmental movement of the 1970s and '80s however that public concern and non-instrumental science coalesced to produce political and legislative change at the level of the state. This chapter considers the salient differences between the first and second wave environment movements in Australia in terms of their relationships with non-instrumental science, the state, the market and civil society.

6.1 A fertile environment for the natural world

Australian scientists and some sectors of the public had long been concerned about the degradation to the natural environment at the hands of unconstrained development.[163]

[162] Instrumental science would emerge as an entity in its own right from the 1980s. This transformation is discussed in Chapter 8.
[163] The earliest signs of this concern had emerged during the 1880s but had been restrained by the interpenetration of the state, the market and scientific knowledge during the first half of the 20th century. The

By the 1960s however developmentalism in Australia was losing ground to the emergence of a 'second wave' of environmentalism (Hutton & Connors 1999: 89). This second wave was initiated by the *cultural left* during the fertile social and political conditions of the early 1970s (Hutton & Connors 1999: 125) and opened up the political public sphere (Habermas 1981) for rigorous debate. This debate in turn produced a capacity for value-rational social action on the part of the polity and a positive political response. The causal factors of this rise in public concern for the environment are both indistinct and complex and will not be interrogated in any great detail within the scope of this thesis.[164] This section considers the two waves of environmentalism associated with non-instrumental science that have occurred in Australia (Hutton & Connors 1999; Robin 1994).

The first wave which proceeded from the 1860s to the end of World War II was a non-movement based on awareness and discussion amongst the learned societies[165] and a small base of concerned citizens. On the other hand, the second wave of environmentalism demonstrated a powerful coalescence between the production and diffusion of non-instrumental scientific knowledge and a concerned public. Despite the bonds between the state and the market in favour of the primary industries extant in

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interpenetration had served to support the ideology of developmentalism in Australia and the accompanying growth of primary and secondary industries.

[164] At least seven primary stimuli have been associated with the escalation of environmentalism in Australia during the 1970s and beyond and are footnoted here as background and context. These stimuli included: international forces accompanying globalisation and the intensification of the dynamics of modernity (Giddens 1990; Castells 1996, 1997, 1998, 2005; Inglehart 1977, 1997, 1990); Australian public dissatisfaction with state support of industry at the expense of social amenity (Macintyre 1999; 2004; 2009); a romantic counter-movement to over-development on the part of the citizenry (Benton 1991, 2002); the rise of a new social movement around environmentalism that was initiated by the cultural left (Hutton & Connors 1999); the use of non-instrumental science in the political public sphere to present a rationale for preservation of the natural environment (Robin 1994; 1998); a fertile political environment (Manne 1999) and a temporary relaxation of the intimate bonds between the state, the market and scientific knowledge.

[165] These learned societies included the Australasian Association for the Advancement of Science (AAAS), the Royal Society of New South Wales and the Linnaen Society.

the late 1960s, an underlying public interest in environmental issues had been simmering since the 1860s and was gathering strength. This interest was being stimulated by educational groups such as nature clubs (Hutton & Connors 1999) in conjunction with a steady stream of scientific awareness being created by some scientists (such Rachel's Carson's with *Silent Spring* ([1962] 2002) or Paul Erlich (1968, 1970)) around the significance of non-instrumental science to the protection of the natural world. The following section discusses the first wave of environmentalism in Australian before proceeding to consider the contextual basis for the emergence of the politically successful second wave.

6.1.1 The first wave: 1880s to World War II

Despite scientific and public anxiety around the environmental fallout of the primary and secondary industries in Australia, the first wave movement was largely unsuccessful in engaging political attention. As Hutton and Connor note,

> The political strategies of early conservationists showed little variation, largely relying on traditional lobbying and public meetings. When blocked, they tended to retreat to educating the public on environmental values; but they also developed campaigning techniques that are still used by the modern movement. Early campaigns never developed the mass scale of their contemporaries, the labour, women's or peace movements, and this has contributed to their historical invisibility. Yet the conditions of Australia's development provoked a number of anxieties that fed a series of largely sequential mobilisations around environmental issues that sustained environmental opposition until World War II (1999: 19).

Notwithstanding the ongoing public unease around developmentalism and the accomplishment of some important environmental aims such as the 'first national parks and state legislation for flora and fauna protection', 'the scientist stream of the movement began to decline' (Hutton & Connors 1999: 59). Moreover, the early achievements of the movement had included the formation of a state bureaucracy designed to facilitate environmental policy delivery and ensure environmental compliance. However, as Hutton and Connors find, the 'structures resulting from movement's efforts had surrendered within a few decades to control by the resource industries that they were supposed to regulate' (1999: 59). Robin (1994; 1998) also notes that the environmental agenda that had been established within the scientific community since the late 19th century and carried forward by institutions such as the Australian Academy of Science (AAS)[166] and the Australian Conservation Foundation (ACF),[167] was politically unproductive.

Notwithstanding the scientific authority of these organisations (Robin 1994) and their importance in maintaining the political discourse around environmental degradation, ultimately neither the influence of these organisations nor the civically motivated public campaigns were constructive in changing the focus on development agendas. The tensions between Australia's scientific community, its underlying concern for the natural world, its desire to undertake non-instrumental science in this largely

166 'The Academy was founded on 16 February 1954 by Australian Fellows of the Royal Society of London with the distinguished physicist Sir Mark Oliphant as founding President. It was granted a Royal Charter establishing the Academy as an independent body but with government endorsement. The Academy's Constitution was modeled [sic] on that of the Royal Society of London. It receives government grants towards its activities but has no statutory obligation to government. The objectives of the Academy are to promote science through a range of activities. It has defined four major program areas: recognition of outstanding contributions to science; education and public awareness; science policy; international relations' (AAS 2015: online). Also see Section 4.3 for a discussion of the Australian Academy of Science and its predecessors the Australian and New Zealand Association for the Advancement of Science (ANZAAS) and the Australian National Research Council (ANRC) in Fenner (1995 and 2008).

167 The Australian Conservation Foundation (ACF) is a leading national environmental organisation in Australia. It was founded in 1963 by 'distinguished entomologist Francis Ratcliffe (when he) was inspired by a memo from the Duke of Edinburgh. He consulted with his CSIRO colleagues and alongside conservationists and community leaders, worked to establish a national conservation body. The memo was actually a request for help to start a World Wildlife Fund branch in Australia, but instead led to the accidental start of the Australian Conservation Foundation. And so, at a conference of 44 delegates in Canberra in 1964, the organisation that was to become the Australian Conservation Foundation was born. A Commonwealth grant of £1000 helped with establishment costs…today the ACF is a community-based, not-for-profit organisation focused on advocacy, policy research and community outreach' (ACF 2015: online).

undiscovered (in scientific terms) continent, and the active role it played in Australian public life can be observed from the early 1800s.[168] Where these early scientists were yoked to the goals of development they were also cognoscent of the risks to the environment associated with an unbalanced approach to instrumental scientific knowledge production and diffusion. While instrumental science was important for the economic development of the nation scientists agreed that this position needed to be balanced with non-instrumental science linked to more value-rational social aims.

The first-wave of concern around over-development was marked out by the President of the Australasian Association for the Advancement of Science (AAAS) James Hector in the late 19th century. In his inaugural address recorded in the Report of the Third Meeting that was held in New Zealand in January 1891, Hector pointed out that over-zealous pastoral and agricultural industries had depleted the soil nutrients; he cautioned fellow scientists against 'the rapid deterioration which the soil must be undergoing by the steady export of the constituents on which plant and animal life must depend for nourishment' (1891: 14). The problems associated with introduced species was also flagged by Hector during the same address,

> … The facility and rapidity with which changes are effected at the present time should put us on our guard against rashly accepting species which may have been accidental intruders, though wafted hither by natural causes, as belonging to the original endemic fauna or flora (Hector 1891: 18).

[168] These tensions were discussed in terms of the state policies supporting instrumentalism and developmentalism in Chapters 3, 4 and 5.

Additionally, scientists at the same meeting in 1891 spoke out against a devastating new worm disease affecting and ultimately killing the oysters in the oyster fisheries of New South Wales,

> The Hunter, the Hawkesbury, and the Clarence rivers may be mentioned not only as the most important of the oyster-growing areas, but also as those in which the worm disease, or, as may be more correctly termed, the "mud disease", has been most prevalent. In my opinion it is the altered conditions of these rivers, brought about mainly through human agency that has induced the diseased condition of the oysters, their waters, in fact, being rendered more or less incapable of supporting the mollusc in a healthy state (Saville-Kent 1891: 565).

This first-wave of concern articulated by the AAAS was escalated in 1909 with the founding of the Wild Life Preservation Society of Australia (WLPSA) by the marine biologist, ichthyologist, oceanographer, conservationist and writer David Stead (McKern 1966). The main aims of the WLPSA at first 'centred on the need for absolute protection for some species' with the group submitting 'draft bills for the improvement and simplification of fauna and flora protection legislation, e.g. Birds and Animals Protection Act 1918 and the Wild Flowers Protection Act 1927' (McKern 1966: 261).

The WLPSA was also actively involved in recommendations for National Parks and Nature Reserves and submitted proposals to the Australian & New Zealand Association for the Advancement of Science (ANZAAS) Conferences advocating for a wider role for the Commonwealth Scientific and Industrial Research Organisation (CSIRO) in their surveying of wildlife, and requesting the Federal government establish 'a coordinating authority with the States on wildlife conservation' (McKern 1966: 262). This advocacy on the part of the WLPSA was part of a push to establish the Wildlife Survey Section in the CSIRO[169] which aimed to conduct the non-instrumental science necessary to petition the state for political action. The following section finds that there were a range of pressure groups involved in the establishment of the Wildlife Survey Section of the CSIRO, none of which were successful in altering the instrumental character of the organisation.

6.1.2 Advancing the second wave: 1950s-1980s

The second wave of environmentalism in Australia was prefaced by a cross-over from the old guard of scientists who were keen to carefully balance nation-building aims with protection of the natural world and the new guard who were more radical in approach and who were keen to take the environmental protection argument up to the state. This tension can be seen through the struggles of Francis Ratcliffe who, as an active member of the Australian Academy of Science, found the organisation too bureaucratic in approach and who went on to found the more politically active Australian Conservation Foundation. Ratcliffe was also the first head of the nascent Wildlife Survey Section within the CSIRO.

Many conservationists at this time were endeavouring to move the arguments around environmental protection from the State to the Federal level. The three potential advocates for this process (the CSIRO, the WLPSA and the Federal government) were however unable and unwilling to actively participate in the argument. This powerlessness was mainly due to the instrumental character of the separation of responsibilities between the State and Federal governments. The scientists in the new Wildlife Survey Section of the CSIRO were well qualified in their scientific fields and

[169] The instrumental character of the early organisation was discussed in Chapter 6.

were mainly 'serious naturalists and conservationists' (McKern 1966: 260) but their efforts were bureaucratically confined to solving agricultural problems such as the rabbit crisis (Schedvin 1987).[170] Secondly, the national environmental organisation, the Wild Life Preservation Society of Australia (WLPSA), found that a national approach to conservation was problematic, not least because land policy was governed by individual States. Thirdly, the Federal government itself was deeply embroiled in the ongoing political relationship between the state, the market and scientific knowledge production that had been in place since the late 19th century. As shown in Chapter 5, this political relationship was prefaced in favour of industrial capital whose special interests were more aligned with industrial development than with non-instrumental science dedicated to environmental concerns.

Robin (1994) finds that the distinctive history and identity of each of the Australian States made it difficult to coordinate a national case for environmental protection. Robin notes,

> The national boundaries provided by its coastline are visible on a map, but the political and administrative boundaries created by the governments of separate states have dominated environmental and land management. The states hold the constitutional power over land and its uses, not the national government. The political imperative of 'states' rights' has dictated land use patterns for most of Australia's post-settlement history (Robin 1994: 1).

Thus the justification for action against national industrialists was diluted by the historical pattern of land ownership. Moreover, Burgmann (2003) observes that these early state-based conservation groups were politically unproductive. She writes,

[170] The 'rabbit crisis' will be explored more thoroughly later in this section.

> …however, they operated in a political environment that paid them scant attention – so much so in fact that the contemporary movement is largely oblivious of their efforts…In the immediate post-war period, too, those who warned about the finite nature of the Earth's resources and their rapid depletion, and the extent of pollution and its devastating effects, were prophets crying aloud in a rapidly shrinking wilderness. Few heard them (Burgmann 2003: 166).

McKern (1966) notes that irrespective of the difficulties associated with coordinating a national political effort, by 1966 there were fifty State-based organisations affiliated with the Nature Conservation Council of New South Wales.[171]

Additionally,

> Many of these groups are local and specialized groups, doing good work in the field and at meetings. There are however several societies with State-wide membership. Publications of the Royal Society of NSW and the Linnaean Society embodying researches on the natural resources can be of value in the whole conservation complex (McKern 1966: 261).

The first sign of a national political commitment to environmental concerns and accompanying non-instrumental scientific knowledge was made in the late 1940s by the zoological scientists (Schedvin 1987) of the Australian and New Zealand Association for the Advancement of Science (ANZAAS) (McKern 1966) who were criticising the 'paucity of ecological studies of flora and fauna' (Robin 1994: 2). The Royal Zoological Society of New South Wales (RZSNSW)[172] was also an interlocutor, albeit a tentative participant, in

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[171] The NCCNSW held its first conference in 1955 which was called by F J Griffith, the first Chief Guardian of Fauna. The Chief Guardian's office had been established under The Fauna Protection Act, 1948 (Act No.47, 1948) and was abolished under The National Parks and Wildlife Act, 1967 (Act No.35, 1967) (McKern 1966; NSW SR 2013: online). The name of the Council was chosen in the conference of 1959 (McKern 1966). The NCCNSW continues in the 2010s as the peak body of an active network of local community environmental organisations which work to mount and coordinate State based environmental campaigns.

[172] 'The RZSNSW was founded in 1879 in order to support the activities of the acclimatisation movement. It founded the first 'zoo' in 1883 with a collection of birds housed at the Botanic Gardens. The collections of 'exotic' birds and animals continued to grow and in 1884 were rehoused in the Moore Park Zoological Gardens which was open to the public; this 'zoo' proved very popular with the locals. The Society, following significant financial problems and 'begging' requests to the NSW Government, was eventually granted land in 1912 at Bradley's Head on the 'north shore' of Sydney Harbour where the current Taronga Zoo is located. The

a number of 'conservation battles that dominated public debate around the country' (Hutton & Connors 1999:97). A result of these debates was the decision taken by the president of the RZSNSW to 'reformulate the society's policy position on conservation' in which he proposed

> …That council agree that it should not associate itself with any public protest on a conservation problem except when it is capable of making a specifically zoological contribution. Scientists working for the government were under pressure to conform to industry facilitation goals (Hutton & Connors 1999: 97).

This position is indicative of the reluctance of the scientific academies to mobilise in favour of issues-based politics other than to provide *disinterested* scientific knowledge; disinterested production of scientific knowledge being seen as antithetical to political mobilisation.[173]

Despite their reluctance to mobilise, ANZAAS scientists recognised the need for a national research body to work towards 'preserv(ing) habitats' and pressured the Federal government to establish the Wildlife Survey Section of the CSIRO in 1949/50 under the leadership of Francis Ratcliffe (McKern 1966; Robin 1994; Day & Chesser *et. al* 2004: 9), an ''English-Born' and 'Oxford-trained' biologist[174] who acquired an abiding concern for the Australian biota' (Day & Chesser *et. al* 2004: 9). Despite the force

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management of the zoo was given over to the state in 1912 through the auspices of the "New Zoological Garden Trust". By 1917 the majority of trust members were also members of the RZSNSW, so in effect the Society continued to manage the zoo and its emerging scientific research activities. In the 2010s the zoo has become a significant tourist attraction and an important producer of scientific knowledge. The RZSNSW has transformed into a 'non-profit, scientific organisation dedicated to the study and conservation of native Australian fauna' (RZS NSW 2015: online).

[173] This tension between the 'norms of science' and active participation in the political milieux will be discussed more fully in Chapter 8.

[174] 'Francis Noble Ratcliffe was born at Calcutta, India on 11 January 1904. After graduating with First- Class Honours in Zoology from Oxford University, Dr Ratcliffe spent a year at Princeton University as a Proctor Fellow before coming to Australia to work for CSIRO in 1929' (CSIROpedia 2013: online).

applied by the interest group, the WLPSA, to establish a national body, McKern explains that the formation of the Wildlife Survey Section of the CSIRO eventually resulted from pressure applied by the learned academy of ANZAAS in combination with agricultural concerns around the exploding populations of non-indigenous rabbits and their detrimental effects on soil, flora and fauna. This outcome was to set the tone for the production of early environmental science in Australia. As McKern notes,

> …The formation of the Division (sic) was stimulated by two events. The first was a series of recommendations from the Australian and New Zealand Association for the Advancement of Science that a research group should be set up to study the Australian native fauna which is of world-wide interest and needs a conservation policy based on sound ecological knowledge. The second stimulus was the post-war rabbit situation which had become exceptionally serious in every State, leading to widespread and repeated demands that it should be tackled scientifically on a national basis (1966: 258).

Robin reports that 'despite the designation 'Wildlife Section', its primary or 'normal' research function was in fact to seek a solution to the rabbit problem' (1994: 2). The rabbit problem had been the result of the introduction of the English rabbit into Australia which soon developed into a national emergency; the introduced species exploded in population terms and caused extensive damage to both farming and non-farming lands. Day, Chesser and colleagues (2004) confirm that the control of rabbits was a leading factor in the decision to establish the Wildlife Section. Further, that it was Francis Ratcliffe who convinced the Chairman of the CSIRO Sir Ian Clunies-Ross to expand the Section. Day, Chesser and colleagues write,

> Although the initial stimulus for setting up the Wildlife Section was to control the rabbit, Ratcliffe wrote to Sir Ian Clunies Ross, the then Chairman of the Organisation, that 'an unrelieved mental diet of rabbit....is likely to prove rather depressing', and he received approval for his staff to

> spend one-fifth of their time studying native birds or mammals". At the time, there was a marked lack of knowledge of the biology of the native fauna, and the researchers set about helping to redress this situation (2004: 9).

The solution to the rabbit problem was discovered by the Wildlife Section in 1950 and hinged on the introduction of the myxomatosis virus into wild rabbit populations; this solution led to a dramatic reduction in Australian rabbit populations by the following year. 'The virus killed 99.8 per cent of rabbits that caught the infection. It was the world's first biological control of a pest mammal' (Beltrane, McColl & Strive 2013: online) and propelled the Wildlife Section into a more permanent position. Despite his team's success with eradicating the rabbit pest, Ratcliffe himself was professionally unfulfilled and continued to evolve and champion his 'visionary plans for the conservation of Australia's natural heritage' (Warhurst 2014: online).

Ratcliffe's vision however was ahead of its time. The Australian political and public milieux in the 1950s[175] implicitly agreed that science was bound up with development, and thus were disinclined to free up the production of pre-instrumental scientific knowledge; particularly when that freedom was intended to assess the balance between the needs and wants of the social world and the ramifications on the natural world. As Robin and Griffiths note,

> Dead rabbits were clear signs of 'progress', value for expenditure by tax-payers on science, but when science suggested giving up pastoral possibilities or valuable land for the sake of plants, whether they be saltbush or beech forest, it appeared to be reaching beyond its brief. Governments welcomed clear scientific definitions of problems and instant solutions. They were

[175] It was not until the 1970s that Australian civil society changed focus to support the tenets of environmentalism in the face of 'rampant' developmentalism.

> less comfortable with scientists who called for social and environmental balances, for longer-term planning and incremental solutions in the interests of non-human species (2004: 451).

Ratcliffe became increasingly frustrated with the bureaucracies and the limited resources available for the production of non-instrumental science within the CSIRO. Robin and Griffiths contend that this was a difficult time for non-instrumental science, as 'scientific leaders continued to claim government funding on the basis of science's role in developing (the) nation(s), so calls for environmental restraint were unpopular' (2004: 451). As the chief scientific bureaux of the nation, the CSIRO had a legislated commitment to produce pre-instrumental science in support of the primary and secondary industries.

Notwithstanding Ratcliffe's considerable efforts to expand his Wildlife Section into non-instrumental wildlife surveys, the instrumental character of the organisation won out in the end. Ratcliffe's frustrations with the CSIRO carried over into his relationships with the Australian Academy of Science (AAS). Where he had originally perceived the newly formed AAS as being an overarching champion for the conservation of Australia's unique natural heritage, this was not to be the case. Ratcliffe thought the AAS would be

> …a possible umbrella for something "planned, positive and national" for the endangered Australian biota. He recognized that this required "more than a dash of idealism" and appealed for support and sponsorship (Robin & Griffiths 2008: online)

Unfortunately for Ratcliffe however, 'The academy promoted nature conservation through its committees but did not have the capacity to do more than "point the way"' (Robin & Griffiths 2008: online).

The founding of the Australian Conservation Foundation was arguably a result of Ratcliffe's falling out with the Australian Academy of Science (Robin 1994). Ratcliffe was a complex character, a polymath who was both an artist and a scientist in the academic sense; he authored books about his travels in a romantic, evocative style but was also a well-disciplined scientist who insisted on the highest scientific quality for the articles published by the ACF. Ratcliffe's interests and talents were more in line with the natural philosophers of the European renaissance than with the more tightly specialised notions of art and science that existed in mid-century 20th century Australia. Mosley concurs that Ratcliffe was both an artist and a scientist,

> To understand the great national institution that ACF has become, it is essential to understand Francis Ratcliffe…Francis Ratcliffe was a worrier, deeply pessimistic at times, because he could see the world's beauty and the fate that threatened it. Fortunately for us his mind did not stop there (Mosley 1996: 4).

This polymathic outlook saw Ratcliffe cross swords with the pre-instrumentally inclined scientists of the Australian Academy of Science (AAS)[176] and eventually with the environmentalists of the Australian Conservation Foundation (ACF) who were pressing for more radical political action (Robin 1994). In some ways the founding of the ACF was a result of Ratcliffe's dissatisfaction with the bureaucratic orientation of the AAS. Where Ratcliffe had been agitating for institutions to ''do conservation' for most of his working life (and) was losing faith in setting up systems…(he) wanted to see some real scientific action into conservation issues' (Robin 1994: 12). He was aware that the Wildlife Survey Section of the CSIRO was not the organisation to tackle wildlife conservation. It could not

> …cope with all the wildlife conservation research needed in Australia, therefore he had called on the Australian Academy of Science in 1957 to take over the task. By 1963, he could see that the

[176] Many of these scientists were employed by the CSIRO or as teachers in the universities and were thus unlikely to take up a position of 'bad faith' towards their employers or their instrumental projects.

> Academy could not establish a system that could cope with the large volume of conservation work required (Robin 1994: 12).

Ratcliffe became convinced that it would be enthusiastic amateurs rather than the AAS who would drive the conservation cause in Australia (Robin 1994) and he subsequently gathered together a raft of high profile Australians in order to form the ACF. Coman describes the power of the ACF at that time, writing that it was a

> …veritable "who's who" of well-known Australians at the time -- wildlife administrators in the states, prominent lawyers, scientists, captains of industry, pastoralists, and high-order administrators. It is really a testament to Ratcliffe's power as an organiser and communicator that he was able to pull together such a seemingly disparate group under one banner and for a common goal (1998: 20).

Moreover, Mosley reports that 'the ACF's founders in the sixties were drawn from Australia's scientific, bureaucratic and political elite' (1996: 4) and worked closely together for the common aim to protect the natural world from the ravages of over-development. By the decade's end however, Ratcliffe's cautious and even-handed approach was becoming untenable as the organisation began to develop its own political identity and the members began to agitate for political relevance. The significant tensions between the old school environmentalists and the new school are embedded (somewhat polemically) in the following passage. It describes Ratcliffe's more conservative position over the increasingly radical positions being adopted by the environmental movement in the 1970s and 1980s.

> The difference was, at bottom, one of where humans were placed in the scheme of things. To many of the new school, man was little more than a naked ape which had got out of control and was hell-bent on destroying a world which was not his, any more than it belonged exclusively to termites or sea urchins. To Ratcliffe and his school, man was at the centre and conservation

could not ignore his needs. Without him, there was no "wilderness", no "ecological balance" -- these were human concepts. It was man, and man alone, who could put a value on nature (Coman 1998: 20)

Warhurst (2014) observes that Ratcliffe used both his good standing at high levels of government as well as his passion and his scientific knowledge and skills to found the organisation.

…(He) made an enduring contribution through his role as founding spirit and honorary secretary (from 1964) of the Australian Conservation Foundation… he drove the new and independent A.C.F. with dogged determination. He used his network of friends, acquaintances in high places and scientific colleagues to bring together the necessary people and funds. To this end, he needed to win over the 'hot-shots' and to tolerate the 'small-time, emotional conservationists'…Ratcliffe was a perfectionist. He insisted that the foundation's publications should always be of the highest scientific quality and wrote a number of them himself, including the very first, on the conservation of kangaroos (2014: online).

Warhurst also finds that Ratcliffe was often difficult to work with and he did not always appreciate the 'diverse range of individuals—scientists, grass-roots amateurs, government officials and business leaders—with differing viewpoints' (2013: online) who populated the second wave environmental movement. Ratcliffe disagreed with the call for the radical activism that was being promulgated throughout the organisation at the time and instead maintained that rational science would win out over radical activism. Not keen to take the ACF down the radical path, Ratcliffe eventually relinquished his formal role in the Foundation in 1970. In the years following the departure of Ratcliffe the character of the ACF altered significantly.

It changed from 'cautious mainstream lobby group to a radical component of the Green Movement' (Warhurst 1989) and became involved in a wider number of major political issues. These include: Lake Pedder, Franklin Dam, Kakadu National Park, Tasmanian Power Dam, Fraser

> Island and Ranger Uranium. Its aims have been to 'further the code, philosophy and practice of conservation', by looking at long term conservation policies. It is involved on a local, regional, state, national and international level (NLA 2014: online).

So, despite the longitude and durability of the first wave of environmentalism that had been organised by motivated scientists and concerned citizens, it was not until the early 1970s that the social conditions existed to elevate the non-instrumental science, on the back of the second wave of environmentalism, into the political public sphere. The following section looks at the importance of a post-materialist civil society to the elevation of non-instrumental scientific knowledge into the political public sphere.

6.2 Environmentalism in civil society

In line with the social unrest and economic upheavals experienced in Australia during this period, a number of movements for change emerged. These social movements included the women's movement, the indigenous rights movement, the gay and lesbian movement and the second wave (Hutton & Connors 1999) environmental movement. The majority of these movements could be described as new social movements brought about by the 'new politics' around 'problems of quality of life, equality, individual self-realization, participation and human rights' (Habermas 1981: 33). In particular, the new environmental movement was both a civil response to the social conditions that had been generating in Australia since Federation (in 1901) and a component part of a set of global influences that had served to shift conceptions of civil society in the West from materialist to a post-materialist settings during the 1960s and 70s. This section looks at how these global and local shifts were generated before moving on to discuss the domestic conditions for a new form of environmentalism.

During the 1960s and 1970s a series of global and local social forces were instrumental in elevating environmental issues into the public domain. A number of social theorists, including Giddens (1990) and Inglehart (1977, 1997, 1990) have developed theories to explain the rise of new social movements within the context of deeper processes of reflexive modernisation. Giddens[177] argues that these social forces included shifts in the global space-time continuum which resulted in the disembedding of traditional knowledge from local contexts; so intensifying environmentalism and powering the emergence of public movements for change. On the other hand, Inglehart proposes that environmentalism was an outcome of the shift in the western thinking where the West evolved from materialist conceptions of civil society to a more intangible, post-materialist way of looking at the world; that where western values had traditionally focused on material goods and consumption, those born after 1945 were more oriented towards attaining a good quality of life. Inglehart also argues that post-materialist values emphasise self-expression over consumption including rejecting technology if it is not supportive of post-materialist ideals. Environmentalism is a significant motif within this new way of interacting with the social world.

[177] This was a time when the social world was in state of flux; when, as Giddens (1990) observes, globalisation was intensifying the separation of time and space which in turn drove the emergence of disembedding mechanisms which worked to transform the social world. These mechanisms, as reflexive processes, effectively destabilised the individual lifeworld by appropriating knowledge from a range of social spaces and places in order to reframe traditional customs and standards. Giddens (1990) argues that these shifts were the consequences of an intensification of the dynamics of modernity, facilitated by the forces of rising globalisation. For Giddens (1990), the chaotic flavour of the modern world is the result of an ongoing social process through which traditional knowledge is disembedded from specific locations, re-examined, reformed and then relocated. Giddens elucidates further,

> The reflexive appropriation of knowledge, which is intrinsically energising but also necessarily unstable, extends to incorporate massive spans of time-space. The disembedding mechanisms provide the means of this extension by lifting social relations cut of their "situatedness" in specific locales (1990: 53).

These dynamic global mechanisms functioned to produce a gamut of social changes that first appeared internationally and then locally during the late 1960s. These included 'the rise of new social movements and the creation of novel political agendas' (Giddens 1990: 52) such as environmentalism.

Critics of Inglehart have highlighted the continuing prevalence of materialist values in contemporary society and the continually high levels of technological adoption. However, as Inglehart explains, while post-materialist values may reject technological advancement that, for instance may harm the environment, new technology may be harnessed to achieve specific social aims. For example, environmental protesters who rally against the materialism of mining companies and their incursions into pristine wilderness may live in the trees at the site of the protest but may still use sophisticated technology to communicate with the outside world. The theories developed by Giddens and Inglehart help to explain the convergence of social forces that served to push environmentalism to the fore in public life. Notwithstanding the fit of these global theories in explaining the prevailing social forces that precipitated the new social movements, as discussed in Section 6.1, it remains problematic to accurately disentangle the precise local conditions that pushed non-instrumental science into the post-materialist public sphere in Australia.

Crook and Pakulski (1995) observed at the time that the motivating factors for the surge in public concerns around environmental issues were complex. McAllister and Studlar (1993) also noted that despite long-standing concerns in Australia about over-development, the concept of *the environment* had only been popularly understood in Australia since the early 1970s. Moreover, public interest in environmental issues varied widely and tended to be galvanised around specific issues and tied to the issue reaching salience in the public sphere. Those in favour and those against environmental issues 'are often finely balanced, implying at least some potential for political debate and argument as opposing groups seek to win popular support for their view' (McAllister & Studlar 1993: 356). McAlister & Studlar found that,

> Public opinion on many of the major contemporary environmental issues is evenly divided. Such a distribution of opinion fulfils two of the three basic requirements that have to be met before an issue can become politicized: that it is considered important by the population; and that there is a balance of opinion both for and against it. The third condition, that political parties see an electoral advantage in politicizing the issue, has yet to be completely met (1993: 360).

This neutrality in terms of politicisation suggests that environmentalism between the 1970s and 1990s remained an important area of discussion in the public sphere. Rather than becoming an 'electoral advantage' for the elites, used to 'mould the direction of public opinion to their own electoral advantage' (McAlister & Studlar 1993: 359), during this period environmentalism remained comparatively free of influence by the politics of the state or the desires of the market. It was arguably the unevenness of public concern around specific issues, coupled with the wide spread of issues, that mitigated its politicisation and legitimated its place in the public sphere. McAlister and Studlar found that,

> Apart from factory discharges of dangerous chemicals, then, there is little popular consensus on what leads to environmental damage. The results suggest that popular opinion has little coherent view on which activities constitute damage to the environment – aside from a high level of support for identifying factory discharges of dangerous chemicals. There is no broad consensus on any single group of potential causes, a result which may reflect the diversity and complexity of the problem in the public mind (1993: 359).

While the cause of the spikes in environmental concern amongst the general public could be put down to galvanisation around specific issues (McAllister & Studlar 1993), Crook's and Pakulski's (1995) work confirms that an activist-led environmental movement ran parallel to public concern around specific issues; one side did not necessarily generate the other.

By the late 1990s environmentalism had been 'absorbed' and 'routinised' (Pakulski & Tranter 1998: 44) by the State and Federal governments and their agencies. This did not mean that environmental issues were no longer of importance to the general public, more that, 'these concerns (had) stabilised in intensity, spread widely, diversified, and detached themselves from their original social and political carriers' (Pakulski & Tranter 1998: 235). The environment remained an important public issue into the 2000s however it was no longer viewed an 'urgent social concern' (Pakulski & Tranter 1998:44). Writing in 1995, Crook and Pakulski found that

> …by 1992-3 green concerns seem to have subsided. They have disappeared from the headlines, have been overshadowed by unemployment, and perhaps more significantly, have been dropped by both major parties from the agenda of the 1993 election (Papadakis 1994) (1995: 44).

It seems that as the state took on the mantle of environmental governance so the salience of the public debate decreased. As Pakulski and Tranter note,

> Environmental concerns have now been appropriated by all important political actors. This means that their original carriers, the green groups, have to compete for attention on a more crowded scene, where claims to exclusive ownership and representation cannot be defended. This may result in a withering away of green groups or their transformation into conventional political lobbies: the cruel irony of history where a victory brings a demise (sic). Alternatively, we may witness an intensified bifurcation in which the old issue carriers (green groups and movements) come to monopolise a left-libertarian-green niche. One can see support for both scenarios in the survey data (Pakulski & Tranter 1998: online).

This shift points to a partial rationalisation of environmentalism since its peak. While the green agenda remained active, its former potency at the political level had been mitigated by the rationality of the various bureaucracies and the neoliberal agendas[178] of state. So the substantive, value-rational action inspired by the operation of an effective political public sphere within a post-materialist civil society had been diluted by a more formal, purposively-rational action administered by the state.

The Crook and Pakulski (1995) findings also suggest that non-instrumental science acted as an important facilitator and *interlocutor* in environmental discourse. This second wave of environmentalism both propelled science into the political public sphere and mitigated its instrumental role in the market. Where the scientists associated with the first wave of environmentalism had lacked political efficacy, the coalescence of a public-inspired environmentalism with non-instrumental science produced by both the public-facing institutions and the universities proved to be politically effective. The following section investigates the salient influences around the intensification of environmentalism in Australia between the 1960s and the 1990s.

6.3 Political conditions for a new environmentalism

After twenty three years of the conservative Robert Menzies as Prime Minister and several moderate Liberal (conservative) Prime Ministers in quick succession (Holt 1966-1967; Gorton 1968-70; McMahon 1971-1972) the left-wing Whitlam government (1972-1975) was swept into power on the basis of a raft of new public policy. These new policies had formed the centrepiece of the 'It's Time' election campaign and included special focus on problem issues associated with health care, urbanisation, the national economy and the Vietnam War (Manne 1999). Whitlam's government, as directly representative of this turbulent era, also played host to a range of new

[178] This bureaucratisation process and the accompanying neoliberal agendas are discussed in depth in Chapter 8.

ideologies that were emerging ‘on the streets’ during the late 1960s and early 1970s. Moreover, Whitlam was quick to embrace the ‘real cultural revolution’ that was surfacing in Australia at the time. Manne writes that this ‘real cultural revolution’

> …dissolved forever the old certainties on which attitudes to sexuality, male-female relations, race, ethnicity, political authority, social hierarchy and the natural environment had for generations been based…New issues moved to the centre of political life – censorship, abortion, child care, pollution, environmental protection, Aboriginal land rights, the anti-apartheid struggle, Asian immigration… the Vietnam War…Conflict over these issues turned into set-piece battles between forces of cultural resistance and of cultural change…by 1972 (Whitlam) was in the process of becoming… the symbol of hope for a new generation of the cultural left (1999:183).

While the Liberal (conservative) McMahon government (1971-1972) had established the first Department of the Environment, Aborigines and the Arts, neither the Prime Minister nor the Minister who was appointed to lead the department, Peter Howson, had been alert to these issues of growing public concern. As Mungo MacCallum writes of the Liberal (conservative) Howson,

> As he left the new prime minister’s office, a colleague asked him what he had got. Howson snarled back: “The little bastard gave me trees, boongs and poofters.” He was referring to the admittedly incongruous grab-bag of Environment, Aborigines and The Arts, three areas in which the McMahon government had not the slightest interest. In that sense, Howson was the ideal choice. His ignorance of the environment led me to christen him Peter Howson-Garden. His disdain for matters aesthetic resulted in Phillip Adams describing him as a pain in the arts. And on Aborigines, he was a dedicated Hasluckian: they could assimilate or perish and he didn’t really care which (2014: online)

Howson's 'grab-bag' of a department managed 'activities related to the environment; aboriginal affairs; support for the arts and letters; the National Library; Australian films; national Archives; general services of printing, publishing and advertising (including the Gazette) world expositions; grants to national organizations; overseas visits; War Memorial and War Graves; and overseas property' (NAA 2014: online). The incoming Whitlam government on the other hand demonstrated their commitment to 'The Arts', 'Aborigines' and 'The Environment' by abolishing the former Howson department in 1972. The functions of the old department were transferred to six new departments under Whitlam: Aboriginal Affairs; Environment and Conservation; Media; Prime Minister and Cabinet; Special Minister of State (including Science); and Services and Property (NAA 2014: online). Through the action of environmentalism therefore, the non-instrumental sciences that had originally been linked to the advancement of civil society (but dissipated during the 18th and 19th centuries) were, under Whitlam's governance, re-attached to substantive ends in order to steer the process of value-rational social action. This value-rational action however meant that the 'environmental sciences' were split out from other non-instrumental sciences[179] which would have ramifications for the non-instrumental sciences down the track.

The Whitlam initiated department was the first dedicated Department of the Environment and Conservation in Australia's history and was overseen by Dr Moses (Moss) Cass. Cass, a medical doctor and Research Fellow in Experimental Surgery at the Royal Children's Hospital of Melbourne, was a confirmed 'greenie', hence the epithet

[179] This splitting out of the environmental sciences and its attachment to civil society however emphasised the vulnerability of non-instrumental science in the face of a progressive instrumental science agenda on the part of the state and the market. This dynamic is discussed later in this chapter and in Chapters 7 and 8.

‘Moss’, who ‘helped pull the environmental vote to Labor in the 1970s’ (Heinrichs 2002: online). However, Cass

> …soon earned the nickname "Minister for Lost Causes" when he failed to get Labor to reverse the previous government's decisions to allow the flooding of Lake Pedder and the construction of a tower on Canberra's Black Mountain…. The issues of sand mining on Fraser Island and uranium mining were also thorny, and Dr Cass' main contribution was to get through legislation that allowed for inquiries into them. Sand mining was stopped under the Fraser government - but Justice Fox's report on uranium was largely ignored. Other achievements included legislation prohibiting mining in national parks (Heinrichs 2002: online).

Cass also served on the House of Representatives’ Standing Committee on the Environment and Conservation. Moreover, he attended the OECD Environment Committee in 1974 and the South Pacific Conference on National Parks and Reserves in 1975. Despite his high-level environmental credentials Cass finds that,

> In 1972, it wasn't - let's face it, I wouldn't have managed all that if I hadn't been supported by a general move in the community. There's no question about that…But then in the '80s, it all dribbled away. The boom came again, capitalism proved it could bury everything else, and no one wanted to listen (Cass interviewed by Heinrichs 2002: online).

The ‘general move in the community’ that is reported by Cass demonstrates how the state had temporarily disengaged from its former position supporting the market in order to encourage the development of a new form of civil society motivated by, amongst other issues, public concern for the natural environment.

While the natural environment benefited from this increased focus, the new structure became a double-edged sword for scientific knowledge production and diffusion. The re-structuring in effect set up a trend that assigned some fields of non-instrumental knowledge production to cultural production,[180] separating them from other producers of scientific knowledge. This other science had fuelled the material economy and would by the 1990s be transformed to service the monetary economy. Indeed, as Homeshaw finds 'Whitlam, after proselytising the need for a separate science ministry administering a definite science policy, dropped science when the ALP was elected in 1972' (1995: 525). On the other hand, the Whitlam government was responsible for a range of environmental legislation that sought to protect the environment.

Whitlam's establishment of the Australian Heritage Commission (which applied to the built, cultural and natural environments) in effect linked the *culture industries* with the production of non-instrumental science. This move shifted the traditional public-facing producers of non-instrumental science[181] – the museums, botanic gardens, zoological gardens, aquariums, marine parks, national parks and so forth – from their identification with science and educational policy into a newly established *cultural heritage* milieu. The Whitlam Institute notes,

> The Australian Heritage Commission was created in June 1975 to create a register of significant heritage places throughout Australia. The listing of sites of significance to Australia's **cultural and natural heritage**[182] helped to raise awareness of their value and provide some protection against damage to them. The Australian Heritage Commission also helped to recommend and prioritise which conservation projects should receive government funding (2014: online).

This was the first time that the state had moved to provide 'systematised government protection of Australian Heritage sites' (Whitlam Institute 2014: online). The Whitlam

[180] The claim on non-instrumental science by the cultural sphere will be addressed in the next chapter.
[181] These traditional producers of non-instrumental science were also important interlocutors of science in the political public sphere. This function dissipated as these institutions became more firmly entrenched as cultural artefacts. This shift is discussed more thoroughly in the next chapter.
[182] Emphasis added by author

government created a national register (the National Estate) which listed cultural and natural sites of significance in order to 'Raise awareness of their value and provide some protection against damage to them'. Whitlam's 1969 election policy speech had declared that the purpose of the register would be 'to keep the beauty we have been given and keep out the ugliness we can only make for ourselves' (Whitlam Institute 2014: online). The Australian Heritage Commission prioritised and recommended the conservation projects which would receive state funding. Hundreds of sites were identified including the Camden Park Estate established by John Macarthur and Elizabeth Farm established by Elizabeth, his wife. While this establishment of a heritage list can be seen as a noble act, no doubt generated with the best of intentions by the Whitlam government, the extension of the term *heritage* to encompass the natural environment effectively worked to transition the protection of the natural world into a cultural framework, aestheticize it and isolate it from mainstream science.

Where the production of non-instrumental scientific knowledge around the natural world is a dynamic, ongoing project, the re-positioning of the natural environment within the auspices of heritage and history arguably works to position it as an historic artefact and so deprive it of its dynamism and contemporaneity. For instance, a heritage building is confined within a fixed, inert and historical milieu however the natural world is an evolving, active and dynamic aspect of real life that is entirely essential to human futures.

The designation also focuses the heritage assessor into a subjective framework. For example, in order for a site of environmental significance to be placed on the National Heritage List it must be deemed significant in terms of a single indicator; that is *biodiversity* (Dep of Environment 2013). Moreover, 'significance is determined based on rigorous comparisons of specific natural values' and to find a place on the list the area 'must be shown to have "outstanding heritage value to the nation"' (Dep of Environment 2013: online). This determination requires a highly subjective and historically embedded assessment of the significance of that natural place against other natural places in Australia with similar merits but differing aspects of biodiversity. The subjective comparison between an historical building and a place of natural significance that is developed by the bureaucracy in Australia would thus seem to be problematic.

So, the new policy settings initiated by the Whitlam government produced both a positive and negative effect on the production and diffusion of non-instrumental scientific knowledge in Australia. On the positive side, public interest in environmentalism was high and this high level of interest elevated environmental science as a category into the public sphere. In the longer term however the traditional producers of public-facing scientific knowledge were claimed by the *cultural left.*[183] By the late 1970s the state was gearing up for the new monetary economy which drove a further transformation of scientific knowledge production in Australia.

As the economic crisis reached its zenith during the mid-1980s the Hawke government (1983-1991), with Keating as Treasurer, implemented a set of radical structural reforms that would introduce the uncompromising policies that formed the basis of *economic rationalism* and would transition the Australian economy into the global *neoliberal* era.[184] The following section looks at how public interest in environmentalism had not only gained traction between the 1960s and the 1990s, it had

[183] This idea is explored in the next chapter.
[184] This transformation is explored in Chapter 8.

galvanised around specific issues. These issues were closely linked with the emergence of non-instrumental scientific knowledge as part of an active political public sphere.

6.4 Non-instrumental science in the political public sphere

Non-instrumental science was central to the debates conducted in the political public sphere generated around environmental issues between the 1970s and 1990s, and to the political and legislative changes that resulted from these public debates. The outcomes of this citizen-based social action demonstrated that the boundaries between the purposive-rational conduct of science and value-rational social action could become permeable, and ideally remain permeable, in order to benefit both science and society. Science does not stand alone; nor does the social world. Both spheres are deeply entrenched in 'particular political realities' (Stehr 1994: 257) and, provided the boundaries between science and society remain permeable, stay negotiable within the space of the political public sphere, and continue uncorrupted by special interests at the hands of the state, both science and society stand to benefit.[185]

Thus non-instrumental scientific knowledge that has been produced for human good without political restriction, obstruction or interference, and the unmediated transfer of that knowledge between the scientific world and the social world, is critical to the wellbeing of all individuals. The conventional producers and distributors of this non-

[185] As Stehr argues, 'Science is deeply implicated in social action and political agendas hold sway over science. Precisely how dependent or interdependent science and politics are is a matter of genuine debate and continued empirical analysis. But the widespread disenchantment with science and the extensive material dependence of the scientific community on the state should not give rise to the equally unrealistic proposition that the boundaries between politics and science have vanished without a trace. Science is embedded in particular political realities, and as long as it is situated and implanted in a specific form of civil and political society, in particular one free of totalitarian strains, scientific activity benefits. By the same token, as long as the traffic across the boundaries of science and the rules which govern such transactions remain open in principle and negotiable, both science and society stand to gain' (1994: 257).

instrumental science include universities, research centres, museums, zoological parks and botanic gardens as well as co-operative research institutes such as the Australian Institute of Marine Science (AIMS) and the Sydney Institute of Marine Science (SIMS). This section reviews how the Australian Museum, as one example, produced and diffused non-instrumental scientific knowledge during the 1970s to cultivate a growing public interest and to temper deepening concerns for the environment.

During the first half of the 20th century the Australian Museum was deemed to be antiquated and outmoded. In the 1920s it had undergone a period of modernisation during which the production and diffusion of non-instrumental science has been reduced in favour of theatrical-styled displays aimed at entertaining the public rather than facilitating scientific debate.[186] It was not until the first signs of the environmental movement in the 1960s that the museum transformed into a valuable public-facing resource for the production and diffusion of non-instrumental scientific knowledge around environmentalism.

During the 1960s the museum resolved to conduct science to address environmental issues; it subsequently facilitated the transfer of this new knowledge to the public, to schools, universities and the media, and actively networked with other producers of non-instrumental environmental science. The 1973/4 Annual Report of the Museum confirms that, in response to shifts in public awareness and calls to strengthen scientific knowledge production and diffusion, the ecological and environmental sciences became a priority for the museum.

[186] This modernisation process was discussed in Section 5.6.2.

> The museum continues to be active in its traditional areas of research-systematic zoology, anthropology and geology. Such research is essential to an understanding of our environment and constitutes the base on which many other fields of biological, medical and geological research is built. It is heavily dependent on the museum's collections, and many field and laboratory studies are broadly aimed at making the collections more valuable as research tools…in response to changing community needs, a greater component of the museum's research effort is now geared to broader ecological and environmental problems, especially as these problems relate to the conservation and wisest use of our natural resources (AM AR 1973/4: 12)

During this peak era for environmental science, the museums, zoos, botanic gardens and other research institutions around Australia remained sufficiently independent to carry on with realistic, non-partisan and non-instrumental science associated with the environment with minimal intervention on the part of the state. Further, these research organisations worked to form strong and productive networks with each other. For instance, the Australian Museum comments in their Annual Report for 1973/74,

> A number of major events occurred during the year which affects museums throughout Australia. In August, 1973, the Commonwealth Government announced the formation of an interim council to formulate plans for an Australian Biological Resources Study. This project, first suggested in 1962 by the Australian Academy of Science, aims to provide substantial information on the distribution and abundance of terrestrial and fresh-water Australian animals and plants, particularly in habitats characteristic of Australia which might be threatened by human impact. Dr H. G. Cogger, Curator of Reptiles, was appointed to the interim council. The museum received two grants from the council in the 1973-4 year. These related to the studies of rain forests (to be carried out jointly with the Queensland Museum) and a study of the application of automatic data processing methods to museum collections (AM AR 1973/74).

Certainly the Australian Museum was very active in environmental research and public education between the mid-1960s and the late 1970s; indeed, the museum was considered a leading national scientific organisation at that time (Strahan 1979). The champions of the museum's environmental credentials and the primary envoys between science and the public sphere during this period were Dr Don McMichael, Dr Frank Hamilton Talbot, Dr Alex Ritchie and Dr Michael Archer amongst other eminent non-instrumental scientists.

Dr Don McMichael, former Assistant Director of the Australian Museum was appointed the first Director of the Australian Conservation Foundation in 1967. Professor Frank Hamilton Talbot had a strong international reputation in marine science before taking up the position of Director of the Australian Museum in 1966. Professor Talbot relinquished his directorship of the museum to found the Centre for Environmental Studies (CES) at Macquarie University in 1978; he remained the guiding force behind the subsequent Graduate School of the Environment (GSE) which was only disestablished in 2014 due to a change in academic strategy by the Faculty of Science at Macquarie University. Professor Talbot[187] was rewarded as the New South Wales State Finalist Senior Australian of the Year in 2014. Dr Alex Ritchie was an internationally respected palaeontologist and Curator of Fossils at the Australian Museum. Professor Michael Archer was Curator of Mammals at the Queensland Museum and the Professor of Biological Science at the University of New South Wales before being appointed Director of the Australian Museum in 1999, subsequently returning to the University of New South Wales as Dean of Science in 2004. These scientists were both eminent in

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[187] The prestigious award was made to honour his 'career, contribution and achievements (and to) demonstrate his extraordinary leadership skills, intelligence and outstanding scientific record… he has inspired thousands of young Australians to pursue careers in science and marine conservation' (AG AoY 2014: online)

their professional fields and motivated to deliver their scientific discoveries to an engaged public.

As discussed earlier in this chapter, Frank Talbot was Director of the Museum during this fertile period for non-instrumental science. Talbot was an internationally renowned marine biologist who contributed extensively to the Australian Conservation Foundation and introduced ecological research and education to the Australia Museum. It was under his guidance that the museum was established as a robust contributor to the Australian public sphere. Further, Talbot led numerous scientific expeditions involving museum scientists, universities and research institutes and established research stations at Lizard Island and One Tree Island in the Great Barrier Reef.

Talbot's scientific research credentials were important to the development of the environmental research conducted both within the walls of the Australian Museum and across its various Australian research units. Moreover, it was under Talbot's scientific leadership that the Australian Museum went on to generate international commendation for both the environmental science it conducted and for its role in promoting the environmental agenda. Talbot's research credentials came to be internationally recognised and saw him become a Director of the California Academy of Sciences and Director of the National Museum of Natural History at the Smithsonian Institution in later years (AM 2013).

Talbot also precipitated an overall broadening of the Australian scientific research agenda and moved to facilitate the linkages between the museum's scientific output and an engaging public sphere. In the Annual Report of the Australian Museum of 1969/70 Talbot writes,

> The research side has also changed and research into the Australian environment done within museums has widened its scope to include ecology, physiology, comparative chemistry and animal behaviour. This wider research is now able to lead to wider kinds of display-not only display of animal form but also of animal function (AM AR 1969/70: 7)

Moreover,

> Man is moving more or less rapidly to an environmental crisis. The more adult citizens know of their own environment, their place in it, and mankind's complete dependence on his living and non-living surroundings, the more we shall be able to make sound judgements affecting our own future. Museums can play a role in the continuing education of the nation's citizens, and perhaps have a duty to do so (AM AR 1969/70: 8).

Talbot was also responsible for a marked increase in scientific, education and display programs during his tenure at the museum (Strahan 1979). This increase in public programs, endeavours that were underpinned by non-instrumental scientific knowledge, demonstrates the ongoing research agenda of the museum and its role in producing and diffusing rational knowledge in order to power rational debates in the public sphere. The Annual Report for the year 1973/4 states,

> Staff attended many scientific meetings, lectured to societies and at universities; research projects on numerous groups of animals and in geology and anthropology continued; 42 scientific papers were published by staff. School children in larger numbers than ever visited the museum. Several temporary exhibitions were staged and a new gallery was commenced. By the end of the year the number of staff had increased to 140. Visitors to the museum numbered approximately 560 000; this compares with 569 000 in 1972-3 and is an increase of 54 per cent in 10 years (358 000 in 1964-5) (AM AR 1973/4: 12).

Another internationally recognised scientist located at the museum was Dr Alex Ritchie, the Curator of Fossils. Ritchie was an acclaimed scientist and was also skilled at engaging the public with the non-instrumental science of palaeontology. In 1993 Ritchie initiated the ABC Quantum Appeal[188] to save *Eric*, an opalised pliosaur *Umoonasaurus demoscyllus* skeleton found in Coober Pedy, South Australia. The opal value of the specimen was a$25,000 however the unprepared specimen was sold to a private collector in 1988 for a$125,000 (and another aus$25,000 was spend on preparation). In 1993 the private collector went into a state of bankruptcy and the receivers were set to sell *Eric* to the highest bidder. Ritchie's public appeal to purchase the skeleton for the Australian Museum collected around a$450,000 in one month. *Eric* was purchased for a$320,000 from the receivers and the remaining funds were held in trust for the ongoing purchase of opal fossils (Willis 2012: online).

Notably, despite the importance of the Eric specimen to scientific knowledge, the Australian Museum did not possess sufficient funding to purchase Eric without the direct financial contribution of the citizenry. This is a common refrain in the world of non-instrumental science, particularly in regards the purchase of palaeontological and geological specimens (Meszaros 2013: PC).[189] This growing problem cannot be explored fully within the constraints of this thesis; suffice to say that the popularity of natural history specimens (to be used in private museums or for decorative purposes in private spaces) is increasing. As the private market grows and the prices of these specimens' rise, scientific institutions are concurrently becoming more financially challenged; public science institutions thus find it difficult to purchase important

[188] Quantum was the official 'science' television program produced by the public broadcaster in Australia, the Australian Broadcasting Corporation (ABC).

[189]As an aside, the incursion of the market into non-instrumental science is a dilemma that has beset scientists since the early traders of the European renaissance began collecting and trading specimens to both scientific and lay collectors of 'natural history' (Findlen 1994). The literature is filled with accounts of valuable specimens that have been bought and sold by private collectors on the open market and so lost to citizens. This practice was certainly common in colonial Australia and continues to the present day. The 'saving' of Eric demonstrates the active capacity of non-instrumental science to generate public support for the natural world.

scientific specimens on the open market. These institutions sit within the purview of both the public and the academy and as such are valuable contributors to civil society. Ritchie's personal contribution to civil society is seen in his work with the Devonian fish fossils found at Canowindra in New South Wales.

Ritchie's work with the Canowindra community and the local fossil bed of Devonian fish is distinguished. The Royal Society of New South Wales describes Ritchie's work,

> Alex Ritchie's rediscovery of one of the world's richest fossil sites, near Canowindra in central NSW, was a highlight of his professional career. The Canowindra site was first discovered in 1956 when a rock slab with about 115 well-preserved Devonian fossil fishes was uncovered during road works - but the actual layer from which it came was not recorded at the time.
>
> In 1993, after almost 20 years of searching, Alex Ritchie relocated this unique, world-class fossil site. With massive community help (council, farmers, business people, high schools etc.), he excavated it and recovered 60-70 tonnes of rock bearing an estimated 3,700 fossil fish, the largest of which reached 1.6 metres long. Eight fossil fish taxa are now known to be present, most of them new to science, but many more specimens remain buried at the same site awaiting excavation, making this a potential World Heritage site.
>
> Alex Ritchie and his colleague, Dr Zerina Johanson,[190] who are studying these spectacular fossil finds, were assisted by hundreds of paying "volunteers", working in groups, to clean and cast the fossils for study. **Community & public participation was one of the most exciting features of the Canowindra project.**
>
> Largely as a result of Alex's spectacular discoveries at Canowindra, a new "Age of Fishes Museum" has been created to house and display the remarkable fossils found there in 1993. His main aim was to combine scientific research and innovative displays to produce a major

[190] Now Curator with the Natural History Museum in London

> educational and tourist facility with long-term economic benefits for central west New South Wales (RS NSW 2002: online).

The saving of Eric and the public enthusiasm for the Devonian fossil find demonstrate the active capacity of non-instrumental science to generate public support for the natural world and engage the public in the processes of unmediated scientific knowledge.

Professor Michael Archer is another example of a scientist dedicated to sharing non-instrumental knowledge. Professor Archer, originally a geologist and biologist with degrees from Princeton University, was appointed Director of the Australian Museum in 1999 and became a significant contributor to public education and debate during his tenure. As a vertebrate palaeontologist and mammalogist, Archer had been the Curator of Mammals at the Queensland Museum and the Professor of Biological Science at the University of New South Wales before joining the Australian Museum. Prior to his appointment at the museum, Archer had won the inaugural Eureka Prize in 1990 (the nations' preeminent prize for achievements in science) for his contribution to the Promotion of Science in Australia.

Archer's establishment of the World Heritage Riversleigh Project near Mt Isa in Queensland has been particularly significant in terms of both non-instrumental scientific knowledge production and the public dissemination of that knowledge. The Riversleigh fossil site is supported by the Riversleigh Fossil Centre where palaeontologists educate the public, and in real time, extract and interpret the fossils that have been retrieved from the nearby fossil bed. An Annual Dig is held at the fossil site and public tours are conducted on a regular basis out to the fossil beds themselves. The Centre describes the importance of the fossil beds,

> The Riversleigh discoveries have already more than doubled the sum of knowledge about the history of Australia's unique fauna. In addition, because of the diversity of ages represented among the discoveries, the Riversleigh deposits are providing a rare opportunity to trace the discoveries of this fauna over the past 25 million years of history (CREATE 2013: online).[191]

Archer was also influential in producing intense public and scientific debate around his plans to harness the DNA of the extinct Tasmanian tiger (*thylacine*) in order to bring it back to life. The Science arm of Australia's public broadcaster, the Australian Broadcasting Corporation (ABC), reports on their web site that 'the ambitious project to clone the thylacine from a preserved pup made headlines around the world when it was launched in 1999 by the museum's then director Professor Mike Archer, who is dean of science at the University of New South Wales' (Skatssoon 2005: online). Despite considerable controversy at the time, Archer's rationale for continuing with the project was to demonstrate Australia's capacity to produce non-instrumental science,

> The impact of Australian science has been declining for at least ten years. We need "thylacine" projects to demonstrate our scientific confidence: if we can't be prepared for big challenges (and possibly failure) then the nation must inevitably become a scientific backwater (Colgan & Archer 2000 in Greer 2009)

Setting aside Archer's abilities as an important scientific interlocutor,[192] Greer finds that 'for a seasoned media performer, Archer seemed remarkably surprised at all the media

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[191] The Riversleigh site charges minimal entry fees for public participation. On the other hand, the privately owned and run Australian Age of Dinosaurs tourist attraction at Winton, again in Queensland, charges $3,300 per head for one week's participation in regular 'digs' with palaeontologists. These are both important sites showcasing Australia's scientific history and producing non-instrumental science and present a stark contrast in terms of opportunities for participation in civil society.

[192] Archer left the Australia Museum in 2004 to take up the position of Dean of the Faculty of Science at the University of New South Wales (AM 2013: online) where, as Professor of the School of Biological, Earth & Environmental Sciences, he continues to explore the possibility of cloning the thylacine from DNA under the appellation the Lazarus Project (Clausen 2013: online).

attention the project attracted' (2009: online). It seems that Archer's passion to freely share scientific knowledge with fellow Australians was the motivating force behind his public-facing work. Indeed, this propensity for sharing knowledge has been a founding principle of non-instrumental science since its earliest days. Archer comments,

> The publicity wasn't something we went out to seek. It sort of sought us. We announced we were doing this project, and we were beset by hundreds and hundreds of media groups desperately wanting to do a story on this (Archer in Greer 2009: online).

It thus seems that non-partisan, non-instrumental scientific knowledge is able to cultivate public interest, engage the citizenry and contribute to the development of a robust civil society; provided of course that the cost to participate is not prohibitive. The conventional producers and distributors of this non-instrumental science include universities, research centres, museums, zoological parks and botanic gardens as well as co-operative research institutes such as the Australian Institute of Marine Science (AIMS) and the Sydney Institute of Marine Science (SIMS). Given supportive political conditions, these institutions have the potential to enrich the lifeworld and contribute to the wellbeing of society in general.

6.5 Conclusion

Non-instrumental science underpinned each of the two waves of environmentalism in Australia. The first wave began during the 1880s with the concerns of Australia's early scientists and a small group of citizens. This early movement was not politically successful but simmered at the level of the lifeworld and did not enter the national consciousness until the 1970s when its public salience increased and it was reattached to a post-materialist civil society though the medium of the public sphere. The second wave environmental movement shifted the boundaries between the state, the market and civil society and the borders between science and society became temporarily permeable; it was this permeability that facilitated the development of an active and ultimately successful political public sphere.

The active public debates conducted during the second wave of environmentalism were able to pressure the state for positive change. These changes included policy and legislation that served to protect the environment from harm at the hands of overzealous development agendas. While these bureaucratic changes produced at the level of the state worked to 'absorb' and 'routinise' the environmental agenda and precipitated a wane in mainstream environmentalism in the public sphere, non-instrumental science remained, and remains, essential to the delivery of public policy at state level.

Thus a blend of value-rational social action with a substantively rational type of science (such as the production and diffusion of non-instrumental science) is valuable in a social world where formal rationality, intensified through the trajectory of purposive-rational social action, works to colonise the lifeworld. Moreover, the impermeable boundaries between science and society, frequently erected by the state in support of the market, often discourage the sharing of new knowledge across boundaries. Where the new social movement of environmentalism that was salient between the 1970s and 1990s could rely on non-instrumental scientific institutions (such as universities, research institutes and universities museums) to provide non-partisan, balanced knowledge to support their civic participation, this type of knowledge is not so readily available in the contemporary milieu.

The following chapter argues that public-facing science has become increasingly aestheticised under cultural policy introduced in the 1970s; this relocation into the cultural realm has worked to compromise the non-instrumental scientific knowledge produced and diffused through these channels. Moreover, the final chapter of this thesis argues that the ideology of neoliberalism is embedding the non-instrumental science produced by universities and research institutes into commodified (and so private) partnerships with business interests, thereby formally erecting non-permeable barriers between science and society. This new set of formal boundaries precludes the flow of knowledge between science and civil society and thus denies essential oxygen to the public sphere.

7 1970s-1990s: Non-instrumental science and postmodernism

The turbulent social and political conditions associated with the development of the new social movements during the 1960s also facilitated a new style of government in Australia. The left-wing Whitlam government was swept into power in 1973 on back of a strong public call for change and promised to embrace the new mood that was stirring on the streets. This new public mood and the government's promises to govern for the benefit of all citizens saw the beginnings of a 'real cultural revolution' (Manne 1999: 183) in Australia.

This cultural revolution was driven by a set of complex social and political forces that drew on the theories of *postmodernism* and a corresponding set of policy positions that emphasised the importance of cultural practice in the lifeworld. Moreover, an element of this broad set of theories sought to re-position culture from that of an elite practice consumed predominantly by social elites to instead embrace the artefacts of culture that were produced during, and reflecting, everyday life. This repositioning was seen by some as a move towards deconstructing the oppressive strictures of social class that had arguably been maintained by mediating public access to knowledge, particularly culture-based knowledge. By expanding access to cultural knowledge the *cultural left* hoped to level out social inequalities reproduced by the class system.

The global academic debates precipitated a new wave of scholarship in the social sciences. The debates were primarily conducted between cultural scholars who argued against the project of modernity and those scholars who continued to support the rational aims of the modern project. Post-modernists claimed that modernity and its accompanying knowledge claims (realised through the structural disciplines of, for example, social history and the natural sciences) perpetuated inequality through classed-based power relationships and they instead declared a new postmodern era. This new way of thinking maintained that there are many different ways of knowing and many different ways of interpreting facts and the truth; that knowledge was relational and the truth was open to individual interpretation. Much of the argument was founded on how the power elite used knowledge, language and communication in order to sustain extant power relationships.

Many cultural scholars drew on the work of Michel Foucault and/or Jürgen Habermas to support their arguments. Foucault was a leader of post-structural thinking whereas Habermas argued that the rational promises of modernity were not yet complete. The debates and the theoretical positions are extensive and are referenced here only in terms of their context and their role in the facilitation of the cultural turn in social science, its influence on cultural policy and praxis, and so public-facing science in Australia.

Australia was particularly influenced by the scholarship of postmodernism and the cultural turn in the social sciences which presents an important framework for understanding the development of scientific knowledge in Australia during this period. This chapter reviews how public-facing scientific institutions and their interlocutors in the public sphere were aestheticised and transformed through the application of cultural policy within the neoliberal state of Australia.

7.1 The arts and the sciences

The arts have been held in high regard in Australian public policy since the 19^{th} century. Cultural practice has been viewed as an important adjunct to civil society, particularly in terms of nation building and the formation of individual, community and national identity. As has been discussed in the previous chapters scientific practice has also been an important consideration in public policy however has been more bound up with another kind of nation building; that of developing economic outcomes through its utility in growing the primary and secondary industries.

By the 1970s the environmental movement and non-instrumental science had coalesced to inform and promote public debates around overdevelopment.[193] This process had served to elevate public-facing non-instrumental science into the light of the public sphere. Within the context of a flourishing cultural sphere, the absence of a robust national science policy,[194] and the promises of more secure funding streams, the public-facing scientific institutions moved to embrace cultural policy.[195] For context, this section reviews cultural policy in Australia before moving on to discuss how these policies in turn influenced the future direction of public-facing scientific institutions.[196]

Throsby notes that cultural policy has become firmly established in the national consciousness and that artistic expression continues to define and refine the national identity,

> Finally, whatever the ebb and flow of political fortunes at the federal level in Australia, it is likely that a broad-ranging Commonwealth government cultural policy will evolve further in the years ahead, necessarily containing as one of its elements a specific stance towards public support for the arts. If so, there seems little doubt that such an arts policy will continue to be predicated on the threefold objectives noted earlier - a drive for the highest possible standards in artistic creativity, innovation and expression; an opening up of enjoyment of the arts to as wide an

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[193] These debates have been explored in Chapter 6 on environmentalism.
[194] The introduction of formal science policy is discussed in Chapter 8.
[195] Direct causal factors are difficult to establish within the confines of this thesis; however, the evidence is clear that the public-facing institutions producing and diffusing scientific knowledge were claimed and altered by their assumption into cultural policy.
[196] This analysis begins in Section 7.2.

> audience as possible free from economic and locational barriers; and a further enhancement of the arts' unique role in defining what it means to be Australian (Throsby 2001: online)

Craik (2007) agrees with Throsby at the conceptual level. She finds that the structural re-definition of arts policy as cultural policy aimed to both increase citizen access to the arts and to foster greater participation in artistic practice; that the move sought 'to remove the elitist tag from traditional arts and include forms of cultural practice that had broad popular appeal' (2007: 26). In other words, cultural policy aimed to break the nexus between 'the experts' (adjudicated by the market) and 'the system' (controlled by the exchange value awarded by the market), and to reposition artistic and cultural practice within the lifeworld. As will be discussed in the remainder of this chapter, the shift from arts policy to cultural policy also swept up and aestheticised public-facing scientific institutions.

Craik (2007) finds however that the planning did not match the practice; that moves to redefine arts policy into the broader terms of cultural policy only met with lip-service from the gate-keepers of the arts, the Australia Council. To demonstrate her argument, Craik (2007) offers a useful model of cultural policy and practice in Australia since colonial times (see Table 7.1). The model serves to confirm the proposition that postmodernist approach did for a brief moment mitigate the expert quality of the arts in Australia but any attempts to permanently reposition it more permanently as enrichment for the lifeworld have been largely unsuccessful. For context Craik's (2007) model is reproduced below.

TABLE7.1 Key moments in Australian arts and cultural policy development

Period	Characteristics
Pre 1900 – Federation Establishment of settler cultures	Colonial/state based models of cultural survival, moral regulation and assertion of settler independence.
1900-1939 State cultural entrepreneurialism	Early state cultural entrepreneurialism particularly through the establishment of the Australian Broadcasting Commission (e.g. orchestras, concert broadcasts, tours by overseas artists) and development of commercial cultural entrepreneurs (such as J C Williamson).
1940-1954 Setting parameters of Australian culture	Wartime state regulation of culture and communication, concern about external negative cultural influences (fascism, American black music, Hollywood films/popular culture) but apart from measures of regulation, 'all talk not action' in terms of cultural facilitation.
1955-1966 Organisational patronage	During this period a number of cultural organisations were established with government playing the role of elite architect.
1967-1974 Growth and facilitation	A period of growth and facilitation with a diversity of cultural organisations and funding bodies plus recognition of multiculturalism as an important influence on national cultural development.
1975-1990 Access and equity	Continued policies of previous era with emphasis on the mantra of increasing access to cultural resources and addressing issues of equity and marginalisation.
1991-1996 Cultural policy and cultural industries	Revision of the scope of cultural corporations and activities under new governance strategies and concepts of corporatisation and cultural industry models within Australia's first articulated federal cultural policy, *Creative Nation*.
1996-Present The review cycle and neo-patronage	Bifurcation of cultural policy between promotion of creative industries and sustainable cultural forms, and shoring up of unsustainable and elite cultural forms by a return to neo-patronage.

(Source: Craik 2007: 76)

In the absence of a robust science policy and within the context of a flourishing cultural sphere and with the promises of more secure funding streams, the public-facing scientific institutions moved to accept their re-positioning under cultural policy. Craik's model shows that between the mid-1950s and 1990 the national cultural milieu underwent three distinct periods of growth, comprising: the establishment of state owned cultural organisations; the expansion of the cultural sphere and the associated increase in funding opportunities; the further expansion of cultural resources in order to increase access and equity. Throsby calls the period between 1968 and 1990 'the great expansion' and finds that 'enlightened public patronage' served to enlarge the cultural sphere. Throsby writes,

> The first half of the 1970s is sometimes seen as marking Australia's 'cultural renaissance', a period when the creative arts blossomed throughout the country as never before, thanks to enlightened public patronage…During the remainder of the 1970s and 1980s arts funding continued to grow at all levels of government (2001: online).

Craik's model demonstrates that by the 1990s however the arts were being reabsorbed into the market system by way of the culture industries; that the national cultural policy *Creative Nation* worked to broaden the scope of cultural praxis using the 'new governance strategies and concepts of corporatism and cultural industry models' (2007: 76). By the late 1990s cultural policy cycled between 'the promotion of culture industries and sustainable cultural forms…shoring up of unsustainable and elite cultural forms by a return to neo-patronage' (Craik 2007: 76).

This seemingly fruitless struggle on the part of the postmodern movement to secure cultural practice from re-colonisation by the market has special implications for the extant public-facing scientific institutions located within the remit of cultural policy. Not only was the movement unsuccessful in permanently re-integrating the arts into the lifeworld but it severed links between public-facing scientific institutions and their formerly high status within education policy, and submerged them within the cultural realm, so facilitating their confinement within the heritage sector.[197] As will be discussed later in this chapter, this re-positioning of public-facing scientific institutions

[197] As was demonstrated in Chapter 5 within the context of Environmentalism, 'natural heritage' was absorbed by the cultural sphere during Whitlam's government. As will be demonstrated in the next section 'cultural heritage' now includes 'museums, libraries and archives' as well as 'nature parks and reserves, zoological parks, aquariums and botanic gardens' (ABS 2013).

effectively sterilised their potential as working research centres producing and diffusing non-instrumental scientific knowledge, making them more vulnerable to increasing irrelevance under the doctrines of neoliberalism. The following section traces the transition of public-facing scientific institutions into the cultural sphere.

7.2 Public-facing non-instrumental science in the cultural sphere

The fertile years of state focus on the 'growth and facilitation' and 'access and equity' of Australian culture between 1960s and the 1990s have reshaped the production and diffusion of non-instrumental science in Australia. Postmodern influences and the expansion of the cultural sphere during these years arguably worked to absorb many of the extant producers and distributors of non-instrumental science. Large scientific institutions such as the Australian Museum and other State based museums; a plethora of smaller museums and sites of scientific importance such as the Geological and Mining Museum in Sydney; the Age of Fishes Museum in Canowindra; the Wellington Caves and the Jenolan Caves in New South Wales; the Riversleigh Museum in Queensland; aquaria, arboreta, herbaria, botanic gardens, zoological parks, wildlife sanctuaries; and *in-situ* fossil sites, geological sites, nature reserves and others were transferred to the praxis of cultural policy.

Swept up by an expanding cultural policy and its associated funding initiatives during the 1970s, directors and managers of these formerly scientific institutions tacitly agreed to reframe the institutions within the cultural context of 'man and his environment' (Pigott 1975: 71); to emphasise their museological (a.k.a. arts/culture) character; and to highlight the collections and exhibits over their role in the production and diffusion of non-instrumental scientific knowledge. Indeed, early strategies for the development of a National Museum of Australia demonstrate this cultural bias,

> The Committee of Inquiry is recommending for Canberra a novel treatment of natural history in the context of man's environment, not a traditional natural history museum. Accordingly, the research of its staff should be directed towards these environmental issues … The manner in which man has coped with and utilised his natural environment has been a determining factor in his social, cultural and economic development. The implications of the uncontrolled use of the environment are only now being appreciated. Environmental protection is likely to be a subject of continuing concern and research (Pigott 1975: 71).

The roots of this reframing exercise can be seen in the *Report of the Committee of Inquiry on Museums and National Collections including the Report of the Planning Committee on the Gallery of Aboriginal Australia* undertaken by the Whitlam government and released in 1975. Informally known as the Pigott Report (1975), the review handed down a number of recommendations that confirmed the importance of natural history collections and research[198] as sources of non-instrumental scientific research and the diffusion of that knowledge,

> As resource centres for research in Australia, the major museums are rivalled only by the libraries in importance. The museums have long had a special capacity to gather collections and to conduct research in the natural sciences. In Australia the State museums and the CSIRO's research collections have dominated the study of taxonomy and systematics. Those collections are still indispensable for gaining an understanding of ecosystems. Likewise, the journals published by the larger museums have, in some decades, been a crucial outlet for the dissemination of research findings. In several disciplines—for instance, zoology and anthropology—Australia's most important libraries until recent years were gathered within museums. Natural history has been the main theme of research in Australian Museums; here

[198] The epithet of *natural history* has been used to describe knowledge associated with the collection, taxonomy and research to do with specimens retrieved from the natural world. Natural history is traditionally conducted by 'naturalists', scientists who tends towards to the descriptive rather than the experimental side of science. This scientific practice has been traced back to the Greco-Roman period and continues to flourish around the world. 'Natural history' in the contemporary world has a broad multidisciplinary, taking in the scientific disciplines of geology, palaeontology, astronomy, botany, biology and zoology amongst others.

> were great opportunities for studying unique antipodean facets of zoology, geology and related sciences. In anthropology and ethnology the museums were active as research bases long before universities entered the field (Pigott 1975: 12).

The Committee of Inquiry (1975) also supported the positioning of these scientific institutions as interlocutors in the public sphere. Although the Australian Museum was habitually called upon to add to scientific debates, other museums and scientific organisations were more reticent to take up this role. The Committee proposed that further programs be developed that would provide the public with broader access to recent, balanced scientific knowledge; programs that would cover

> … Both sides of unresolved issues. Continental Drift, for instance, was more suited to a museum display when the concept was heresy than when, today, the concept is widely favoured. It is doubtful whether any museum in the world displayed the concept between 1912 (when Wegener put forward the idea) and the 1960s when it gained massive support. And yet the major museums have a rare but untapped ability to promote an understanding of many speculative issues. Here they have advantages which no film, book or cassette can quite emulate. Major museums could become more influential in tertiary education if they displayed controversies or issues of uncertainty, but their officials will justifiably point out that such displays cost money (1975: 14).

This recommendation that 'major museums have a rare but untapped ability to promote an understanding of many speculative issues… [and that major museums could] become more influential in tertiary education if they displayed controversies or issues of uncertainty' (1975:14) is an important theme regularly addressed throughout Pigott's (1975) report. For instance, under the Aims of Museums the committee found that

> Museums should satisfy curiosity and arouse curiosity. • Museums should educate formally and informally. • Museums should extend the front-lines of knowledge. • Museums should enable

> curious spectators to visit those front-lines and understand how some of the battles to extend knowledge are fought (1975: 6).

Moreover, that museums and their collections remain at the forefront of knowledge-making,

> …any museum worth the name is engaged in the difficult search for new knowledge. Truth is elusive in most of the natural sciences, social sciences and those disciplines for which museums specially cater. For that reason the accurate documenting of a research collection in, say, marine biology or ethnology is vital. Collections have to be carefully preserved so that later scholars can re-examine the evidence on which earlier theories or observations were based (1975: 11).

Special mention was made by the report of the risks associated with taking a market oriented approach to the knowledge produced and diffused by museums, 'we recommend that funds not be granted to museums which are so strongly directed towards tourism and entertainment that their standards of historical accuracy are violated' (1975: 3).

By the 1990s however the natural world, or the environment, and its accompanying public-facing institutes of non-instrumental science had not only been assimilated by the cultural sphere it had been colonised by neoliberal economic policy through the praxis of cultural tourism. The *Creative Nation* (1994) cultural policy makes this clear,

> The Government will further develop links between the Department of Tourism, the Australia Council and the Department for Communications and the Arts to initiate programs to provide further opportunities for cultural tourism. The Cultural Industry Development Program will allocate $250,000 annually to initiatives to develop cultural tourism including: measures to enhance the business management skills of the cultural industries as they apply to cultural tourism, utilising existing business development programs; measures to improve access by the cultural industries to tourist markets, including the development of marketing and distribution

networks; and the identification of new tourist markets for cultural products (AG CN 1994: online).

Moreover, the Australian Bureau of Statistics (ABS) signalled the formal uptake of this new cultural positioning with their inclusion of natural history museums within the new cultural category of *Museums* (8560.0) in 1999-2000. In that year's report, the museum types surveyed were 'art museums/galleries, historic properties, social history, natural history, science and other museums operated by the private and government sectors' (ABS 8560.0: 1999-2000). Note that science museums did not produce non-instrumental scientific knowledge. These museums instead performed as interactive discovery centres for children, young families and school children.[199]

The same *Museums* report published again by the ABS in 2003-2004 and 2007-2008 (the most recent report) was significantly different in scope to the 1999-2000 report. It expanded to cover: historic trusts and sites; historic societies with a collection; house museums; social and natural history museums; archives (excluding the national and state archives); art galleries (excluding commercial art galleries); keeping places and cultural centres; outdoor museums; science museums; maritime museums; military museums and transport museums. Again, although important and worthwhile in their

[199] There are currently at least five 'science and technology discovery' centres in Australia including the Canberra based Questacon which opened in 1980; SciTech in Perth which demonstrates 'science, technology, engineering, maths' (STEM) and which opened in 1988; Scienceworks in Melbourne (1992); the Bendigo Discovery Science and Technology Centre a children's discovery centre (1995); and the family oriented Wollongong Science Centre and Planetarium (2004). While worthwhile institutions in their own right these 'science' museums cannot be classified as producers of non-instrumental scientific knowledge. Moreover, the scientific knowledge that these institutions communicate is usually 'settled' scientific knowledge that has been reshaped to support cultural policy.

own right these institutions are largely cultural centres, reflective of Australia's culture and heritage.

Note that the major museums have been reallocated from natural history museums to social and natural history museums. Originally, the natural history museums researching and delivering non-instrumental scientific knowledge to the citizenry (the National Museum of Australia, Melbourne Museum, Queensland Museum, Museum of Tropical Queensland, South Australian Museum, Western Australia Museum, Tasmanian Museum and Art Gallery, Queen Victoria Museum in Launceston; Museum and Art Gallery of the Northern Territory) now deliver cultural interpretations of both social and natural history.

However, some retain non-instrumental scientific research, mainly in palaeontology. Small museums such as the Age of Fishes Museum in Canowindra, the Australian Fossil and Mineral Museum in Bathurst and the Riversleigh Museum near Mount Isa retain their scientific integrity by concentrating on the scientific discipline of palaeontology. These museums do not have the same levels of funding as the major museums and are thus more reliant on the three tiers of government to provide grants in order continue their scientific work. On the other hand, privately owned museums and fossil records such as the Australian Age of Dinosaurs in Winton, and the *infotainment f*ocused National Dinosaur Museum in Canberra offer tourists an experience of Australia's natural history however is subject to the pressures of the profit imperative. This profit focus guides their scientific work and demands strong marketing initiatives in order to attract the tourist dollar and encourage the maximum number of 'bums on seats'. This focus on tourism over science is demonstrated in the repositioning of natural history into the *Culture and Recreation* and *Cultural Industries – Heritage* categories by the Australian Bureau of Statistics (ABS).

By 2004 these large and small museums and natural sites of scientific importance had again been reclassified by the ABS. They subsequently appeared within the category of *Culture and Recreation* which comprised 'Museums; Environmental heritage; Libraries and archives; Literature and print media; Performing arts; Music composition, distribution and publishing; Visual arts and crafts; Design; Film and video; Broadcasting; Arts education' (ABS 2014: Cat No 4147.4.55.001: online). Furthermore, by 2013 the ABS had reclassified the broad category encompassing 'zoos, parks, gardens, libraries, museums and galleries' as *Cultural Industries – Heritage* (ABS 2013: online).

This reframing of non-instrumental scientific knowledge by the ABS demonstrates the authority of cultural policy and practice in Australian policy settings. More importantly, the official categories prescribed by the ABS are used extensively in public research and in public policy setting and continue to influence government decision-making into the future. So not only is the ABS describing museums as sites of cultural practice it is aligning them with political decision-making. An outcome of the re-framing of non-instrumental science was the emergence of the *deficit model* of communication policy.

7.2.1 The deficit model

The cultural approach to scientific knowledge diffusion has arguably drawn on the British inspired *deficit model* of public science communication. British scholars in particular have argued that a cultural approach to science takes 'scientific principles out of both the natural and the social worlds' (Gregory & Miller 1998: 208); that

> …science centres do not generally make clear (that) the demonstrations they present to the public are part of an existing knowledge system. There is a danger that science is presented as simplistic truth, a mirror image of a 'real' physical world' (Butler cited in Gregory & Miller 1998: 209). Moreover that… 'it is arrogant and naïve of science centers to presume that their visitors would be unable to comprehend their experience within a particular conceptual framework (Gregory & Miller 1998: 209).

Thorpe and Gregory (2010) note that the COPUS Grants Committee set up in Britain in 2004 to promote public science communication activity erected the framework for the practise of the deficit model in that country,

> Copus, while associated with many positive values and festive events, had also become identified with a one-directional mode of science communication and the deficit model of public understanding of science, which posited an urgent need for scientists and their champions to fill the empty heads of the public with scientific facts (Thorpe & Gregory 2010: 274)…The 'deficit model' of public understanding of science, which sees the public as blank slates or empty vessels – as minds in deficit that need scientific information in order to be replete (Gregory & Miller 1998: 17).

Thorpe and Gregory go on to argue that the committee succeeding COPUS, Sciencewise, turned in the other direction, instead encouraging dialogue and engagement,

> —multidirectional communication concerned with values, aspirations and concerns—and placed responsibility for science communication with professional practitioners funded by policy-makers and interest groups, rather than with university scientists or amateur enthusiasts. This turn 'from deficit to dialogue' in the discourse of science communication was advocated and anticipated by social scientists and has been well documented; it affected many of the novel institutions of science communication that, alongside Copus, had peppered the UK scene since the late 1980s (Wynne, 1992; Gregory & Miller, 1996; Irwin & Wynne, 1996; House of Lords, 2000; Gregory & Lock, 2008; Lock, 2009) (Thorpe & Gregory 2010: 274).

This new way of conceptualising public engagement with science sees the relationship as 'properly reciprocal and reflexive', unlike the broadcast model of science communication which locates scientific knowledge at one end of 'one-way transfer of knowledge and information from science to the public' (Thorpe & Gregory 2010: 276).

This concept of a multidirectional communication is more closely associated with the Habermasian model of communicative action that embraces 'values, aspirations and concerns' of the lifeworld and encourages rational debate. This promising literature that is being developed in Britain has not yet been fully extended in order to take in the Australian situation. There is a limited scholarship currently based on the Australian context and this opens up a potentially fruitful opportunity for further research outside the scope of this thesis. The question remains in Australia whether to continue with the cultural approach to scientific knowledge which takes the 'scientific principles out of both the natural and the social worlds' (Gregory & Miller 1998: 208) or whether to instantiate a new model of public-facing non-instrumental science which encourages 'dialogue' and 'engagement' (Thorpe & Gregory 2010: 274).

So, a confluence of forces has contributed to the transfer of many public facing producers of non-instrumental scientific knowledge to the cultural realm. Outcomes include the aestheticisation of scientific knowledge in the public sphere (through the shifting of public-facing institutions concerned with non-instrumental science into the remit of cultural policy), weakening the potential for public engagement with science (by adopting a cultural approach to science thus stripping scientific principles from both the natural and social worlds) and limiting the scope for the re-integration of science as a topic for debate in the political public sphere (through the application of the deficit model to non-instrumental scientific knowledge that has been prepared for public consumption).

The following section demonstrates the transformation of the traditional producers and diffusers of non-instrumental science in Australia into mediums for cultural messages and the display of cultural objects. The argument relies primarily on the case of the Australian Museum, the primary institution of this kind in Australia. This institution has been reflective of the status of non-instrumental science in Australia since its inception in the early 19th century and thus provides an important case study indicative of these larger developments.

7.3 The case of the Australian Museum

As discussed in previous chapters, the Australian Museum has been producing and delivering non-instrumental scientific knowledge in Australia since the early 18th century. It inherited a long tradition of natural history museums acting as public-facing scientific organisations. Natural history museums as scientific collecting, describing, classifying and research institutions can be confidently traced back to at least the European renaissance (Findlen 1994). Moreover, they have acted as important interlocutors in the public sphere since that time (Fara 2009, Yeo 2001, Habermas 1991, Findlen 1994). This section traces the penetration of cultural policy into the Australian Museum and demonstrates its transformation from a scientific organisation into a cultural institution delivering cultural messages and displaying the creations of the culture industries.

As discussed earlier in this chapter, by the mid-1970s the cultural turn was well underway in Australia and the scope of cultural policy had widened to assimilate nontraditional fields into arts policy and practice. Despite its impeccable international and local credentials in both scientific research and public engagement at the time (Strahan 1979), the Australian Museum was nevertheless transferred from the New South Wales Department of Education (where it had resided since 1880) into the newly formed Department of Cultural Activities.

The new department took responsibility not only for the Australian Museum, one of Australia's leading non-instrumental scientific institutions, but the Opera House, the Art Gallery, State Library and what was then the Museum of Applied Arts and Sciences, now the Powerhouse Museum. Director Frank Talbot comments on the move below. His concerns around the diminution of the Australian Museum in both political standing and in its decreasing significance as a non-instrumental producer and distributor of scientific knowledge in the newly emerging cultural sphere are unmistakable,

> …I find myself in a difficult position. When the Ministry was first formed…I particularly asked the question of the Chairman (of the Public Service Board) who my direct superior would be. This has in the past been the Director-General of Education, and it seemed to me a retrograde step for the institution to have the Director responsible to the Secretary of the Ministry, a more junior official. I was assured that I would, under the new Ministry, refer directly to the Minister. I now find that, in fact, this is not correct. I refer to an administrative officer and not, as in the case of the Director-General of Education, a most senior academic educationalist. This leads to a lack of understanding of the very nature of the Australian Museum by someone in a clerical position and relegates the Australian Museum to the position of a sub-department and a not a corporate body. I am finding almost daily that there is increased communication of a trivial nature between the museum and the Ministry… I find for the very first time that my own very real enjoyment of building a museum which we can be proud of is being whittled away by constantly niggling battles for autonomy with a Ministry which is determined to exert maximum control…of the

> Australian Museum without knowledge or understanding of what the institution is about (Talbot cited in Strahan 1979: 97).

Strahan notes that the new Australian Museum Trust Act legislated in 1975 also altered the balance of power between the Trustees and the state, and functioned to cede power to the Minister of Cultural Activities. Strahan comments, 'it is clear that the possibility is now open for radical changes in the composition of the museum's governing body and its responsiveness to the wishes of individual ministers' (1979: 97). This proved to be the beginning of a major transformation for the museum. Talbot's vision for the Australian Museum as a leading scientific institution and as a robust interlocutor in the political public sphere was now at risk of being eroded by its collapse into arts and cultural policy.

In a further shake-up the Department of Cultural Activities was absorbed in 1975 into the even larger Department of Culture, Sport and Recreation. An increasingly frustrated Frank Talbot resigned to take up the foundation chair in Environmental Studies at Macquarie University (Strahan 1979). Strahan (1979:98) notes that 'Talbot's resignation aroused little response from the press but *The Bulletin* devoted a page to an article based on an interview with him:

> The Australian Bureaucracy chalked up a major victory for itself last week with the resignation of Dr Frank Talbot as Director of the Australian Museum in Sydney. Foul play is not suspected…The phenomenon is familiar enough within newly created government departments, particularly so within the ragbag and therefore most junior kind as originated and typified by the Ministry of the Environment, Aborigines and the Arts set up by the McMahon Government in 1971 and demolished by the Whitlam Government in 1972. The intervening period is now recalled as the dark night of the soul for artists, Aborigines and the environment… (Cited in Strahan 1979: 98).

A brief review of government administration of the Australian Museum is shown in Table 7.2. The table illustrates the measured transfer of non-instrumental science into the policy areas of culture, the arts, and finally to its current position under the patronage of the Department of Trade and Investment.

TABLE 7.2: List of Ministries or Departments administering Australian Museum

Year	**Department**	**Organisations governed by the Ministry or Department**
1880-1971	Department of Education	The portfolio encompassed the management of public education: primary, secondary and tertiary. Planning for tertiary education included the administration of Tertiary institutions such as universities, and colleges of advanced education. The portfolio also administered specialist education such as migrant, nurse; music and adult education. Technical Education was also administered in this portfolio including administration of Technical and Further Education Colleges.
1971-1975	Department of Cultural Activities	Archives Office of New South Wales, Art Gallery of New South Wales, Library of New South Wales, Australian Museum, Museum of Applied Arts and Sciences, Sydney Observatory, Advisory Committee on Cultural Grants, Library Board of New South Wales, NSW Film Council, and the Sydney Opera House Trust.
1975-1976	Department of Culture, Sport and Recreation	Advisory Committee on Cultural Grants, Archives Office of New South Wales, Art Gallery of New South Wales, Australian Museum, Greyhound Racing Control Board, Museum of Applied Arts and Sciences, NSW Film Council, National Fitness Council of NSW, The Library of New South Wales, Sydney Cricket Ground and Sports Ground Trust, Sydney Observatory, the Sydney Opera House and Sport and Recreation Service of NSW. The last organisation aimed to promote physical fitness and recreational opportunities which was achieved by providing camping facilities, swimming instruction, school vacation play centres.
1976-1984	Division of Cultural Activities within the Premier's Department	The Minister for the Arts became responsible for legislation administering the Archives Authority of New South Wales, the Art Gallery of New South Wales, State Library, Sydney Opera House, the Australian Museum, the Museum of Applied Arts and Sciences, and the Historic Houses Trust of New South Wales
1984-1986	Office of the Minister for the Arts	Archives Authority of New South Wales, the Art Gallery of New South Wales, State Library, Sydney Opera House, the Australian Museum, the Museum of Applied Arts and Sciences, and the Historic Houses Trust of New South Wales
1986-1988	Minister for Heritage	Archives Authority, the Australian Museum, the Museum of Applied Arts and Sciences, the Historic Houses Trust and the State Library of New South Wales
1988-2006	Ministry for the Arts	Australian Museum and all 'arts' organisations in New South Wales. A key function of the new Ministry was the 'official recognition to the importance of

		the arts in the life of the community, and established a mechanism for greater co-ordination and accountability in the operations of all the State's cultural institutions.'
2006-2009	Department of Arts, Sport and Recreation	The three main business arms of the Department were: Arts NSW; the NSW Office of Liquor, Gaming and Racing; and, NSW Sport and Recreation. Each agency sought to work closely with local communities, industry partners and government to maximise community participation in the arts, sport and recreation and to regulate the liquor, gaming, racing and charity industries. Arts NSW managed the Art Gallery of New South Wales, the Australian Museum, the Film and Television Office, the Historic Houses Trust, the Powerhouse Museum, the State Library, State Records and the Sydney Opera House.
2009-2011	Communities NSW	The new principal department, Communities NSW, had oversight of the following agencies: Arts NSW, NSW Office of Liquor, Gaming and Racing, NSW Sport and Recreation, Office for Children, Office of the Community Relations Commission, Office of the Minister for Western Sydney, Office of Volunteering, Australian Museum, Museum of Applied Arts and Sciences (Powerhouse Museum), Historic Houses Trust of New South Wales, Art Gallery of NSW, State Library of NSW, Sydney Opera House, Casino, Liquor and Gaming Control Authority, Parramatta Park Trust, Parramatta Stadium Trust, Centennial Park and Moore Park Trust, Hunter Region Sporting Venues Authority, Western Sydney Parklands Trust, Sydney Cricket and Sports Ground Trust, Wollongong Sports Ground Trust, State Sports Centre Trust, Sydney Olympic Park Authority, Sydney Olympic Park Authority Aquatic and Athletic Centres, NSW Institute of Sport, and Office of the 2009 World Masters Games Organising Committee
2011-2015	Department of Trade & Investment	Three main areas of the 'super department': Tourism, Major Events, Hospitality, Racing and Arts (includes Australian Museum); Mineral Resources and Energy; Primary Industries, Food and Water; Trade, Business and Investment.

(Source: Adapted from material provided by State Records NSW 6: online)

A review of these shifts in state administration reveals that the governance of the Australian Museum during this period has largely traced the instantiation of political ideology. From its emergence in the early 19th century as an organisation dedicated to the production and diffusion of non-instrumental scientific knowledge and to the development of a robust civil society, the Australian Museum has since the 1970s weathered the controlling influences of the cultural turn, only to become entangled in the demands of neoliberalism and its doctrinal insistence on small government, privatisation, deregulation and free markets.[200]

An extensive review of the Annual Reports of the Australian Museum between the years 1960 and 2013 has found that the significant outcomes of this transfer to the cultural realm and neoliberalism have comprised: a greater emphasis on cultural display over the production and diffusion of scientific knowledge; a reduction in the number and diversity of non-instrumental scientists employed by the museum; a pronounced shift from educating diverse age groups to family entertainment, so rationalising the introduction of an admission fee for both regular attendance and for attendance at special exhibitions, or *blockbusters*; a more regular incidence of non-scientific blockbusters; a greater stress on marketing activities; more emphasis on the role of corporate sponsorship to support self-funding initiatives; an expanding use of the museum as a venue for local cultural events; a decreasing emphasis on scientific knowledge in the literature provided for museum Members and the general public; the growing importance of the Australian Museum as a tourist destination; and the growing role of the museum as a vector for celebrating indigenous culture.

An examination of the list of public exhibitions and displays conducted by the Australian Museum between 1905 (when the first temporary exhibitions started to appear in addition to the more permanent scientific and anthropological displays) and 1971 shows that 100% of these events were themed to the natural world. Between 1971 and 2014 there is a distinct turn towards the inclusion of cultural exhibitions in the museum's event program. A closer examination of the temporary exhibitions shows

[200] These new demands will be discussed within the context of neoliberalism in Chapter 8.

that only 14% of exhibitions between 1971 and 2014 were scientific in character whereas the remaining 86% were either cultural or anthropological displays.

A small sample of these cultural exhibitions follows: the paintings of *Pierre Bonnard* (1967-1947) a French impressionist painter, draughtsman, photography, printmaker, illustrator and interior designer who was best known for his domestic scenes, still life and portraits in 1972; *Indonesia Today* in 1973; *Cambodian Sculpture* in 1974; *Craft and Jade* in 1975; *American Glass Sculpture* in 1976; *Contemporary American Ceramics and American Bicentenial* (sic) *Celebration* in 1976; *Life in India and the Himalayas* in 1976; *Indian Exhibition* in 1977; *China Exhibition* in 1978; *African Art* in 1979; *Musical Instruments* in 1979; *Women Artists* in 1982; *Power of Love: six centuries of diamond betrothal rings* in 1990; *Dia de los Muertos (Day of the Dead)* in 1999/2000; *TORTURE: inquisition, capital punishment* in 2005/2006; *Fashion Less Waste* in 2011; and so on until the present day (AM Exhibitions Timeline 2014: online).

The museum also hosted a number of blockbusters under the directorship of Frank Howarth (2004-2014), a career public servant. Blockbuster exhibitions are commonly pre-packaged international travelling exhibitions that are curated by overseas institutions and installed locally for short periods of time in order to attract attention to the local museum and increase visitor numbers. These blockbusters usually attract a premium admission price and demonstrate good merchandising potential. More often than not these international exhibitions are drawn from the world of art and culture.

Blockbuster shows mounted by the Australian Museum under Howarth's directorship have included: *Gold and Sacrifice: treasures of ancient Peru* from the Rafael Larco Herrara Archaeological Museum in Lima, Peru in 2004; *Egyptian Treasures: art of the* *pharaohs* (sic) from the Kunsthistorisches Art Museum in Vienna in 2011*;* and *Alexander the Great*: *2000 years of treasures* from the State Hermitage in St Petersburg, Russia in 2013. The themes of these blockbuster exhibitions refute an argument made by Turner that this style of exhibition connects the museum 'with international scholarship, researching existing collections and enhancing those collections' (2014: online); the international scholarship networks with which the museum's scientists are connected is primarily in the field of non-instrumental science.

There had been considerable disquiet amongst the international community of scientists for some time regarding the policy directions being undertaken by the Australian Museum. Figure 7.1 shows the shift in numbers of scientific staff employed by the Australian Museum.[201] The two big shifts in scientific staff numbers were the result of the addition of large research sections around environmental science and anthropology. Environmental science peaked between the mid-1970s and the end of the 1990s. As environmental science contracted in the years 1995/96 the anthropology section expanded (AM AR 1996) so supporting the museum's shift from scientific institution to cultural organisation. The impact of neoliberal praxis can be seen in the restructuring of the organisation and resultant reduction in scientific staff from 2004/04 onwards.

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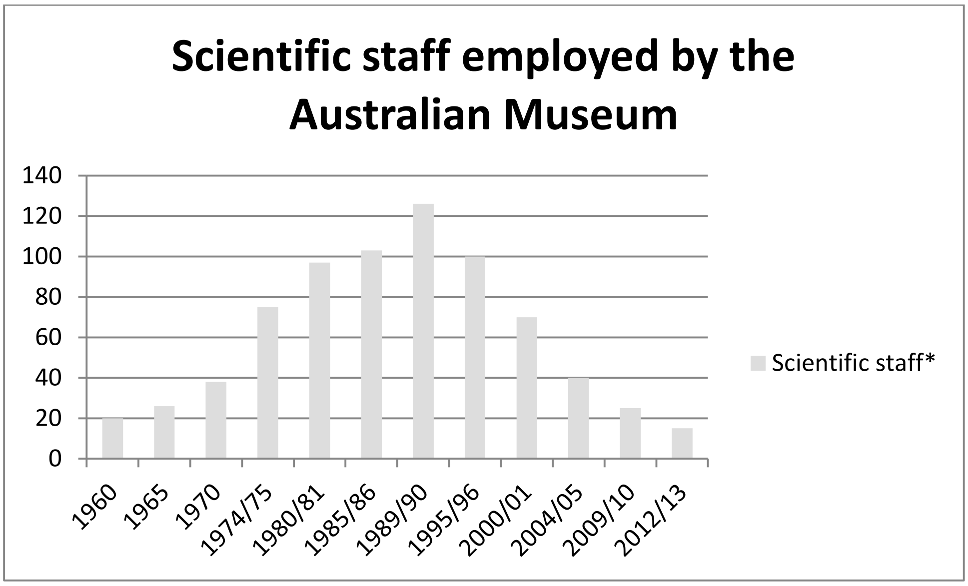
[201] The figures covering the years 1960 to 1995/96 have been compiled using the staff lists published in the Annual Reports for each year. From the years 2000/01 the scientific staff numbers have been estimated as the Annual Reports no longer published lists of staff, rather they used Organisational Charts to describe the structure of the museum. During the year 2000/01 the museum experienced significant restructuring and a number of voluntary redundancies were taken up by museum staff. The estimates from 2004/05 have referenced the organisational charts, an article in the Sydney Morning Herald (Phillips 30 Nov 2013: online) to assist with the estimations of scientific staff and an essay by Tim Flannery (2012).

Figure 7.1 Scientific staff employed by the Australian Museum (see Footnote 181)



* Includes research scientists, curators, technical officers and research assistants

The disquiet around the diminution of scientific staff since 2004/05 is encapsulated in the following letter written to the Minister in July 2013 and published in The Australian Geologist, a magazine produced by the Geological Society of Australia. The Geological Society had been concerned for some time about the decreasing ability of the museum to conduct and promulgate non-instrumental science particularly earth science. In order to accentuate the importance of its contents, the letter is reproduced in its entirety.

> 26th July, 2013
> Dear Honourable Minister,
>
> We, the Executive Committee of the Geological Society of Australia Incorporated represent over 3000 earth scientists, employed across a wide range of sectors including academia, industry and government. Some of our members are in senior positions in a number of companies and organisations. We would like to bring to your attention a number of issues concerning scientific research and collection management in Geosciences at the Australian Museum, which is under your ministry. These were communicated to us by a number of our members and have raised serious concerns amongst the earth science community as a whole.

Firstly, a statement made by Dr Brian Lassig (Assistant Director, Research and Collections, Australian Museum) as reported in the *Sun Herald* and *The Age* on 10th February, 2013. In this, Dr Lassig stated that the museum had reviewed its priorities and moved away from the geosciences to focus more on 'topical issues' such as biodiversity conservation'. To quote Dr Lassig in his own words as reported in both newspapers 'What happened millions of years ago is interesting, but it's not going to influence the government's current thinking'. We view this statement as a direct attack on the relevance of our science, and one made in complete ignorance of our discipline. Many of our members are leading the way in terms of our understanding of climate change and evidence for anthropogenic causes. There are numerous other examples of the relevance of our discipline to 'topical issues' and to cite just a few: water sustainability, alternative energy, sustainable resources, and hazard management.

Secondly, since 2007 the Australian Museum has employed no research scientists working in any field of geology. In its Geoscience section, it employs a single Collections Manager for both Mineralogy/Petrology and Palaeontology (a recent enforced amalgamation) and only 2 technical officers to curate its expansive and diverse mineral, rock and fossil collections. This would appear to breach *The Australian Museum Trust Act 1975* which states under:

7. Objects of the Trust
1. The objects of the Trust are to propagate knowledge about the natural environment of Australia and to increase that knowledge.
2. When acting in pursuance of its objects, the Trust shall give particular emphasis to propagating and increasing knowledge in the natural sciences of biology, anthropology **and geology**.

Thirdly, between 1996 and 2001, over 300 of the most important Devonian fish fossils from the Canowindra fossil site in NSW were described in detail (including the formal description of new species). In order for these to be published and figured in the scientific literature, the specimens had to firstly be registered by an internationally recognised museum, in this case, the Australian Museum. The museum management at the time approved of this and gave the specimens official Australian Museum AMF numbers (around 270 AMF numbered specimens). These specimens include unique type and figured specimens of long-extinct fishes known only from Canowindra, NSW. They are crucial to our understanding of the evolution of life and especially to the transition of backboned animals from water to land. Also, from a scientific viewpoint, as type specimens they are the most important in any collection.

In 2009, the current Australian Museum management arbitrarily declared that these same AMF registration numbers to be 'invalid' on the grounds that 'they were never properly accepted' by the Museum Trust. Type specimens are the 'crown jewels' of any natural history Museum and strict international regulations control their de-accession, or transfer to other bodies. This would be a great loss for New South Wales and Australia. Despite requests for documentary proof that the Australian Museum Trust had been asked to approve de-accessioning the Canowindra type specimens no such confirmation has been provided by the Australian Museum management to substantiate this remarkable claim.

Emeritus Professor Ken Campbell, ANU, one of Australia's leading palaeontologists, familiar with the Australian Museum's fossil collections and also with the latest discoveries from Canowindra, expressed concern at the Australian Museum's reported 'de-accessioning' of the unique Devonian fossil fishes discovered near Canowindra, as follows:

"*Palaeontologists around the world regard this site at Canowindra as one of the best in the world for understanding the critical period of evolution from fish to amphibians and, as such, it must be cherished as one of New South Wales' contributions to global palaeontology*."

"*But Canowindra is only one of hundreds of sites around Australia from which the Australian Museum's collections have been assembled for over 150 years. These collections must be well curated and made available to visiting scientists for examination, in perpetuity*."
"*The Museum Trustees should also remember that new advances in technology enable scientists to examine many such specimens by non-destructive methods, unknown only 10 years ago, which leave the original specimens intact*."

We urge you to resolve this issue to allow the international scientific community to have continued confidence in the Australian Museum's commitment to its responsibilities as one of the world's most significant type repositories —and also in its ability to increase and propagate public knowledge about the geological heritage of New South Wales — as legislated in its own *Australian Museum Trust Act 1975*.

We would greatly appreciate your help in resolving these issues.
On behalf of the Executive Committee of the Geological Society of Australia Incorporated
Yours Sincerely,
LAURIE HUTTON
President,

Geological Society of Australia Inc.

Moreover, scientist, academic, writer and public broadcaster Professor Tim Flannery (a former research scientist with the Australian Museum) has argued on a number of occasions about Australia's extinction crises and the shadow of climate change and the importance of non-instrumental science to mitigate these crises. Flannery's essay *After the Future: Australia's new extinction crisis* (2012) traces the political machinations of governments around socio-scientific issues. Flannery laments the decline of non-instrumental science in Australia arguing that 'tragically, the very organisations charged with custodianship of our natural heritage have been allowing their research capacity to wither on the vine' (2012: 36). In providing evidence for his argument, Flannery points specifically to the CSIRO and the Australian Museum as 'dismal' cases of state reluctance to support non-instrumental science by arguing that the

> Australian Museum in Sydney offers one example of how low things have sunk in the state museum sector. When I joined its staff in 1984, over thirty researchers were employed…today there are just twelve fully qualified, full-time curators or research scientists in the department of

reptiles, fish, archaeology, palaeontology, arachnids (spiders), minerals and echinoderms (2012: 36).

Despite the concerns of the non-instrumental scientists, the management of the Australian Museum continues to define its activities in terms of cultural policy. In its determination to 'attract new audiences (and) raise the profile of the institution with government and the public' (Turner 2014: online) the marketing team opened up 'the whole museum' on Tuesday evenings for six 10-week seasons in 2011-2013 to host 'Jurassic Lounge'. The Jurassic Lounge was a joint venture between the event company, 'The Festivalists', and the Australian Museum marketing department in order to attract new audiences' to the museum. The event company 'programmed, produced and promoted the event, with the museum providing the overall brief, budget and some staffing resources' (Festivalist case study 2014: online). The official web site describes Jurassic Lounge as such,

> Jurassic Lounge is Sydney's wildest after-hours party against a stunning backdrop of dinosaurs, wild animals and precious gemstones….Every night at Jurassic Lounge will be filled with spectacular line-up of artists, including comedians, bands, pole dancers, DJs and burlesque performers, alongside craft markets, dance lessons and science experiments. Expect the unexpected! (Jurassic Lounge 2014: online)

The case study prepared by the event management company, The Festivalists, judges the event as successful,

> Blending interactive entertainment and education, the idea connected very strongly in the marketplace, becoming a benchmark for museum engagement, audience development and an oft-cited case study in the City of Sydney's late-night economy strategy. The event won the Remix: The City award at Sydney's Music Arts & Culture Awards….Over the course of six seasons, Jurassic Lounge welcomed more than 66,000 visitors, of whom 80% are 18-35. Audience surveys

show that 98.9% of visitors would recommend Jurassic Lounge to their friends. Many nights reached audience capacity (2000), turning Jurassic Lounge into a cultural phenomenon in Sydney (Festivalists case study 2014: online).

As the 'benchmark for museum engagement and audience development', this exercise would seem to have been that derived from the culture industries rather than an attempt to engage the citizenry in the production and diffusion of scientific knowledge. Indeed, the event is described as a 'cultural phenomenon' and an award-winner in 'Music Arts and Culture'; 'science experiments' seem an afterthought. Under the extant policies of neoliberalism, a total of 66,000 visitors over six seasons/three+ years (when the total visitation rate in 2012/2013 was 438, 454) would seem to be unsustainable. The case study provided by 'The Festivalists' could profit from a cost-benefit analysis.

This section has shown how cultural policy and practice has transformed the Australian Museum. Designation as a cultural organisation has seen the museum shift from an internationally recognised and public-facing producer and distributor of non-instrumental science for the general public, as well as for the communities of professional and lay scientists, to something altogether different. Its function as an interlocutor in the public sphere has also been debased.

7.4 Conclusion

This chapter has argued that, after a brief respite in the lifeworld as the rational companion of environmentalism,[202] the non-instrumental science produced by public-facing institutions in Australia has been reabsorbed and aestheticised by state policies that are founded on a particular understanding of postmodernism. Through the praxis

[202] This emergence of non-instrumental science into the public sphere was explored in Chapter 7.

of the cultural turn in the social sciences, these policy settings sought to shift artistic practice from the realm of experts into everyday life. This objective has not been wholly successful in Australia and the arts have been largely been returned to the authority of experts and to management by the state.

This dynamic has, however, produced two sets of negative consequences which have arguably served to further drain the lifeworld of richness and vitality. The public-facing institutions producing and diffusing non-instrumental science have been assimilated into cultural practice. More curiously, the natural world itself has been absorbed into the political realms of cultural policy and thus into the purview of the arts. Paradoxically, as the arts are re-hitched to the realm of experts, the natural sciences are decoupled from the expertise of scientists and repositioned under the expertise of marketing and communications professionals. This theme is carried forward in the following chapter which explores the shifts in the production and diffusion of scientific knowledge under the precepts of neoliberalism.

8 1990s-2010s: Scientific knowledge and neoliberalism

The Australian nation has relied on the production and diffusion of scientific knowledge production and diffusion since the early days of white settlement in order to advance economic goals and so support social and political aims. This thesis so far has traced the shift of scientific knowledge production from its function as an implicit factor within the traditional factors of production, i.e. land, labour and capital to the beginnings of a changing global landscape in the 1980s. In order to bring the story up to the present day, the current chapter demonstrates the movement of scientific knowledge to its extant position as an explicit factor of production and as a marketable commodity traded between transnational corporations. It also looks at how the traditional factors of production have expanded to take on new forms that favour the new globalised tertiary knowledge industries.

The production and diffusion of scientific knowledge in Australia during the first half of the 20th century was aligned with state imperatives around economic and industrial development. These strategies of development encouraged a significant expansion of pre-instrumental science on the part of the state and a further weakening in the production and diffusion of non-instrumental scientific knowledge. By the end of the 20th century, global forces both economic and political in combination with the advent of real-time digital communication capabilities had yielded a new hybrid form of instrumental scientific knowledge in Australia. This 'new science of innovation'[203]

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[203] The OECD defines 'innovation' as a national system of knowledge production that links the state and the market. 'The study of *national innovation systems* directs attention to the linkages or web of interaction within the overall innovation system. An understanding of these systems can help policy makers develop approaches for enhancing innovative performance in the *knowledge-based economies* of today. The smooth operation of innovation systems depends on the fluidity of knowledge flows – among enterprises, universities and research institutions. Both *tacit knowledge*, or (sic) know-how exchanged through informal channels, and *codified knowledge*, or information codified in publications, patents and other sources, are important. The mechanisms

encourages the producers of non-instrumental scientific knowledge to work directly with the market in order to produce market-ready instrumental scientific knowledge.

This hybrid form of knowledge production is no longer routed through the vector of pre-instrumental scientific knowledge; rather the state removes itself from the process of knowledge production and diffusion by delivering that function directly to the market. Moreover, the coalescence of global forces and Australia's domestic policy responses have effectively completed the shifting of scientific knowledge from an implicit factor of production to an explicit factor of production within the production process. This process of separation has fostered the conversion of scientific knowledge from a holistic, integrated element of the production of goods and services to a standalone product in its own right; and so scientific knowledge has been transformed into a product, travelling in a *space of flows* (Castells 2005) and housed in strategic *knowledge hubs* around the world to be bought and sold on the open market at the will of new corporate 'owners'.

Prior to these global transformations of the 1970s and beyond, the Australian state had employed economic protectionist strategies to safeguard the nascent primary and secondary industries; an important component of this protectionism had been the provision of pre-instrumental scientific knowledge. By the 1960s however Australia's protectionist policies meant that the nation was struggling to compete in an increasingly global market place and a domestic economic crisis precipitated. As a method of remediating these problems the Australian state, along with other western

for knowledge flows include joint industry research, public/private sector partnerships, technology diffusion and movement of personnel (OECD 1997: 3).

nations, adopted strategies of *neoliberalism*. This theoretical position applies many of the principles of *neo-classical* economics, i.e. a free market economy divested of the protection of the state and the transfer of state utilities to the market.

The primary and secondary industries that had been closely bound to the state and that were reliant on the state provision of pre-instrumental scientific knowledge are slowly being weaned off this form of state delivered subsidy. This divestment strategy on the part of the state has impacted the CSIRO; the nation's universities are similarly affected as the state attempts to defray costs by expanding the role of Australian Research Council (ARC) and the National Health and Medical Research Council (NHMRC) in order to increase competition for reduced levels of state funding. Moreover, the introduction of a new science of innovation, a hybrid of non-instrumental and instrumental scientific knowledge, has been created. This 'new' science is constructed in order to leverage the global transformation of scientific knowledge from its place as an embedded factor of production to a disembedded product in its own right.

This chapter argues that this new science of innovation is in reality new form of developmentalism, whereby special interests, in the form of economic elites drawn from the tertiary industries sector, attract preferential treatment and government protection in the same way that the primary and secondary industries did during the 19th and 20th centuries. What was formerly non-instrumental scientific knowledge has been split into two categories under neoliberalism: firstly, the scientific knowledge supporting the new *knowledge markets* by partnering with non-instrumental scientists to shape the new science of innovation; and secondly non-instrumental scientific knowledge informing environmental concerns and categorised under sustainability policies. As sustainability policy has broadened to encompass a wider range of social and economic areas, innovation policy has correspondingly narrowed to focus on expansionary market-based initiatives.

The new developmentalism that has emerged under the praxis of neoliberalism emphasises the dialectical character of this new science. Rather than securing protection for the citizenry and autonomy on the part of the individual, neoliberal praxis reduces the possibilities of emancipation of the lifeworld and increases the potential for colonisation by the market. Indeed, neoliberal strategies that: demand the privatisation of formerly state sponsored scientific knowledge producers; that de-accession scientific knowledge from the state to the market (notably, that scientific knowledge funded by, and produced on behalf of, the citizenry); that increase the prevalence of scientific knowledge as corporate private property; that pitch non-instrumental scientific knowledge as a rhetorical device in the form of marketing strategies and advertising messages; and that shift the production of pre-instrumental science into a more closely bonded relationship with the market, are contributing not only to the decline of non-instrumentally aligned scientific knowledge production and diffusion but are potentially risking the sovereignty of both the citizenry and the nation.

The following section looks at the introduction of neoliberal strategies into Australian public policy settings, and their influence on scientific knowledge production and diffusion. The chapter then moves to discuss the origins and development of innovation policy in Australia and its positioning as a new form of developmentalism.

8.1 Neoliberal policy settings in Australia

In order to mitigate the growing economic crises that arose in the 1970s, Ronald Reagan (US President: 1981-1989) and Margaret Thatcher (UK Prime Minister: 1979-1990) drew on the work of American economist Milton Friedman (1912-2006) to restructure their domestic economies, and Australia followed their lead. Neoliberalism[204] was first introduced into Australian politics in a soft form by the Liberal Fraser government (1975-1983), thereafter consolidated into increasingly more robust forms by the Labor government of Hawke-Keating (1983-1996), the Liberal government of John Howard (1996-2007), the Labor government of Rudd-Gillard (2007-2013) and the Liberal (conservative) government of Abbott-Turnbull (2013-current). Pusey's (1991; 2003) extensive work into economic rationalist policy and praxis extant in the Federal bureaucracies of Australia points to a 'weakness of culture and civil society' as a key element of the successful instantiation of neoliberal policies accompanied by neoclassical economics (1991: 10). Pusey writes,

> We find that this state apparatus is caught within projections of reality that give primacy to 'the economy', second place to the political order, and third place to the social order. Indeed, perhaps the most central finding is that, since the 1970s, reality has been turned upside down and society has been recast as the object of politics (rather than, at least in the norms of the earlier discourses, as the subject of politics). Further, society has been represented as some sort of stubbornly resisting sludge, as a 'generic externality' and even as an idealised opponent of 'the economy'. The tail that is the economy wags the dog that is society and this inversion forces consideration of how and in what respects culture and identity can have an 'structure forming effects' (1991: 10).

On the other hand, *free market* economist and neoliberal stalwart Milton Friedman argues that an enlarged and interventionist state threatens individual freedom and so thwarts economic efficiency; that an unfettered market is the only way forward.

[204] Neoliberalism in Australia is often referred to as economic rationalism. This latter term was coined (after Weber) by Pusey (1991) to describe the economically potent variant of neoliberalism that has evolved in Australian policy settings.

Neoliberal policy and praxis has varied over time and differs across borders but frequently operates to benefit large, globalised companies. In particular, conservative economic policies 'associated with innovation, trade liberalization, reduced government spending on entitlements and decreased state restrictions on labor, health and environmental hazards of production' (Moore *et. al* 2011: 507) present ideal economic conditions for transnational corporations.

In Australia neoliberal policy was originally aligned with conservative economic forces and was favoured by the *new right*. It began to emerge in Australia behind the scenes of the conservative Liberal, Fraser government during the 1970s and advocated a free market approach to the production of the majority of goods and services in society, both public and private goods and services. Cahill notes that the new right is best understood 'as an elite social movement with a specific ideological character — the radical neo-liberal movement' (2004: 2). This radical movement positions the free market as 'the most efficient, and most moral, way of producing and distributing most goods and services in society — whether they be consumer items or public goods such as education and healthcare' (2004: 2). This radical iteration of neoliberalism has underwritten significant changes to the production and diffusion of scientific knowledge in Australia. Under the neoliberal strategies of *globalisation*, *entrepreneurialism*, *competition*, *privatisation* and *efficiency* the production of scientific knowledge in Australia has evolved into an increasingly instrumentalised form of knowledge creation that is increasingly subsidised by the state.

As discussed in previous chapters the primary industries in Australia have relied on the production of pre-instrumental scientific knowledge since the early 19th century; the secondary industries were also recipients of pre-instrumental scientific knowledge during the first half of the 20th century. As the 20th century drew to a close however the Australian government began to implement these same protectionist strategies with the emergent tertiary knowledge-based industries in Australia. This new protectionism is delivered through science policy and praxis that is designed to sustain local industries within the global, networked knowledge markets of the 21st century. The following section explores the origins of this new approach to Australian science policy.

8.2 Origins of a globalised, networked science policy for Australia

As globalisation and digitisation worked to disembed knowledge from its source and redistribute it along international flows, a global knowledge economy began to emerge.[205] As the world's major economies were transformed from material economies to monetary economies (Stehr 1994), disembedded flows of money, information and knowledge became the key drivers of this new form of developmentalism. This section explores how the Organization for Economic Cooperation and Development (OECD) was influential in the execution of these political and economic transformations and how Australia's membership of the OECD contributed to the formation of the extant science policies in the nation. Further, the section traces the execution of a new level of instrumentalism in Australian policy settings finding that the external influence of the OECD and the internal pressures of an emerging neoliberal praxis coalesced to again transform scientific knowledge production and diffusion.

The OECD had been on a mission since 1961 to 'build strong economies in its member countries, improve efficiency, hone market systems, expand free trade and contribute to development in industrialised as well as developing countries' (OECD 2014 1: online).

[205] The theoretical bases for the new *network society*, its *space of flows* and associated *knowledge hubs* are discussed in Chapter 3.

The predecessor of the OECD was the Organisation for European Economic Co-operation (OEEC) which administered aid sourced from America and Canada for use in the reconstruction of Europe after World War II. The OEEC was formed under the auspices of the Marshall Plan, a plan for the rehabilitation of Europe following the war that was generated by the US Secretary of Defence at the time, George Marshall.

The OEEC was superseded by the OECD in 1961 and has, over the last fifty years, functioned to support the economic development of its member countries. Scientific knowledge production and diffusion has been critical to the implementation of this plan. As each decade passed the OECD broadened its reach and scope to move beyond the boundaries of its member countries and towards 'setting its analytical sights on those countries - today nearly the whole world - that embrace the market economy '(OECD 2014 1: online).

It has long been recognised in the literature that the OECD was instrumental amongst member nations in both defining the need for national science policy and in developing a model that would link scientific knowledge with economic policy (Henriques & Laredo 2013: 801). Henriques and Laredo find,

> The OECD has always been recognised as an influential actor in most areas of public policy. This is also the case for science and technology policy (Elzinga and Jamison, 1995; Godin, 2009; Djelic and Sahlin-Andersson, 2006; Porter and Webb, 2008; Martens and Jakobi, 2010). However, the impact on S&T policies has been different from those applied in other policy areas. This specificity is linked to the role of OECD as a policy innovator enabling the creation, diffusion and institutionalisation of national S&T policies (2013: 802).

This OECD strategy to transform scientific knowledge from its supporting role in material economies to its current position in the monetary economy commenced in the

1960s and has developed quickly and extensively since then. The preliminary aim of the OECD strategy was to bring together disparate producers and diffusers of scientific knowledge within each nation under the authority of one national science policy. At the time the production and diffusion of scientific knowledge within member countries was generally uncoordinated and most nations did not have an existing national science policy (Henriques and Laredo 2013). The position has shifted markedly since the 1960s through the operation of a global strategy to install complementary science policies across member nations.

The OECD has been delivering on its centralised, networked model for science policy through a political and economic process comprising four key elements: modifying the frequency of OECD reviews so that the member countries are motivated to apply for an OECD review, thereby ensuring that the nation is committed to a national science policy; modifying the review process in that the review is treated as background whereas the primary agenda is the 'evaluation and recommendations (that are) carried out by a small panel of high level 'experts'' (Henriques & Laredo 2013: 814); introducing confrontation style meetings that attract the actors directly involved in the political decision-making around science and so to effect unmediated policy changes; introducing standardised background reports in order to shape the analyses of science and policy settings (Henriques & Laredo 2013). This process explains how the model continues to be 'embedded into policy structures, which, once in place, tend to evolve incrementally'; how the 'evolutions in the conceptual framework (moving from the 'linear' to the 'system' approach) and in focus (from 'science' to 'innovation') do not change the need for the functions, thus the relevance of the existing structures' (Henriques & Laredo 2013: 815).

By the time Australia joined the OECD in 1971 this co-ordination of scientific knowledge was well underway. By 1975 the first Review of Science Policy by the OECD was proceeding in Australia and the first report was issued in 1977. This global coordination on the part of the OECD ushered in changes which set the local strategic direction for a new national science policy. The preliminary signs of this change in strategic direction can be seen with the re-organisation of the CSIRO (Philip 1978; Gannicott 1979; Flood 1984). The CSIRO had been an authoritative and independent organisation since World War II but 'by 1975 the Commonwealth Scientific and Industrial Research Organization no longer dominated Australian science as it had once done, but it was and still remains the major scientific institution of the country' (Philip 1978: 400).

John Philip was a member of the 'task force' set up by the Whitlam government, and headed by 'Nugget' Coombs, to investigate the institutional frameworks of scientific knowledge production in Australia. Philip writes,

> Our terms of reference were to examine the conduct and co-ordination of scientific work carried out or supported financially by the government. The task force was to review the existing organisation of scientific research and of scientific services in government; and to suggest appropriate institutional and managerial arrangements for the research and performance of services. In considering questions about the autonomy and control of institutions, the task force was instructed to take into consideration statutory, departmental and other forms of organisation and also to have regard to any specific requirements of pure and applied research work and of operational work; it was also to assess the adequacy of existing arrangements for determining conditions of employment and patterns of promotion for scientific and quasi-scientific staff and suggest desirable changes. The task force was to refer where necessary to developments overseas (1978: 398).

These terms of reference heralded the arrival of the OECD plan into Australian science policy settings. Philip obliquely refers to the influence of the OECD in the government's creation of the task force and goes onto rebut the direction in which the government was moving,

> This traditional autonomy of science is being increasingly called into question. The ever-growing role of government in providing the resources for science has led to demands from society in general for much more visible procedures of accountability. The most immediate consequence of this pressure has been the establishment of highly centralised bureaucratic arrangements to generate and administer "national science policy". This is satisfying to general administrators, both the theorists and the practitioners; it is based, however, on the view that administrative arrangements should be uniform, regardless of differences in the activities to be administered. In the last decade most of the world's richer countries have adopted the pattern of centralised science policy. No evidence to hand suggests that any have been positively successful (1978: 402).

Following its deliberations, and contrary to the model of the national science policy being promulgated by the OECD, the 'science task force' lead by Philip recommended that the production of scientific knowledge in Australia remain autonomous. That in light of the problems that had been experienced with a centralised model of science administration, the most productive plan was to support diversity, adaptability and mobility instead,

> In the view of the task force, most of the difficulties revealed in the evidence submitted to it, or perceived by the task force itself, had their basis in an excess of uniformity, centralisation, and rigidity. The task force expressed the belief that virtually all problems examined could at least be mitigated by a deliberate effort to introduce into institutional arrangements the maximum of diversity and to provide as much adaptability and mobility as possible. It affirmed the need to confer as much autonomy as possible at as lower a level in the system as possible (1978: 411).

> …The task force affirmed the conception of the Australian Science and Technology Council as a supra-departmental statutory body, with a rotating membership of experts drawn mainly from outside government (Philip 1978: 412).

Philip comments that the co-ordinator and secretary of the task force were in the process of finalising the report when the Whitlam government was dismissed from office; this was on 11 November 1975. By the 20 November 1975 'the "science and technology policy" of the conservative parties was announced and embodied in a pamphlet. The "policy" manifested all the illusory faith in centralism and bureaucratic processes which the task force had hoped to dispel' (Philip 1978: 413). As the Fraser government took over from the Whitlam government the first signs of managerialist and marketised language can be seen filtering into the public service landscape. For example, Gannicott writing in the Australian Journal of Public Administration in 1979 discusses the 'customer/contractor principle' in relation to scientific knowledge production and argues that for too long scientists in Australia had held the high ground and that scientific knowledge in Australia needed to become more accountable to the state and to the market.

> We should cease the practice in government science in Australia of leaving research objectives and programs in the hands of the scientists performing research. The decision on what applied research to do must instead be put in the hands of the customers of that research, with the public service acting as either direct or proxy customer, and advised by a proper scientific advisory structure within each department that sponsors research, and also advised where possible by non-public servants who are the direct customers for research (1979: 365).

Submissions to the Senate Standing Committee on Science and the Environment (SSCSE) in 1979 also referred extensively to earlier reports produced by the OECD.

By the time the Hawke-Keating government came to power in 1983 the state had been prepared for change. For example, the transformation of the structure of the labour movement in Australia during the late 1970s and early 1980s demonstrates the global movement towards centralising knowledge production, and so working towards consolidating the power base of the state and the market. Where knowledge production and policy initiatives had traditionally originated from a dispersed union membership, the research and policymaking role was now ceded to the new *technocratic labourist*, or *labour intellectual*. This newly centralised area of union knowledge work operated hand in glove, at the seat of power, with the state/market nexus, in order to formulate and prosecute labour policy thus working to diffuse the power of the rank and file (Beilharz 1986; Scalmer & Irving 1999). Moreover, the structural reforms established by the Hawke-Keating (1983-1996) government worked to open Australia up to international money markets and, potentially, to international knowledge (a.k.a.: science and technology (S&T)) markets. By the end of the 20th century the OECD was proclaiming that the 'structural changes' adopted by member countries were preparing the way for the nascent knowledge economy,

> Structural changes in OECD countries reflect the increasing importance of the production, diffusion and use of knowledge and information for improving the competitiveness of firms and overall economic performance. Scientific and technological advances seem more rapid and more pervasive than ever before (OECD 1999: 8)

Further, the OECD actively encouraged member nations to integrate into the world economy through the judicious application of both structural changes and a nationalised science policy. In particular, the OECD argued that the economies of its member nations 'are increasingly based on knowledge and information…Knowledge is now recognised as the driver of productivity and economic growth, leading to a new focus on the role of information, technology and learning in economic performance' (OECD 1996: 3).

There is little doubt that the OECD has been intimately involved in the transformation of the production and diffusion of scientific knowledge in Australia. By 1999 Australia was viewed by the OECD as one of the fastest growing knowledge-based economies amongst member nations,

> Although the pace may differ, owing to economic, social or institutional factors, OECD countries are moving *towards a knowledge-based economy*. Selected indicators show that:
> – Knowledge-based industries have been outpacing growth of GDP for many years in virtually all OECD countries. In OECD-wide GDP, the share of this broadly defined group (*i.e.* high- and medium-high technology manufacturing industries and services such as finance, insurance and communications) is now more than 50%, up from 45% in 1985. Knowledge-based industries are most important in the larger economies, especially Germany, the United States and Japan. Since 1985, knowledge-based industries have increased fastest in Korea, Portugal, **Australia**, the United Kingdom, Japan and Finland. **In all countries, knowledge-based services are much more important than knowledge-based manufacturing industries** (OECD 1999: 8).[206]

Again in 2003 and 2004, Australia's economic performance in terms of science and innovation policy was flagged as positive by the OECD examiners,

> Dogged pursuit of structural reforms across a very broad front, and prudent macroeconomic policies firmly set in a medium-term framework, have combined to make the Australian economy one of the best performers in the OECD, and also one notably resilient to shocks, both internal and external. Incomes growth has remained brisk, employment is expanding, inflation is under control, and public finances are healthy (OECD 2003: 7)…Science and innovation policy

[206] Emphasis added by author

> initiatives are among the structural reforms that have contributed to this achievement, by consolidating and broadening the basis for economic growth in the country, and thus accelerating its transition from a natural resource-based to a knowledge-based economy (OECD 2004 a: 7).

In Australia by the 2010s, the discourse around knowledge production had transitioned in public policy settings from science to innovation.[207] Non-instrumental, state funded science had become part of the *innovation system*, provided it could deliver economic benefits. So economically viable knowledge that could be produced by universities and research institutes was therefore repositioned under innovation policies and transformed into a form of pre-instrumental science.

> Innovation no longer depends solely on how firms, universities, and research institutes perform independently, but, increasingly, on how they co-operate. Co-operation between business and non-business entities is one aspect of a growing trend in co-operation among actors in innovation systems which takes various forms. Firms seek access to the fundamental knowledge necessary for their research; universities seek links to commercialise their research and obtain funding; governments look to alliances that ensure that the economy benefits from public research (OECD 1999: 42)

The OECD plans to broaden its scope by 'looking ahead to a post-industrial age in which it aims to tightly weave OECD economies into a yet more prosperous and increasingly knowledge-based world economy' (OECD 2014: online). This emphasis on the 'knowledge-based world economy' can be traced back to the OEEC which 'had already put science on the agenda of economic development' (Henriques & Laredo 2013: 814). The association between the development of a 'knowledge-based world economy' and the epithet of 'innovation' to the standalone category is not new; the global

[207] This transitioning and restructuring process will be explored in the following section.

development of this 'new' science has been engineered by the OECD over a number of years through the employment of a centralised science policy model within member countries. Conversely, in Australia non-instrumental scientific knowledge production and diffusion has not enjoyed such robust support.

8.2.1 Non-instrumental science and neoliberal policy settings

Non-instrumental science that *cannot* be leveraged into the global economy and that continues to require state funding is generally that science related to the protection of the environment. In Australia under the praxis of neoliberalism this type of non-instrumental form knowledge production has been regularly subject to efficiency measures. This thinning of state support for scientific knowledge related to value-rational concerns is in direct contrast to the new science of innovation (a salient example of purposive rational action) which is being funded at increasingly robust levels by the state.[208] Furthermore, it is arguable whether environmental science would persist at its current levels in Australia without the influence of supra-national agencies such as the United Nations or the Inter-governmental Panel on Climate Change (IPCC) that are regularly, and publicly, calling for participation and contribution. Ironically, the OECD likewise counsels its members about the importance of continuing with the production of public science,

> **Scientific knowledge** is broadly applicable across a wide and rapidly expanding frontier of human endeavour. Technological knowledge stems more from the refinement and application of scientific knowledge to practical problems. Science has been considered that part of knowledge which cannot or should not be appropriated by any single member or group in society, but should be broadly disseminated. It is the fundamental knowledge base which is generic to technological development. Because of this, much of science is considered a "*public good*", a good

[208] These funding initiatives are explored in section 8.5.3.

> in which all who wish can and should share if social welfare is to be maximised. The public-good character of science means that, like other public goods such as environmental quality, the private sector may underinvest in its creation since it is unable to appropriate and profit adequately from its production. The government therefore has a role in ensuring and subsidising the creation of science to improve social welfare, just as it does in regulating environmental protection (OECD 1996: 21)

This call for the maintenance of state production of non-instrumental science does suggest that the players in the market understand and appreciate the necessity of basic science to the production of instrumental science; moreover, that corporations are keen to reduce their *cost of goods* (in this instance, scientific knowledge) by continuing to both harness state funding and to leverage state strategies around protectionism for new markets. This set of circumstances may be likened to the state sponsored development of the pastoral, mining and secondary industries in Australia where the state contribution of pre-instrumental science supported market initiatives. In the 19th century however, scientific knowledge was an integral part of manufacturing, manufacturing produced local employment and local company profits and was subject to local taxation, so delivering local state revenue and increasing the standard of living of the citizenry.

In the 21st century where pre-instrumental scientific knowledge remains a factor of production, its positioning within the structures of the state is antithetical to the ideology of neoliberalism. As such non-instrumental science is being transformed into a type of pre-instrumental science; a hybrid type that becomes harnessed to market outcomes and transformed into a saleable product for multinational corporations. This saleable product may be sold in its own right or may be incorporated into tangible products that are manufactured elsewhere. This splitting of the production process into conceptual, research and development, manufacturing, distribution and sales functions and the broad global distribution of sales, would appear to benefit transnational corporations more than the nation states that supplied the non-instrumental scientific knowledge.

For the state, scientific knowledge remains a factor of production similar to the raw materials of iron ore, coal or wool. For transnational corporation however the splitting of the production process on a geographic basis may mean incremental revenue is achieved at each stage of the process. For instance, once the preliminary royalties for intellectual property are paid to the nation state,[209] non-instrumental scientific knowledge may be used to create and then recreate a range of products or services; each stage of the process presents the opportunity to value-add and so increase revenue options. So once the product is finally sent to market it may have provided its 'owners' with a number of opportunities for profit creation that have occurred through value-adding at each stage of the process.

This splitting of the production process means that although the 'sale' of state sponsored scientific knowledge may attract local revenue it is the transnational corporation that profits from the ongoing production, distribution and sale of the associated products. Moreover, the transnational corporation may 'income-split' between high and low taxing nations and may extract labour from 'poor' countries in order to sell the finished product to 'rich' countries at the maximum price. This global

[209] This is if royalties are even due to the state; ownership terms vary across projects and national policy conditions.

process effectively diminishes both the income generating capacity of the nation state and its control over its own knowledge resources.

This globalised, instrumentalised form of scientific knowledge production and diffusion may lead to a set of circumstances where a nation state such as Australia contributes the 'raw materials' of non-instrumental scientific knowledge appropriately shaped to the needs of the market. The transnational corporation then embeds that product-specific knowledge into its own products and/or 'holds' that knowledge in off-shore knowledge hubs until the global market is ready to pay the highest prices possible.

This economic praxis may thus leverage supply-driven market dynamics to preclude the state and its citizenry from accessing that instrumentalised scientific knowledge, from recycling it for other purposes, or from reselling it to in order deliver incremental state revenues. For instance, pharmaceutical companies and medical device companies may leverage the break-through science developed by non-instrumental scientists located within nation states in order to deliver products to market at prices inflated through value-adding at each stage of the manufacturing process; this practice may then lead to transnational companies withdrawing access to that instrumentalised knowledge, and the resulting products, on the basis of the ability to pay. Furthermore, under this schema the citizenry of the nation state may be denied access to the non-instrumental knowledge produced by local, state-funded institutions and to opportunities for the state (on behalf of the citizenry) to reinvest profits and taxes from the sale of the knowledge into local infrastructure or into essential products and services. The next section explores the movement of neoliberal ideology into scientific knowledge production in Australia and demonstrates the efficacy of the OECD science policy model in sustaining this movement. It also presents a salient example of the implications of neoliberal policy and praxis for non-instrumental science.

8.3 Reforming science policy under neoliberal governments

From its soft launch behind the scenes of the Fraser government (1975-1983) to the hard-line neoliberalism practiced by the conservative liberal Abbott and Turnbull governments (2013-current) the overarching policy and praxis of neoliberalism has transformed science policy in Australia. Despite its positioning as the way of the future, the emerging knowledge economy, on closer investigation, appears to rely on the protectionist model that underpinned the development of the primary and secondary industries in Australia during the 19th and 20th centuries. Just as the primary and secondary industries were provided with low-cost land, labour, capital and scientific knowledge this 'new' tertiary industry known as innovation is similarly endowed.

Under the policy settings supporting innovation in the 21st century state endowment towards the factors of production have shifted to a different dimension. The provision of low-cost land has converted to the national Information and Communications Technology (ICT) infrastructure, labour to the research capacity of the nation's scientists and capital to the heavily subsidised venture capital and the preferential taxation treatment offered by the state to the market. In a further conversion, the provision of pre-instrumental scientific knowledge has, under the precepts of neoliberalism, worked to bind the production and diffusion of non-instrumental science more closely to the aims and ideologies of the market. This heavy state buttressing of the knowledge market is, to all intents and purposes, a protectionist economic strategy overlaid on a neoliberal framework. This section and the following sections explore how scientific knowledge production has shifted from its function as a factor of production to a marketable commodity traded between transnational corporations and how the traditional factors of production (i.e. land, labour and capital) have expanded to take on new forms.

During the 1970s Australian politicians advocating the ideologies of the new right were known as the *dries*, whereas those more socially liberal politicians who favoured protectionism and the 'domestic defence model' that had been in place since World War II were referred to as *wets*. Malcolm Fraser was not a dry, nor was he a member of the new right faction, or a radical neoliberal; however, neoliberalism[210] effectively incubated behind the scenes of his prime ministership to come to fruition with the Labor Hawke/Keating governments during the 1980s (Pusey 1991, 2010; McKnight 2005 *et. al*). The softening of the political and economic landscape during Fraser's leadership led the way for the major economic and structural reforms that were undertaken by the Hawke-Keating government (1983-1996). Western and colleagues (2007) argue that the neoliberal restructuring implemented by Hawke and Keating was the most transformative of any government since Federation.

Quiggin posits that the microeconomic reform undertaken by the Hawke-Keating government (1983-1996) and the subsequent Howard government (1996-2007) can be apportioned across three somewhat overlapping phases.

> In the first, deregulatory, phase, the main focus was on rationalising public intervention in private sector markets, with the object of 'getting prices right'. In the second phase, referred to

[210] The type of liberalism advocated by neo-liberals is antithetical to that originally defined by the scholars of the enlightenment – Bacon, Kant, Locke, et al. – which was discussed in Chapter 2.

here as the 'privatisation' phase, attention shifted to market-oriented reforms of the public sector, including corporatisation and competitive contracting as well as privatisation. In the third 'competitive regulation' phase, the idea of deregulation was replaced by regulation designed to produce, or simulate, competitive market outcomes (2002: 158).

The second and third phases of Quiggin's (2002) model, privatisation and competitive regulation, are particularly pertinent in terms of scientific knowledge production in Australia. Under the privatisation agenda the state developed a number of Public-Private Partnerships (PPP) in the form of Cooperative Research Centres (CRCs) and undertook other similarly market-oriented projects.[211] Moreover, Quiggin's (2002) competitive regulation strategy was introduced into the frameworks under which universities and scientific research institutes currently operate.[212]

As discussed in Section 8.1.1 the early work of transforming science policy had commenced with Whitlam's task force into science in Australia. This task force went on to recommend that science policy ought to encompass 'diversity, adaptability… (and) mobility' (Philip 1978: 411) however this position was antithetical to the plans of the OECD and senior members of the Liberal Opposition who instead sought to centralise and 'manage' all scientific output (including that of the CSIRO, the universities and the research institutes). The Fraser government (1975-1983) did manage to reorganise the CSIRO but did not alter the universities or the research institutes.

On the other hand, the Hawke government (1983-1996) under the leadership of Science Minister Barry Jones, and Minister for Employment, Education and Training John Dawkins, did move to radically alter the direction of scientific knowledge production

[211] The specifics of CRCs and suchlike will be explored in section 9.4.
[212] This market oriented approach to scientific research will be explored in section 9.4.

and diffusion in Australia. Homeshaw finds that it was not until Science Minister in the Hawke government (1983-1990), Barry Jones, applied his 'messianic zeal' to science and technology that 'the political will to implement change was felt in science policy' (1995: 525). An advocate of technological 'progress' (1982; 2006) Jones held that market principles needed to be more firmly applied to scientific knowledge production in Australia (Homeshaw 1995). As Homeshaw puts it,

> Jones' hard-won achievements were to restructure the research community and to wean it away from the funding teats of government. Through Jones, the research dollar has become much more accountable to national economic objects, applied research organisations are oriented more to the needs of their customers than of their scientists, and the knowledge produced is used for profit rather than being disseminated as a public good, or as 'a gift to the world' as one scientist expressed it (1995: 525).[213]

Moreover, under John Dawkins, a key supporter of Paul Keating, major changes were made to the structure of higher education and accordingly, to non-instrumental scientific research.[214] Dawkins had been the Minister for Finance in the first Hawke Ministry (1983-1984); Minister for Trade in the second ministry (1984-1987); the Minister for Employment, Education and Training in the third ministry (1987-1990); and the Treasurer in the Keating government (1992-1993). Dawkins was thus conversant with, and supportive of, the economic agendas of neoliberalism that Hawke and Keating were beginning to implement in Australia.

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[213] This overt shift in the functional role of scientists demonstrates the beginnings of the transformation of 'labour' as a factor of production. In line with the primary and secondary industries of the 19th and 20th centuries the application of state-sponsored labour to the production process was replicated in 21st century Australia with the emergence of the tertiary industries and the 'new science of innovation'.

[214] This restructuring of the university system as the accepted providers of non-instrumental science also contributed to the transformation of labour.

In his function as Minister for Employment, Education and Training, Dawkins presided over the merging of Universities with Colleges of Advanced Education (CAEs) and Institutes of Technology (ITs) and the re-introduction of university fees in the form of a Higher Education Contribution Scheme (HECS). These measures were in line with Keating's structural changes to the Australian economy and would prove to have a significant influence on the production and diffusion of scientific knowledge.

The merger between universities, CAEs and ITs delivered significant consequences for both non-instrumental and pre-instrumental science production in Australia. Under the previous structure CAEs and Institutes of Technology had not been funded as research organisations or as providers of postgraduate education in the same way that universities had been (Werner in SSCSE: 1977). While the Dawkins reforms were still some time away, the submissions to the Senate Standing Committee on Science and the Environment (SSCSE) in 1979 illustrate the financial and political conditions pre-empting the Dawkins policies. Eager to maximise their public funding, both sets of institutions (the universities and the CAE/ITs) declared their support for pre-instrumental science and their capacity to deliver research relevant to 'industry and commerce'. The New South Wales Institute of Technology put forward that

> The Institutes of Technology occupy a special position in Australian Higher Education. In terms of their charter, they have developed strong links with industry and commerce through the interaction of their staff with the industrial and commercial world and through involvement with their students for whom the institutes offer educational programs relevant to their careers, many of which will be in industrial and commercial environments (Werner in SSCSE 1977: 3).

In their submission, the universities attempted to both confirm their position as the conventional incubators of non-instrumental scientific knowledge and to demonstrate the importance of that function to postgraduate research and teaching; additionally, they sought to reinforce the significance of fundamental research to the production of technical innovation. The Australian Vice-Chancellors' Committee submitted, amongst other rationales, the following,

> Governments and other granting agencies hope that economic and/or social benefits will result from fundamental research, particularly in the sciences and social sciences. It must be recognized, however, that its takes time to bring a research result into practical application. It has been suggested, for example, that basic or fundamental research which leads to a technical innovation is often completed some ten years before the development of the innovation itself (Hambley in SSCSE 1977: 385).

Notwithstanding their ambivalent public positions and apparent support for pre-instrumental science, Forsyth (2012; 2013) finds that as the Dawkins reforms moved closer the two oldest universities in Australia were, behind the scenes, increasingly concerned that the policies would stifle the creative element necessary in the production of non-instrumental scientific knowledge; this concern however was tempered by the need for continued research funding. As Forsyth writes,

> University of Melbourne Vice-Chancellor, David Penington, approached the University of Sydney hoping the two oldest universities might decline entry to Dawkins' 'Unified National System'…Penington's concern was… for the public value of research: 'Research policies controlled from Canberra, he [Penington] says, run the risk of being short-term and politically motivated. Had the Dawkins policies been in place during the polio epidemics, research funds would have gone into creating better iron lungs. The discovery of the Salk and Sabine vaccines which eradicated polio were the result of simple curiosity. It is impossible, he says, to dictate creativity'… Despite Penington's vocal opposition, the alliance with Sydney required to reject it was unsuccessful, for Sydney's Vice-Chancellor, John Ward was unwilling to risk the loss of funding that would result. (2013: online).

Twenty years later in his analysis of the outcomes of competition that had been instituted within the Dawkins re-structure, Marginson finds that

> …if productivity, efficiency and consumer responsiveness in the leading institutions have improved, such improvements are incidental to competition reform – which suggests that any credit for such improvements should be claimed not by the Government but by the institutions. While the spirit and the mechanisms of competition have become entrenched, the automatic effects intended by reform have not. At the bottom end of the market, institutions find themselves cutting costs and marketing harder, but this does not lead to any improvement in their status and it probably takes place at the expense of teaching and learning quality (2003: 13).

Notwithstanding the marginal outcomes of these shifts in science policy and the restructuring of the tertiary education system the political mood was ripe for the introduction of innovation as the new science that would restructure Australia's economy and further integrate the nation into global networks. The next section explores the emergence of this new science of innovation.

8.4 The 'new' science of innovation

The conservative Liberal Howard government (1996-2007) was instrumental in the conversion of science policy to innovation policy. This conversion is associated with the decline of pre-instrumental scientific knowledge production and the binding of the formerly non-instrumental science to instrumental scientific knowledge. The restructuring was undertaken to facilitate a less restrictive and more rapid transformation of scientific knowledge to the outcomes dictated by the market. Under these conditions, scientific knowledge production appeared to be more consistent with both the OECD vision to integrate all member nations into a global knowledge economy and the neoliberal agenda at work in Australia. These revised domestic policy settings however are laissez faire in concept only; in reality the new science of innovation would attract a strong suite of protectionist policy and praxis. Section 8.5 investigates the strategies of the new developmentalism. In the meantime, this section traces the introduction of this new science.

Cahill notes that the Howard government (1996-2007) was 'much more sympathetic to the radical neo-liberal agenda' and that a number of his Cabinet ministers 'most notably Peter Costello, David Kemp and Rod Kemp were once key activists within the radical neoliberal movement' (2004: 25). Furthermore, Beeson and Firth find that neoliberalism as a 'political rationality' was also 'evident in the assumptions about the economy and population that underpin the policies of the Liberal-National Party Coalition government elected in 1996' and their success in being able to

> …Inculcate new values in the population at large. Whether these are described as 'entrepreneurial', 'flexible', or simply as more 'competitive', their intent was to facilitate a style of governance that may most usefully be understood as flowing from a distinctive neoliberal political rationality (1998: 228).

Presaging Howard's new policy *Backing Australia's Ability: An Innovation Action Plan for Australia* (2001) was the Chief Scientist Robin Batterham's *Australian Science Capability Review*. The Final Report from the Chief Scientist, the *Chance to Change* (2000) uses conventional neoliberal lexicon to deliver its political message. The report declares that 'Innovation is the only way forward' (2000:9) and prescribes a plan to steer the production and diffusion of science knowledge in that direction.

Batterham's review shadowed and often overlapped the work of the Innovation Summit Implementation Group (ISIG) that had been convened by the Prime Minister's Science, Engineering and Innovation Council (PMSEIC) in 1999. (The PMSEIC was arguably an outcome of the OECD drive for centralisation and the close management of scientific knowledge production.) Chief Scientist Batterham applauded the Innovation Summit's final report as providing 'government decision-makers with some new and exciting ideas on what needs to be done to stimulate innovative activity in Australia (Batterham 2000: 3). Moreover, in his own report, *Chance to Change*, Batterham (somewhat hyperbolically) argues that

> Innovation is the driver of every modern economy – it is the key to competitiveness, employment growth and social wellbeing. The cycle of innovation must be fed by new ideas and basic knowledge which are capable of being transferred and accepted by end-users. Our international partners and competitors are investing heavily in their SET[215] bases. Clearly the pace of development is quickening. For Australia to participate and thrive, we must, first, be part of this international process and, second, be committed to developing an innovation process for pursuing scientific advances and implementing them successfully. It is not sufficient for Australia to be a fast user of other nations' technology. We must have leading edge capabilities so that we can develop pioneering technologies that will ensure the competitiveness of our industry in the global marketplace of the future. Global customers are both discerning and demanding (2000: 9).

Notwithstanding the Chief Scientist's reference to 'basic knowledge', it is difficult here to miss the second and the third phases of Quiggin's (2002) model describing the policy and praxis of neoliberal doctrine. The market-centric initiatives of privatisation and competitive regulation (Quiggin 2002) are firmly embedded in the Chief Scientist's statement. Batterham continues that commercialisation of scientific knowledge through the strategy of innovation and its integration into the knowledge economy is the only possible solution for Australia's economic future.[216] The Chief Scientist

[215] Science, Engineering and Technology (SET)
[216] This reference to neoliberal strategies being the 'only way forward' is a common rationale for the introduction of neoliberalism.

advocated developing strong links between the state, the market and scientific researchers in order to reinforce the integration of these three sectors. The development of the 'linkages' were to be 'incentivised' through the 'competitive' grants process and is aimed at 'universities and government research agencies' in order to motivate the 'transfer of knowledge to business and society, across all sectors of the economy' (Batterham 2009: 11).

Batterham's pre-policy report demonstrates a marked political leaning to Howard's form of right wing neoliberalism and clearly presents the underpinnings of the shift to innovation science. Some of the concrete indicators of this shift are examined later in this chapter. A large tract of Batterham's pre-policy document is reproduced here in order to demonstrate the transformational character of the changes that were being anticipated in the production and diffusion of scientific knowledge in Australia.

> The ultimate measure of success in innovation is the value placed on it by consumers and the community. Integrating the innovation system across all points can increase the chance of generating more products and processes that enhance our lifestyle. The innovation system is dependent on strong links between all players, government, industry, and research performers. Government has a special role to play in aiding the linkage process. We need to think about new ways to develop alliances, connections and partnerships between the SET base and other players. Government plays the central role in building the environment for change. Successful government initiatives should be expanded, and the recipients of government research funding encouraged to play a greater role in making connections with the business community in line with the changing needs of society and national priorities. In particular, the government - funded research agencies must play a stronger role in the creation of new businesses by a much improved effort at business incubation. Such a commitment is consistent with their essential mission of conducting research for the benefit of the Australian community. In conjunction with this, we need to introduce incentives for researchers in universities and government research

> agencies to make the most of the knowledge they create, and build upon this to elevate their role in the economy. The challenge for them is to stimulate and facilitate the increased transfer of knowledge to business and society, across all sectors of the economy (2000: 11).

This statement is highly reflective of the changes that have taken place since 2000. For instance, in a subsequent discussion, *Australia, Science Policy and the Commercialization of Ideas* (TSI 2001) that was hosted by the right wing The Sydney Institute and conducted on the Australian Broadcasting Corporation's (ABC) influential Science program featured Batterham, in concert with colleagues 'Professor Ron Johnston, Centre for Innovation and International Competitiveness, University of Sydney, Professor Ann Henderson-Sellers,[217] Director, Environment Department, ANSTO and Catherine Livingstone,[218] Company Director and former CEO of Cochlear Limited' (TSI 2001). The 'gang of three' – Batterham, Henderson-Sellers and Livingstone – were at the time senior executives within three high profile and politically important scientific institutions and were in the position to strongly influence ongoing science policy in Australia. Batterham, Henderson-Sellers and Livingstone have subsequently each demonstrated a robust commitment to these neoliberally aligned science policy measures during their own career trajectories.

Catherine Livingstone is both an advocate for business and a strong supporter of the commercialisation of scientific knowledge. Under Livingstone's chairing, the CSIRO underwent a set of major structural reforms known as the National Flagship Initiative (Sandland & Thompson 2012). The purpose of this major restructuring program was to

[217] Educated at Macquarie University; currently Professor with the Climate Futures research centre at Macquarie University

[218] Educated at Macquarie University; former Chair of the CSIRO board and a member of the panel conducting the review of Australia's innovation system in 2008; currently Chair of the Board of Trustees at the Australian Museum; President of the Business Council of Australia; independent voting director of the Macquarie Bank and the Macquarie Group; also sits on the board of Macquarie Bank and Telstra.

re-shape the CSIRO to fit within the new regime of neoliberal science policy. Sandland and Thompson who were facilitators in the actual re-structuring process remark,

> CSIRO enjoyed a reputation as Australia's pre-eminent research agency for some 80 years, but in 2001 its entire existence was called into question when it was completely overlooked in a major government funding agency. Something had to be done, and fast (2012: xxi).

Livingstone, at the time the Chair of the Telstra Board and an incoming member of the Board of Trustees for the Australian Museum, reveals an ongoing positive relationship with Batterham. She writes in the Preface to the book describing the implementation of the National Flagship Initiative over which she presided, that 'The review of the flagship program in 2006 by the Chief Scientist [Batterham] concluded with a glowing endorsement' (Sandland & Thompson 2012: xiv).

On the other hand, science writer Damien Murphy reports that these reforms were made to 'drive a new era of commercialisation' and were not accepted without problems. Murphy contends that the CSIRO 'has moved from a research-based institution generally perceived as working for the public good to an enterprise-based institution with an emphasis on making money for its research rather than taxpayers continuing to foot the bill' (2005: online). According to Murphy, the CSIRO has increased its selling and licensing of scientific knowledge produced by its scientists by way of the patents system. He reports that…

> …revenue from selling and licensing CSIRO's intellectual property is projected to grow from an expected $29 million this year to $46 million next year and $73 million the following year. Garrett chose Mehrdad Baghai, a former McKinsey consultant, to drive the new era of commercialisation (Murphy 2005: online).

Ann Henderson-Sellers, a professor of physical geography, is an elected Fellow of Australia's Academy of Technological Sciences and Engineering and has had a distinguished international career in climate science. Henderson-Sellers is also a strong supporter of the commercialisation of scientific knowledge, most recently as Professor with the Climate Futures research centre located within the Faculty of Science at Macquarie University.

The centre focuses on risks associated with climate change, particularly those risks linked with the areas of water, food, biodiversity, economies, financial markets and national security. The centre describes its work,

> At Macquarie University, our strategy is to use science and impact assessment infused by and packaged within a framework of economic, financial, and legal risk. This packaging is not cosmetic: it is a re-development of the science to communicate directly in the language of economics, policy, and regulation (MQU FoS 1 CF 2014: online).

Nested within the Climate Futures research centre is Risk Frontiers, 'which is a world leader in natural hazards (sic) risk assessment and provides insurers with sophisticated research-based solutions' (MQU FoS 2 RF 2014: online). So it seems that the early neoliberal vision of Henderson-Sellers and her colleagues is being played out in the research/business relationships between Climate Futures and Risk Frontiers and their commercial insurance customers.

The first sign of specifically innovation policy in the public realm was when Prime Minister John Howard unveiled his vision in 2001 for a range of reforms that were designed to further enhance Australia's research capability and the nation's integration into the international knowledge economy, particularly in the fields of ICT[219] and biotechnology. Although Howard was one of the first to move innovation policy into the public sphere, these strategies for scientific reform had been in wings for some time and would continue to be upheld and advanced by governments of all political persuasion into the future. Howard notes,

> A key aim of the strategy is to strengthen Australia's research capability, to ensure the flow of new ideas which underpin innovation, to create critical mass in leading research fields, and to build competitive advantage in ICT and biotechnology (2001: 15).

The economic and financial incentives built into the original strategy included incremental funding delivered through the National Health and Medical Research Council (NHMRC) and the Australian Research Council (ARC) in order to boost funding to Cooperative Research Centres[220] (CRCs) by 80%; increasing the number of university places in the disciplines of science, mathematics and technology; strategies to 'raise the understanding of the importance and the commercial potential of science and technology particularly amongst the young' (AG InnPol 2001: 21); the introduction of additional tax concessions to support the commercialisation of research; and 'strengthening Australia's IP protection system' to more heavily favour corporate activity (AG InnPol 2001: 19). Howard's policy echoes the claims of the Chief Scientist, reiterates Australia's political drive to integrate into world markets, and its domestic compliance with the global objectives of OECD, i.e. 'The OECD and the US Federal

[219] Information and Communications Technology (ICT) is the term used to describe the convergence of computer networks with audio-visual and telephonic systems through a single cabling or link system. There are significant economic incentives in the merger of all three systems. Australia's National Broadband Network is an example of ICT in action.

[220] A type of Public/Private Partnership (PPP); the first PPP to be seen in Australia was associated with the expansion of the merino sheep market in Australia under the guidance of John Macarthur in the early 19th century.

Reserve have found Australia's productivity performance to be particularly impressive' (AG InnPol 2001: 10).

Confirming the bipartisan support for the neoliberal innovation approach across both major Australian political parties, the Rudd Labor government came to power in 2007 and in terms of innovation policy it was business as usual. Rudd's letter in November 2007 to Professor Stuart Cunningham, President of the Council for Humanities, Arts and Social Sciences (CHASS) confirms that the Rudd government would be adding 'the humanities, creative arts and social sciences' to the innovation program.

> As you may be aware, Federal Labor detailed our Innovation Future for Australian Industry on 21 November, affirming our belief that problem solving, creative ideas and new technologies are vital to meeting the economic, social and environmental challenges we face as a nation…A Rudd Labor Government will build a truly national innovation system, valuing the breadth of Australian research effort across the humanities, creative arts and social sciences as well as scientific and technological disciplines (Rudd 2007: online).

Moreover, the incoming Minister for Innovation, Industry, Science and Research, Kim Carr, reiterated Rudd's advice to CHASS in his policy document,

> A Rudd Labor Government will build a strong national innovation system, bridging the cultural divide between public research and the private sector. Innovation will be valued as a driver of economic prosperity and harnessed to address national challenges…Australia's potential success in ICT industries is being held back by our poor broadband performance…Australia must have better ICT infrastructure if the true potential of this sector is to be realised (Carr 2007: 1).

Furthermore, it was under Rudd's Prime Ministership (2007-2010/13) that the issue of 'poor broadband performance'[221] was addressed, with Rudd announcing in 2009 the plan to 'deliver Australia's first national wholesale-only, open access broadband network to all Australians' (NBN 2013: online); this plan began implementation under the Gillard government (2010-2013). Moreover, under Julia Gillard's leadership, innovation policy came to be linked with politically popular employment creation[222] programs.

Gillard's Industry and Innovation Statement was entitled *A Plan for Australian Jobs* and promised to provide 'the necessary support and infrastructure for industry, researchers and governments to work together to transform a good idea into a commercial success' (AG I&IS 2013: online). Gillard's rationale was that the more the state invested in 'growth' through 'innovation' the more jobs would be created. 'Innovation' was seen as the 'key driver'. The Gillard government's (2010-2012) policy document, describes 'innovation' as the creation of knowledge to produce 'better economic outcomes' (AG IIS 2013: viii). Moreover,

> Innovation is about creating knowledge and using practical know-how to convert this knowledge into better economic outcomes. Australia can do better here…Innovation is often equated with investing more in research to create knowledge and technology. However, innovation is about more than creating knowledge and ideas; it is about applying knowledge and ideas in new ways to create value. Knowledge and ideas are most likely to find new applications when competition, capabilities and connections are strong (2013: viii).

[221] The National Broadband Network (NBN) can be viewed as a transformed factor of production in the same way that free or cheap 'land' was provided to the primary industries in the 19th century Australia.
[222] These 'employment creation programs' are further evidence of the transformation of 'labour' that is being effected in the developing tertiary industries of the 21st century.

The Gillard government began the task of developing these new tertiary industries by applying a protectionist style of policy as well as significant funding initiatives[223] to the undertaking. All up, the Gillard government (2010-2013) planned to invest a minimum of $4,563 million cash plus an unknown figure in tax offsets in order to encourage knowledge markets[224] to bond with the producers of non-instrumental scientific knowledge. This 'new' strategy around innovation however is similar in effect to the protectionist strategies employed by both colonial and Australian governments when establishing the primary and secondary industries in Australia during the 19th and 20th centuries. The market-centric position of neoliberalism thus appears to be a new form of protectionism, one again reserved for special interest groups.

Gillard's Industry and Innovation statement was delivered in 2013. By the end of that year the Abbott government (2013-2015) had attained power. Abbott's government under Ian Macfarlane the first Minister for Industry, committed to continuing the

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[223] The strategy to be adopted to bring these plans to fruition included: the continued funding (at $236.3 million) of the Industrial Transformation Research Program (ITRP), an arm of the Australian Research Council (ARC) Linkage Project team that provides funding across 'priority research areas' and the collaboration 'between higher education researchers and other parts of the national innovation system, undertaken to acquire new knowledge, and that involve risk or innovation'; funding of $294.1 million from 2012-13 to 2015-16 for Commercialisation Australia which 'builds the capacity of, and opportunities for, Australia's researchers, entrepreneurs and innovative firms to convert intellectual property into commercial ventures'; funding of $625.3 million from 2012-13 to 2015-16 to support the CRC program which 'delivers economic, environmental and social benefits to Australia by supporting research partnerships between publicly funded researchers and end-users'; funding of $1,419.5 million from 2012–13 to 2015–16 for the CSIRO's National Flagships Program 'which aim to increase economic, social and environmental wellbeing in areas of complex challenges through the provision of information, advice and scientific solutions'; funding of $1,611.6 million from 2012–13 to 2015–16 to support the CSIRO's 'core research and service activities, science outreach and national research infrastructure activities; funding of $350 million for the Innovation Investment Fund (IIF), 'A co-investment scheme where the government licenses private sector fund managers and provides capital for investment which must be matched with capital raised by the fund manager from the private sector. IIF venture capital funds invest in early stage companies commercialising Australian R&D and enable private sector investors to leverage off public equity capital and R&D Tax Incentive provides a tax offset for eligible R&D activities and is targeted toward R&D that benefits Australia' (AG IIS 2013: 50).

[224] This 'capital' injection is similar in effect to those protectionist initiatives undertaken by the state in the development of the primary and secondary industries in Australia.

support of innovation policy claiming that 'We help to drive economic growth, productivity and competitiveness by bringing together industry, energy, resources, science, skills and business' (AG Macfarlane 2013: online). Notwithstanding its commitment to innovation policy the Abbott government had not appointed a Science Minister by the end of 2014.

Furthermore, the 2014 Budget Papers announced $450 million in cuts to science agencies.[225] Suzanne Cory, President of the Australian Academy of Science, observes that these 'cuts are on top of an A$470 million decline in funding for science over the previous two budgets. We're going backwards as other countries move forwards' (2014: online). Within the context of innovation and its expansionary policies, this move appears to be deeply unsound.

So, under the precepts of the hard-line neoliberalism practiced by the Abbott government all knowledge production must be put out to the market and that knowledge that is not marketable becomes irrational and thus irrelevant within the context of neoliberal rationality. On the other hand, the non-instrumental knowledge that is produced by the universities and the research centres that can be more closely bonded with the market is maintained in favour of a more 'balanced' approach and a reframing of the relationship between environmentalism and developmentalism. The following section takes a closer look at this new form of developmentalism.

8.5 The new developmentalism

[225] These cuts included: CSIRO $111.4; Australian Research Council $74.9 million; Cooperative Research Centres $80 million; Australian Institute of Marine Science $7.8 million; Defence Science and Technology Organisation $120 million; Australian Nuclear Science and Technology Organisation $27.6 million; and Geoscience Australia $36 million (Cory 2014: online).

By the 2010s national policy settings associated with scientific knowledge production and diffusion in Australia has been transferred either to the Department of Industry and Science or to the Department of the Environment. This section examines the shifting ground between value-rational social action (that associated with environmentalism and/or climate change) and purposive-rational social action (that embodied in the new science of innovation) within the context of the new developmentalism and the state's aim to 'balance' the tensions between social and economic goals.

Due to the rapidly changing character of government policy in the 2010s this section offers a snapshot of the state of the nation in terms of science policy as at early-2015 by investigating science policy associated with the sustainability of the natural environment (focusing specifically on the broadening of policy parameters around sustainability and the introduction of efficiency measures to the production and diffusion of non-instrumental science) before moving on to the policy frameworks underpinning the more overtly market-based scientific knowledge production integral to the new science of innovation.

8.5.1 The Department of the Environment

The Department of the Environment under Prime Minister Tony Abbott claims to support a value-rational framework in relation to the protection of the environment; however, the neoliberal policy positions that underpin the department suggest a softening of these substantively-rational aims. This softening action may lead to a diminishing of the value-rational, protective approach extant in the department in favour of a more 'balanced' attitude to market development. The department, under the paradigm of increased efficiency, has moved to activate these aims by installing a permanent task force located within the department. This task force has been assigned the role of mitigating tensions between the protection and the development of the natural world by way of policy intervention. This political initiative is particularly focused on the regulation/deregulation of state policy, praxis and legislation around the issues associated with market development. Despite its mission to ‘balance’ the relationship between the market, society and the environment, the stated purpose of Department of the Environment presents a firmly value-rational façade,

> (The department) … designs and implements the Australian Government’s policies and programmes to protect and conserve the environment, water and heritage and promote climate action. The environmental framework is being delivered under four pillars: clean air, clean water, clean land, national heritage (AG DoE 2015: online).

Under the Abbott government, environmental policy remained operational under the terms of the Ecologically Sustainable Development (ESD) strategy introduced by the Hawke government in 1992. Since then however the remit of sustainability policy has expanded to include the task of ‘balancing’ the nation’s social, economic and environmental goals.

8.5.1.1 Ecologically sustainable development

Due to the rapidly shifting ground in the current era this section explores recent policy settings that offer the most critical context through which the utilisation of scientific knowledge in Australia may be understood. Amid continuing and mounting grievances around issues of over-development and environmental degradation from a range of quarters, the Hawke-Keating government instituted the National Strategy for Ecologically Sustainable Development (ESD). Sustainability was to act as a solace for three stakeholders; the citizenry, the cultural left and the market.

A broad range of definitions can be applied to sustainability policy, the majority of which include the economic principles of the triple bottom line in which environmental, social and economic outcomes are considered equally in policy setting (Fischer et al 2007; Markulev & Long 2013). In Australia the National Strategy for Ecologically Sustainable Development (ESD) has steered the government's approaches to ecological sustainability. The intention to expand the strategy beyond its application to the natural world can be seen in the broad remit of the 'Goals', 'Core Objectives' and 'Guiding Principles' attributed to the scheme at planning stage.

The chief 'Goal' of ESD was to pursue:

> Development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends (AG ESDSC 1992: online).

The 'Core Objectives':

- To enhance individual and community well-being and welfare by following a path of economic development[226] that safeguards the welfare of future generations; to provide for equity within and between generations
- To protect biological diversity and maintain essential ecological processes and life-support systems' (AG ESDSC 1992: online).

The 'Guiding Principles':

- Decision making processes should effectively integrate both long and short-term economic, environmental, social and equity considerations;
- Where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation;

[226] Note the positioning of economic development as primary to 'individual and community well-being and welfare'.

- The global dimension of environmental impacts of actions and policies should be recognised and considered;
- The need to develop a strong, growing and diversified economy which can enhance the capacity for environmental protection should be recognised;
- The need to maintain and enhance international competitiveness in an environmentally sound manner should be recognised;
- Cost effective and flexible policy instruments should be adopted, such as improved valuation, pricing and incentive mechanisms;
- Decisions and actions should provide for broad community involvement on issues which affect them (AG ESDSC 1992: online)

Despite the putative ecological intentions of the ESD strategy a closer look at the framing of the Goal and the Core Objectives demonstrates that economic matters were of particular significance in this implementation document. In other words, positive ecological outcomes were desired provided they did not interfere the overall economic development.

The implementation of the ESD strategy began with Prime Minister Hawke's announcement that he intended to 'establish nine sectoral ESD Working Groups, involving government officials, industry, environment, union, welfare and consumer groups, to examine sustainability issues in key industry sectors' (AG ESDSC 1992: online). These 'key industry sectors' included the primary industries of agriculture, fisheries, forestry and mining, the secondary industries of manufacturing and energy production as well as the service industries of tourism and, urban and transport planning. The ESD strategy was the outcome of several years of 'extensive consultation with all levels of government, business, industry, academia, voluntary conservation organisations, community based groups and individuals' (AG ESDSC 1992: online).

On close inspection, the critical strategy document pertains directly to the 'balancing' of scientific knowledge gathered from the natural world with social and economic outcomes but reveals a noticeable absence of analysis or analytic data to support the competing claims of developmentalism and environmentalism. Moreover, the engagement of the 'nine industry sectors' as the starting point suggests an underlying partiality towards these industries, particularly taking into account the neoliberal strategies that were being installed in parallel to the ESD. Further, the repetitive references to economic outcomes within the core objectives, the loose construction of the objectives, and the absence of benchmarks or points of reference suggest that sustainability was to become a moving target. Excerpts such as the following also demonstrate the open-ended character of the strategy.

> By following an ecologically sustainable path of development, we should be able to reduce the likelihood of serious environmental impacts arising from our economic activity. The number of divisive and damaging confrontations which have characterised some of our development projects should also decrease. More practically, ESD will mean changes to our patterns of resource use, including improvements in the quality of our air, land and water, and in the development of new, environmentally friendly products and processes (AG ESDSC 1992: online).

A further diminishing of the strategy occurred once the working groups had concluded their discussions and produced their recommendations. Each report was submitted to committees of Federal and State public servants who 'weakened or even omitted many of the original recommendations and no action plans or timelines were determined' (Hutton & Connors 1999: 244). Hutton and Connors note

> By this stage, conservation groups were so outraged at the gutting of the working groups' recommendations that they boycotted the process. Even non-conservation groups were angered by the public servants' actions…In a phenomenon seen many times in environmental disputes,

bureaucrats in industry facilitation departments were even more committed to cutting corners on the environment to ensure short-term industry profitability than the industries themselves. This was often the case where the industry facilitators were also environmental regulators of these industries (1999: 244).

Notwithstanding its counter-balancing potential, sustainability under the Australian model of neoliberalism has broadened to include a range of 'sustainability indicators covering social and human, natural and economic factors' (AG NSC 2013: 1). In order to explain the broadened meaning of sustainability the Federal government set up the National Sustainability Council in 2012. A 264-page report was published in 2013 outlining Australia's progress on 'sustainability'. The *Sustainable Australia Report 2013: Conversations with the Future* (2013) offered some 'uncomfortable' news such as the 'key challenges' that still needed to be addressed by the state:

> Key challenges highlighted include reducing the link between educational performance and disadvantage, boosting innovation and connectivity in Australian businesses, planning for an ageing population, planning more sustainable cities, reducing greenhouse gas emissions and adapting to climate change, reducing the environmental impact of economic growth, protecting biodiversity and ecosystems, sustainable food and agriculture, and tackling inequality and disadvantage (AG NSC 2013: 1).

This broadening strategy can be seen in the Liberal Party's Environment Policy leading up to the 2013 Federal election:

> **Supporting communities – creating a sustainable environment**
>
> We will adopt a practical, balanced and sustainable approach to environmental issues based on linking sound scientific findings with the needs of all users resulting in more sustainable commercial activities and better environmental outcomes.

For example, we will support the fishing industry. We will adopt a more balanced approach by setting up more rigorous assessments for new Marine Protected Areas that will mean the areas are assessed in accordance with objective **scientific, economic and social evidence.**[227] Our aim is to continue to protect marine environments and the fishing communities which rely on them (LP Policy 2013: online).

These ESD policy settings that harness sustainability as a key element in scientific knowledge production and diffusion provide the most critical context through which non-instrumental scientific knowledge can be understood in contemporary Australia. The 'balance' between developmental and environmental strategies has shifted markedly from the ESD policies delivered by the Hawke government in 1992 to the election of the Abbott government in 2013. Where the emphasis under the Hawke Labor government was loosely based on ecological protection the 'balance' has shifted to economic protection under the policy framework of the Abbott conservative government. The next section reviews the bureaucratic outcomes of this shift.

8.5.1.2 Economically sustainable development

The Department of the Environment is divided into three broad policy areas: Environment Protection; Climate Change and Water; and the Office of Environmental Science and Economics. Non-instrumental scientific knowledge production associated with the protection of the natural world is located within the Office of Environmental Science and Economics. In this Office, scientific knowledge producers sit alongside: a General Counsel; the Corporate Strategies Division; Policy Analysis and Implementation Division; and the Australian Antarctic Division (which also includes some scientific staff). The composition of this Office suggests that not only has non-instrumental

[227] Emphasis added by author.

scientific knowledge production become more closely associated with economic outcomes it is to be 'balanced' against corporate strategies through the rule of law. This organisational structure presents a picture of an increasing emphasis on the instrumentalisation of the environmental sciences within the neoliberal Abbott government. The emphasis on value-rational ends of the Department of the Environment, as it was first established by the Whitlam government in 1972,[228] has shifted and broadened.

This broadening effect administered by the extant Department of the Environment, arguably through the praxis of sustainability policy, now incorporates economic imperatives located within the frameworks of developmentalism. The contemporary policy settings can be seen in the Terms of Reference framing the inquiry by the House of Representatives Standing Committee on the Environment that was conducted in 2014. The purpose of this inquiry was to alleviate the bureaucratic regulation around the protection of the environment in order to make it quicker and easier for development approvals. In the following extract from the Terms of Reference note the continuing use of the word 'balance' that is employed extensively by neoliberal governments in attempts to rationalise the loosening of value-rational policy settings.

> The Committee will inquire into and report on the impact of 'green tape' and issues related to environmental regulation and deregulation. The inquiry will have particular regard to: ⧫jurisdictional arrangements, regulatory requirements and the potential for deregulation; ⧫ the balance between regulatory burdens and environmental benefits; ⧫ areas for improved efficiency and effectiveness of the regulatory framework; and ⧫ legislation governing environmental regulation, and the potential for deregulation (AG HoR SCoE 2014: online).

[228] The value-rational emphasis of the department was discussed in Chapter 7.

Moreover, the references to 'deregulation', 'efficiency' and 'effectiveness' of the existing regulatory 'framework' are indicative of the neoliberal policy settings and the utilitarian character of the Terms of Reference underpinning the inquiry. Furthermore, the title of the committee's report *Streamlining environmental legislation: Inquiry into streamlining environmental regulation, 'green tape', and one stop shops* (AG HoR SCoE 2014: online) demonstrates particular resonance with the purposively rational goals of the Abbott government; particularly in terms of the 'balance' between development and environmental concerns.

Specifically, the *Environment Protection and Biodiversity Conservation Act 1999* is seen to be of significance, along with its interpretative guide *Department of the Environment, Guide to the EPBC Act, 2010.* Many of the committee's recommendations are centred on this legislation and its interpretation by the Commonwealth and State governments. The committee published 13 recommendations in response to the Terms of Reference and summarised its report as follows,

> This report has investigated the current regulatory environment and the potential for deregulation with regard to environmental legislation. In particular it has targeted those areas of regulatory duplication which, if addressed, can further enhance economic prosperity without sacrificing protection of the environment. The Committee has explored in this report many areas of regulation which can be rationalised to find a balance between economic benefits and environmental benefits (AG HoR SCoE 2014: vii)

The main action to come out of the inquiry was the transfer of the authority for final approval from the Commonwealth to the State governments viz,

> The Committee recommends that the Department of the Environment ensure that reasonable statutory time frames—that is, within or about the time frames currently set out in the

> *Environment Protection and Biodiversity Conservation Act 1999*—are established in each bilateral assessment agreement and bilateral approval agreement that the Commonwealth concludes with each state and territory (AG HoR SCoE 2014: xiv).

A careful examination of the ideology inherent in the structure of the extant Department of the Environment and its approach to the production, diffusion and regulation of non-instrumental scientific knowledge reveals three central paradoxes. Firstly, the production and diffusion of non-instrumental science particularly that knowledge production and diffusion concerned with the protection of the environment (customarily seated within the tenets of civil society), has shifted its protective action from the citizenry to the market. So rather than the state honouring the social contract and its promises (first realised during the enlightenment) to protect the individual from threats to his or her survival the state is instead seeking to share this responsibility with the market. The effort by the state to transform non-instrumental science from substantive, value-rational social action to formal, purposive social action in effect reneges on the social contract by preferencing the wants of the market over the needs of the citizen located within civil society.

Secondly, the norms of science (communality, universalism, disinterestedness and organized skepticism (Merton [1942] 1973)) under which strict adherence contemporary scientific research is undertaken, are under pressure. This pressure can be witnessed in the Department of the Environment's attempts to incorporate a political ideology through the application of a 'balanced' approach between the wants of the market and the needs of the citizenry. Thirdly, the neoliberal ideology encountered in the function of the Department of the Environment and its Regulatory Reform Task Force denies the fundamental characteristics of the natural world. As the department continues to promote efficiency through the lens of sustainability (particularly economic efficiency and sustainability) protective action by the state on behalf of the citizenry in relation to the natural world is diluted. This political position effectively transforms substantive rationality (enacted through value-rational social action) to formal rationality (enacted through purposive-rational social action) thus denying the importance of the natural world to the survival of civil society and indeed the survival of human society.

This section has traced the shift of ecologically sustainable development to economically sustainable development within the purview of the state. This loosening of the value-rational ends associated with environmentalism effectively weakens citizens' claims to clean air, water, food and other rudiments of an uncontaminated existence. The other department tasked with the management of scientific knowledge production it the Department of Industry and, latterly, Science. The contemporary character of this department is traced in the following section.

8.5.2 The Department of Industry (and Science)

The government department central to the regulation of the nation's production of scientific knowledge is the Department of Industry (and Science).[229] Under the Abbott government this department is composed of six broad policy areas: Business; Energy; Industry; Resources; Science; and Skills. Within the policy area of Science are: Innovation Policy; the Inspiring Australia program;[230] International Collaboration

[229] The department was initially known as the Department of Industry but following controversy in the public sphere, it was renamed to include 'science' approximately 18 months after the Abbott government was installed.

[230] The Inspiring Australia Program is a 'national strategy for engagement with the sciences'. The strategy is looking at how 'the media' may inspire the citizenry to more fully engage with scientific knowledge. There is insufficient opportunity within the scope of this thesis to engage in a full exploration of public engagement with scientific knowledge. Suffice to say that British research (Gregory & Thorpe 2010) suggests that within

(China and India); Science Agencies – the CSIRO,[231] ANTSO[232] and AIMS;[233] Astronomy and the Square Kilometre Array (SKA) program; and Innovation Infrastructure. The overarching theme of science policy promulgated by the Department of Industry is Innovation. Moreover, this department is the home of the Office of the Chief Scientist which continued to be supportive of the commercialisation of scientific knowledge.

The Department of Industry, Innovation and Science is openly concerned with the economic, purposive-rational outcomes of scientific knowledge. As such it is increasingly focused on commercialising scientific knowledge in order to develop and expand the 'new' tertiary industry of innovation. The department describes its remit,

> Our vision is to enable growth and productivity for globally competitive industries. To help realise this vision, the Department has four key objectives: supporting science and commercialisation, growing business investment and improving business capability, streamlining regulation and building a high performance organisation (AG DII&S 1 2014: online).

At the time of writing, Australia's Chief Scientist Professor Ian Chubb was very much in support of this aim. In his presentation to the Prime Minister's Science, Engineering and Innovation Council in 2013 he released 'five breakthrough actions governments could take to make Australia a more innovative nation' (AG OoCS 2 2013: online). These 'breakthroughs' resulted from submissions received from '63 organisations, peak bodies and individuals' in response to the question put by the Chief Scientist Chubb:

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the deeply politicized environment of the 2010s media alone is ineffective in engaging the broader community in scientific debate. The success of environmentalism in Australia during the 1970s was arguably due to the unpoliticised character of the debate at the time (see Chapter 7). Current socio-scientific problems such as 'climate change' are deeply politicized hence their minimal 'stickiness' within the public interest.

[231] Commonwealth Scientific and Industrial Research Organisation;

[232] Australian Nuclear Science and Technology Organisation

[233] Australian Institute of Marine Science (formerly in the Department of the Environment)

> What are the top breakthrough actions that the Commonwealth and state/territory governments, research agencies, universities and the business community can take to utilise fully Australia's substantial research capability to contribute to national productivity growth through innovation? (AG OoCS 1 2012: 1).

It is useful to note that this Research Question, in terms of its research validity, is an unusually leading question; one which appears to embed the ideology of neoliberalism and economic rationalism within its framework. The Research Question also takes on the assumption put by neoliberal ideology that there is 'no other way forward'. The five 'breakthroughs' reported by the Office of the Chief Scientist (AG OoCS 2 2013: online) following the analysis of the submissions are: 1. establish an Australian Innovation Council; 2. strengthen business access to publicly funded research expertise, infrastructure and data; 3. encourage mobility of researchers between academic and business or other enterprises; 4. harmonise IP frameworks across the publicly funded research sector; 5. emphasise the role of STEM[234] education in changing the culture. These 'breakthroughs' clearly demonstrate the policies and practices of the new developmentalism and the protectionist strategies that accompany this ideology.

Further investigation reveals that the Chief Scientist and the Department of Industry (and Science) head a large structured system of scientific knowledge production and diffusion that works to further the National Science Policy of Innovation. This large, centralised bureaucratic science system underpins scientific knowledge production and diffusion in Australia and, despite shifts in the tone of political announcements, continues the policy work that was started by the OECD in the 1970s and has been supported by neoliberal governments of either political persuasion since. The central

[234] Science, Technology, Engineering and Mathematics

policy priority for the science system in Australia remains the commercialisation of scientific knowledge and the translation of different modes of scientific knowledge production into factors of production. The following section considers this set of dynamics more closely.

8.5.2.1 The structure and funding of the Australian science system

The Australian Public Service (APS) finds that 'the interactions between policy makers and decision-makers and the science community are complex' (AG DIISRT APS200 2012: 2). Their study *APS200: The place of science in policy development in the public service* (AG DIISRT APS200 2012) sought to address the divide that currently exists between public policy and scientific knowledge produced by the *Australian science system*. Figure 8.1 (below) that was prepared for the APS study is useful here in that it shows the Australian science system as it stood at the time of writing.[235]

Within the coloured circle are the key scientific policy makers such as funding agencies, major publicly funded research agencies and coordination bodies. Outside the formal science system lie the Public/Private Partnerships known as Cooperative Research Centres (CRCs), the Medical Research Institutes (MRIs) and the Higher Education Providers. As discussed earlier in this chapter, the OECD in concert with the Australian government have been moving towards a centralised science system since the 1970s. The diagram (Figure 8.1) illustrates the make-up of the contemporary system and demonstrates that a centralised, bureaucratised science policy and praxis has largely been achieved in Australia. A unified set of bureaucracies managing the production and

[235] This divide between public policy and it use of scientific knowledge is an important area for research however due to size constraints it will not be addressed in this thesis; it presents a fruitful area for research into the future.

diffusion of all scientific knowledge in Australia suggests that a central concentration of power has been achieved and that plans to fully instrumentalise science are well underway.

Figure 8.1 The Australian Science System (AG DIISRT APS200 2012: 2).

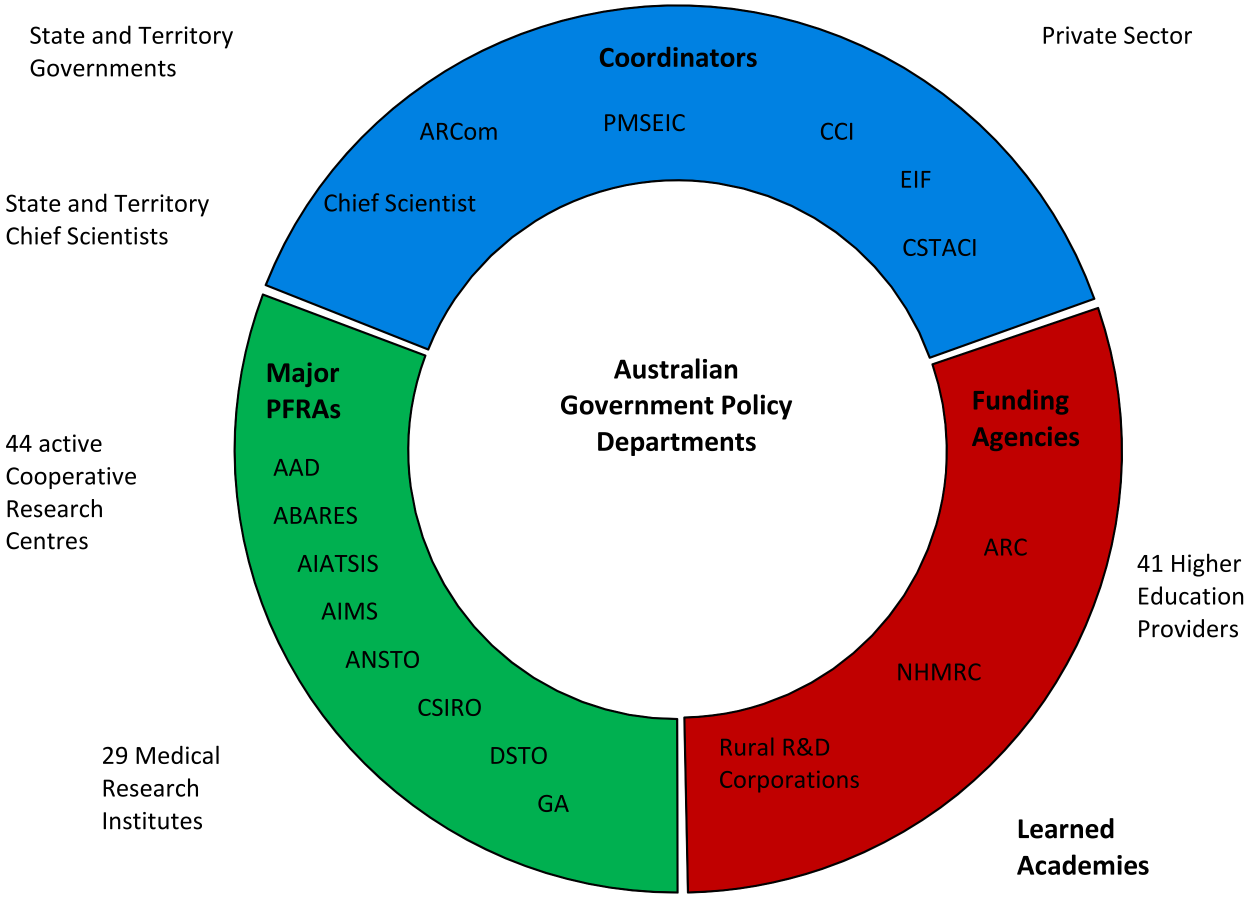

Table 8.1: List of acronyms used in the Australian Science System (AG DIISRT APS200 2013: 51)

AAD	**Australian Antarctic Division**
ABARES	**Australian Bureau of Agricultural and Resource Economics and Sciences**
AIATSIS	**Australian Institute of Aboriginal and Torres Strait Islander Studies**
AIMS	**Australian Institute of Marine Science**
ANSTO	**Australian Nuclear Science and Technology Organisation**
ARC	**Australian Research Council**
ARCom	**Australian Research Committee**
CCI	**Coordination Committee on Innovation**
CRCs	**Cooperative Research Centres**
CSIRO	**Commonwealth Scientific and Industrial Research Organisation**
CSTACI	**Commonwealth State and Territory Advisory Council on Innovation**
DSTO	**Defence Science and Technology Organisation**
EIF	**Education Investment Fund**
GA	**Geoscience Australia**
NHMRC	**National Health and Medical Research Council**
OCS	**Office of the Chief Scientist**
PFRAs	**Publicly Funded Research Agencies**
PMSEIC	**Prime Minister's Science, Engineering and Innovation Council**

In terms of funding arrangements, it has been estimated that the total Australian Government expenditure on 'science, research and innovation' in 2012-13 was $8.97 billion (AG DoI AIS 2013). Funding for research is most often provided by government funding agencies such as the Australian Research Council (ARC) and the National Health and Medical Research Council (NHMRC) and through taxation incentives linked to corporate 'Research & Development'. As the Australian government reports, 'Government provides 30% of Australia's gross expenditure on R&D (GERD) and a significant proportion of business sector investment is facilitated by Government programs such as the R&D tax credit' (AG DoI AIS 2013: 111).

In order to successfully compete for these state funded grants, bids for project funding must adhere to the principles guiding research investment laid down by the Federal government. These principles are prepared by the Australian Research Committee (ARC) chaired by the Chief Scientist and are published in the National Research Investment Plan (AG DIISRT NRIP 2012). In broad terms these principles seek to address the commercialisation of Australian scientific knowledge by 'Encouraging increased business sector research; setting priorities for mission-based research that improves national wellbeing; ensuring Australia has a strong basic research capability that drives discovery and underpins innovation; supporting the training of researchers; funding research infrastructure that cannot be provided by business or individual research organisations; and facilitating domestic and international research collaboration' (AG DIISRT NRIP 2012: v).

Despite the functional positioning of innovation policy within the Department of Industry, the ARC (as the chief funding body for all science apart from that associated with medical science) is administered by the Federal Department of Education and the NHMRC (as the chief funding body for medical science) sits within the Federal Department of Health. As neoliberal policy settings have become embedded in the Federal and State portfolios of education and health the dictates of both 'competition' and 'commercialisation' are also demonstrated in the mission of both the ARC and the NHMRC.

All researchers must compete for funding, and researchers seeking Linkage grants are obliged to develop partnerships with other research teams and universities as well as with 'other parts of the national and international innovation systems'; that is within Public/Private Partnerships led by the market. Similarly, the NHMRC's 'priority actions' are aimed at generating non-instrumental and/or pre-instrumental[236] knowledge and fast-tracking that new knowledge to the market to satisfy innovation policy. The formal aims of the organisation as detailed in its 'Strategic Plan' are,

> Create new knowledge through support of discovery[237] research; Accelerate research translation; Build Australia's future capability for research and translation; Set high standards in ethics in health care and research; Work with partners – States and Territories, health bodies, health industries and community and consumer groups' (AG NHMRC SP 2013: iii).

While these aims may be one step removed from the commercial demands of the market the impetus to 'translate' this 'discovery' (or non-instrumental) knowledge into instrumentalised knowledge as quickly as possible is embedded in the imprimatur of both the ARC and the NHMRC. Moreover, the Minister's note at the beginning of the strategy document supports this preference for haste in 'translating' knowledge to support market-based initiatives,

> The plan identifies the need to focus on known and emerging health issues arising from infectious diseases, environmental changes, and accelerating global mobility. It acknowledges that we must more quickly implement knowledge gained from research, requiring closer cooperation with States and Territories, non-government organisations, community and consumer groups, and the private sector (Plibersek/AG NHMRC SP 2013: v).

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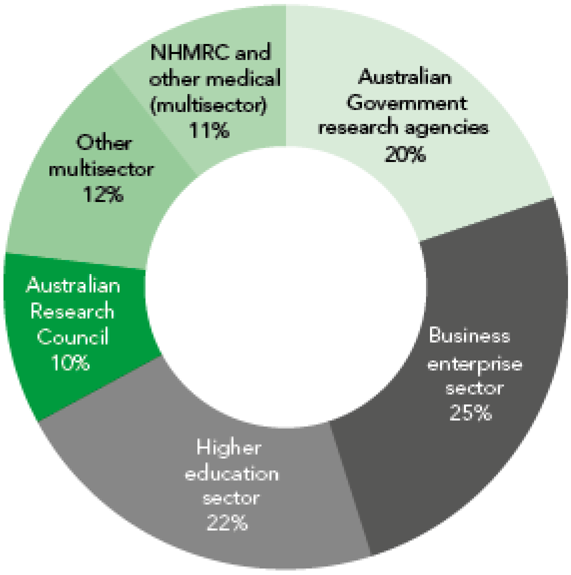
[236] Under the terms of innovation policy non-instrumental research moves into the purview of pre-instrumental scientific knowledge
[237] Discovery research means the production and diffusion of non-instrumental scientific knowledge

This aim to fast-track the commercialisation of scientific knowledge, and reward this behaviour with state grants, is demonstrated in the statistical analyses prepared by government agencies including the Australian Bureau of Statistics (ABS). The following diagram (Figure 8.2) shows how the Federal government allocated $8.9 billion dollars in support of science, research and innovation for the financial year 2012–13 (AG ARC AR 2013: 24). Of note is the large allocation of funding (through taxation incentives) provided to the business enterprise sector for the commercial development of products and services.

Figure 8.2: Australian Government support for science, research and innovation 2012-13 (total funding $8.9 billion)



NOTE: Other multi-sector includes Cooperative Research Centres, Rural, Energy and the Environment and Other Science Support

Source: (AG ARC AR 2013: 24)

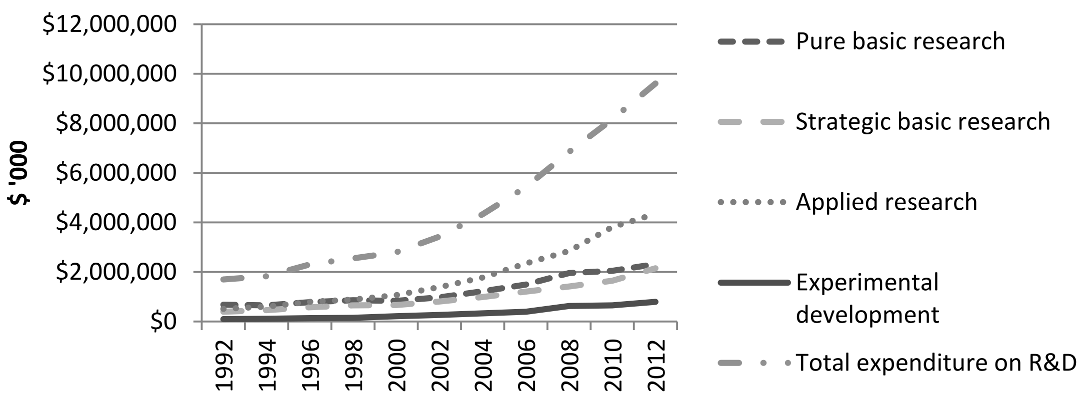
A more detailed analysis of the funding trajectory is provided by the ABS within their Research & Development[238] statistical reports and are shown in Figures 8.3, 8.4, 8.5 and 8.6 on the following pages. These analyses demonstrate how non-instrumental (pure basic) scientific knowledge has declined since 1992 while instrumentalised knowledge (strategic basic, applied and experimental) has increased. The analyses also indicate how instrumental knowledge developed by the market has grown.[239] Statistics related to *Innovation, science and technology* are nested within the *Industry* topic area and statistical reports associated with environmental matters can be found within the *Environment and Energy* topic area.

[238] R&D is defined in accordance with the Organisation for Economic Co-operation and Development (OECD) standard as comprising 'creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications'. Type of R&D activity comprises pure basic research, strategic basic research, applied research and experimental development. Data in this classification are subjectively allocated by respondents at the time of reporting, using OECD/ABS definitions. The ABS makes every effort to ensure correct and consistent interpretation and reporting of these data and applies consistent processing methodologies. Analysts using this classification should bear the original subjectivity in mind. For a more comprehensive interpretation of the definition of R&D activity, contact the ABS or refer to the OECD publication The Measurement of Scientific and Technical Activities (Frascati Manual 2002), OECD, Paris, 2003.

[239] Note that the figures used in the following charts have not been adjusted for inflation and reflect the actual expenditure in each year.

Figure 8.3 below demonstrates Research & Development by the Higher Education[240] (HERD) sector over the last twenty years. The analysis demonstrates that in 1992 non-instrumental science (pure basic research)[241] accounted for the largest proportion of activity (at 40%) followed by pre-instrumental and instrumental research (applied research)[242] (at 30%). As the years progressed, the proportion of non-instrumental science decreased as instrumentalised research (applied research, strategic research[243] and experimental development)[244] increased. In 1996 the production of instrumentalised science in the higher education sector surpassed the production of non-instrumental science. (Source: ABS Cat No. 8111.0 2012: online)

Figure 8.3: Higher education expenditure on R&D, by type of activity



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240 Higher education sector: This sector includes all universities and other institutions of post-secondary education whatever their source of finance or legal status. The Higher education sector for the R&D survey excludes non-university post-secondary education institutions (e.g. Technical and Further Education colleges) because it is considered that their contribution to total R&D activity would be minimal (ABS/specified by OECD)

241 Pure basic research is carried out without looking for long-term benefits other than the advancement of knowledge (ABS/specified by OECD).

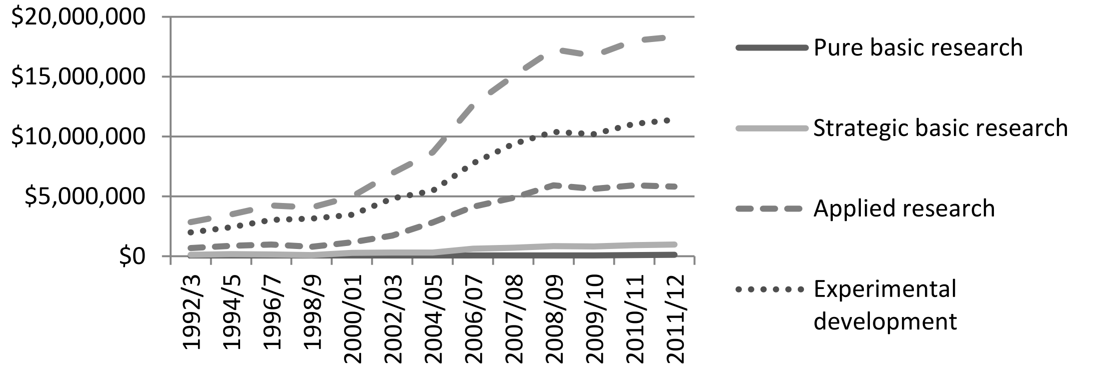
242 Applied research: original work undertaken in order to acquire new knowledge with a specific application in view. It is undertaken either to determine possible uses for the findings of basic research or to determine new methods or ways of achieving some specific and predetermined objectives (ABS/specified by OECD).

243 Strategic basic research is directed into specified broad areas in the expectation of useful discoveries. It provides the broad base of knowledge for the solution of recognised practical problems (ABS/specified by OECD)

244 Experimental development: systematic work, using existing knowledge gained from research or practical experience, for the purpose of creating new or improved products/processes (ABS/specified by OECD)

Figure 8.4 below illustrates the growth in Research and Development by the Business[245] sector. Total expenditure has grown steeply since 1992 with (as could be expected) the majority of scientific research being undertaken in instrumental areas. Non-instrumental science is rarely undertaken by the Business community. Instead it is the state-funded institutions that contribute to the development of the market through the provision of non-instrumental scientific knowledge.

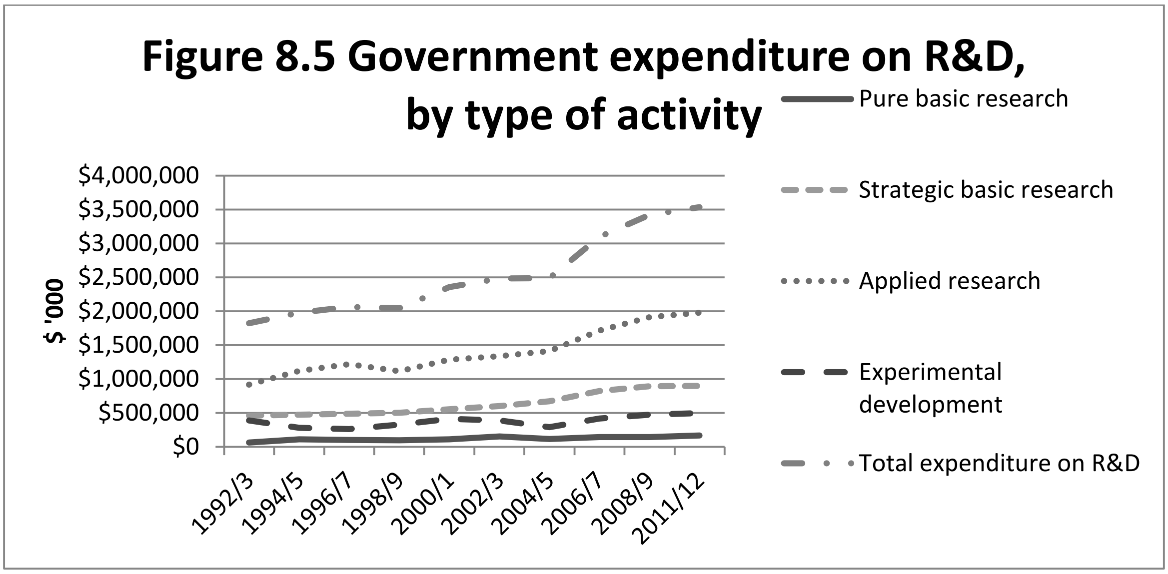
Figure 8.4: Business expenditure on R&D, by type of activity



(Source: ABS Cat No. 8104.0 2013: online)

[245] Business sector: This sector includes all businesses whose primary activity is the production of goods or services for sale to the general public at a price intended to cover at least the cost of production, and the private non-profit institutions mainly serving them (ABS/specified by OECD).

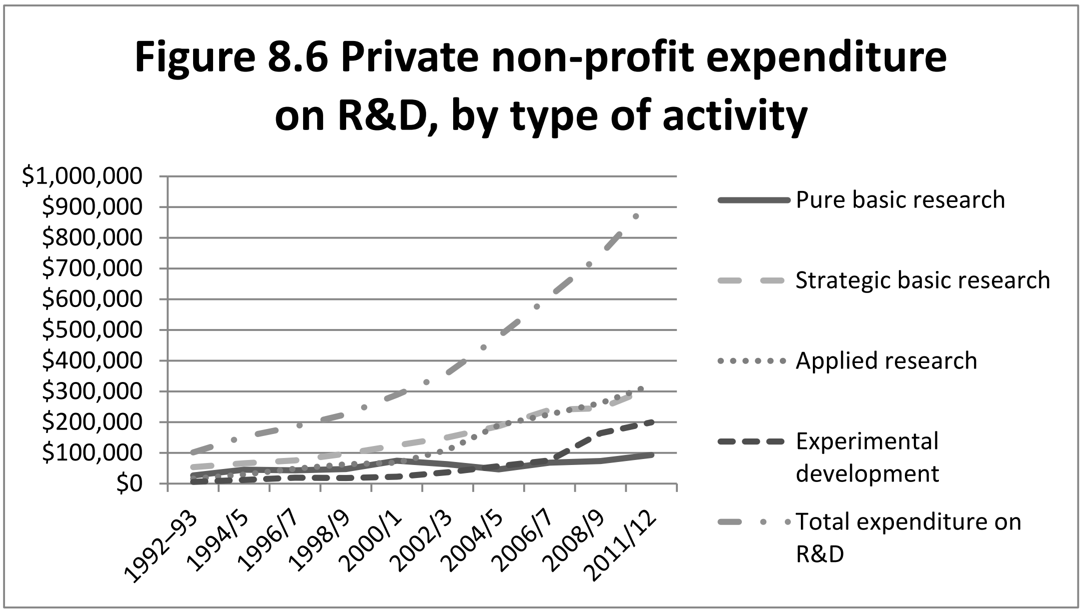
Figure 8.5 below illustrates the growth in Research and Development in the Government[246] sector. Since 1992 the state has grown its research budget however it is the instrumentalised sciences that have benefited from this expansion. This graph indicates that the focus on non-instrumental science has remained static over the last twenty years however the pre-instrumental sciences has grown rapidly, reflecting the state's preference for employing scientific research for purposive-rational aims.



(Source: ABS Cat No. 8109.0 2013: online).

[246] Government sector: This sector includes all Commonwealth, state and local government departments and authorities. The Government sector for the R&D survey excludes local government organisations because it is considered that their contribution to total R&D activity would be minimal. Public sector organisations mainly engaged in higher education (e.g. universities) are included in the Higher education sector whilst those mainly engaged in trading or financial activities are included in the Business sector.

Figure 8.6 below illustrates the growth in Research and Development in the Private Not-For-Profit[247] sector. This graph demonstrates that total expenditure on research has escalated in this sector and is reflective of the state's neoliberal policies to privatise government instrumentalities. It also suggests that these non-for-profit organisations are producing knowledge for both non-instrumental and instrumental purposes for both the state and for private clients. This privatisation of non-instrumental and pre-instrumental knowledge presents issues around the role of the state in the contemporary milieux.

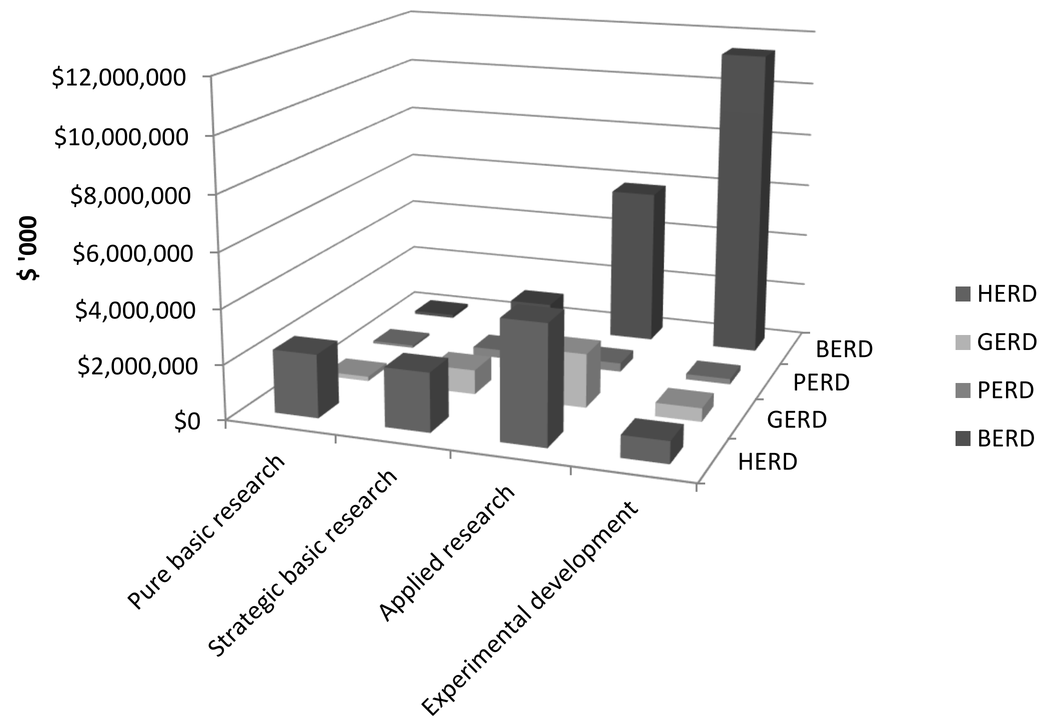


(Source: ABS Cat No. 8109.0 2013: online)

[247] Private non-profit sector: This sector includes private or semi-public incorporated organisations which are established with the intention of operating without making a profit.

Figure 8.7 below shows the total expenditures by each sector (Higher Education, Government, Not-For-Profit and Business) for the year 2012. The chart demonstrates that the higher education sector conducts the majority of non-instrumental and pre-instrumental science. Government agencies and private not-for-profit organisations do not significantly contribute to research and development (even taking into account the non-instrumental environmental sciences) however the business community is a strong contributor but only in terms of applied and experimental (pre-instrumental) research that contributes to preparing a product or service for market.

Figure 8.7 Total expenditure on R&D (HERD, GERD, PERD, BERD) by type of activity, 2012



(Source: ABS Cat No. 8111.0, 8104.0 and 8109.0, 2013: online)

This section has demonstrated that funding for non-instrumental science continues to decline in favour of heavily instrumentalised scientific knowledge destined for private knowledge markets. The following section explores the trajectory of scientific knowledge within the National Innovation System.

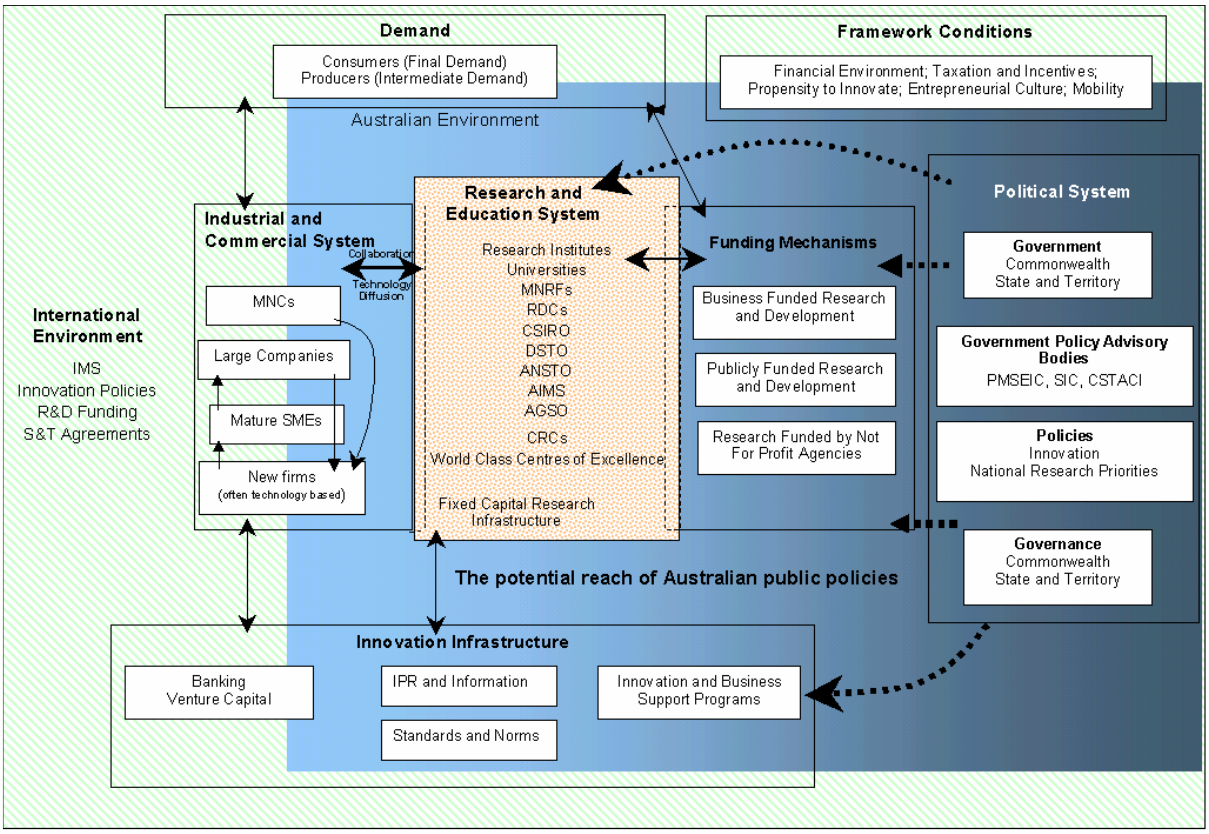
8.2.1.1 The production of scientific knowledge within the National Innovation System

As discussed in previous sections, the state and the OECD have worked together since the 1970s to achieve the goal of a National Innovation System, a domestic policy and praxis that will integrate more easily into global markets. The diagram shown in Figure 8.8 demonstrates that this goal had largely been activated and has been ready for final implementation since at least 2004. The Innovation Statement made by conservative Prime Minister Malcolm Turnbull at the end of 2015 could thus be conceived as window dressing on a project that has been a long time in the making. It also suggests that any genuine, rational public debate mounted at this stage could be both ineffective and fruitless.

The diagram helps to illuminate the often complex relationships between the different organisations involved in the National Innovation System. It illustrates how the state (the political system) provides funding so that the science system (research and education system) may produce instrumentalised scientific knowledge for the express use of the market (the industrial and commercial system). There does not seem a viable position for the production and diffusion of non-instrumental science in this model.

Figure 8.8: Main components of the Australian Innovation System in 2004

(Source: OECD 2004b: 9)



Despite the continuing necessity for non-instrumental science in order to produce instrumentalised science, the OECD model embeds basic research within a thoroughly economic paradigm. In other words, non-instrumental science in and of itself is transformed into a factor of production for the new global knowledge markets.

The OECD positions the success of the science system as contingent upon variables such as consumer demand and the proceeds of intellectual property rights. Moreover, under this model the state is obliged to provide direct funding by way of research grants, and indirect funding through taxation concessions, in addition to the provision of supportive legal frameworks and protective Intellectual Property (IP) legislation. The overall success or otherwise of the new science of innovation is predicated on a favourable financial environment; on the state provision of taxation relief and R&D incentives; on an entrepreneurial culture that is supportive of innovation policies; and the mobility of actors across the innovation system.

The active participation of the state has been vital to the realisation of this schema. It suggests that the OECD has worked closely (and without public consultation) with the state in order to undertake effective planning and the realisation of this model. It is difficult however to see an active position for the citizenry or for rigorous public debate within the bounds of this model. It seems another instance of the basic components of civil society rejected by the state in favour of advancing the money and power of economic elites. Yet within the global innovation system, Australia is a very small player.

Notwithstanding the extensive planning, modelling and the building of bureaucratic infrastructure to support a National Innovation System the most recent study conducted by the Department of Industry (released in 2013) reports that Australia currently produces only 3% of the world's knowledge and consistently relies on 'innovations' generated by other nations.

> The Australian innovation system generates only 3% of world knowledge, so the economy relies on innovations generated elsewhere. The majority of Australian firms are modifiers and adopters of innovation and technology. It is therefore important to understand how our innovation system fits with other innovation systems in countries of the Asian region, which are demanding high levels of novelty in innovation (AG DoI AISR 2013: 14)

As this thesis suggests, this data reveals a long-standing pattern in Australia that can be traced back to the 19th century, when the majority of non-instrumental knowledge was imported either tacitly by farmers, miners or technical people or in a formal manner by way of post-graduate research undertaken overseas.[248] This long-standing pattern appears problematic in the highly competitive global marketplace of the 21st century where the reliance on the non-instrumental scientific knowledge that has been produced by other, equally competitive, nations appears unrealistic. In particular, the result of reduced funding for Australian science, the state's reliance on depleted capacity, and the dwindling political will to produce non-instrumental scientific knowledge, suggests that Australia will be unable to effectively compete in the global knowledge market.

Perhaps in an effort to motivate the production of non-instrumental scientific knowledge, the Australian Innovation System Report (2013) cautions that without the continued production of break-through scientific knowledge the Australian economy will not thrive; that without this non-instrumental, basic research, Australian scientists will be unable to break the cycle of reinvention or inject originality and creativity into the system.

> Without basic research, applied research will continue to drive greater efficiencies, but the chance of more radical, new-to-the-world innovations will be limited. Australia has shown the capacity to produce radical innovations in wireless technology[249] and medical devices—innovations that had their genesis in basic research. It is difficult to determine what the right balance between these forms of R&D as it is time-and context-specific. Even when the majority of

[248] As discussed in Chapters 4-6, the pastoral, mining and agricultural industries developed local knowledge from the tacit knowledge brought with them by immigrants or by direct transfer from overseas institutions. Further, much non-instrumental scientific research was conducted overseas by Australian post-graduate students who were forced to relocate in order to continue their studies and advance their research projects in more mature tertiary milieux. Until the 1950s scientific knowledge production was confined to the pre-instrumental bureaux and universities were teaching rather than research institutions.

[249] Wireless technology was originally developed as part of a project conducted by the CSIRO in co-operation with university-based researchers as part of the response to World War II.

> Australian firms are adopters and modifiers of innovations generated elsewhere, Australia needs an innovation system capable of undertaking radical and new-to-the-world innovation—and basic research underpins this capacity (AG DoI AISR 2013: 114).

Thus non-instrumental science remains mandatory to the production of new knowledge, irrespective of its uptake by the market, or its use by the state to support the development of civil society. This case for the production and diffusion of non-instrumental scientific knowledge is however contrary to the policies and praxes of neoliberalism. Under the tenets of neoliberalism, the state continues to reduce the production and diffusion of non-instrumental knowledge and, as outlined in the previous section, the Australian marketplace is similarly disinclined to produce the necessary non-instrumental science.

This disinclination on the part of both the state and the market to produce non-instrumental science presents a conundrum. Adding to this conundrum, is the necessity for Australia to co-operate with other nations who do currently produce non-instrumental scientific knowledge, in order to inject fresh and original thinking into its knowledge pool. However, this necessity for co-operative behaviour in the face of a highly competitive global marketplace, and the ongoing benchmarking of Australia against other OECD nations, suggests a level of irrationality that is both structurally based and economically and politically unrealistic.

Moreover, this determination to circumvent the production of non-instrumental science persists within the political frameworks underpinning the sustainability policies that steer the non-instrumental science associated with environmentalism. In point of fact, the Australian Innovation System Report (AG DoI AISR 2013) finds that a potential way out of this conundrum is to develop new markets for green innovation. Petersen champions 'green' innovations as a 'new economic growth paradigm that is responsive to the earth's ecosystems (which) can also champion human development' (Petersen cited in AISR 2013: 141). Petersen's argument is based on the principles of *relative*[250] and *absolute decoupling*.

Tim Jackson (2011) maintains that the principles of decoupling are favoured by classical economists who seek to escape the problem of economic growth and its relationship with finite ecological limits. Moreover, Jackson finds that evidence for the successful application of relative decoupling to national economies is slim and the evidence for absolute decoupling measures is non-existent. He argues that the common economic targets for 'ecological investment' such as 'carbon reduction…resource efficiency, resource substitution infrastructure changes, ecosystem protection and ecological enhancement' (2011: 83) are flawed; that neoliberal calls for 'efficiency' and 'growing markets' to solve environmental dilemmas are 'not at all uncommon in the tangled debates about environmental quality and economic growth' however do not present a realistic way forward (2011: 76).

Conversely, the proponents of 'green' innovation argue that the new way forward for the Australian economy may well be under the category of 'eco-innovation',

> Australia could quickly become a global leader in the pursuit of a green growth strategy… Australia's high skill base, combined with suitable encouragement of its emerging experience with eco-innovation, will enable our industries and researchers to contribute to the creation of a global economy that has decoupled development from increased resource and energy use and

[250] Relative decoupling means resource use may increase, however, at a slower rate than economic growth. Absolute decoupling is achieved when resource use declines over time while the economy grows.

> the destruction of biodiversity. Our competitive advantage can shift from primary industries to a more enduring future in eco-innovation (Sharpe & White 2013:162).

It appears therefore that under the auspices of 'environmentally sound' economic strategy the last stronghold of non-instrumental science in Australia (that pertaining to environmental science) may yet be turned over to growing new markets.

8.6 Conclusion

This chapter has traced the development of a centralised science policy in Australia and its relationships with neoliberal policies and praxes. The emergent set of policy initiatives has been guided by the OECD towards Australia's integration into a global knowledge economy and in particular towards the shaping of a hybrid form of scientific knowledge production and diffusion known as the 'new' science of innovation. Under the tenets of neoliberalism, innovation strategies in Australia are replacing pre-instrumental scientific knowledge production and diffusion in order to both divest the state of the responsibilities associated with knowledge production and to tighten the bonds between non-instrumental science and the wants of the global market.

This economically motivated dynamic has completed the shift of scientific knowledge from its place as an implicit factor of production to that of an explicit factor of production and to a product in its own right. Moreover, the policies of neoliberalism and attendant protectionist strategies are transforming the traditional factors of production of land, labour and capital in Australia. In a move to position innovation as the new tertiary industry, set to replace the primary and secondary industries as the nation's key export sector, the state has erected a set of protectionist strategies that echo the protectionism instituted in the 19th and 20th centuries. That protectionism sought to advance the interests of the primary and secondary industries and took the form of developmentalism.

Notwithstanding the contemporary neoliberal settings, the current development strategies replicate the state endowment of land, labour, capital and scientific knowledge, albeit in a different form, that were used to support the special interests associated with the development of primary and secondary industries in Australia. For instance in the new digital age, the *land* provided at low or no cost to the early industrialists takes the form of Information and Communications Technology (ICT) such as the National Broadband Network; the *labour* provided by the convicts and the working class has morphed into the labour of non-instrumental scientists and it too is subsidised by the state; the low-cost *capital* that was extended to the primary and secondary industries is now provided by the state in the form of grants and tax concessions; and the scientific knowledge provided by the pre-instrumental scientific bureaux is shifting to the increasingly revenue-neutral universities and publicly funded and highly instrumentalised research institutes. Moreover, the non-instrumental character of environmental science is being readied for transfer to the market through the vector of green innovation.

Where scientific knowledge has been bound up with notions of freedom and self-determination since the enlightenment the political and economic forces at work in Australia since the 1970s are, paradoxically, weakening the claims of national sovereignty. Rather than securing autonomy on the part of the individual, neoliberal praxis reduces the possibilities of emancipation of the lifeworld and increases the potential for colonisation by the market. The highly instrumentalised praxis of neoliberalism is thus transforming the substantive, value-rational character of non-instrumental scientific knowledge and repositioning it within a framework of purposive rationality. This repositioning of non-instrumental science not only denies the lifeworld, it shifts the balance of power towards the market and risks the protective character of scientific knowledge. As Weber suggests, under these conditions reason turns to unreason.

9 Conclusion

This research project set out to explore the production and diffusion of knowledge pertaining to the natural sciences in Australia, particularly in relation to the institutions of state, the market and civil society. A tripartite analytical model was created in order to provide a rational lens through which to analyse the levels of instrumentalism evident in scientific knowledge production in Australia. The model draws on the foundational work of the scholars of the enlightenment, their contributions to the establishment of the modern state, to the development of capitalist markets, to a conception of citizen sovereignty safe-guarded by a protective state, and ultimately to advancement of civil society, and is used to analyse the period between the 1770s and 2010s in Australia.

The research and subsequent analysis finds that, in Australia at least, the rational aims of the enlightenment are tenuously founded. That the rationally inspired enlightenment envisioned by Bacon, Kant and other scholars of the enlightenment has held a fragile position at best in the Australian nation, and that the contemporary ideologies of neoliberalism work to further compromise the potential of science to effectively contribute to the cultivation of civil society. While the settings were originally in place for developing non-instrumental science as an active part of civil society in Australia, the long-standing push to develop markets and to instrumentalise scientific knowledge has largely engulfed these early efforts. State-led developmentalism, tied to the establishment and growth of the primary and secondary industries, instead leveraged pre-instrumental scientific knowledge to construct new forms of economic protectionism. These protective mechanisms were challenged as state transitioned to take up the ideologies of neoliberalism.

The ongoing political challenge to non-instrumental scientific knowledge, and so to the evolution of civil society, peaked between the 1970s and 2010s as the shifts and changes in Australian politics redirected it into three new organisational streams; non-instrumental science as cultural practice, non-instrumental science that could be leveraged to achieve economic aims, and non-instrumental science used to support sustainability themes. These political moves were component to the economic restructuring under the incoming policies of neoliberalism, and continue to intensify within the policy settings of the 'new', tertiary-based science of innovation.

Innovation policies leverage instrumentalism to create a return to policies associated with developmentalism and protectionism, policies that were critical to the success of the primary and secondary industries during the 19th and first half of the 20th century. The new tertiary industries generated by innovation policies however seek to animate a direct commodification of scientific knowledge through linking non-instrumental science directly with market actors. New forms of state-provided economic protectionism accompany this return to developmentalism; albeit a new form of developmentalism oriented towards the tertiary industries. Under these conditions the democratic potentials of non-instrumental science are subsumed under a state/market nexus that effectively precludes development of an effective civil society and instead favours the special interests of the economic elites over protective action in favour of the citizenry. So, as the hyper-instrumentalisation of scientific knowledge grows ever stronger in Australia, the pilot light of non-instrumental science and its links with civil society grow 'dim and dimmer'.

In Australia, the production and diffusion of scientific knowledge since white settlement has been heavily characterised by instrumental rationality. This instrumentalism has shifted over time but has escalated since the 1980s when the neoliberal policies and praxes of the Hawke-Keating government were instituted into the national agenda. This new phase of instrumentalism has seen the production and diffusion of pre-instrumental scientific knowledge go into decline. This decline has occurred in concert with the progressive colonisation of non-instrumental scientific knowledge by market forces and has been instigated by state policies and praxes. Paradoxically, this rise in instrumentalism is occurring during a period when risk is increasingly devolved to the citizenry; when the citizenry is called upon to engage in rational decision-making around increasingly politicised socio-scientific problems and associated government policies.

Common socio-scientific problem areas addressed at the political level in Australia include mitigation against global climate change, the pollution and degradation of the natural environment through industries concerned with, for instance, mineral extraction and agriculture, the future of energy production and consumption, the availability of clean and potable water, the decline in biodiversity and its consequences, and other pressing issues associated with primary and secondary industries. Problematically, the non-partisan scientific knowledge necessary to fuel national debates is increasingly compromised by economically motivated special interest groups that have progressively colonised the machinery of state and have contributed to the blurring of relationships between the state, the market and the advancement of civil society. As scientific knowledge production and diffusion is gradually privatised by the state under the policies and praxes of neoliberalism, the special interests of the marketplace work to counteract the protective action embedded in the *raison d'etre* of the state. Thus, as argued throughout this thesis, the potential of the protective action of scientific knowledge is arguably transmuted from a fragile state/citizen axis during the early period of white settlement to a robust state/market axis commencing during the first half of the 19th century and continuing to the present time. As Bacon and Kant and the other scholars of the enlightenment clarify, access to rational knowledge issues the bearer with the power to exercise autonomy and control. Under the founding principles of the western nation state this power remains in the hands of the state in order to protect the autonomy of the individual citizen. Under current settings however, the nation's non-instrumental scientific knowledge is largely transferred to the market for incorporation into products and services to profit the special interests of the market.

As this thesis has shown, this process of increasing instrumentalism presents three paradoxical positions. Firstly, the position violates the basic tenets of citizen sovereignty that underpin the foundations of the nation state. By employing state assets to produce scientific knowledge specifically for instrumental use by the market, the state is in effect opening up opportunities for colonisation by economically motivated special interest groups. Non-instrumental scientific knowledge that is instrumentalised and combined with the economic imperatives of the market remains lost to the citizenry. While critics may argue that the citizen benefits from the goods and services provided as a result of this instrumentalisation, the scientific knowledge used in the production of these marketable products is to all intents and purposes controlled by corporations that are not bound by the laws and social responsibility inherent in the nation state. Moreover, this embedded scientific knowledge becomes irretrievable by either the state or the citizenry. This position weakens the power that has been invested in the state on behalf of the citizenry by ceding power to the market; in doing so diminishing the protective action afforded a civil society and its citizens.

Secondly, the privatisation of scientific knowledge production may distort the rational process of western democracy; a form of governance that has been central to the development of civil society within western nations since the enlightenment. The privatisation of state assets opens the nation and its citizenry up to colonisation by the steering mechanisms of money and power that may be brought to bear by economically aligned special interest groups. This partiality towards special interest groups on the part of the state may contribute to a distortion in the democratic process. Scientific knowledge that has been commodified is open to control by a market concerned with money and power over the wellbeing of individual citizens. This reshaping of the economy to serve the market over the citizenry reneges on the basic promises of the enlightenment and its aims to advance individual freedom and enhance social wellbeing through the application of value-rational scientific knowledge.

Finally, the delivery of scientific knowledge to the market is antithetical to the promises of the enlightenment which saw rational knowledge tethered to notions of freedom and autonomy. The progressive hyper-instrumentalisation of scientific knowledge production on the part of the state (to the detriment of non-instrumental scientific knowledge production) effectively destabilises the linkages between rational scientific knowledge and self-determination. The rational project of the enlightenment moved to free the individual from the magical thinking of the medieval period, and from rule by the deity or the monarchy, by promoting individual access to rational knowledge. Under contemporary neoliberal settings in Australia however both rationality and freedom are at risk; rational knowledge is distorted by a state divesting knowledge production to special interests, interests that are motivated by money and power. In the global drive for money and power the practices of the market may distort the rational character of scientific knowledge. This highly partisan approach to scientific knowledge disturbs the rational relationship between scientific knowledge and the citizenry, to all intents and purposes recapturing the magical character of the medieval period.

Moreover, by ceding free access and the subsequent control of non-instrumental scientific knowledge to transnational corporations, the state is effectively setting up a new consortium of powerful rulers. These new rulers are not guided by the protective and democratic actions of the nation state and do not employ rationally-derived scientific knowledge to enhance notions of civil society. Rather, these consortiums are motivated by scientific instrumentalism and its possibilities for accruing money and power. Under these conditions citizen sovereignty is being risked by the state in favour of the aims of the market. It would seem therefore that the rational aims of modernity are being purposefully re-negotiated in favour of a form of re-feudalisation. However, rather than the deity or the monarchy controlling the people (through private access to knowledge), under current settings transnational companies are on a trajectory to generate a new type of empire; a new realm controlled by the exigencies of the market. The following section outlines the key arguments made in the thesis in order in order to highlight the implications of the more specific arguments presented.

9.1 Scientific knowledge in Australia

The focus of this research project was refined during valuable time spent as a doctoral student in the Department of Environment and Geography in the Faculty of Science at Macquarie University. Working and socialising alongside the natural scientists in the Faculty was constructive in developing a deeper understanding of the natural sciences and the tensions present in the production and diffusion of scientific knowledge in the contemporary milieu. It also became clear during this time spent in the Faculty of Science that natural scientists acted with a framework of ethical norms that had been laid down during the enlightenment and which continued to guide their daily work.

The rational scientific method that had been introduced by natural philosopher Sir Francis Bacon in the 17th century remained in everyday use but the reasons for producing scientific knowledge constantly shifted and changed with the dynamics of the social world. While the rational scientific method remained the primary *means* of conducting scientific exploration, the shifts and changes in the social world often determined a variety of rationally derived *ends* for scientific knowledge production and diffusion. These ends, depending upon the social environment in which they were conceived and enacted, could alter the focus and outcomes of the scientific research. For instance, a highly rational society such as Australia may position scientific knowledge production and diffusion as a means to achieve a set of especially instrumental ends; ends that are conceived through a politicised bureaucratic process, that are focused on utilitarian outcomes, and that have become particularly susceptible to exploitation by the special interests of economic elites.

A central aim of the thesis was to investigate the tensions between that scientific knowledge produced for non-instrumental (or value-rational) ends such as the generation of social wellbeing and the advancement of civil society, and the scientific knowledge produced for instrumental (or purposive-rational) reasons such as for war or for the advancement of markets. A review of the existing literature revealed a narrow range of sociological work around the production and diffusion of knowledge associated with the natural sciences in Australia. While there was some good historical investigation of the natural sciences, the available literature did not specifically analyse the shifts and changes in the social world and how these sociological dynamics influenced the natural sciences; nor did it consider the conditions of scientific knowledge production and diffusion in Australia under the policies and praxes of neoliberalism. As a result, this research project needed to go back to basics and reconsider scientific knowledge production and diffusion in the light of the rational project of modernity and in conjunction with the learned work of the scholars of the enlightenment, upon which the contemporary notions of the modern state, the market and civil society are founded.

A deep and systematic analysis of both the literature and documentary evidence was undertaken in order to more clearly understand the historical roots of the modern state of Australia, the social conditions under which it was founded, and the shifts and changes evident in the social world during the period between white settlement and the contemporary neoliberal milieu. Overlaid on this analytical work was a review and analysis of the treatment of scientific knowledge production and diffusion within the social, economic and political settings of each historical period. The task was never to provide a deep history or a highly specific analysis of a particular time period or specific scientific discipline but to offer a broad basis for future research and to act as a catalyst for a rational discussion of the purpose and use of scientific knowledge within Australian society.

Max Weber's concept of rationalisation, particularly substantive rationality delivered through a framework of value-rational social action and formal rationality delivered by way of purposive rational social action provided an excellent tool with which to analyse the material. Moreover, Adorno and Horkheimer's work on instrumental rationality was a key to opening up the space for the evaluation of the natural sciences and their relationships with the state, the market and civil society. The work of these theorists facilitated the development of a model that could bridge the gap between the conditions present in the social world and social, economic and political influences on the production and diffusion of scientific knowledge during each period studied.

The work of these theorists facilitated the development of a model that provides a means through which to bridge the gap between the conditions present in the social world and the social, economic and political influences on the production and diffusion of scientific knowledge during each period. This tripartite model frames scientific knowledge within three ideal types of *non-instrumental science* (that knowledge most closely associated with the wellbeing of all people and the development of civil society), *pre-instrumental science* (that knowledge produced by the state specifically for use by the market or for the purposes of warfare) and *instrumental science* (that knowledge produced by the market to enhance its own competitive position).

As discussed throughout this thesis, non-instrumental scientific knowledge production and diffusion is heavily linked to the rational aims of modernity, the evolution of the modern nation state, and the emergence of civil society. Notwithstanding the extant linkages between non-instrumental scientific knowledge and sovereign power, the Australian nation has been slow and inconsistent in establishing and developing these links. Instead, a highly instrumental focus has been present in the production and diffusion of scientific knowledge in Australia since white settlement. This high level of instrumentalism is arguably linked to modern Australia's founding at the peak of the industrial revolution. The rise of the industrial revolution and Australia's social, political and economic positioning as a product of that revolution has worked to shape the policy and praxis of scientific knowledge, settings that resonate to the present day.

The industrial revolution placed a particularly strong emphasis on scientific instrumentalism. This emphasis on instrumentalism, in combination with the high levels of utilitarianism employed by colonial governments and their associated bureaucracies, effectively set aside the civil importance of non-instrumental scientific knowledge and instead generated the ideal type of pre-instrumental scientific knowledge.

Pre-instrumental scientific knowledge production and diffusion was first instituted in Australia order to standardise and regularise the production of the primary industries so that the colony could effectively compete in global markets. This bureaucratisation of scientific knowledge was largely to subsidise and protect these nascent markets in order to generate economic self-sufficiency from the British state. This move to bureaucratise scientific knowledge production and diffusion in Australia effectively marginalised the significant opportunities for conducting non-instrumental scientific activity in this largely unexplored continent. Instead, the British state, the colonial government and the bureaucracy concentrated on instrumentalising the majority of scientific knowledge that was produced in Australia in order to effectively engage in the global economy. These high levels of protectionism, facilitated through instrumental scientific knowledge production and diffusion, have been a common theme in the economic history of Australia and continue to dominate in the contemporary milieu.

This early bureaucratic move to detach instrumental scientific knowledge from the production process effectively triggered the disembedding of scientific knowledge from its position as an *implicit factor of production*. Rather, the bureaucracy effectively worked to transition scientific knowledge production and diffusion in Australia towards a new position as an *explicit factor of production* and eventually, in the early stages of the 21st century, to a product in its own right. The subsequent privatisation of scientific knowledge production under the advent of neoliberal ideology during the 1980s-2010s would further activate the commodification of scientific knowledge and facilitate the transfer of scientific knowledge to control by the market. This move on the part of the state both subverts the democratic aims of the enlightenment and shifts the protective attention of the state from the citizenry to the market. The beginnings of this dynamic can be observed following the introduction of complex bureaucracies in Australia, in particular during and after the nation's engagement in World Wars I and II.

The global ramifications of World Wars I and II and the post-war focus on the development of primary and secondary industries shifted the relationship between science, the state and the market in Australia. These shifts can be seen in the highly potent form of instrumentalism to be found in the management of the natural sciences in Australia between the 1910s and the 1950s. The political and economic conditions associated with the war years and the post-war reparation strategies also produced a change in how scientific knowledge was shared amongst its users. In the hundred years prior to World War II scientific knowledge had been frequently shared amongst those in the field in order to benefit both the individual producers and the market as a whole. During the years of the Second World War, and in the post-war years, the state instead worked in a comparatively clandestine relationship with big business in order to found and develop the secondary industries in Australia. The clandestine and competitive character of these interactions thus re-characterised the production and diffusion of scientific knowledge arguably to the detriment of both the small producer and the citizenry at large.

The competitive character of war, post-war reparations and the advent of these new secondary industries transitioned the production and diffusion of scientific knowledge from the field to the laboratory and reinforced the private, confidential qualities of this new way of looking at scientific knowledge. This new private attitude towards scientific knowledge on the part of the state and the special interests of the market was arguably the beginning of the process that led to the establishment of scientific knowledge as a product in its own right. As scientific knowledge became more economically valuable, corporations began to set up their own research laboratories that were designed to supplement the scientific knowledge already provided by the state. These early corporate laboratories were eventually linked into corporate networks and hubs as new forms of economic globalisation took hold during the 1980s.

Non-instrumental science did not fare well between the 1910s and the 1950s. The state was heavily intertwined with the primary industries and the emergent secondary industries, and instrumentalism underpinned the majority of scientific knowledge production during this period. By now instrumental scientific knowledge in Australia was an explicit factor of production, delivered by the state as part of a suite of protectionist policies designed to enhance the development of primary and secondary industries. This developmentalism was set to alter during the late 1970s when global environmentalism and the local environmental movements used non-instrumental scientific knowledge to support their arguments against the rampant developmentalism conducted by the primary and secondary industries. The argument went that unfettered developmentalism had degraded the natural world to the point where life was at risk. 'Saving' and 'protecting' the natural world from environmental degradation caused by overdevelopment was the primary aim of these new social movements.

Natural scientists in Australia had long been concerned about the deleterious effects of unfettered primary and secondary industry on the natural world. It was not until the environmental movements of the 1970s however that non-instrumental science was reunited with the value-rational impulse within civil society in order to effect political change. A complex range of local and global forces coalesced during the 1960s, '70s and '80s to re-position non-instrumental science alongside the politically effective environmental movement. As a result, non-instrumental science flourished, the state was supportive, and scientists were encouraged to freely contribute to the public debates. This period also saw an increase in state funding for non-instrumental science in general and particularly for public facing scientific institutions such as natural history museums and sites, research institutes and university faculties. These institutions were encouraged to conduct value-rational science in order to support the state's role in the protection of its citizenry and the natural world and ultimately for the advancement of civil society. So, the late 1960s to the mid-1980s was a particularly successful period for the advancement of non-instrumental science. However, this new focus also introduced the concept of sustainability into state parlance which, paradoxically, contributed to the decline of non-instrumental science during the 1990s and beyond. This dynamic is reviewed later in the chapter. Also contributing to the weakening conditions for non-instrumental scientific knowledge production and diffusion was the antagonistic position taken towards natural science by the proponents of the cultural turn in the social sciences.

The global 'science wars' in the 1990s reactivated the volatile relationship between the arts and the sciences that had been fermenting in various forms since early modern times. This 'war' was conducted between those academics promoting the cultural sphere as primary to the development of civil society and those natural scientists who argued for the importance of non-instrumental science to rational civil society. The raging debates that ensued argued for and against the end of the rational project of modernity. Scholars such as Jürgen Habermas maintained that the rational aims of modernity, aims that had been envisaged by the scholars of the enlightenment period, were not yet complete. On the other hand, postmodern scholars led by theorists including the post-structuralist Michel Foucault claimed that the modern project had concluded and that a new age of post-modernity was beginning. These post-structuralist scholars denounced the longitudinal approach of the natural sciences by claiming that the tendency towards overarching scientific theory was unsupportable. Certain forms of postmodernism, promulgated through the literature of the cultural turn, was particularly effective in capturing the attention of the Australian state during the 1970s and '80s, and as a result the importance of cultural practice to national identity came to be more deeply embedded in both the national culture and state policy settings. An outcome of this theoretical wrangle between the arts, the sciences and theoreticians of modernity and postmodernity, was the introduction of cultural policy that effectively aestheticised public-facing non-instrumental science production and diffusion in Australia.

The primary, and largely successful, arbiters of public-facing non-instrumental science in Australia between the 1960s and 1980s – the natural history museums, the science media, and parts of research institutes – were relocated from the bureaucratic portfolios of scientific research and education, to cultural policy. A consequence of this relocation was a shift in the *raison d'etre* of these institutions. Redesigned under economic rationalist policy settings these institutions were subsequently encouraged by the state to deliver 'infotainment' by 'communicating' to 'visitors' or 'consumers'. Accordingly, the public communication of scientific knowledge was largely given over to 'marketing' communication 'experts' who had been trained in the cultural sphere, who were specialists in combining scientific knowledge with entertainment, and who were nested within particular political and economic regimens. And finally, a primary outcome of this aestheticisation dynamic (conducted in concert with sustainability policy and practice) saw the natural world re-envisioned as a heritage item. This repositioning further neutralised the political efficacy of both these public-facing institutions and the non-instrumental scientific knowledge they produced and disseminated. An outcome of the shifts and changes experienced in Australian politics, and so in policy settings, between the 1970s and 2010s was a redirection of non-instrumental scientific knowledge production and diffusion into three organisational streams; science as cultural practice (as reviewed above), science that could be leveraged to achieve economic aims (as reviewed below) and science to support sustainability themes (which will be reviewed later in this chapter). These moves set the scene for the economic restructuring first undertaken in the mid-1980s, and that continue, under the auspices of neoliberal ideology to the present day.

The most important of these streams to neoliberal policy settings involves the non-instrumental scientific knowledge that is most easily transformed into a market-ready resource. This type of non-instrumental knowledge, now recognised as a necessary factor of production, is traditionally produced by universities and research institutes. In an effort to more quickly and 'efficiently' leverage this scientific knowledge, universities and research institutes have been repositioned as 'partners' with the market and are thus transformed into direct suppliers of scientific knowledge for instrumental purposes. This move, to all intents and purposes repositions non-instrumental scientific knowledge as the raw material for a growing tertiary market. Paradoxically however this new way of leveraging the protective factors inherent in scientific knowledge that are being delivered through the policies of neoliberalism are part of a suite of policies aimed at protecting the market as distinct from the citizenry.

Just as the Australian state invested heavily in pre-instrumental scientific knowledge production to grow primary and secondary industries during the 19th and 20th centuries the state is now investing in scientific knowledge production to support the nascent tertiary industries of the 21st centuries. However, where the state had ostensibly retained the direction and control of pre-instrumental scientific knowledge under previous political ideologies, the policy settings of neoliberalism in the 21st century instead cede the direction and control of this new form of commodified scientific knowledge to the market. This neoliberal strategy problematises the linkages between scientific knowledge and citizen sovereignty. In a neoliberal policy environment of decreasing pre-instrumental knowledge production, the state is instead provisioning the market with scientific knowledge derived from the nation's universities and research institutes. These research areas have long struggled to maintain the production of non-instrumental scientific knowledge in order to underpin the advancement of civil society and have attempted to resist commodification strategies. However, the new, more 'efficient' strategies that are indicated by neoliberal ideology are highly effective in leveraging non-instrumental scientific knowledge for economic purposes. These policies work to instrumentalise non-instrumental science and quicken the pace of this knowledge to market.

As the state hastens to provide protection for the nascent knowledge markets it destabilises the potential for the protective action of scientific knowledge that is controlled by the state. Rather than positioning scientific knowledge as protective of the interests of the citizenry, these new neoliberal strategies work on the side of markets and the special interests associated with markets. Despite pre-instrumental scientific knowledge being part of a suite of protectionist policies offered to support the primary and secondary industries, the direction and outcomes at that time were ultimately controlled by the state. Conversely, the control and outcomes of the emerging tertiary industries are directed and controlled by the market. For instance, the awarding of research grants has become a highly competitive process and the new science of innovation sees the universities and research institutes rewarded for partnering with market actors. Moreover, the tertiary industries are rewarded by the state for assuming the direction and control of that non-instrumental scientific knowledge. Under these new forms of protectionism, market actors are rewarded with not only the direction and control of knowledge production but with significant taxation concessions, cash grants and direct access to citizen-funded scientific knowledge. Under these new regimes the rational project of modernity appears under threat. As Bacon and Kant and the other scholars of the enlightenment worked to support the notion of rational knowledge delivering individual autonomy and freedom from external controls the new regimes of neoliberalism are turning this conception on its head. After a brief respite during the environmental movements of the 1970s-1990s the tight bond between the state and the market in Australia has continued apace.

The ideal type of non-instrumental science and its linkages with protective action by the state on behalf of the citizenry is best seen during the environmental movement in

Australia between the 1970s and 1990s. During this turbulent era the citizenry leveraged the rationality of the non-instrumental natural sciences to protest against the 'rampant' developmentalism that had occurred during the first half of the 20th century and the associated adverse consequences for the natural world. Environmentalism was particularly effective at engaging the protective mechanisms of the state in favour of its citizenry and much protective legislation and many new policy settings were implemented as a result. The longer term outcomes for non-instrumental scientific knowledge production and diffusion however were mixed. The introduction of Ecologically Sustainable Development (ESD) practices as a response to citizen concerns eventually led to the absorption of environmental science into the bureaucracy, effectively normalizing and routinizing this third stream of non-instrumental science. Its position as a part of the bureaucracy also left non-instrumental science exposed to the 'efficiency' measures implemented by the state under the advancing praxes of neoliberalism.

Currently, environmental science is under pressure from the state to comply with the neoliberal edict of economic 'efficiency' and so, under this strategic direction, non-instrumental scientists have been retrenched by the state, and budgets for non-instrumental scientific knowledge production reduced. This move appears paradoxical when, in the contemporary milieu, the findings of non-instrumental science are becoming increasingly important to protecting the citizenry from the effects of global climate change and other more local socio-scientific problems such as mineral extraction, large scale farming and energy generation and distribution. Moreover, under the operation of neoliberal governments since the 1980s, the remit of sustainability policy and praxis has been broadened to the point that it has become both common parlance and politically impotent. The practice of sustainability was originally linked to environmental goals and dedicated to the 'balance' between 'the economy' and 'the environment'. Under contemporary policy settings however, the concept of sustainability has shifted to largely preference economic goals over social and environmental goals.

So, the splitting of non-instrumental scientific knowledge production and diffusion into three streams; that scientific knowledge given over to the cultural sphere; that knowledge appropriate for commodification; and that knowledge attached to notions of sustainability has effectively sterilised the political potency of non-instrumental science in Australia. The current settings for non-instrumental scientific knowledge production in Australia are a counterpoint to the rational aims of the scholars of the enlightenment upon which the constitutional and political realms of the nation-state were founded.

9.2 Looking ahead

Instrumentalism is deeply embedded in the character of the Australian nation. In contrast, the socio-scientific problems of the contemporary milieu demand a value-rational approach to state policy and praxis. This obligation to value-rationalism is deeply embedded within the constitutional authority of the nation state and necessitates the state delivering protective action to ensure the wellbeing of its citizenry. The high levels of instrumentality associated with the production and diffusion of scientific knowledge in Australia are progressively destabilising the links between the state and the political will to provide democratic protective action for the citizenry. This position requires a public re-evaluation of the purpose and function of scientific knowledge in Australia.

In the first instance, it is the Australian citizenry who are most at risk in the further instrumentalisation of scientific knowledge production and diffusion. This increasing risk on the part of the citizenry emphasises the necessity for responsible action on the part of the state. The responsibility of the state is to provide rational, non-partisan knowledge and to encourage its citizenry to engage with that knowledge through the vector of the political public sphere. This repositioning of non-instrumental scientific knowledge into the political public sphere is critical for the both long-term protection of the democratic rights of the citizenry and indeed for the maintenance of all life. Only an engaged and organised citizenry may effectively re-claim these entitlements. This thesis hopes to provide an initial catalyst for discussion and debate around the purpose and conduct of scientific knowledge production in Australian life.[251]

Moreover, the structure of the science system in Australia requires a root and branch review and evaluation in terms of its ability to protect the wellbeing of all citizens and to provide protective outcomes for the Australian people as a whole. Many questions remain unanswered and these questions demand both non-partisan knowledge to inform a range of policy responses and rigorous discussion in the political public sphere. For instance, in the wake of the decline in the primary and secondary industries in Australia the political public sphere is inundated with the state mantra of 'jobs, jobs, jobs' and the new science of innovation is increasingly linked to the growth of 'jobs'. This linking of 'jobs' to plans for advanced scientific knowledge production presents a range of new questions. Is Australia effectively positioned to compete in a global market for scientific knowledge? How realistic are the links between this state support

[251] The work of Jürgen Habermas provides an ideal theoretical position from which to begin the next phase of this project. Habermas' contribution to the notion of rationality and its place in contemporary life, particularly his theories of communicative action and the ideal type of the political public sphere, offer a rational way forward.

for the development of 'innovation' industries and the structural problems persisting in the Australian economy? How will these new 'jobs' arise, and what will they look like? Will there be a place in this new economic structure for all Australians? This work is vital if it is to engage all citizens in steering a path to the future; a path that attempts to fulfil the promises of the scholars of the enlightenment, that rational scientific knowledge will offer a means to advance the social wellbeing for all Australians and not simply those with money and power.

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