Essays on the determinants of innovativeness and firm performance of Indian enterprises: the role of financial development, government innovation support and external collaborations

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by

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Under the Supervision of

Principal Supervisor
Associate Professor Pundarik Mukhopadhaya

Associate Supervisor
Dr. Chris Heaton

DEDICATED

TO MY PARENTS AND TEACHERS

DECLARATION

I certify that the work presented in this thesis is original, except where due acknowledgement is made or otherwise indicated. All the sources of information and literature used in this study have been appropriately cited. Further, the work has not been submitted either in whole or in part for a higher degree to any other university or institution.

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ABSTRACT

The importance of R&D capabilities and innovativeness is widely acknowledged in innovation economics and industrial organisation literature. The extant literature has examined the importance of these factors independently and/or jointly in determining the economic performance of the economies and firms. During the last decade, the economic reforms in India have given importance to building innovation capabilities of firms to enhance their competitive advantage. With the rise of new imperatives, firms in an emerging economy such as India, are no longer relying only on internal innovation capabilities, but concentrating on external and contextual factors in enhancing their innovativeness and firm performance. This thesis focused on Indian enterprises and studies how the firms in India are responding to this new environment by acknowledging the importance of national innovation systems (NIS) and external collaborations. The focus of this study is on the determinants of firm innovativeness and impact of innovation on firm performance in the context of resource-based view (RBV) and knowledge-based view (KBV) theoretical settings.

In this thesis, we propose four standalone, yet interwoven papers about financial market development, government innovation support measures, external collaborations and firm innovation, in answering questions regarding their relationship, determinants of innovativeness and their impact on business performance of firms. All these issues that have been and will remain critical drivers of competitive advantage and economic performance of firms in any developed and/or emerging economies. The first paper deals with the review of empirical literature on innovation performance to show a general picture of research on firm innovativeness during the last 25 years and highlights the opportunities for future research. Paper two proposes the relationship between economy's financial market development and innovation activities at cross-country level, suggesting a well-functioning financial system is a necessary condition for explaining innovation activities in emerging as well as developed countries. In the third paper, NIS is integrated with RBV to provide a theoretical framework for understanding the determinants of firm's innovation performance. It proposes government innovation support and external collaborations are equally important and are the key drivers of innovation outcome. Paper four investigates how firm innovativeness aids in enhancing the business performance based on the KBV theoretical approach. Although the importance of

innovation has been widely recognised in determining firm performance, there is little empirical evidence to explain how the external knowledge sources mediate the relationship between innovation and performance, especially in an emerging economy such as India. The analysis reveals the positive relationship between firm's internal R&D capabilities, innovation, and performance. Moreover, it explains the partially mediated role of external knowledge in the innovation-performance nexus.

The empirical base for this research is provided by the data collected from Center for Monitoring Indian Economy's *Prowess* database, *Capitaline*, firm's annual reports, World Bank's World Development Indicators, World Intellectual Property Organisation, World Bank's Financial Development and Financial Structure Dataset, and World Bank Governance Indicators. Overall, through these three essays, we attempt to demonstrate the importance of NIS, external knowledge sources, and innovativeness to provide a fresh perspective in examining the determinants and outcomes in the case of an emerging economy.

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ABBREVIATIONS

ACAP	Absorptive Capacity
AVE	Average Variance Extracted
CDM	Crepon-Duguet-Mairesse
CEO	Chief Executive Officer
CIS	Community Innovation Surveys
CMIE	Centre for Monitoring Indian Economy
CRC	Composite Reliability Coefficient
DCG	Domestic Credit to Private Sector by Banks to GDP
DIVERS	Diversification
DOMFIRM	Domestic Firm Collaborations
DOMUPCOL	Domestic Upstream Collaborations
DSIR	Department of Scientific and Industrial Research
DV	Dependent Variable
EXPREV	Export Earnings
FAME	Financial Analysis Made Easy
GDP	Gross Domestic Product
GDS	Gross Domestic Savings to GDP
GEE	Generalized Estimating Equations
GIR	Global Innovation Roundtable
GMM	Generalized Method of Moments
GoI	Government of India
GOVOWN	Government Ownership
INHR&D	In-house R&D
INNVPROD	Innovative Products
INTFIRM	International Firm Collaborations
INTUPCOL	International Upstream Collaborations
KBV	Knowledge-Based View
LLC	Levin-Lin-Chu
LLY	Liquid Liabilities to GDP
LV	Latent Variable
NB	Negative Binomial
NIC	National Innovation Council
NIC	National Industrial Classification
NIS	National Innovation System
OECD	Organisation for Economic Cooperation and Development
OLS	Ordinary Least Squares
PATAPP	Patent Applications

PATAPPPC	Patent Per Capita
PATGRANT	Patent Grants
PLS-PM	Partial Least Squares Path Modelling
PRIOWN	Private Ownership
PROF	Profitability
R&D	Research and Development
R&DINT	R&D Intensity
R&DSPEND	R&D Spending
RBV	Resource-Based View
RNI	Research on Innovation Networks
SeIC	Sectoral Innovation Council
SEM	Structural Equation Modelling
SERC	The Singapore Economic Review Conference
SIC	Station Innovation Council
SMEs	Small- and Medium-Sized Enterprises
SRMR	Standardized Root Mean Square Residual
TRAINEXP	Training and Development Expenditure
TURN	Turnover
VAR	Vector Auto Regression
VIF	Variance Inflation Factor
WB	World Bank
WDI	World Development Indicators
WTO	World Trade Organisation

Chapter 1

Introduction

1. Introduction

This chapter presents the research agenda and outline for this thesis. By establishing the research background to this study, the chapter provides detail on the importance of innovation to organisations, and the evolution of innovation literature. This is followed by discussion on the identified main research problem, and motivations for the research, a summary of all the inter-connected individual essays investigating the current standing of the research on innovation performance (Chapter 2), causal relationships between finance and innovation (Chapter 3), determinants of organisational innovativeness (Chapter 4), and an overview of the innovation and performance relationship (Chapter 5). Finally, the discussion ends with the outline of the structure of the thesis in Figure 1.1.

1.1 Research Background

The growing competition environment among firms in both developed and emerging economies is forcing firms to rely on innovation when facing such competition, and to strive towards organisational performance. The term innovation represents "production or adoption, assimilation, and exploitation of a value-added novelty in economic and social spheres; renewal and enlargement of products, services, and markets; development of new methods of production; and establishment of new management systems. It is both a process and an outcome" (Crossan & Apaydin, 2010, p. 1155). According to Baregheh et al., (2009, p. 1334) "innovation is the multi-stage process whereby organisations transform their ideas into new and/or improved products, service or processes, in order to advance, compete and differentiate themselves successfully in their marketplace". In economics and strategic management literature, innovation research stands as a core factor in firm performance (Anderson, et al., 2004). Joseph Schumpeter (1934; 1911), an Austrian thinker and economist, advanced the economic theory that innovation (at firm-level) can be seen as the most significant driving force for long-term economic growth and development. Based on the seminal work of Schumpeter, the industrial firms in Western economies provide evidence by showing that innovation is vital to a firm's competitive advantage and superior business performance (OECD, 2001). Over time, this has also become true in the case of rapidly emerging economies such as India, China,

Taiwan, Malaysia, and Korea, to name a few (Altenburg, et al., 2008). These countries have leveraged innovation capabilities in order to catch up with the growth and development of advanced economies (Altenburg, et al., 2008). After Schumpeter, the surge of interest in innovation research led to the emergence of several seminal contributions to the disciplines of economics (Schmookler, 1965; Nelson, 1959), strategic management (Burns & Stalker, 1961; Penrose, 1959), and sociology (Rogers, 1962). During the course of the last few decades, especially since the 1990's, research on innovation has received much attention from other researchers, academics, and policy makers, covering a wide range of topics and has yielded voluminous literature focusing on understanding innovation (Fagerberg & Verspagen, 2009) (see Chapter 2 for a detailed discussion on the theoretical development and growth of innovation studies).

This growing interest in innovation as a source of sustainable competitiveness has led to explorations of the determinants, mediators and moderators of innovation performance (Crossan & Apaydin, 2010; Hoskisson, et al., 2011). Over the years, the literature has grown and more relationships have evolved. The research in the present paper began by concentrating on the determinants that have greater explanatory power (Hammond, et al., 2011) and understanding the contribution that innovativeness makes to superior firm performance (Teece, 2007), which comprises the broader focus of this thesis. On this basis, research gaps and the motivations for the research were identified.

1.2 Research gaps and objectives

This study is an extensive empirical analysis of the determinants of innovativeness and the influence innovation has on firm performance. It comprises an examination of the roles of financial development, innovation policies, and external collaborations using appropriate statistics and econometric techniques. To this end, the existing literature, in particular, highlights the role of external collaboration as an essential component for knowledge creation and the influence that innovation policies have on increasing the innovation performance of firms. The "triple helix concept" proposed by Ranga and Etzkowitz (2013) highlights that the generation of new knowledge takes place through the interaction between industries/sectors/firms, universities/academia, and government policy making. Although, the roles played by the each of the actors differs in the innovation process of firms, the researchers highlight the importance of the contribution of external collaborations with universities, research institutes and think-tanks (Zhang, et al., 2015; Robin & Schubert, 2013; Tomlinson,

2010) and government innovation policies (Samara, et al., 2012; Hewitt-Dundas, 2006; Smallbone, et al., 2003; Godin & Gingras, 2000) in enhancing innovation capabilities. However, the literature shows that the research focus has largely been on firms in developed countries (Kafouros, et al., 2015).

The aim of this thesis, therefore, is to focus on the neglected aspects of the mainstream literature with regard to the direction of causality between financial development and innovation at the macro-level, and on investigation of several topics related to the determinants of innovation and performance at the firm level. The motivation for this thesis comes from the identified research gap where empirical researchers have paid little attention (especially, in the context of developing economies such as India) to a study of the influence of external factors such as government innovation policies (Seker, 2011; Ghosh, 2009; Lee & Wong, 2009), and contextual factors (external collaborations) that have profound implications on a firm's innovation outcome and business performance (Tripathy, et al., 2013; Sharma, 2012; Lee & Wong, 2009; Kafouros, et al., 2015) (a brief discussion on essay-wise identified gaps and research questions is presented in Section 1.4). The main research setting in this thesis is Indian innovative enterprises. In a broader context, this study is one of the few to focus on themes such as financial development, innovativeness and superior firm performance, which represent the trinity in a broader arena of a firm's business cycle. Research on these themes is directly linked to the growth and competitiveness of modern-day firms.

This thesis comprises four essays. The first is a systematic review of empirical studies in the field of innovation performance published since 1995 in top-ranked innovation economic journals. The second essay tests the direction of causality between financial development and innovation using panel data of 64 countries during 2001–2012. The third essay deals with modelling the influence of innovation policies and external collaborations on firm innovativeness using the count data regression models in the context of Indian enterprises. The fourth essay employs the partial least squares method to provide evidence on the influence of innovation on firm performance, and also highlights the mediating role of external collaboration in strengthening the innovation-performance relationship.

1.3 The context

As mentioned, the empirical setting of the study encompasses firms in India. India is a lower-middle-income economy with USD1.8 trillion GDP in absolute terms for 2014

(Senapathy & Jibak, 2016). Currently, India spends about 0.9% of GDP on R&D and has set an objective to increase this to 2% by 2020 (Westmore, 2013; WDI, 2012). Data also show that India witnessed notable growth in patent filing[1] by firms (an average 15% increase) during 2005–2011 due to notable changes in patent policy in accordance with the Trade-Related Intellectual Property Rights under the WTO (Ambrammal & Sharma, 2014).

Recognising the importance of innovation, the Government of India has recently implemented several innovation policies focusing on innovation support schemes and encouraging external collaborations with a view to improving the innovation performance of firms in different industries and sectors. The main objective of the government is to make India an innovation hub in particular and one of the most innovative countries in the world in general, which is reflected in *Science, Technology and Innovation Policy 2013* (GoI, 2015). The new policy initiatives are:

- *National Innovation Act 2008*, which was formulated to encourage India to become one of the most competitive knowledge-based economies.
- The Government of India (GoI) introduced a wide range of innovation support schemes such as the *National Innovation Policy 2008* and the *Decade of Innovation 2010–2020* to provide innovative stimulus to firms, industry, and sectors (GoI, 2015).
- The *Science, Technology and Innovation Policy 2013* was introduced to promote innovation-led solutions for sustainable and inclusive growth. Realising the importance of firm-level innovation, the GoI created the National Innovation Council (NIC) to map the innovation opportunities in states and sectors, State Innovation Councils (SIC) and Sectoral Innovation Councils (SeIC) were established to encourage regional governments and innovation actors to respond to the needs of firms in the respective states and sectors (GoI, 2015).
- To link knowledge entities with firms in the national innovation system, the GoI developed the Global Innovation Roundtable (GIR), enabling national and international collaboration on innovation.
- The India Inclusive Innovation Fund was set up to solve the finance-related problems of the enterprises.

[1] In a leading journal in the field of innovation economics, Hasan and Tucci (2010, p. 1273) report that "in summary, we find that both the quantity of inventive activity, as well as its quality, are associated with economic growth", which held true across developed and developing countries with publicly available patent data.

Together with this policy framework, the country has vast innovation-supportive infrastructure. The Indian national innovation system comprises knowledge actors, R&D laboratories, and knowledge users (firms) in the public and private sectors. There are about 280 public universities, including Indian Institutes of Technology and the Indian Institute of Science, more than 150 self-financing and deemed universities, and about 2500 firm in-house R&D centres generating knowledge for the benefit of society. To cater for the different research needs, the GoI established several science structures, which include the Council of Scientific and Industrial Research (39 labs), Indian Council of Agricultural Research (99 institutes and 17 research centres), Indian Council of Medical Research (30 labs), and Defence Research & Development Organisation (48 labs). In addition to the above, there are about 1200 privately- or state-funded Scientific and Industrial Research Organisations (DSIR, 2015). Moreover, the availability of data makes the selection of Indian enterprises an appropriate research ground for the purpose of this analysis.

The description of the identified gaps and research setting highlights that Indian enterprises make an important case study. The examination of this emerging economy's firms in establishing a link between innovation systems, external collaborations and firm-level innovations and performance is crucial in enabling them to catch up with firms from developed countries in the global economy in terms of innovativeness and business performance.

1.4 Contribution of this thesis

This section outlines the contribution and structure of the present thesis in detail. This study comprises a compilation of four inter-connected essays. As the essays are set up as individual papers, they comprise theoretical background, the research questions addressed, objectives, empirical data, and methodology relevant to the specific paper. The structure of the thesis is presented in Figure 1.1. An overview of each paper is outlined below.

1.4.1 Essay 1: Empirical studies on innovation performance in the manufacturing and service sectors since 1995: a systematic review

The first essay (Chapter 2) is a systematic review of the literature that provides a broad overview of the empirical studies published in the field of innovation performance. The review recognises the important internal, external and contextual factors that influence firm innovativeness. A comprehensive model is developed to explain how the variables in these three major research streams (internal, external and contextual indicators) are inter-linked by

explaining the relationship (direct and indirect) and how they influence (positive and negative) firm innovativeness – a major source of achieving sustainable competitive advantage. The analysis finds that (i) innovation is a continuous process and engine of productivity and growth; (ii) especially since the 1990's, this field has witnessed an increasing number of studies devoted to various topics related to innovation; and (iii) contextual factors such as external knowledge collaborations, i.e. partnerships with domestic and international academic institutions, research think-tanks, R&D labs, and firms in the same business-chain outperform conventional internal indicators (especially R&D expenditure) with regard to their influence on firms' innovation performance. Table 1.1 summarises the characteristics of this study. The complete paper is discussed in Chapter 2. This paper has been revised and resubmitted to *Economic Papers: A Journal of Applied Economics and Policy* for possible publication.

Table 1.1: Overview of Essay 1

Research gap	• Prior research has identified the internal, external, and contextual factors and their impact on firm innovativeness separately. • Studies explaining the inter-links of one variable with another in explaining innovation performance are sparse. • The existing conventional and systematic review studies mostly focus on the manufacturing sector, while ignoring the service sector.
Research question	What are the determinants of innovativeness in light of new strategies adopted by firms, and the innovation policies recently implemented by several national governments?
Data	Empirical studies published on the topic "innovation performance" from 1995 until 2014 in top innovation economics journals.
Method	Systematic review of the literature
Focus	Manufacturing and service sectors

1.4.2 Essay 2: Financial development and innovation activities: Panel Granger-causality evidence

In the panel econometrics literature using the Granger-causality method, researchers investigate the direction of causality between financial development and economic growth extensively (Calderón & Liu, 2003; Odhiambo, 2008; Kar, et al., 2011; Hsueh, et al., 2013; Hassan, et al., 2011; Taivan, 2016; Pradhan, et al., 2013), focusing on cross-country data, geographic regions, countries categorised by income groups, and so on. There is little empirical evidence from examining the causality between financial development and innovation. Some recent studies (Hsu, et al., 2014; Meierrieks, 2014; Tee, et al., 2014) focus on analysing the correlation between and impact of financial development on national innovation activities, but

the direction of causality between these variables is less well understood. To this end, this paper (Chapter 3) is the first to recognise this gap and explicitly test the direction of causality between financial development and innovation (following the approach of Hartwig 2010) using panel data of 64 countries for the period 2001–2012. Table 1.2 provides an overview of this essay. Based on the panel Granger-causality estimation technique, we calculate the results.

The analysis finds conclusive evidence to support the proposed research question/objective of whether financial development is good for growth in innovation activities; it can be unambiguously answered as positive. The results show that financial development Granger-causes growth in patenting activities and increase in innovation output stimulates the growth of the financial market system substantiating the presence of both "finance-push" and "innovation-pull" effects. The findings from this chapter are summarised in a paper entitled, "Financial development and innovation: Panel Granger-causality evidence", that was presented to the Australasian Development Economics Workshop 2015 at Monash University, Melbourne, Australia. We received valuable comments from the participants in the workshop, which helped in the development of the final version of the paper. The complete study is presented in Chapter 3.

Table 1.2: Overview of Essay 2

Research gap	• Prior literature analyses the correlation between and impact of financial development on national innovation output. • Examining how the causality direction between finance and innovation is less researched, which is an important dimension from which to derive policy implications.
Research question	How does a well-developed financial system stimulate the innovative activities of a nation?
Paper type	Empirical research
Years	2001-2012
Dependent variable	Patent applications per capita
Independent variables	Six financial development indicators (overall size, activity, structure of the financial development, liquidity as % of GDP, domestic credit as % of GDP, savings as % of GDP)
Theory	Endogenous and exogenous theories
Data	World Bank's World Development Indicators 2016, World Bank's Financial Development database
Method	Panel Granger-causality framework
Focus	64 countries during 2001-2012

1.4.3 Essay 3: National innovation policies, external collaborations and firm innovativeness in India

The literature on open innovation and national innovation systems (NIS) highlights the inevitable role of external collaboration (Zhang, et al., 2015; Robin & Schubert, 2013) and government innovation policies (Samara, et al., 2012; Hewitt-Dundas, 2006; Smallbone, et al., 2003) in enhancing a firm's innovation output. However, the existing research is largely focused on firms in developed countries (Kafouros, et al., 2015), whereas little attention has been paid in the context of emerging-market firms. To address this gap in the literature, in this essay (Chapter 4) Indian innovative enterprises are selected as the research setting in which to examine this important phenomenon. Modelling the relationship between innovation policies, collaborations and innovativeness is explained by developing a conceptual model integrating the NIS and resource-based view (RBV) theories. The objective of this paper is to investigate (i) whether the Government of India's recent innovation support initiatives are stimulating firms' innovation output; and (ii) when the Indian firms are more likely to be innovative based on location-specific collaborators, i.e. domestic or international. Results are estimated using count data regression models.

The findings yield strong evidence supporting the proposition that the scale of international academic and firm collaboration is stronger than that of domestic collaboration in influencing the patent generation capabilities of Indian firms. The additional contribution of this study to the existing literature is that it introduces a new lens through which to investigate the moderating role of innovation policies in the present context. Results show the moderating effects of innovation policies in strengthening the relationship between international academic and firm collaborations with firm innovativeness in India. The overview of this essay is presented in Table 1.3.

The findings of this chapter have been summarised in a paper entitled, "National innovation policies, innovation actors and firm innovation performance in India: Evidence from count data estimation methods", that was presented at the Research on Innovation Networks (RNI) conference on "Innovation and R&D policies: Crossroads between the North and the South" in August 2015 at University of Picardie Jules Verne, Paris, France and The Singapore Economic Review Conference (SERC) 2015, Singapore. The comments and suggestions received from these conferences helped to develop the final version of the paper

in terms of structure, methodology, and analysis. This paper is under review by the *Journal of Business Research*.

Table 1.3: Overview of Essay 3

Research gap	• Existing research on the role of external knowledge collaboration and innovation policies on firm innovativeness is largely focused on developed countries. • Not much empirical evidence available on emerging-market firms.
Research question	• Which innovation sources (academic and inter-firm) and collaborations (domestic and international) are crucial for firm innovation performance? • What is the role of government innovation policies in improving firm innovativeness?
Paper type	Empirical research
Years	2010-2012
Dependent variable	Patent applications
Independent variables	R&D intensity, training expenditure, state innovation council, sectoral innovation council, domestic academic & firm collaborations, international academic & firm collaborations
Theory	National Innovation System & resource-based view theories
Data sources	CMIE's Prowess, Capitaline, firms' annual reports & websites
Method	Count data regression models
Focus	707 Indian innovative enterprises

1.4.4 Essay 4: Linking innovativeness and firm performance: The mediating role of external collaborations

The fourth essay (Chapter 5) more closely examines the innovation and performance nexus, and also aims to contribute to the literature by addressing the research gap: how external collaborations mediate the relationship between innovation and firm performance. This study is important in the context of an emerging economy such as India because there is a gap in the mainstream literature in terms of how innovation and firm performance improves through external knowledge collaborations within emerging economies. To this end, building upon the knowledge-based view (KBV) theory of the firm, we employ partial least square (PLS) path analysis in modelling the relationships. The model includes both internal and contextual factors. Internal factors are captured in the dimensions of absorptive capacity, innovation capabilities, and firm performance. Contextual factors are related to the collaboration and networking activities, which are designed to discover the impact of firm innovation on its performance.

The findings reveal that (i) innovation is a crucial factor in determining firm performance, which provides additional support to the existing literature; (ii) a firm's absorptive capacity and innovation capabilities increase with an increase in efforts to collaborate with external partners, especially international collaborations (similar to the findings in the Chapter 4), which is often seen as complementary. With respect to the mediating role of external collaborations, we find a partial mediation effect. The effect suggests that an increase in the number of external knowledge partners improves the firm's innovativeness, and in turn positively affects superior business performance.

The findings from this chapter have been summarised in a paper entitled, "The impact of innovativeness on firm performance: An econometric study of Indian enterprises", that was presented at the 28th PhD Conference in Economics and Business, November 2015 at the University of Queensland in Brisbane, Australia. We received valuable comments and suggestions which helped in developing the structure and final version of the paper. We are in preparation for submission of the final version of the paper to *Technovation* journal. The overview of the Essay 4 is presented in Table 1.4.

Table 1.4: Overview of Essay 4

Research gap	• Researchers in the mainstream literature have studied the relationship between innovation and performance while ignoring the mediating role of external collaborations in linking these two variables.
Research question	• How do external collaborations mediate the relationship between innovation and superior firm performance?
Paper type	Empirical research
Year	2012
Dimensions & variables	Firm innovativeness (patent applications and grants, no. of innovative products); Absorptive capacity (R&D expenditure, training expenditure, in-house R&D facility); Domestic collaborations (no. of domestic academic and firm collaborations); International collaborations (no. of international academic and firm collaborations); Firm performance (profitability, sales turnover, total export earnings)
Theory	Knowledge-based view theory
Data	CMIE's Prowess, Capitaline, firms' annual reports & websites
Method	Partial least square path modelling
Focus	707 Indian innovative enterprises

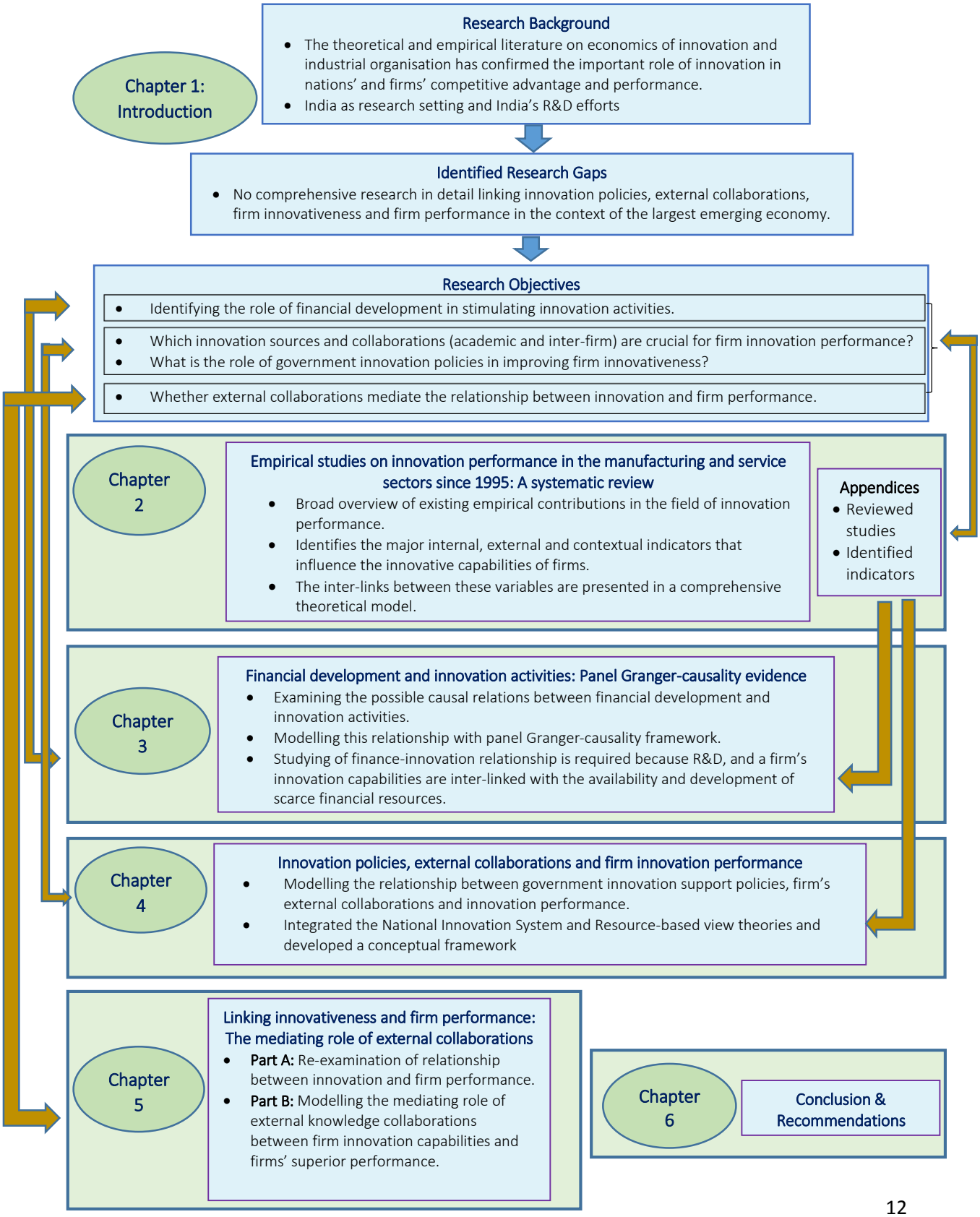
1.5 Concluding remarks

The findings of the thesis are relevant to researchers, practising managers, and policy makers. The future research directions presented in this thesis are useful for researchers to model the unexplored areas in this field. The findings suggest that managers focus on collaboration with a variety of partners such as universities, research institutes, R&D laboratories and other firms in the same value-chain in improving firm innovativeness and, in turn, develop superior business performance. The findings are also useful for policy makers in framing various innovation support policies to encourage external collaboration, especially international partnerships with world-class universities, research think-tanks, and institutes.

1.6 Structure of the thesis

Figure 1.1 below shows how the four essays, which constitute the body of the thesis, are interconnected.

Figure 1.1: Structure of the thesis



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Chapter 2

Empirical studies on innovation performance in the manufacturing and service sectors since 1995: a systematic review[2]

Abstract: This chapter reviews the literature on firm innovation performance from 1995 until 2014. The empirical literature on this topic has been growing continuously over the last few decades. Previous research has investigated the explanatory variables and their impact on firm innovativeness separately. The present systematic review brings together all explanatory variables explored in the literature, classified according to their direction of causality and impact on innovation. These are represented in a comprehensive framework that includes three major research streams: internal, external and contextual indicators, and examines how they influence the innovative capabilities of firms. In addition to this re-examination, the study shows that the majority of these variables are inter-linked with other variables in explaining the relationship with innovation, which is represented in a comprehensive theoretical model. The aim of this review is to draw a general picture of the standing of the research on innovation performance, specifically in areas where unanimous results have already been achieved, and to highlight the opportunities for future research.

Keywords: innovation, innovation dimension, innovation determinants, systematic review

JEL codes: O14, O31, O38, L14, L21, L32

2.1 Introduction

Innovation is viewed as the engine of progress, competitiveness and economic development. It has been considered as the driving force behind the survival, growth and development of firms, and is becoming a key component in the success of enterprises in both developed and emerging economies (Johansson, *et al*., 2001). Today, irrespective of their age, size and industry, enterprises' production processes are more technology-driven, and knowledge- and innovation-based (Szirmai, *et al*., 2011). Increasing competition as a result of globalisation has also been forcing enterprises to look at innovation in two ways; to offer innovative products and services on one hand, and to lower the costs of meeting their long-term business objectives on the other (Porter, 1998). Innovation is a process by which opportunities are transformed into practical

[2] We follow the terminology and method coined by Becheikh, *et al*., (2006), Schneider & Spieth (2013); Crossan & Apaydin (2010); and Ozman (2009). For this review, we comprehensively identified and tracked down all the available literature on a specific topic (i.e. empirical studies on innovation performance) by focusing on top-ranked journals (Thongpapanl, 2012; Becheikh, et al., 2006; Linton & Thongpapanl, 2004) and set a specific time horizon for the research.

utility, and one that enables firms to respond to diversified patterns of demand and make improvements to their different activities (Tidd, *et al*., 2009; Cooke, 1998). Therefore, over the past few decades, questions like; what are the determinants of innovativeness?; what is its relationship with a firm's performance?; etc., sparked the interest of economists, researchers, managers and public policy makers.

The idea of linking innovation and economic growth can be traced from the writings of Adam Smith (1776). Smith recognised the importance of technology transfers from suppliers to users and the role and function of R&D in the economy, along with the division of labour in order to increase productivity. After Smith, Schumpeter was one of the first economists to link innovation with growth, and his seminal contributions *The Theory of Economic Development* (1934) and *Capitalism, Socialism and Democracy* (1942), led to the field's evolution. Schumpeter introduced a comprehensive definition of innovation and categorised it into: new products; new methods of production; new supply sources; expansion into new markets; and new ways to organise business. Furthermore, he argues that firms operating in highly competitive industries are most likely to be the major source of innovation, and a capacity to innovate is among the most important factors that impact on a firm's performance (Schumpeter, 1934). Since then, economists have been trying to investigate the significance and impact of technological progress on nations', industries' and firms' long-run economic growth and financial performance. Although Schumpeter laid the foundation for the evolution of this field, empirical studies started addressing the topic more frequently only after Robert Solow's (1957) seminal work "Technical change and the aggregate production function". Solow introduced innovation into formal economic growth models and studied the determinants of innovative activities and their impact on business performance (Santos, *et al*., 2014).

Over the last five decades, an increasing body of research has emerged on this topic and it is believed that innovation is central to the survival of modern organisations and for maintaining competitive advantage or expanding into new markets (OECD, 1997; Stock, *et al*., 2002; Ko, *et al*., 2011). The role of R&D and innovation in a firm's life cycle has become an axiom among firms, managers, consultants, politicians and governments (Christensen & Raynor, 2003).[3] In recent years the emphasis on research in technology and growth and/or

[3] *Firms* want to develop their innovative ability for their future success; through innovativeness *managers* derive solutions to business problems and challenges; *consultants* are busy following up with companies in understanding the usefulness of innovative ideas. For *politicians*, innovation has become a hot topic at various levels of

innovation performance has shifted from regional to the national level to firm specific (Fan & Hu, 2008). Linking innovation inputs and outputs (for example, R&D investment and expenditure, patents, new product developments, etc.) to performance has caught the attention of researchers and there is a prominent belief that investment in R&D acts as an important and effective input in firm performance. Researchers in economics, business strategy, marketing and management, finance, and public policy are all focusing on various aspects of innovation, and are concerned about understanding the factors that determine firms' innovativeness. Fagerberg and Verspagen (2009) analysed that (i) since the early 1960s the field has grown tremendously and today there would be more than a few thousand scholars worldwide who identify themselves with innovation studies; and (ii) the potential for this field may be largest for economics because more than half of the researchers in this area have a background in economics.

2.1.1 Economic theory and innovation[4]

In economics, the theory of the firm is considered a "black box" when it comes to understanding the innovation process in creating new products and services, commercialisation of the products, and profitability (Teece, 2010). In applied economics literature on innovation and allied topics, innovation has been characterised as an unavoidable element in a firm's survival and prosperity (Schumpeter, 1942; 1934). Schumpeter (1934) added innovation as another factor input to existing factors such as land, labour and capital. Within economics literature, the *Neoclassical Economic Theory* on firm behaviour assumes that all firms will converge to their optimum size and equilibrium position in the long-run (Knight, 1921). Conversely, literature on various industries also suggests that enterprises that perform better today due to their capabilities in generating new knowledge, will have a relatively better position in the industry and are more likely to perform better in the long run (Klomp & Van Leeuwen, 1999). From a different perspective, Solow-Swan's (Solow, 1957; 1956; Swan, 1956) *Exogenous Growth Model* considered technological progress as exogenous, and for a sustainable positive long-run growth rate, firms must have access to scientific resources and advancements in technological knowledge.

government because they are busy designing socio-economic policies that stimulate innovation and innovative activities in the economy (e.g. European Commission's innovation policy, China's innovation policy 2006-2020, India's National Innovation Act 2008, India's *Decade of Innovation 2010-2020*, etc.).

[4] On the empirical side, over the years researchers have analysed the link between innovation and economic growth. This paper tries to explain briefly what factors account for the innovative activity of the firm using established correlations and theoretical models developed in an effort to establish a causal link between innovation and economic growth.

Proponents of the *New Growth Theory* (considered technological progress as an endogenous variable) recognised the role of innovation in driving productivity growth and considered that investment in innovation leads to better performance (Grossman & Helpman, 1989; Grossman & Helpman, 1991; Smolny, 2000). The neoclassical thought on growth has been criticised by Nelson and Winter (1974; 1982) because it does not take into account the innovation process within firms. Further, Nelson and Winter (1982) proposed the *Evolutionary Theory* and argued that in-house knowledge, physical, financial and human assets, organisational structure, and R&D are the basic characteristics of an innovative firm. In their opinion, the diffusion of knowledge may help firms in emerging economies and markets to access new knowledge and technologies without bearing the risk of new investments.

Nelson and Winter's (1982) perspective is compatible with the *knowledge-based view (KBV)/ new economy approach*, which is built on the foundations of the *resource-based view (RBV) theory*. The theory proposes that knowledge is a significant resource in creating new products and achieving competitive advantage. Firms explore and generate new knowledge by recognising their knowledge-related resources, competitive advantage, and strategic assets, and therefore, its capabilities are difficult to imitate (Raphael & Schoemaker, 1993; Olavarrieta & Friedman, 2008). Particularly in knowledge-driven economies, the key factor of economic growth is innovative capacity stimulated by the knowledge and technological collaborations of firms, not by capital accumulation as indicated by neoclassical theory (Alvarez, *et al*., 2013). Owing to the growing interest, several economic theories have emerged and the theory of the firm has moved beyond the standard micro model of the firm as a labour-capital function.

2.1.2 Developments in innovation performance

The evidence from the literature is that innovation performance is an economic or social outcome extracted from knowledge or knowledge-related indicators (R&D spending, R&D intensity, patents, publications, trademarks, the market share of knowledge-intensive products and services, etc.). It is a process of creating, diffusing, and transforming ideas to generate new or improved products, services, processes, strategies or organisational capabilities (Samson & Gloet, 2014). The two-dimensional conceptual framework suggested by Ryan (2010) defines innovation performance as the quantity and quality of innovative ideas, and the efficiency and effectiveness of the implementation of those ideas to establish innovation processes.[5] These

[5] $Innovation\ performance = (quantity + quality\ of\ ideas) + (efficiency + effectiveness\ of\ implementation)$

parameters are independent and inter-dependent, and combine and define innovation performance.

Researchers have studied the topic quite extensively, and large numbers of research papers have evolved over the years justifying the undeniable importance of innovation at the industry and firm levels in various countries. These studies invariably made interesting findings with respect to the significant effects and benefits of innovation. A substantial body of empirical research examining the relationship between innovation and performance has found that innovation inputs have a positive impact on firm performance. For example, Griliches (1986) tested the cross-sectional data of US firms between 1972 and 1977 and found that higher R&D spending leads to higher productivity growth. In the case of the UK, Wakelin (2001) explained that R&D intensity has a positive and significant effect on a firm's productivity growth. Research by Morbey and Reithner (1990), Doukas (1991), Erickson and Jacobson (1992), Ito and Pucik (1993), Johnson and Pazderka (1993), Long and Ravenscraft (1993), and Lee and Shim (1995) oppose the positive association between R&D expenditures and firm performance. Similarly, Quo *et al*. (2004) use cross-sectional data on China's software industry and report that R&D intensity has a significant negative effect on firm profitability and productivity. The reason for such varying results from research on the contribution innovation makes to firm productivity and the variations in estimations are attributed to the different specifications of models and the estimation methods used (Mairesse & Sassenou, 1991). The study by Klette and Kortum (2002) reports that R&D elasticity differs from time-series data when compared with the elasticity obtained from cross-section data (due to the presence of a degree of heterogeneity in the results).

Despite the impressive volume of work, the limitations and inconclusive results relating to an understanding of the nexus of firm innovativeness and performance are complicated, and therefore offer vast opportunities for further research. First, although researchers have tested the effects of a large number of innovation-related variables on performance, there is no precise prescription for successful innovation performance (Rothwell, 1992). Furthermore, with similar variables, different degrees of association have been discovered between innovation and performance (Souitaris, 1999). The heterogeneity of variables and the difficulties in understanding their relationships and in distinguishing ambiguities have hindered research in this area (Cainelli, *et al*., 2004). Second, the present literature on firm innovativeness and performance is fragmented across several academic disciplines, with little theoretical and

empirical integration (Hauser, *et al*., 2006). Researchers have applied different qualitative and quantitative techniques under multiple approaches to studying the relationship between innovation and performance, but have failed to reach a standard theoretical consensus regarding the importance of R&D investment for company innovation (Jiménez-Jiménez & Sanz-Valle, 2011). Third, researchers have studied the relationship between firm innovativeness and performance for small and large firms in high-technology and low-technology industries in the context of industrialised economies, but few studies have been recorded on this issue from the perspective of developing countries (Zeng, *et al*., 2010). This uneven focus also invites further investigation from the point of view of emerging economies. Finally, the results that relate to firm innovativeness and performance differ substantially across studies due to divergent methodologies and a variety of innovativeness and performance measures, and the different sets of control variables used. At the same time, contextual factors are less often incorporated in the development of hypotheses or in the study design (Rubera & Kirca, 2012).

Existing empirical studies report either inconclusive, positive, negative or neutral results on the innovation-performance relationship. It is also generally believed that the relationship controversy might have its origins in the measurement of firm innovativeness. Given the importance of innovation for firm performance and firm competitiveness, researchers and practitioners have attempted to better understand those factors that promote innovation capabilities. This paper aims to go beyond the highly dispersed work on innovation performance outcomes by providing a systematic review of empirical studies on innovation performance in the manufacturing and service sectors published between 1995 and 2014.

The objective of this literature survey is twofold: (i) to study how researchers have measured the variable "firm innovativeness" and to find the major explanatory variables that determine innovation performance of the firms; and (ii) to summarise results from the studies to better focus the future research agenda. The overall purpose behind the above objectives is to examine previous findings and integrate the results in order to identify where the conclusions converge and diverge. Researchers believe that innovativeness and firm performance are interconnected, therefore it should be reasonable to assume that innovation performance is positively associated to competitive advantage. This survey of two decades of intensive research in this field is important because it examines what the literature has revealed, what are the main findings, existing research gaps, and the areas that need further research in the future. This investigation may also help firms in developed as well as emerging economies in mapping

their technological capabilities and innovativeness, and framing better policies for their long-term business objectives.

We have developed the structure of the paper following the prior studies of Hong *et al*. (2012), Crossan and Apaydin (2010) and Becheikh *et al*. (2006). Hong *et al*. (2012) explained the role played by innovation surveys in investigating how empirical awareness of innovation has evolved over the last few decades. They focused mainly on measures of innovation, examining innovation surveys from around the world (Canada, US, EU, Malaysia, Taiwan, Australia and New Zealand) as the major source for their study. In terms of explaining dependent and independent variables, Hong *et al.* analysed the indicators that the researchers used in measuring innovation and the determinants of innovation. Becheikh *et al*., (2006) discussed the determinants of innovation in manufacturing by bringing together a set of variables related to the process of innovation and the factors driving it. Moving further, we include the studies that relate to both manufacturing and services pertaining to innovation surveys, firm-level innovation surveys and individual researchers' own innovation surveys covering both developed and emerging economies.

The organisation of the paper is as follows. The next section explains the scope and justification for the study, Section 2.3 presents the research method used and the general characteristics of the reviewed studies. The results are discussed in detail in Section 2.4, and finally, Section 2.5 concludes with implications and policy recommendations for researchers, managers and policy makers.

2.2 Scope and justification of this Review

The selection of the year 1995 as the lower limit of the temporal horizon of the research reviewed is justified as follows. First, the research from the 1960s, 70s and 80s has been inconclusive and diversified in terms of findings. In the 1990s, researchers had access to better data sources, more developed econometric tools and several alternative measures of firm innovativeness (Symeonidis, 1996). Second, the *Oslo Manual* of 1992 and 1997 (OECD, 1992; 1997) developed guidelines for gathering and interpreting data on technological innovations, which led to more comparable and comprehensible results. The 1990s saw noticeable changes in innovation research with empirical orientation due to the introduction of firm-level surveys, which transformed understanding of the determinants of innovation and the role played by innovation in firm growth (Hong, *et al*., 2012). Finally, for the past 20 years or so, a number

of both developed and developing countries have implemented several reforms and framing policies related to R&D dissemination, innovation, knowledge management, etc. to encourage innovativeness in enterprises. The best example is the Community Innovation Surveys (CIS), carried out by almost all European countries, which made it possible to learn what factors influence firm innovation performance and the impact of innovation on enterprise performance (Kleinknecht & Mohnen, 2002). Hence, recent research helps in understanding the innovation variables, performance variables, and econometric methods more profoundly, which not only encourage firms' sustainability and provide examples of innovative practices, but also inspire future research.

The following criteria have been followed with regard to the selection of studies for this review:

1. The review considers only empirical articles published in peer-reviewed journals. It excludes non-empirical, conceptual, and qualitative studies for better comparability.
2. The present research is more interested in understanding how innovation is measured and the driving forces of innovativeness. Therefore, it considers only the studies that focus predominantly on product and process innovations by adopting econometric tools for measuring innovation and performance. Studies with organisational, managerial, marketing, cultural and other types of innovation research studies are not included.[6]
3. Recent review studies have focused only on the manufacturing sector (Becheikh, *et al*., 2006; Rubera & Kirca, 2012; Linton, 2009), while the service sector [7] has been studied the least. Therefore, the present review covers both the manufacturing and service sectors.

[6] The reasons for concentrating only on product and process innovations in this paper are as follows: (i) product and process innovations were in the first and second editions of the *Oslo Manual*; (ii) other innovation types such as marketing and organisational became familiar concepts to firms in some countries (especially European economies) and have been popular in Innovation Surveys after 2005; and (iii) according to the OECD (Statistical Office of the European Communities), although marketing and organisational innovations are defined in the Manual, but their definitions in general are not as well established as product and processes. Their definitions are still under development in the Innovation Surveys and other surveys (OECD, 2005).

[7] The intention behind including services in the current paper is based on the growing prominence and importance of innovation processes in the service sector in both developed and emerging economies, which are recognised in both the empirical and theoretical literature. Despite the potential offered by service-sector enterprises in developing economies, only a few studies have focused on exploring the relationship between innovation and performance at the firm level (Cooper, 1984; Cainelli, *et al*., 2004). Hence, we include the service sector in order to better understand the differences between manufacturing and services with respect to innovation activities, processes and changes.

4. There is no proper acknowledgement in the literature of the innovation practices of firms that are doing business in developing countries (Chudnovsky, *et al*., 2006). Hence, the present review covers research articles published from both developed and emerging economies' perspectives, the results of which will become clear in the summary of the findings.

2.3 Research review method

As this paper reviews extant literature with the objective of identifying relevant innovation performance variables and models, a systematic review process was selected.

2.3.1 Inclusion criteria and selection of articles

Papers for review have been selected based on the criteria that the study has to: (i) focus on product/process innovations; (ii) must be published in a peer-reviewed journal between 1995 and 2014; (iii) must be an empirical study using econometric methods; and (iv) the research should consider innovation as the dependent variable. To select potential studies, we carried out a computerised search of databases namely, EBSCO and ScienceDirect of Elsevier (the highlighted sections are: "Business Management and Accounting" and "Economics, Econometrics and Finance"), which provide access to 7,985 articles. During the second stage, we excluded 6,573 studies based on journals, titles and abstracts, and selected all articles published between 1995 and 2014 (including articles in press) in three referred journals in the field of innovation, namely *Research Policy, Technovation* and *Technological Forecasting and Social Change*.[8] A considerable number of studies use various issues related to innovation, but a clearly defined measure of innovation (product or process or both) has to be present in the studies. Only a limited number of studies use either product or process or both and presented an in-depth analysis of the effects of internal, external and contextual indicators on innovation performance. After the first two steps, the obtained articles were sorted and reviewed, which allowed us to exclude 1,217 articles that do not meet the inclusion criteria. The remaining 195

[8] The selection of three journals (*Research Policy, Technovation and Technological Forecasting and Social Change*) is based on the works of Thongpapanl (2012), Becheikh et al. (2006), and Linton and Thongpapanl (2004). The research by Thongpapanl (2012) provides an up-to-date ranking of the top-innovation speciality journals using citations from the articles published in top innovation journals. Based on the total citations and overall score, these three journals rank among the top ten. In terms of number of citations and strong economic perspective, *Research Policy, Technovation* and *Technological Forecasting and Social Change* are the most prestigious target journals (see (Thongpapanl, 2012) for more details). Fagerberg and Verspagen (2009) offer information on these three journals suggesting that they are representative of leading journals in the field of innovation. Becheikh *et al*. (2006) considers the same three journals in their research that focuses on empirical innovation studies in the manufacturing sector.

potential articles were subject to screening beyond the title and abstract into the main text of the papers and allowed us to exclude 132 articles which again did not meet the inclusion criteria. Finally, 63 potential studies on innovation performance were found that match the inclusion criteria and were selected for more detailed evaluation. Undoubtedly, this process does not allow us to capture a large part of published research in this area, however, this approach guarantees a meaningful and systematic comparison of the different research results obtained (De Man & Duysters, 2005).

Given the large amount of research on firm innovation performance, the present review is constrained by strict temporal horizons; it starts with the work of Harabi (1995) and ends with the recent work of Wu and Wu (2014). The information from surveyed studies were tabulated in a spreadsheet by each article's author(s), title, theory, year, type of innovation referred to, sample size, name of the country and sectors of the firm investigated, dependent variable used with reference to innovation, independent variables used, statistical or econometric methods applied for data analysis, and major findings.

2.3.2 Descriptive analysis of reviewed articles

This section provides a descriptive analysis of our sample and reviews the innovation dimensions captured in the surveyed papers. We also provide a conceptual model of the existing research to the extant understanding of the concept and contributions. The reviewed studies can be categorised into two groups. The first group consists of articles measuring the effect of internal and external variables on the innovation performance of firms. The second group of papers investigates the effect of contextual indicators such as networking, collaboration, government R&D policies, national innovation systems, etc. on the innovation performance of firms. The general characteristics of the reviewed studies and a more detailed discussion on publication outcomes, regions and sectoral background, and type of innovation of the surveyed articles are provided below.

Figure 2.1A shows the publication outcome with innovation measurement as the topic[9]. Beginning with a limited number of articles per year for the period 1995-2005 (an average of 2.09 articles per year), the rate of empirical studies grew remarkably after 2006 at an average of 4.44 articles per year. The years 2008, 2012 and 2013 witnessed the highest number of articles published.

[9] Internet search engine "Science Direct" used to obtain the data on the publication outcome during 1995-2014.

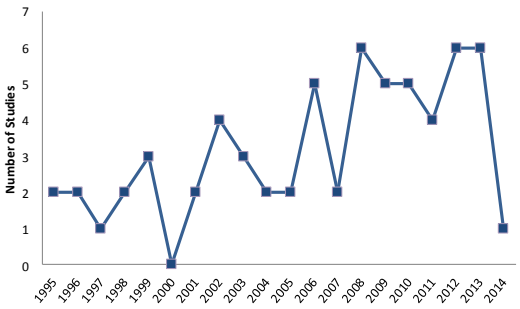


Figure 2.1A: Publication outcome

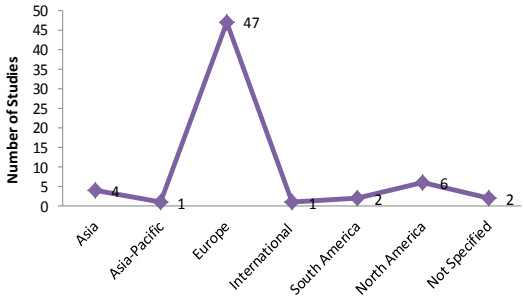


Figure 2.1B: Number of studies by regions

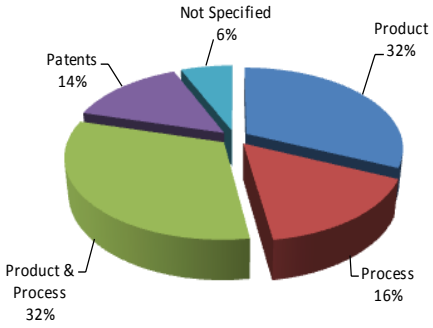


Figure 2.1C: Percentage of studies by type of innovation

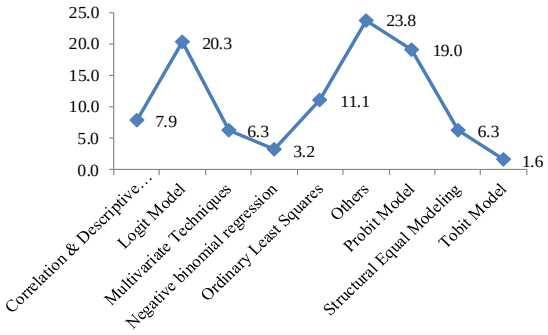


Figure 2.1D: Econometrics Techniques used to study

The reasons for the increase in publications during the last decade could be attributed to the growth in the series of Community Innovation Surveys (CIS) in European countries (Becheikh, *et al*., 2006). In the European Union, CIS are the preferred approach to measuring firm innovativeness (Hong, *et al*., 2012). The increased frequency of the CIS from every four years to every two years through a legislative change in 2007 might explain the increased number of articles published since 2008.

The CIS is the main statistical instrument of the EU and this is reflected in the number of studies by investigated country/regions shown in Figure 2.1B, which reveals that firms in Europe [47] are studied most often, followed by North America [7]. The distribution of articles by country shows that eight out of ten most investigated countries are European, with the other three being USA, Canada and China. Alegre and Chiva (2008) provide some more insight into the impact of geographical location on the success of innovation. They find that locational setting has a significant impact on the success of product innovation performance. On the sectoral background, the majority of articles reviewed (39 articles – 62%) study the manufacturing sector. Nine studies look at the innovation potential of services, and eleven compare both the sectors. Tether and Tajar (2008) conducted an empirical study concerning

the innovation orientations of European firms. They compared three modes of innovation: product-research; process technologies; and organisational-cooperation with different firm sizes and different sectors (manufacturing and services). They identified that product-research and process technologies modes are positively associated with firm size and are prominent among the manufacturing firms (high/medium/low-tech firms). The service firms are rarely engaged in these modes. The organisations-cooperation mode of innovation is prominent amongst service sector firms.

As mentioned in the research methods section, the focus of this systematic review is to consider only technological products and process innovations. Figure 2.1C shows that product innovations were the most often studied (32%), whereas process innovations are studied to a lesser degree (16%), and 32% investigated both product and process innovations. In addition to this, 14% of the articles studied innovation through patent data without specifying product or process innovations. Finally, 6% of the studies did not specify what type of innovation they investigated but they conformed to the conceptual definition of innovation as stated in the *Oslo Manual*.[10]

The research by Becheikh *et al.* (2006) highlights that during the early 1990s to the early 2000s (1993-2003), authors have used multiple regression techniques most extensively, especially Ordinary Least Squares (OLS) regression, to investigate innovation. In this research we note that (Figure 2.1D) Logit and Probit models (combined 39.3%) were used by the majority of authors, while other statistical and econometric methods (23.8%) such as factor analysis, cluster analysis, principal component analysis, count data models, stochastic frontier analysis, data envelopment analysis, and Crepon-Duguet-Mairesse (CDM) models were used depending on the measurement of innovation. We also noticed that Structural Equation Modelling and Correlation techniques (Spearman rank correlation, Pearson's correlation) were used in 6.3% and 7.9% of the studies respectively.

Figure 2.2 shows that innovation was measured in a variety of ways in the reviewed articles. According to the OECD (1997), innovation is a multifaceted and diversified activity

[10] Product innovation is a process that involves activities such as R&D, design and development, manufacturing, and commercialisation and marketing of a new or improved product. Process innovation is the implementation of processes that include significant improvement in techniques, machinery, management, and software to improve production and delivery methods (OECD, 2005).

that involves several interrelated components and data sources. R&D and patent data are considered the conventional innovation measures, however, over time, these indicators have been criticised in the literature due to many perceived disadvantages.[11] But in the present review, the apparent shortcomings have not stopped R&D and patent data from being used (22% of studies used them in measuring innovativeness) due to their availability and accessibility. Findings from this research indicate that firm innovation surveys have emerged as one of the most important indicators, and owing mainly to the efforts of the OECD and Eurostat, these surveys have become the standard method of gathering innovation data directly from firms (Michie, 1998).

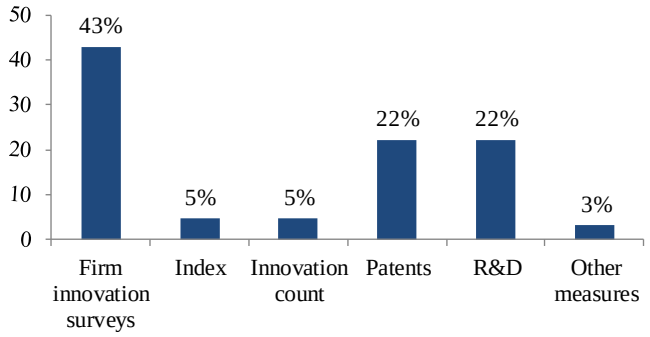


Figure 2.2: Innovation measurement method

Where firm innovation surveys are concerned, the major shortcomings are related to accuracy of response rates due to their representativeness, significance and methodological guidelines (Archibugi & Sirilli, 2001; Amara, *et al.*, 2004). However, instead of providing limited knowledge on decision-making from questions requiring simple "yes" or "no" answers about new or improved products, refining these surveys by introducing new indicators to assess the degree of innovativeness would significantly improve their accuracy (Amara, *et al.*, 2004). It is worth highlighting that the studies included in the review revealed that firm innovation surveys are the most often used measure with 43% of the articles including such surveys, which indicates that the percentage of innovative firms has increased over the last two decades.

2.4 Survey findings

The study of 63 articles in the systematic review highlights a wide range of issues related to innovation and its explanatory variables. A comprehensive and robust framework is developed through the analysis of reviewed studies in order to understand a set of indicators

[11] See Becheikh *et al.* (2006) and Michie (1998) for further explanation of the main disadvantages of the conventional innovation indicators.

related to innovation and the factors driving firm innovativeness. The multidimensional framework combines the firm's internal, external and contextual aspects related to networking, locational and sectoral advantages with innovation performance. In recent literature, several studies have provided insights into the importance of internal and external factors associated with the firm. Additionally, numerous econometric studies have confirmed the positive effects of local and international institutional dynamics' (which include collaboration, industrial parks/districts, regional and national innovation systems, and national innovation policies), significant role in determining innovation. Surprisingly, there are very few studies that have combined these two aspects.

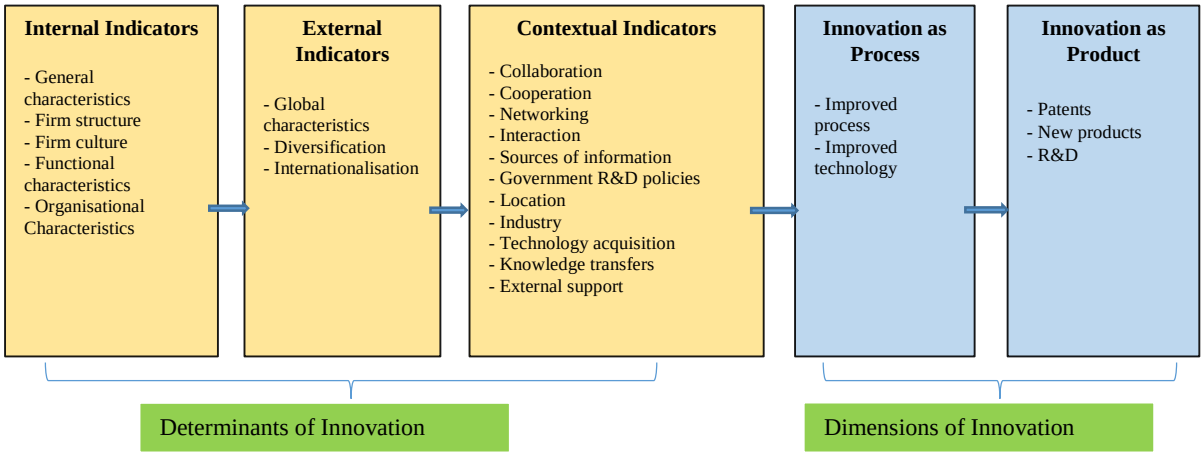


Figure 2.3: Multidimensional framework of review findings

In the proposed framework, the determinants of innovation are clustered into three main groups and refer to the explanatory variables related to internal (firm related variables), external (external environment) and contextual indicators (policy related variables, industry and sectoral variables). About sixty-two variables are identified (see the list of variables in Appendix 1), which are quite varied by nature. Based on these indicators, this section examines the impact on firm innovation performance. Within each of these groups, extant contributions are discussed focusing on the dimension of innovation and findings to the current understanding of the topic for both academics and practitioners.

2.4.1 The determinants of technological innovations

The reviewed papers made an attempt in consolidating the existing research by covering different issues and levels of analysis. To report our findings in accordance with the proposed

comprehensive framework, the results of the review are categorised in three streams: (i) results related to internal determinants of innovation performance; (ii) results related to external determinants; and (iii) details of the contextual determinants of innovation. The categorisation and discussion of results are strongly motivated by the work of Becheikh *et al.* (2006).

2.4.1.1 Stream 1: Internal determinants

An analysis from the microeconomic or firm-level perspective finds many distinguishing characteristics related to the integral and behavioural aspects of innovative firms. The present review identifies about 27 internal determinants, with the variables categorised into five groups namely, firms' general characteristics, functional assets, firms' culture, organisational strategies, and firms' structure. We will examine the role these variables have as determinants of innovation.

2.4.1.1.1 Firms' general characteristics

The general characteristics comprise six variables namely, firm size and age,[12] R&D intensity/expenditure, in-house R&D, and ownership status. Research on the relationship between firm size and innovation has been considered mainly from the perspective of economics. Schumpeter (1942) indicated that larger firms are more innovative than smaller firms, and since then firm size has become one of the most often investigated innovation determinants. In their review, Kamien and Schwartz (1975, p. 15) point out that "a statistical relationship between firm size and innovative activity is most frequently sought with exploration of the impact of firm size on both the amount of innovational effort and innovation success". In the empirical literature, the relationship between firm size and innovation often creates controversial debate, and remains an open issue due to inconclusive evidence. Beginning with Schumpeter's seminal works (1934; 1942) to the present day, the positive relationship between size and innovation is not always found to be statistically significant (Camisón-Zornoza, *et al*., 2004). Camisón-Zornoza *et al.* (2004) also confirm that variations in results are due to the application of size in different forms such as original data (number of employees, assets), logarithmic transformations of the original data, and personnel measures (human resources management systems, planning and control systems, etc). Our objective in

[12] Size and age of firms always contribute significantly to an explanation of the level of innovation. Hence, we have included size and age of the firm as general characteristics or internal resources and identified how researchers consider them as possible determinants of firm innovativeness. We found the studies highlighted that the variable of size is highly significant and positively associated with innovation, whereas the results associated with age are mixed.

this review is not to study the entire gamut of literature on this relationship, but rather to highlight some of the recent relevant research findings.

Firm Size: Studies focusing on an examination of the relationship between firm size and innovation are numerous. More than 70% of the articles in the review investigated this relationship. A large number of studies included in the review provide evidence of a significantly positive effect of size on innovativeness[13] and the results corroborate the Schumpeterian hypothesis (1942). Galende and Fuente (2003) and Stock *et al*., (2002) emphasise that the greater the firm size, the greater the possibility of using resources for innovative activities, hence, size increases the nature of the innovativeness. In contrast, more recently, Hashi and Stojčić (2013) indicate a positive relationship between size and innovative activity by showing that larger firms are more likely to invest more in innovative activities, whereas the relationship between size and innovation output is negative, i.e. innovation output decreases with firm size. In studying the effect of size on sectors, Tether (2002) analyses whether increased firm size among high- and medium-technology manufacturing enterprises increases the propensity to be involved in innovative activities, while the extent of involvement in such activities is marginal to low in high- and low-technology (i.e. utilities) service firms of the same size.

The findings of Paunav (2012) and Cruz-Cázares *et al.* (2013) were contrary to Schumpeter (1942). Paunav (2012) tested the effect of firm size on innovation projects by firms that plummeted in Latin America during the 2008-09 global economic crisis. The author finds a negative significant relationship between firm size and project withdrawal. The probability of discontinuing innovation projects is very high for smaller firms than for the large firms (probability values ranging from 0.387 to 0.218 respectively). Which means that large firms are less likely to drop innovation projects than are the smaller younger firms. The inverted U-shape effect found by Skuras *et al.* (2008) indicates that (i) the conventional view of small firms as followers or constrained firms, may not be true; (ii) as firm size increases, the larger firms might face an acute deficit of resources needed for innovative activities. It means firm size has a linear positive effect on the likelihood to innovate, which in turn has indirect negative

[13] See, for example, Clausen *et al.*, (2013); Tomlinson (2010); Banerjee and Cole (2010); Martínez-Ros and Orfila-Sintes (2009); Coronado *et al*. (2008); Blind, *et al*. (2006); Kannebley Jr. *et al*. (2005); Beneito (2003); Galende and de la Fuente (2003); and Stock *et al*. (2002).

effects on the probability to invest. This is due to the fact that larger firms are more likely to innovate, and thus, indirectly, less likely to invest. This relationship might be influenced by factors such as government policies on innovation, human and physical capital resources, locational factors, etc. (Skuras, et al., 2008; Alegre & Chiva, 2008). Cefis and Orsenigo (2001) extend their analysis beyond an exploration of the relationship between size and innovation to one of firm size and persistence in innovation by considering cross-country and cross-sector specific variables. They found as size increases, persistence in innovation increases in the cases of the USA, UK, France and Italy, but not in the case of Japan and Germany. Furthermore, they found that the size-persistence relationship is complex and if economies of scale exist in innovative activities due to fixed and sunk costs of R&D, larger firms turn out to be more innovative and more persistent, and that innovation persistence is strongly country specific.

In summary, there is a strong positive correlation between size and innovativeness. The results of Skuras *et al*. (2008), Alegre and Chiva (2008), Paunav (2012) and Cruz-Cázares *et al.* (2013) all suggest that the relationship between size and innovation is complex, multidimensional and influenced by several factors. Research within this stream indicates that certain factors have more/less positive or negative influence on this relationship. Thus, there seems no doubt that larger firms have more resources to innovate and have size-related advantages to support innovation activities, while smaller firms are also disproportionately significant sources of innovation.

Firm Age: In the literature, firm age is considered as a possible determinant of innovativeness. Two important findings emerge from the review. The studies by Martín-de Castro *et al.* (2013), Wu (2012), Love *et al.* (2011), and Kumar and Saqib (1996) use this variable and verify a positive impact of firm age on innovative activity. They assert that firms' experience in the accumulation of knowledge and learning through time influences innovativeness. The older firms would have more effective capability to innovate than would younger firms. Freel (2005), while measuring the innovativeness in low- and medium-technology small firms, suggests that the older firms are more innovative than their young counterparts in the manufacturing and service sectors. Whereas research by Cruz-Cázares *et al.* (2013), Clausen *et al.* (2013), Paunov (2012), Tomlinson (2010) and Freel (2003) represent a non-significant or negative impact of age upon the innovativeness of firms. The findings from this survey apparently demonstrate that age facilitates firms to improve efficiency and better their performance with regard to

innovativeness. However, more robust and universally acceptable results are yet to be achieved in sectoral and industry contexts.

R&D expenditure/intensity and in-house R&D: The academic community by and large use R&D expenditure as a crucial determinant of innovation. More than 68% of the studies in the review used R&D expenditure as an explanatory variable in determining firm innovativeness, and about 33% of the studies examined the role of in-house R&D and found a significant and positive relationship between such variables and innovation. The wide body of empirical literature stresses that in-house R&D and design capacity not only increases the firm's capability for innovation and generating new knowledge to develop new products, but that it also enhances the firm's absorptive capacity. In-house R&D indirectly helps the firm to exploit externally available scientific knowledge from collaborators (Vega-Jurado, *et al*., 2008; Álvarez, *et al*., 2009; De Jong & von Hippel, 2009; Love, *et al*., 2011). Such external technological opportunities induce investment in R&D because there is a positive correlation between absorptive capacity, innovativeness and R&D intensity (Vega-Jurado, *et al*., 2008). According to Mansury and Love (2008) and Freel (2005), service sector firms are more likely to develop innovations in collaboration with customers and suppliers by emphasising the collaborative interactions, while firms in manufacturing tend to develop their in-house R&D and linkages with universities. This supports the view of Leiponen (2005) and Kanerva *et al.* (2006). Service firms are more outwardly oriented than manufacturing firms; the external scientific knowledge acquired from customers and competitors positively affects the innovativeness of service firms, whereas in-house R&D had no noticeable influence (Leiponen, 2005).

Ownership structure: The ownership structure of a firm may influence the degree of innovativeness of the organisation. There are mixed results with regard to the effect of ownership on innovation. In general terms, foreign ownership and innovation are significantly and positively correlated. Compared to independent firms, those affiliated to a group,[14] especially in the high technology manufacturing and service sectors, are more likely to be involved in innovation. Also, firms that belong to foreign groups were found to be more innovative than their domestic peers (Tether, 2002). Due to being more competitive, making

[14] Group firms and foreign firms were more likely to have collaborations and co-operation agreements with universities, consultants and R&D labs to learn more about the domestic or local markets compared to the single entities.

higher levels of investments, being less heterogeneous in nature, having workforce training on technological innovations, and having access to resources from parent firms (in the case of a subsidiary firm), foreign-owned firms present as more innovative than domestic firms. Whereas domestic firms in specific industries (e.g. automotive, electronic and chemicals) are slightly more innovative compared to other firms in domestic industries (e.g. the food industry) (Álvarez, *et al*., 2009; Gómez & Vargas, 2012; Griffiths & Webster, 2010; Paunov, 2012). The likelihood of innovativeness reduces by more than 20% if the firm belongs to the state, which means that public firms will have less incentive to improve innovation performance compared to private firms owing to their social welfare or non-profit objectives (Huergo, 2006).

2.4.1.1.2 Variables linked to firm culture and organisational strategies

In recent years, scholars in the discipline of management have focused on firms' internal resources, which are intangible, and on their competencies that are mainly based on information and knowledge, as the primary determinants of innovation capabilities. To analyse the impact of these aspects, researchers focused on the resource-based view (RBV) and the knowledge-based view (KBV) theoretical backgrounds.[15] Relatively few studies examine the internal characteristics such as firm culture, structure and organisational strategies as determinants of firm innovativeness.

Firm innovation culture/orientation: Adamides and Karacapilidis (2006) describe innovation as a knowledge-intensive process; one which depends on a firm's support for innovation culture on the one hand, and individual and collective knowledge of the firm on the other. O'Regan *et al.* (2006) highlight that some organisations face challenges with converting R&D into effective innovation outcomes due to the lack of a strong and well-defined innovation support culture. In fact, Donate and Guadamillas (2010), De Brentani, *et al.* (2010), Akgün, *et al.* (2010), and Kleinschmidt, *et al.* (2007) all found a multiplier effect from firm culture on practices and processes relating to innovation. This would seem to be because the innovation orientation of the firm conveys a message of not only valuing the ideas of employees, but of also inducing people to generate creative thoughts. Finally, it leads to motivation and product

[15] The RBV takes into account the firm's internal resources, such as information and knowledge, as the primary determinants of innovation success. The KBV is a recent development which narrows the focus of RBV; i.e. how knowledge is created, distributed, accumulated, stored, absorbed, and employed in organisations. Furthermore, the KBV is the consequence of the RBV, which states that knowledge management is an important factor in examining the knowledge-innovation link (Martín-de Castro, *et al*., 2013).

innovation. Martín-de Castro *et al.* (2013) provide a judicious explanation of the direct effect of firm innovation culture on product innovation performance (innovation culture has a statistically significant β of .529). According to them, firm innovation orientation provides opportunities for employees to be involved in the decision-making process and to communicate their ideas openly. Therefore, firms should create a conducive environment in which innovation is supported and staff are motivated to innovate (Akgün, *et al*., 2010; Martín-de Castro, *et al*., 2013).

In spite of the importance of firms' incentives and openness in innovation performance, very few studies examine the impact of these factors on innovativeness. Fu's (2012) study is one of the first major empirical examinations and the sole attempt at examining the role of incentives, especially stock options (long-term) and performance-related pay to managers and employees (short-term) in the innovation efficiency of firms. The study draws a sample of 2,130 British small- and medium-sized enterprises (SMEs) covering the period 1998-2001 and measures the firms' efficiency in innovation using both parametric and non-parametric frontier analysis. The results show that both long-term and short-term incentives exhibit a positive association with firms' innovation efficiency, and long-term incentives have a greater effect than short-term incentives. There is a curvilinear relationship between external collaborations (openness) and innovative efficiency, which takes an inverted U-shape. Furthermore, the effect of estimated coefficients for stock option schemes is twice as high as that for performance-related pay schemes on innovation capabilities. A one percentage point increase in managers' and employees' participation in stock option schemes increases the innovative efficiency by two percentage points (Fu, 2012). Additionally, firm innovation efficiency is enhanced through the utilisation of external ideas and by incentivising internal talents. The estimated results do not imply causality, this means that stock option schemes promote effectiveness, motivate the exploration of new ideas, and increase innovation. In the same way, short-term incentives like a performance-related pay variable has a moderating effect, indicating that the effect on innovation capabilities is higher for long-term than for short-term incentives.

Organisational strategies: The literature on the effect of organisational strategy-related determinants allows us to categorise three types of variables: (i) managerial strategies; (ii) board involvement; and (iii) integrated risk management. Overall, these variables are significantly and positively correlated with innovation performance. Souitaris (2002), Flor and Oltra (2004), De Jong and Marsili (2006), Martínez-Ros and Orfila-Sintes (2009) and Griffiths

and Webster (2010) all found that in both "conservative" or "entrepreneurial" firms, the organisational goals and managerial strategies and dimensions are key to stimulating innovation. A positive managerial attitude towards innovation and continuous attention on innovation opportunities help in developing employees' innovative behaviour, which in turn strongly affects the firm's decision to innovate (De Jong & Marsili, 2006). Additionally, the presence of a "project head" in the organisation is recognised as a crucial factor favouring innovation. The project head is an individual who not only enthusiastically supports innovation projects, but is also personally devoted to them (Cooper, 1979; Rothwell, 1992; Souitaris, 2002). There is evidence in the literature that the Chief Executive Officer's (CEO) profile in the firm has a significantly positive influence on innovative capacity. Khan and Manopichetwattana (1989) and Souitaris (2002) found that the younger CEOs who own the firms are more enthusiastic about innovation. Higher educational levels along with transformational leadership of some CEOs enhances a company's vision, goals and reputation, and was found to be positively correlated with firm innovativeness (Becheikh, *et al*., 2006).

A firm's product development project is surrounded by several risks, from planning through to design, testing, process development and production (Wu, *et al*., 2010). Integration of the risks associated with different stages of product innovation enables the firm to allocate resources efficiently, thus improving its capital efficiency and return on R&D expenditure (Cooper, 1984; Wu, *et al*., 2010). Indeed, a firm's Board of Directors plays a crucial role in overseeing the strategic risks through strategic planning, formulation of high-level objectives, and efficient resource allocation, whereas project managers actively oversee the operational risks (Beasley, *et al*., 2010). The only study by Wu and Wu (2014) examines the role of the Board of dDrectors in integrated risk management and product innovation. The results show (i) a negative moderating effect between integrated risk management and the board's direct involvement in risk oversight; and (ii) effective board involvement contributes to product innovation success.

2.4.1.1.3 Variables linked to functional resources and strategies

Functional resources and strategies seem at times to play a dominant role in influencing the innovation behaviour of firms. Tidd (2000) and Del Canto and Gonzalez (1999) focus on identifying firms' internal characteristics with respect to tangible and intangible resources, and the capacities of firms to affect their innovation behaviour by adopting the RBV approach.

Furthermore, they highlight the heterogeneity of firms and the role played by internal indicators in business strategy. These unique resources and capabilities of firms that are developed over time determine the magnitude of efficiency through which they accomplish functional activities (Vega-Jurado, *et al*., 2008). Researchers have classified the basic resources and capabilities of the firm into technological competencies measured by R&D activities (Love, et al., 2009; Love, et al., 2011; Harabi, 1995), human resource competencies measured by a firm's know-how and skills, R&D training and experience of personnel over time (Gómez & Vargas, 2012; Martín-de Castro, *et al*., 2013; Love, *et al*., 2011; Tomlinson, 2010; Huergo, 2006), and organisational competencies acquired through qualified and highly skilled employees (Wu, 2012; Love, *et al*., 2011).

R&D intensity and in-house R&D are largely identified as crucial determinants and are strongly associated with innovation. A firm's in-house R&D and investments in R&D activities not only directly impact innovation capabilities but also impact on a firm's ability to absorb and utilise external knowledge (Marsili & Salter, 2006). Education and experience are important requirements for the understanding and establishment of in-house R&D capabilities. High educational qualifications and the cumulative knowledge of the employees are powerful technological inputs for understanding and developing in-house design and R&D, which induces firms to produce innovative capital goods (Souitaris, 2002; Love, *et al*., 2011; Wu, 2012). Souitaris (2002), Huergo (2006), Gómez and Vargas (2012), Hashi and Stojčić (2013) and Cruz-Cázares *et al.* (2013) recognised that hiring highly qualified workers or employees with special skills are significant sources of innovation. They contribute to the innovation process in two ways: by having an enhanced capacity to think creatively about new techniques; and by integrating new technologies into the firm's activities. Other functional strategies such as training or employee skill development programmes have also proved to be positively associated with innovation. Johnson *et al.* (1996, p. 118) noted that "firms that are innovative must invest in the skills of their workers in order to incorporate new technologies into the firm and offer new products". In both product and process innovations in the manufacturing and service industries, the statistical association between innovativeness and firm-level training intensity is consistent or reliable (Johnson, *et al*., 1996). This means the most innovative firms train more employees. While comparing the manufacturing and service sectors, Freel (2005) notes that innovation is generally a technical activity, and service firms are relatively better in terms of spending more on training than the firms in the manufacturing sector. When firms fail to develop employee skills, they risk being unable to realise the advantages of innovation.

Warner (1996, p. 348) points out that "innovation and training in modern economies are inextricably linked". All these functional or human resource strategies motivate and enable the firms to create new technologies and to better absorb those developed outside by their partners and competitors.

2.4.1.2 Stream 2: External determinants

The effects of a competitive environment (Alegre & Chiva, 2008; Álvarez, *et al*., 2009; Wu, 2012), export intensity, diversification and internationalisation (Souitaris, 2002; Ganter & Hecker, 2013; Gómez & Vargas, 2012) have been identified as drivers of innovation performance in recent years. The external determinants can be sub-categorised into supply, demand and business environment-related factors. The supply factors include tracking down the technological information from competitors. Demand factors consist of understanding the domestic and foreign markets, customers' needs and their perception of innovation, while business environment factors comprise various strategies of the firm (Hadjimanolis, 1999; Souitaris, 2002). Our review focuses on assessing the innovative potential of firms given the direction and dimension shown by external determinants.

Competitive environment: A strong competitive environment inspires firms to adopt a cooperative strategy, which helps in the absorption of new technologies, helps with understanding the changes in domestic and foreign markets, and heightens the firm's performance. The empirical evidence shows that rapidly changing customer needs and a competitive environment are strongly associated with highly innovative firms (Khan & Manopichetwattana, 1989). Six studies in the review found that the effect of a competitive environment on firm innovativeness is positive (Hadjimanolis, 1999; Souitaris, 2002; Alegre & Chiva, 2008; Álvarez, *et al*., 2009; Gómez & Vargas, 2012; Wu, 2012). Furthermore, the only study by Souitaris (2002) empirically shows that a firm's clearly-defined strategy is particularly influential and significantly correlated with a higher degree of innovation in a competitive environment. Strategy enhances the chances of being more innovative than other firms that do not have any strategic orientation. The results indicate, in a competitive business environment that strategic orientation differentiates innovation rates. Especially firms in science-based and specialised suppliers' industries (electronics and chemical firms) are more innovative than supplier dominated firms (agriculture, housing, bulk materials and traditional manufacturing).

In studying the effects of market competition on product innovation performance in high-tech sectors, Wu (2012) argues that market competition coupled with sectoral technological intensity determines both positive and negative effects of technical collaboration on product innovation performance. Rapid technological developments with intense competition stimulates firms to adopt cooperative strategies in order to learn and develop knowledge of advanced technologies and enhance in-house competence because the competitive environment is highly influenced by the actions undertaken by rival firms. The results show that especially in high-tech sectors the effect of technical partnerships on product innovation performance is negative. This is because, when market competition is intense and firms focus on short-term benefits at the cost of collaborators' interests, the opportunistic behaviour of the firm weakens the mutual trust among the partnering firms and effects negatively on the firm's product innovation performance. Hence, firms should pay attention to the long-term prospects of technological collaborative relationships that encourage trust and accrue benefits to all partners. It is clear from the literature that in intense market competition, a well-defined strategy, mutual trust among collaborators, and cultivating long-term cooperative relationships stimulates firms to innovate intensively and increase their product innovation performance and to gain greater competitive advantage in the market.

Export intensity, diversification and internationalisation: In the present globalised environment firms are often confronted with a number of key questions. Should a firm geographically diversify its activities? Do product-diversified firms exhibit better innovative performance? Does a mixed strategy of diversification and internationalisation allow greater innovation performance? What is the impact of export intensity on internationalisation and firm innovativeness? Keeping in view the proposed framework, the literature on diversification can be grouped into two categories. Firstly, the research in international management highlights diversification as a strategy. Secondly, the research in strategic management has focused on product diversification (Hitt, *et al*., 1994), whereas the literature on innovation economics includes both product and international diversification as determining factors of innovation. In an imperfectly competitive market, firms have incentives to improve the quality of their products in order to avoid vulnerability to potential rivals, and this quality improvement requires diversification (geographic, products and technologies) (Garcia-Vega, 2006; Hitt, *et al*., 1994). Research shows that geographic diversification is significantly positively associated with innovation and firm performance. It has also been observed that geographically diversified firms improve their innovative capabilities by utilising the wide range of resources available

internationally. Additionally, such firms promote innovation by exploiting the advantages of establishing partnerships with local competitors, customers, suppliers, universities and research institutes (Kafouros, *et al*., 2008). However, the general relationship between product diversification and innovation is negative (Hitt, *et al*., 1994). Hitt *et al.* (2012; 1994) argue that product diversification is generally associated with employment risk, financial and strategic controls and liquidity crises, and can, therefore, act to destabilise the innovation process. Thus, the relationship between diversification and innovation is an inverted-U, as product diversification leads away from the firm's specialisation or core competencies over time.

The empirical research asserts that specialisation or product concentration enhances innovation. Becheikh *et al.* (2006) and Garcia-Vega (2006) contend that specialisation can augment the economies of scale and can also foster innovation by enhancing the firm's knowledge-acquiring processes. The firms that focus on their core business will have a wide spectrum of technological capabilities that allows them to develop more complex and innovative products. However, geographic diversification provides opportunities to exploit the interrelationships among different geographic markets, business sectors and allied industries (Porter, 1998). Internationalisation is generally defined as "expanding across country borders into geographic locations that are new to the firm" (Hitt, *et al*., 1994, p. 298), and geographical diversification integrates the firms globally by combining production processes, products and firm internal investment functions such as R&D over a broader base by enhancing economies of scale, learning and transferring technological knowledge.

Our review finds that firms that are best at diversification of external activities, or are diverse and internationally oriented, exhibit better innovative performance. Firms' international diversification with partners (competitors as well as non-industry partners) provides access to a wide range of skills, technological capabilities and knowledge sources that may allow them to create developed products (Lokshin, et al., 2011). Results from Heeley and Matusik (2004) suggest that the combination of market and technological diversification strategies leads to incremental innovations, while technological and product diversification leads to open innovation. Overall, the "product strategy acts as a 'modulating' factor in the relationship between diversification and innovation" (Garcia-Vega, 2006, p. 232). With regard to export and internationalisation, the research is almost undisputed: it shows their positive significant effect on innovation and firm performance (Lokshin, *et al*., 2011; Ganter & Hecker, 2013; Gómez & Vargas, 2012).

2.4.1.3 Stream 3: Contextual determinants

Several established theories such as contingency theory (Burns & Stalker, 1961), institutional theory (Parsons, 1966), and industrial economics (Freeman, 1982), state that contextual indicators have a causal influence on innovation strategy or on the behaviour of firms. We have identified about twenty-five contextual determinants in our review that influence the firm's innovation behaviour and performance. In this study, we grouped contextual variables into four categories, namely (1) collaboration, networking and sources of information; (2) government policies and regulation; (3) industry and location related variables; and (4) knowledge and technology acquisition and external support variables.

2.4.1.3.1 Collaboration, networking and source of information

The most pervasive approach to explaining why firms collaborate is the resource-based view (RBV). According to this approach, the most common motive for collaboration is the inter-dependence on resources. In the literature, collaboration is seen as innovation stimulus, and universities and R&D centres are considered drivers of innovation and change. Collaboration within these networks integrate the firm with partners, reduce the transaction costs and risks, and correct market uncertainties, as well as offer access to each other's resources, leading to increased productivity (Zeng, *et al*., 2010; Vega-Jurado, *et al*., 2009; Mention, 2011). The role of cooperation in the case of manufacturing firms, where in-house R&D activity is the most important factor for product innovation, collaboration with universities and other institutions are crucial only when a firm does not have a high level of in-house R&D competencies (Vega-Jurado, *et al.*, 2008). Furthermore, Zeng *et al.* (2010) indicate that the collaborative activities of firms in developing countries (for example, Malaysia) are more influential. The reason is that they are endowed with strong educational institutions, which have a direct impact on the firm's innovative activities. In contrast, the research by Freel (2003) highlights that collaboration with universities and R&D centres constitutes a significant factor for product innovation success, especially in the case of science-based firms. However, partnership malfunctioning will have a significantly negative impact on the innovation process, as it involves the complication of acquiring knowledge and technology, which is essential for a firm's innovation (Lokshin, *et al*., 2011).

With regard to sectoral concentration, Freel (2005), Tether (2002), Tether and Tajar (2008) and Therrien *et al.* (2011) observe that efficient human capital and collaborative

interactions are relatively more important in the service sector compared to manufacturing firms. There is a linear relationship between cooperation behaviour and innovation performance (Trigo & Vence, 2012), showing that the higher the magnitude of cooperation, the higher the level of innovation, and vice versa. Additionally, the results indicate that knowledge-intensive and high-technology service firms are very active as far as external linkages are concerned, whereas distributive service firms (transport, wholesale, retail, hotels, etc.) are low in innovative performance being described as "lonely innovators". This means that the selection of partner and intensity of cooperation are affected by the nature of the service activity. Mention (2011) explores the influence of cooperation practices on magnitude of innovation in service sector firms. The results show that the information received from customers and suppliers stimulates innovation in the service sector (Evangelista, 2006), whereas the same information from competitors does not enhance innovativeness. Interestingly, knowledge sourcing from science-based partners, government-funded research institutions and universities has a strong influence on firms' willingness to introduce new products to the market.

A study by Souitaris (2002) used the taxonomy proposed by Pavitt (1984), namely supplier dominated, scale intensive, specialised suppliers or science-based firms, for analysing the ability to innovate and the determinants of innovation. They confirm the positive and significant effect cooperation networks have on innovation. Lokshin *et al.* (2011) takes a closer look at the significance of a firm's cooperation capabilities, and investigated whether or not the future collaborative results improve when a firm transmutes past collaborative experience into a deliberate learning process. With regard to technological strength, high-technology firms (electronics, computers, pharmaceuticals, etc.) are more innovative than the non-high-tech sectors (Cruz-Cázares, et al., 2013; Ganter & Hecker, 2013; Wu, 2012; Kang & Park, 2012). The high-technology sectors are characterised by fast technological change, and firms need to possess a different set of technologies to compete (Wu, 2012). Collaborating with other firms that generate advanced technologies can facilitate remaining in intense competition and can enhance a firm's response to the ever-changing technology as well as help it capitalise on emerging market opportunities. Hence, collaborations positively influence product innovation capabilities in the long-run. The results obtained in our review corroborate the widely accepted idea that interactions with customers, suppliers, universities, and R&D institutions help firms to fill gaps in information, scientific knowledge, resources and competencies (Becheikh, *et al*., 2006; Romijn & Albaladejo, 2002).

2.4.1.3.2 Government policies and regulations

Government support through policies to promote firm innovation is enhanced by the National Innovation System (NIS) approach. The NIS provides a foundation for government intervention for effective allocation of resources to foster firm innovativeness. Support in the forms of subsidies, incentives, loans, fostering certain sectors, etc. stimulates innovation and/or patenting activities (Souitaris, 2002; Hadjimanolis, 1999; Freel & De Jong, 2009; Tether, 2002; Falk, 2007; Tang, 2006; Kang & Park, 2012; Ganter & Hecker, 2013). Through innovation policies, the government plays an investor role to support firms financially in R&D activities, and encourages networking activities among firms involved in the development of innovation (Kang & Park, 2012). Almus and Czarnitzki (2003) compared the R&D intensity of subsidised firms with that of non-subsidised firms, and found that the R&D intensity of subsidised firms was 4% higher than their non-subsidised counterparts. Using a Canadian firm's data, Tang (2006) found that government support in areas such as R&D tax credits and grants are important and highly significant in the case of product innovation rather than process innovation, whereas for venture capital programmes they are non-significant. Finally, Jensen, *et al*. (2007) argue that innovation policies give priority to R&D activities in high-technology sectors and neglect the organisational learning and user-driven innovations and the strengthening of linkages in traditional manufacturing and service sectors. As a result, firms forgo the benefits of learning by using, doing and interacting in these sectors. Therefore, they strongly suggest that innovation policies should have wider aspects of public policy and institutional building objectives and priorities which prepare the firms to work with global partners as well as involving themselves in learning by doing and using organisational resources.

2.4.1.3.3 Other contextual indicators

The literature on the impact of locational advantage on innovation has been growing notably in the last two decades. This growth is partly due to the emergence of regional innovation systems, in which innovation is seen as a collective learning process which takes place essentially within the local environment (Antonelli, 2009; Ozman, 2009; Coronado, *et al*., 2008). The studies in our review have found that the geographic location where the firms

operate has a significant effect on their innovative capabilities.[16] The literature also supports the notion that geographic location has a significant effect on knowledge spillovers. Such spillover effects generate more citations and have a greater influence on attitudes to innovation (Banerjee & Cole, 2010; Coronado, *et al*., 2008). Previous research shows that due to the availability of specialised or skilled human resources, and better communications and services, firms based in cities or urban clusters are most likely to generate more knowledge that positively impacts firms' attitudes to innovation (Carlino, *et al*., 2007). Similarly, the geographical proximity between the firms and customers, suppliers, financial institutions, universities and R&D centres facilitate the diffusion of innovation and significantly and positively impact innovativeness (Ozman, 2009; Skuras, *et al*., 2008; Romijn & Albaladejo, 2002). Hence, proximity fosters knowledge transfer and exchange (Carlino, *et al*., 2007; Coronado, *et al*., 2008), reduces transaction costs, risks and uncertainty related to innovation (Romijn & Albaladejo, 2002), and provides better access to communication and support in the development of interpersonal interactions (Porter, 1998; 1985).

Recent research on open innovation has emphasised external knowledge and its sources as strategic components in the development of a firm's internal competencies and resources (Clausen, *et al*., 2013). This is because external agents, business entities, and competitors develop new knowledge at a fast pace and on a large scale (Vanhaverbeke, *et al*., 2008). These variables encompass spending on machinery, equipment, software for R&D, licenses and agreements, and other acquisition of external knowledge from various players in the external environment. With regard to these variables, we observe mixed results. The research by Tether and Tajar (2008), Clausen *et al.* (2013), Souitaris (2002), and Lokshin *et al.* (2011) found a significant positive effect, while Tang (2006) and Tether and Tajar (2008) observe a negative relationship between technology and/or knowledge acquisition and innovation. The reasons for the mixed results may be due to the fact that the development of internal or in-house capabilities involves process innovation which is again linked to the acquisition of equipment, machinery and knowledge. Knowledge and technology acquisition depends heavily on the availability of an internal skilled workforce and the absorptive capacity of the firm to understand the advanced technologies (Tether & Tajar, 2008; Tang, 2006). Therefore, Becheikh *et al.* (2006, p. 658) argue that "firms which are able to assimilate, adapt and transform acquired knowledge and

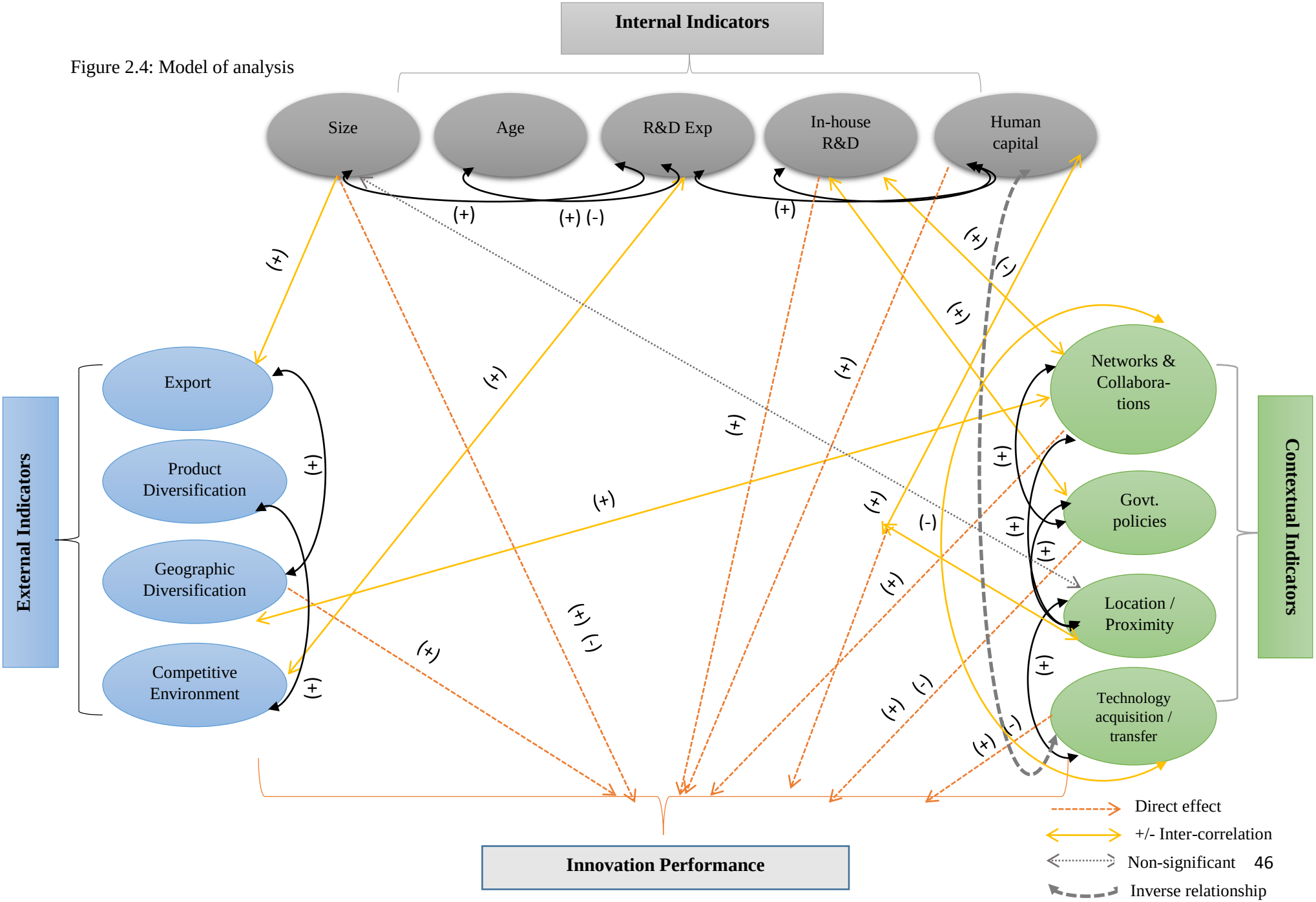
[16] See (Molero & Buesa, 1996; Zander, 1998; Beneito, 2003; Martínez-Ros & Orfila-Sintes, 2009; Skuras, Tsegenidi, & Tsekouras, 2008; Alegre & Chiva, 2008; Ganter & Hecker, 2013; Coronado, Acosta, & Fernández, 2008)

technologies have more chance of using them to innovate than those which are unable to do so". As far as the effect on sectors is concerned, product and/or process innovations focused on inter-firm cooperation through technology and/or knowledge acquisition is/are more prominent in high-technology firms and in services (particularly in trade and distribution services) (Tether & Tajar, 2008).

To summarise the above results from the reviewed studies, geographic location, proximity and technology acquisition are important mechanisms that promote innovation. Furthermore, the role of various factors such as cooperation between customers, suppliers, financial institutions, universities and R&D centres and inter-firm cooperation have a positively significant effect in fostering innovation.

A significant number of explanatory variables in our review shows that innovation is a multifaceted process that is driven by a number of factors. Most of the research investigates the variables and their impact on firm innovativeness independently. The present approach makes an attempt to provide an up-to-date development of variables in the literature and focuses on the inter-linkages between the indicators rather than independency in determining the innovation performance of the firm (see Figure 4).

Figure 2.4: Model of analysis



2.5 Discussion and concluding remarks

The objective of this paper is to provide a broad overview of existing academic contributions in the field of innovation performance by re-examining the major internal, external and contextual indicators that influence the innovative capabilities of firms. The research also contributes an up-to-date synthesis of variables. Possible theoretical foundations, diverse sectors, methodologies of measurement, and dimensions of innovation have been discussed. A comprehensive framework on innovation performance is suggested. Although the paper focused only on leading peer-reviewed innovation journals in an effort to understand the phenomenon, it is believed that the approach followed in the review helps in deriving some meaningful research results.

In spite of the strategic importance of both product and process innovations, today the role of process innovations is studied and discussed less than previously (Mäkimattila, *et al*., 2013). The research on innovation as a process is largely underdeveloped in the literature, whereas scholars primarily focus on innovation in new products (Crossan & Apaydin, 2010). However, product and process innovations are closely inter-linked and interdependent (Martinez-Ros, 1999). When firms neglect process innovations, this can lead to destabilisation of the innovation process, and as a result, it weakens a firm's capacity to develop new products. In contrast, several studies (Freel, 2003; Michie & Sheehan, 2003; Sternberg & Arndt, 2001) show that there are considerable differences in the processes and determinants between product and process innovations. Using a UK database, Michie and Sheehan (2003) observe that the determinants of innovation and their effects vary from product to process to both. Therefore, in future a separate investigation on process innovations could derive relevant managerial and policy implications.

One of the results obtained from this survey of the literature is that innovation is a never-ending process and is viewed as the engine of productivity and driver of growth for firms in developed as well as emerging countries. This systematic review has examined the main internal, external and contextual variables that influence the innovative capabilities of manufacturing and service firms. Apart from a re-examination of a significant number of explanatory indicators, the research shows that these variables are inter-linked and the interaction determines innovation performance. Nonetheless, the studies reviewed here point to a very clear overall conclusion that in the knowledge economy, the contextual indicators

outperform the conventional variables in terms of their effect on innovation. However, more robust results are needed that can be universally acceptable with regard to different sectors, environments, and innovation dimensions. Innovation is measured in different ways by different researchers (for instance, binary variable, actual numbers, etc.), which prevents us from making generally acceptable conclusions for different sectors because the ways of measuring innovation activities in services are different from those in manufacturing. In this review, we draw a general picture of the current standing of innovation performance research, and explore the results that have been achieved with unanimity.

Appendix 1

Internal & External Determinants of Innovation

Category	Variables	References
Firm General Characteristics	Size, Age, R&D intensity, Design intensity, R&D expenditure Group affiliation, Autonomous group Capital intensity. Business type, In-house R&D In-house Design Ownership status Technological resources Sales, No. of Patents	Veugelers & Cassiman (1999); Brouwer & Kleinknecht (1999); Molero & Buesa (1996); Majumdar (1995); Therrien, Doloreux, & Chamberlin (2011); Hashi & Stojčić (2013); Tether & Tajar (2008); Mansury & Love (2008); Tomlinson (2010); Love, Roper, & Bryson (2011); Vega-Jurado, Fernández-de-Lucio, & Manjarrés-Henríquez (2008); Paunov (2012); Paunov (2012); Freel (2005); Cefis & Marsili (2006); Clausen, Korneliussen, & Madsen (2013); Bagchi-Sen (2001); Souitaris (2002); Wu (2012); Huergo (2006); Ganter & Hecker (2013); Freel (2003); Martín-de Castro, Delgado-Verde, Navas-López, & Cruz-González (2013); Freel & De Jong (2009); de Faria, Lima, & Santos (2010); Stock, Greis, & Fischer (2002); Fu (2012); Leiponen & Byma (2009); Gómez & Vargas (2012); Martínez-Ros & Orfila-Sintes (2009); Kannebley Jr, Porto, & Pazello (2005); Simeth & Raffo (2013); Skuras, Tsegenidi, & Tsekouras (2008); Griffiths & Webster (2010); Tether (2002); De Jong & von Hippel (2009); Tang (2006); Wu & Wu (2014); Alegre & Chiva (2008); Jensen, Johnson, Lorenz, & Lundvall (2007); Coronado, Acosta, & Fernández (2008); Beneito (2003); Lokshin, Hagedoorn, & Letterie (2011); Blind, Edler, Frietsch, & Schmoch (2006); Caloghirou, Kastelli, & Tsakanikas (2004); Galende & de la Fuente (2003); Banerjee & Cole (2010);
Global Characteristics (Diversification)	Export intensity Diversification, Market Share Market concentration No. of competitors / Competition environment Industry R&D, Technological opportunities Internalisation (exports)	Baptista & Swann (1998); Molero & Buesa (1996); Majumdar (1995); Love, Roper, & Bryson (2011); Souitaris (2002); Wu (2012); Huergo (2006); Gómez & Vargas (2012); Simeth & Raffo (2013); Tang (2006); Coronado, Acosta, & Fernández (2008); Galende & de la Fuente (2003);

Functional Resources	Educational qualifications Qualified personnel Highly skilled staff Low skilled staff HR Training R&D / Scientific / technical personnel	Baptista & Swann (1998); Jacobsson, Oskarsson, & Philipson (1996); Patel & Pavitt (1997); Therrien, Doloreux, & Chamberlin (2011); Mansury & Love (2008); Tomlinson (2010); Love, Roper, & Bryson (2011); Freel (2005); Souitaris (2002); Wu (2012); Huergo (2006); Ganter & Hecker (2013); Freel (2003); Martín-de Castro, Delgado-Verde, Navas-López, & Cruz-González (2013); de Faria, Lima, & Santos (2010); Gómez & Vargas (2012); Skuras, Tsegenidi, & Tsekouras (2008); Jensen, Johnson, Lorenz, & Lundvall (2007); Coronado, Acosta, & Fernández (2008); Blind, Edler, Frietsch, & Schmoch (2006); Galende & de la Fuente (2003);
Firms Culture	Innovations Lead Time Time Investment, Innovation culture, Performance related pay	Harabi (1995); Martín-de Castro, Delgado-Verde, Navas-López, & Cruz-González (2013); Fu (2012); De Jong & von Hippel (2009);
Organisational Strategies	Managerial strategies CEO Profile Managerial dimensions Board involvement Integrated risk management External audit	De Jong & Marsili (2006); Souitaris (2002); Martínez-Ros & Orfila-Sintes (2009); Griffiths & Webster (2010); Flor & Oltra (2004); Wu & Wu (2014); Alegre & Chiva (2008);
Firm Structure	Employment Structure	Therrien, Doloreux, & Chamberlin (2011); Mansury & Love (2008); Simeth & Raffo (2013);
Firm Performance Variables	Return on Assets Profitability/ profit margins/ growth of sales/ liquidity measures	Cruz-Cázares, Bayona-Sáez, & García-Marco (2013); Skuras, Tsegenidi, & Tsekouras (2008);

Contextual Determinants of Innovation

Category	Variables	References
Collaboration / Networking / Cooperation/ Interaction	Interaction with private & public universities, public & private research institutes and technical institutes, R&D laboratories Science-based/market-based/inter-firm	Veugelers & Cassiman (1999); Hadjimanolis (1999); Brouwer & Kleinknecht (1999); Therrien, Doloreux, & Chamberlin (2011); Mention (2011); Tether & Tajar (2008); De Jong & Marsili (2006); Mansury & Love (2008); Trigo & Vence (2012); Tomlinson

	Cooperation with customers/suppliers Cooperation with independent researchers Inter-firm collaborations Foreign universities and research organisations	(2010); Love, Roper, & Bryson (2011); Vega-Jurado, Fernández-de-Lucio, & Manjarrés-Henríquez (2008); Cruz-Cázares, Bayona-Sáez, & García-Marco (2013); Paunov (2012); Souitaris (2002); Wu (2012); Huergo (2006); Álvarez, Marin, & Fonfría, (2009); Freel & De Jong (2009); Leiponen & Byma (2009); Romijn & Albaladejo (2002); Simeth & Raffo (2013); Skuras, Tsegenidi, & Tsekouras (2008); Flor & Oltra (2004); Alegre & Chiva (2008); Jensen, Johnson, Lorenz, & Lundvall (2007); Lokshin, Hagedoorn, & Letterie (2011); Blind, Edler, Frietsch, & Schmoch (2006); Cefis & Orsenigo (2001); Caloghirou, Kastelli, & Tsakanikas (2004); Zeng, Xie, & Tam (2010); Kang & Park (2012);
Sources of Information / Assistance	Internal, market and Institutional sources Science-based/market-based/inter-firm Professional associations, Marketing agencies, Advertising agencies, conferences & fairs, competitors, Scientific journals Producers / Users Journal articles and citations	Hashi & Stojčić (2013); Mention (2011); Trigo & Vence (2012); Love, Roper, & Bryson (2011); Romijn & Albaladejo (2002); Tether (2002); De Jong & von Hippel (2009); Lokshin, Hagedoorn, & Letterie (2011); Caloghirou, Kastelli, & Tsakanikas (2004); Galende & de la Fuente (2003); Banerjee & Cole (2010);
Government & Public Policies/Regulations	Government R&D support schemes Innovation policies Regulations	Hadjimanolis (1999); Freel & De Jong (2009); Simeth & Raffo (2013); Tether (2002); Falk (2007); Beneito (2003); Kang & Park (2012);
Industry related Variables	Sectoral Dummys High-technology sectors/Low-technology sectors/Medium-tech sectors Knowledge-intensive sectors Manufacturing & services	Brouwer & Kleinknecht (1999); Hashi & Stojčić (2013); Tether & Tajar (2008); Vega-Jurado, Fernández-de-Lucio, & Manjarrés-Henríquez (2008); Cruz-Cázares, Bayona-Sáez, & García-Marco (2013); Cefis & Marsili (2006); Wu (2012); Ganter & Hecker (2013); Freel & De Jong (2009); de Faria, Lima, & Santos (2010); Fu (2012); Leiponen & Byma (2009); Gómez & Vargas (2012); Skuras, Tsegenidi, & Tsekouras (2008); Tether (2002); De Jong & von Hippel (2009); Wu & Wu (2014); Beneito (2003);

Location related Variables	Geographical location and technological capabilities	Molero & Buesa (1996); Zander (1998); Ganter & Hecker (2013); Martínez-Ros & Orfila-Sintes (2009); Skuras, Tsegenidi, & Tsekouras (2008); Alegre & Chiva (2008); Coronado, Acosta, & Fernández (2008); Beneito (2003); Banerjee & Cole (2010);
Knowledge/R&D /Technology Acquisition	Sourcing knowledge / Acquisition Acquisition of Intellectual Property / Licensing Technology transfers External knowledge flows Knowledge intensive services	Hashi & Stojčić (2013); Tether & Tajar (2008); Love, Roper, & Bryson (2011); Paunov (2012); Clausen, Korneliussen, & Madsen (2013); Souitaris (2002); Martín-de Castro, Delgado-Verde, Navas-López, & Cruz-González (2013); Leiponen & Byma (2009); Falk (2007); Tang (2006); Lokshin, Hagedoorn, & Letterie (2011); Caloghirou, Kastelli, & Tsakanikas (2004);
Internal / External Support Variables	Internal financial support/ External Financial Support Consultation of external sources Public funding for innovation projects Government support through Schemes	Hadjimanolis (1999); De Jong & Marsili (2006); Paunov (2012); Ganter & Hecker (2013); Griffiths & Webster (2010); Tang (2006);

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Chapter 3

Financial development and innovation activities: Panel Granger-causality evidence

Abstract: In this chapter, we study the possible causal relations between financial development and innovation activities using 64 countries' data for the period 2001–2012. To provide evidence on whether financial development stimulates innovation, we use an empirical tool – the dynamic panel Granger-causality framework. The results support the view that a two-way causality relation exists between financial development and innovation output. Hence, we argue that a well-functioning financial system is a necessary condition for explaining innovation activities in both emerging as well as developed economies.

Keywords: financial development, innovation, Generalised Method of Moments, Granger-causality test

JEL Codes: O31, G23, G28

3.1 Introduction

Innovation is vital for creating sustainable economic growth and competitive advantage (Solow, 1957). The recent innovation-based growth models proposed by Aghion and Howitt (2009), Aghion, et al. (2005), and Romer (1990) highlight that the innovation efforts of firms or countries are key determinants of economic growth. But the whole innovation process is long and unpredictable, and also involves risk and a high probability of failure (Holmstrom, 1989). The role of financial development in influencing innovation activities is an important area of the recent literature on innovation and the general idea that a well-functioning financial system reduces financing costs, allocating scarce resources, evaluation of innovative projects, and manage risks (Hsu, et al., 2014), has not yet been properly investigated, which motivates this paper. Schumpeter (1911), an early thinker, emphasised the role of a country's financial infrastructure in stimulating economic development and technological innovations. Supporting Schumpeter, using endogenous growth theory, Levine (1997) and King & Levine (1993) in cross-country studies they find a positive association between financial development and innovative activities, and consequently contributing to economic growth. Since the emergence of endogenous-growth theory, empirical researchers have focused on studying how well-

functioning financial market systems influence technological innovations (Hsu, et al., 2014; Meierrieks, 2014). The recent innovation-led growth model proposed by Aghion and Howitt (2009) and Aghion et al. (2005) provides evidence on the role of financial development in creating sustainable innovation-based economies.

Financial development's role in economic growth has been extensively analysed in the economics literature, and empirical studies conclude that it has a positive relationship with growth (Levine, 1997; 2003). Despite the argument that a well-developed financial system is critical for a nation's innovation capacity made by Schumpeter (1911; 1934), there are few empirical studies that exploring the impact of financial development on the production of new knowledge either at the sectoral or country level. Literature up to 2014 focuses mainly on direct cross-country empirical analyses of the correlation between and impact of financial development on national innovation. From such studies, researchers find positive evidence (Hsu, et al., 2014; Meierrieks, 2014; Tee, et al., 2014), which is interesting, but not surprising. Exploring the direction of causality between finance and innovation in order to understand whether for financial development Granger-causes innovation, or whether for innovation Granger-causes financial development (i.e., one way or both ways) are important dimensions that need to be examined closely before deriving some policy conclusions, and this helps to motivate our study. Based on this identified research gap, the current study exclusively provides panel empirical evidence on causality directions among financial development and an economy's innovation activities using the data of 64 countries (34 developed and 30 developing or emerging economies)[17] for the period 2001–2012, which constitute the main empirical part of this paper. We use an empirical tool – the dynamic panel Granger-causality framework – to test causality among finance and innovation.

This study contributes to the finance-innovation literature in three methodological ways. Firstly, as far as the present paper is concerned, this is the first attempt of applying dynamic panel Granger-causality methodology in the field of 'finance and innovation'. Secondly, unlike the previous studies which concentrated on three to four bank-based (Hsueh, et al., 2013; Menyah, et al., 2014; Tee, et al., 2014) or market-based variables (Pradhan, et al., 2016; Meierrieks, 2014) in measuring financial development, we produce a financial development index using six bank, market and economy-based indicators to comprehensively

[17] The list of countries is given in the Appendix 2.

capture the different dimensions of financial market development. Third, unlike prior studies on the relation between finance and innovation, we test explicitly for Granger-causality among the variables using the dynamic panel Granger-causality framework. Finally, the estimated results have the advantage of providing policy implications, since the previous studies focus largely on heterogeneous countries, individual regions or a few country-specific cases.

The rest of the chapter is structured as follows. In Section 3.2 we present a brief overview of the literature and hypothesis development. Section 3.3 presents the description of the data, methodological framework and the empirical results. Concluding remarks are presents in Section 3.4.

3.2 Literature on financial development and innovation

The above discussion has demonstrated that financial development plays a vital role in innovative knowledge creation, which is a significant determinant of growth. Indeed, a number of theoretical contributions emphasise the positive effect of financial development on innovation and growth built on the idea of Schumpeter (1911; 1934, p. 74) who describes this effect: "He [the 'banker'] stands between those who wish to form new combinations and the possessors of productive means. [...] He makes possible the carrying out of new combinations, authorises people, in the name of the society as it were, to form them. He is the ephor of the exchange economy". The literature on this topic is relatively sparse. Instead of providing a comprehensive overview here, we focus on the ways in which financial development and innovation can relate, and how the earlier empirical literature tests the relationship. The literature suggests that the likelihood of innovation activities (generation of new knowledge) depends both on the institutional environment factors and the availability of financial resources. Indeed, some researchers suggest that productivity growth and innovation are linked to finance, or financial sector development (Erosa & Hidalgo Cabrillana, 2008).

Financial sector development is the sum of all financial institutions and instruments that provide financial services to innovative activities in the economy by reducing market frictions, which leads to beneficial economic outcomes. By considering the beneficial role of financial development in innovative activities, researchers set out to identify various national determinants of innovativeness. Several studies find not only the positive influence of R&D expenditure, tertiary education, quantity and quality of R&D personnel, and number of industrial clusters on national innovation (Wang, 2010; Varsakelis, 2006; Tee, et al., 2014;

Dosi, 1990; Maskus, et al., 2012), but also that the financial and policy environment and resource allocation processes of a country exert a positive influence on its innovation activities (Griliches, 1990; Aghion, 2004; Varsakelis, 2006). In their seminal work, Rajan & Zingales (1998) asserted that firms' dependence on external finance liberates them from generating financial resources internally, and that a well-developed financial system supports innovative firms and industries to grow relatively faster. Along the same lines, Barbosa and Faria (2011) find that access to credit for firms, especially technology-based, young or start-ups, is an important determinant of innovation activities. In contrast, unavailability of external financial resources reduces a firm's involvement in innovation activities because innovation failures can occur due to greater financial constraints (Cabral & Mata, 2003).

A well-developed financial system facilitates growth in new products or processes, leading to improvement in the productivity and efficiency of the firms or economies, and this allows them to achieve growth or competitive advantage more quickly (Aghion, et al., 2005). We ask a question: how does a well-developed financial system stimulate the innovative activities of a nation? As pointed out earlier, innovation is a risky and capital-intensive activity, often requiring a greater share of scarce financial resources and the absence of financial market imperfections, which is possible only in countries with technologically-advanced and well-developed financial systems. Buera, et al. (2011) argue that innovation activities will be constrained if the country's financial system is underdeveloped, and further, that an underdeveloped financial system misdirects patenting activities by preventing poor but talented or innovative entrepreneurs from participating in the innovation process due to the scarcity of capital. Thus, well-developed financial systems help to mitigate such agency problems by providing sufficient resources for funding innovative activities, which in turn increase the frequency of national innovation output (Aghion & Howitt, 2009; King & Levine, 1993).

The model developed by Aghion, et al. (2016) shows that innovation growth depends on domestic savings since domestic savings encourage innovative firms to take part in cooperative joint projects through technical collaboration with overseas firms that are familiar with the frontiers of technology. Thus, an economy's innovation progress and its development of financial markets through mobilisation and efficient channelling of savings are directly related. While examining the relationship between financial system structure and industrial innovation, researchers find that cross-country differences in the pace and types of innovation activities are due to bank-oriented and market-based financial systems and stock of knowledge

(Furman, et al., 2002; Dosi, 1990). These differences can be alleviated by public policy measures such as investment in human capital development, intellectual property protection, interaction between innovative sectors, innovation incentives, etc. Recently, the findings of Tee, et al. (2014) suggest that bank-based and market-based financial systems are seen as complement rather than substitute to each other in the provision of high-quality financial services for promoting knowledge-based activities. In summary, we assume a causal relationship between financial development and innovative activities.

3.3 Data sources and methodology

In order to test the proposed assumption that financial development is good for national innovative capacity, we collected the secondary data on innovative activity and indicators for financial development. The annual data for the period 2001–2012 used in this paper comes from the World Bank's World Development Indicators (WDI) (2016) database[18], and Financial Development and Financial Structure Dataset. A detailed description of variables and sources are reported in Table 3.1.

Table 3.1: Variable definition and sources

Variable(s)	Description	Data source
PATAPPPC	Ratio of total number of patent applications applied to national patent office to the total population (in logarithmic form)	WDI
SIZE	Private credit by deposit money banks to GDP and stock market capitalisation to GDP (in logarithmic form)	WB's Financial Development and Financial Structure Dataset
ACTIVITY	Private credit by deposit money banks to GDP multiplied by stock market total value traded to GDP (in logarithmic form)	WB's Financial Development and Financial Structure Dataset
STRUCTURE	Private credit by deposit money banks to GDP divided by stock market capitalisation to GDP (in logarithmic form)	WB's Financial Development and Financial Structure Dataset
LLY	Liquid liabilities to GDP (in logarithmic form)	WDI
GDS	Gross national savings to GDP (in logarithmic form)	WDI
DCG	Domestic credit to private sector by banks to GDP (in logarithmic form)	WDI

[18] WDI database contains the data for 209 countries from 1960 to 2015, but we selected countries and years that have enough data for analysis. The study period 2001-12 also covers the Global Financial Crisis (GFC) of 2008-09, but in our analysis we have not addressed the effect of GFC on the ability of the firms to innovate and invest in R&D. The major obstacle to include this analysis is the lack of data for majority of the countries that contributed to the problems of GFC.

3.3.1 Variables and measures

3.3.1.1 Dependent variable: We use patent per capita (PATAPPPC) data ($Total\ number\ of\ patent\ applicaitons/Total\ population$), which is the standard indicator employed in earlier published work on the determinants of national innovativeness used to measure the level of innovative activities (Griliches, 1990; Kortum, 1993; Ang, 2011). Patents are a fairly reliable proxy for measuring regional and national innovativeness, since they are a reflection of new knowledge (Acs, et al., 2002). Furthermore, to support the measure, Hagedoorn & Cloodt argue that "patent counts are generally accepted as one of the most appropriate indicators that enable researchers to compare the inventive or innovative performance [….] in terms of new technologies, new processes and new products" (2003, p. 1368). Patent applications data is collected from WIPO and WDI databases, and we employ a natural logarithm of patent applications as the dependent variable[19].

3.3.1.2 Explanatory variables: Financial market development is a multi-dimensional concept, and prior studies' definition of an economy's financial development is based on surplus capital and savings that can be used for investment purposes (Hsueh, et al., 2013). There is not one single indicator that can capture the scope this multidimensionality, therefore, researchers use variables including size and structure of the financial system, different financial instruments, financial institutions and regulations, and performance of the financial system. Since many indicators are used in the literature to consider financial development, for the present study we use six indicators, both bank and/or market-based and economy-based, to arrive at more robust findings. The indicators are categorised into financial size and depth, and financial efficiency. Financial activities indicators are denoted by SIZE (private credit by deposit money banks to GDP and stock market capitalisation to GDP), ACTIVITY (private credit by deposit money banks to GDP multiplied by stock market total value traded to GDP), and STRUCTURE (private credit by deposit money banks to GDP divided by stock market capitalisation to GDP). The overall financial development comprises the banking system and the capital markets, hence we use both size of the financial intermediaries and stock market for measuring the overall size, activities, and structure of financial sector development (Tee, et al., 2014; Low, et al., 2015; International Monetary Fund Staff, 2005; Beck, et al., 2010).

[19] Patent applications are exclusive rights obtained by a patent legislation for an invention, i.e., a new technology, new knowledge, or a product or a process that provides new solutions to a predicament (Tee, et al., 2014).

As the size or depth of the financial system by itself might not be adequate to examine the role of financial development in the innovation process, we added to the model a few more indicators of financial efficiency or soundness: LLY (liquid liabilities to GDP), GDS (gross national savings to GDP), and DCG[20] (domestic credit to private sector by banks to GDP). Liquid liabilities as a proportion of GDP measures the ability of the financial system, since the higher the liquidity or money supply, the higher the intensity in an economy's banking system (Menyah, et al., 2014; Hassan, et al., 2011). A strong financial system accelerates the rate of savings, making the intermediation costs lower, leading to cost effective innovation activities (Pathak, 2011). The empirical evidence demonstrates that financial development benefits from higher GDS, and consequently from the higher volume of financial resources available for innovation activities (Pagano, 1993). The reasons for the selection of the aforementioned explanatory variables are: first, the data are available for a large number of countries over a long period of time, without exhibiting large gaps. Second, prior research suggests that these variables are strongly associated with innovation, which in turn stimulates economic development (Levine, 1997; King & Levine, 1993; Menyah, et al., 2014; Hassan, et al., 2011; Hsueh, et al., 2013).

3.3.2 Methodology and results

In the recent panel econometrics literature, researchers use a Granger-causality framework to investigate the causal relationship between certain variables and economic growth, innovation performance, technological developments, etc. For example, several studies focus on foreign direct investment and growth (Dritsaki, et al., 2004; Choe, 2003; Li & Liu, 2005; Tang, et al., 2008; Tekin, 2012), domestic investment and growth (Choe, 2003; Tang, et al., 2008), trade and growth (Kónya, 2006), financial development and economic growth (Calderón & Liu, 2003; Odhiambo, 2008; Kar, et al., 2011; Hsueh, et al., 2013; Hassan, et al., 2011), and energy consumption and growth (Bowden & Payne, 2009; Pao & Tsai, 2011; Acaravci & Ozturk, 2010; Wolde-Rufael, 2009; Soytas & Sari, 2009; Nazlioglu, et al., 2011; Narayan & Prasad, 2008). Panel regressions and cross-country examinations have been done to investigate the influence of financial development innovation activities (Hsu, et al., 2014; Pradhan, et al., 2016; Tee, et al., 2014). As far as the present paper is concerned, this is the first attempt to apply Granger-causality methodology to the field of "finance and innovation".

[20] This variable referring to the financial support provided to firms by financial institutions, is from Menyah, et al. (2014).

If financial development is seen as good for innovation, then financial development should *cause* innovation (the logic of Granger, 1969). The proposed definition of causality by Granger (1969) has become a standard analytical technique in recent empirical economics. The definition suggests that Y_t is said to cause X_t and the knowledge of the past value of Y_t reduces the variance of errors in forecasting X_t. In the applications of applied econometrics, whether Y_t Granger-causes X_t is estimated by the usual regression techniques applied to X_t on its own lags and on the lags of Y_t. If the lags of Y_t are statistically significant, the hypothesis of Granger-non-causality is rejected. Similarly, using the same process, the Granger-causality between X_t to Y_t can be tested.

Before employing the Granger-causality methodology, a panel unit root test needs to be applied to check the stationarity of the variables. The panel-VAR in first difference form will be misspecified if the variables are cointegrated since the error-correction term will be missing. When the test confirms no unit roots, a VAR model is adopted to a panel context (as in Hartwig, 2010) and the form of the equation is:

$$X_{it} = \alpha_0 + \sum_{l=1}^{m} \alpha_l X_{it-l} + \sum_{l=1}^{m} \delta_l Y_{it-l} + \mu_i + u_{it} \qquad (1)$$

X_{it} and Y_{it} are the measures of innovation and financial development, respectively. N countries (represented by i) are observed over T periods (represented by t). μ_i indicates the country-specific effects and the disturbances u_{it} are assumed to be independently distributed across countries with a zero mean.

In Granger-causality it is standard to estimate the causation in both directions. Although the main focus of this paper is to test whether financial development Granger-causes national innovativeness, we also estimate the equation:

$$Y_{it} = \beta_0 + \sum_{l=1}^{m} \beta_l X_{it-l} + \sum_{l=1}^{m} \gamma_l Y_{it-l} + \eta_i + \nu_{it} \qquad (2)$$

We follow the Arellano-Bover (1995) and Blundell-Bond (1998) system generalized method of moments (Sys-GMM) methodology to estimate equations (1) and (2). The conventional estimation techniques, such as OLS and panel data estimates are not appropriate

because of the lagged dependent variables that are correlated with the error term (Nickell, 1981). Therefore, the model is estimated using the System GMM technique and the efficiency of this estimator depends on the selection of right matrix of instrumental variables. The system GMM exploits more moment conditions by using the instruments for lagged differences as lagged levels and using the lagged levels for lagged differences as instruments, which provides for consistent estimation (Blundell & Bond, 1998; Roodman, 2009). System GMM estimators rely on relatively mild restrictions on the initial condition process to improve the performance of GMM estimators in the dynamic panel data context (Blundell & Bond, 1998). Tables 3.3A–3.3F and 3.4A–3.4F present the results using Blundell-Bond two-step system GMM estimations.

We also examine the causality linkages in both directions to test for causality in both directions for the following pairs of variables: (i) size and PATAPPPC (proxied by innovativeness), (ii) activity and PATAPPPC, (iii) structure and PAPAPPPC, (iv) LLY and PATAPPPC, (v) DCG and PATAPPPC, and finally (vi) GDS and PATAPPPC. The estimation is carried out using the Wald test statistics within the Blundell-Bond (1998) system GMM framework. Based on these estimations, the results on causality can be derived with the help of Wald test on the coefficients of the lagged $Y_t's$ to check whether they are jointly equal to zero (Podrecca & Carmeci, 2001; Hartwig, 2010).

Table 3.2: Results of LLC unit root test

	Level			
Variables	**Intercept**	**p-values**	**Intercept + trend**	**p-values**
PATAPPPC	-8.310	0.0000	-10.074	0.0000
SIZE	-14.401	0.0000	-8.648	0.0000
ACTIVITY	-12.912	0.0000	-5.334	0.0000
STRUCTURE	-7.039	0.0000	-12.709	0.0000
LLY	-5.869	0.0000	-11.844	0.0000
DCG	-7.749	0.0000	-4.566	0.0000
GDS	-8.407	0.0000	-9.548	0.0000

We tested for stationarity using the Levin-Lin-Chu (LLC) panel unit root test (2002), which works exclusively for strongly balanced panel data. The results shown in Table 3.2 reject the null hypothesis of non-stationarity of the variables, which provides the necessary condition for applying the panel Granger-causality methodology. Since the causality test estimations are sensitive to the selection of lag length m in the VAR model, it is important to specify appropriate lags. The optimal lag length selected is two, based on the Schwarz Information Criterion (SIC).

Tables 3.3A–3.3F present the results of equation (1) with the Blundell-Bond (1998) one-step and two-step GMM estimator, respectively. The system GMM estimations include period-specific effects. Lags of the dependent variable from at least two periods earlier, as well as lags of the measures of the financial development variables, serve as the instruments. The post-estimation tests results show that the estimated models are found to be valid with regard to the Wald test, Sargan test and Arellano-Bond (AB) test in the Blundell-Bond two-step GMM estimations. The Sargan test is used to check the validity of the instruments. The hypothesis being tested is that the instruments are uncorrelated with the error term u_{it}. In the Blundell-Bond two-step estimations the null hypothesis of over-identifying restrictions in the GMM estimations is confirmed statistically and are valid by this criterion. The AB test also accepts the hypothesis of no second-order autocorrelation in the disturbances of the first differenced equation, and the moment conditions are valid, which suggest that the estimated results are consistent.

Table 3.3A: Estimation of results

	PATAPPPC	
	Sys 2-step GMM	
PATAPPPC(-1)	0.353***	(0.003)
PATAPPPC(-2)	0.359***	(0.001)
SIZE(-1)	-0.075***	(0.003)
SIZE(-2)	0.093***	(0.002)
Number of obs.	640	
Wald test (*p-vlaue*)	0.000	
Sargan test (*p-value*)	0.612	
AB test (*p-value*)	0.888	
Granger causality test	0.0000	

Note: Standard errors are in parentheses.
Estimates for constant term not shown in the table.
AB test: Arellano-Bond test for AR(2) in first differences.
*** indicates significance at the 1% levels.

The estimation finds a positive coefficient for lagged overall size of the financial system. The second lag is statistically significant in the Blundell-Bond two-step system GMM estimation. Focusing on the Wald test results it is evident that overall size has positive impact on patent per capita. The Wald test (Granger causality) rejects the hypothesis that the coefficients of lagged SIZE are jointly equal to zero. Hence, the growth in the size of the financial system Granger-causes PATAPPPC with a positive effect as suggested by the new growth theory.

Table 3.3B: Estimation of results

	PATAPPPC	
	Sys 2-step GMM	
PATAPPPC(-1)	0.327***	(0.003)
PATAPPPC(-2)	0.342***	(0.001)
ACTIVITY(-1)	0.002*	(0.006)
ACTIVITY(-2)	0.050***	(0.002)
Number of obs.	640	
Wald test (*p-vlaue*)	0.000	
Sargan test (*p-value*)	0.685	
AB test (*p-value*)	0.879	
Granger causality test	0.0000	

Note: Standard errors are in parentheses.
Estimates for constant term not shown in the table.
AB test: Arellano-Bond test for AR(2) in first differences.
***, * significance at the 1% and 10% levels respectively.

The coefficients of the first and second lags of the financial development activities are statistically significant in the Blundell-Bond two-step estimations. This indicates that a positive shock to financial activities could boost innovation output growth in the same time period, and in the later periods as the growth rate falls back to its steady state level. The positive coefficients provide evidence in favour of exogenous and endogenous growth theories by showing that financial development activities stimulate patent output growth. When tested with the Granger-causality framework, the coefficient of the lagged activity was found to be significantly positive on PATAPPPC. Hence, results finds Granger causality running from financial development activity to patent per capita and in the opposite direction, showing that growth in financial development activities is good for long-term growth in patent output and increase in the innovation activities Granger-causes growth in the financial development activities.

Table 3.3C: Estimation of results

	PATAPPPC	
	Sys 2-step GMM	
PATAPPPC(-1)	0.366***	(0.003)
PATAPPPC(-2)	0.364***	(0.001)
STRUCTURE(-1)	-0.053***	(0.002)
STRUCTURE(-2)	0.012***	(0.006)
Number of obs.	640	
Wald test (*p-vlaue*)	0.000	
Sargan test (*p-value*)	0.807	
AB test (*p-value*)	0.883	
Granger causality test	0.0000	

Note: Standard errors are in parentheses.
Estimates for constant term not shown in the table.
AB test: Arellano-Bond test for AR(2) in first differences.
*** indicates significance at the 1% level.

The estimation shows a negative coefficient (lag one) for the lagged structure variable. The second lag is statistically significant in the Blundell-Bond two-step GMM estimations. No matter what the coefficient sign, the Wald test statistics are significant at the 1% level, and the test rejects the hypothesis that the coefficients of the lagged STRUCTURE are jointly equal to zero. If the hypothesis is not rejected, growth in the structure of the financial system influences innovativeness with a negative impact as suggested by the endogenous growth models (Podrecca & Carmeci, 2001).

Table 3.3D: Estimation of results

	PATAPPPC	
	Sys 2-step GMM	
PATAPPPC(-1)	0.353***	(0.002)
PATAPPPC(-2)	0.366***	(0.001)
LLY(-1)	0.561***	(0.047)
LLY(-2)	-0.533***	(0.023)
Number of obs.	640	
Wald test (*p-vlaue*)	0.001	
Sargan test (*p-value*)	0.714	
AB test (*p-value*)	0.921	
Granger causality test	0.0000	

Note: Standard errors are in parentheses.
Estimates for constant term not shown in the table.
AB test: Arellano-Bond test for AR(2) in first differences.
***, * indicates significance at the 1% and 10% levels respectively.

Table 3.3E: Estimation of results

	PATAPPPC	
	Sys 2-step GMM	
PATAPPPC(-1)	0.331***	(0.005)
PATAPPPC(-2)	0.350***	(0.002)
DCG(-1)	0.523***	(0.007)
DCG(-2)	-0.355***	(0.011)
Number of obs.	640	
Wald test (*p-vlaue*)	0.000	
Sargan test (*p-value*)	0.775	
AB test (*p-value*)	0.892	
Granger causality test	0.0000	

Note: Standard errors are in parentheses.
Estimates for constant term not shown in the table.
AB test: Arellano-Bond test for AR(2) in first differences.
*** indicates significance at the 1% levels.

Table 3.3F: Estimation of results

	PATAPPPC	
	Sys 2-step GMM	
PATAPPPC(-1)	0.367***	(0.002)
PATAPPPC(-2)	0.365***	(0.001)
DSG(-1)	0.077***	(0.004)
DSG(-2)	-0.071***	(0.006)
Number of obs.	640	
Wald test (*p-vlaue*)	0.000	
Sargan test (*p-value*)	0.668	
AB test (*p-value*)	0.892	
Granger causality test	0.0000	

Note: Standard errors are in parentheses.
Estimates for constant term not shown in the table.
AB test: Arellano-Bond test for AR(2) in first differences.
*** indicates significance at the 1% levels.

Focusing on the other key variables, LLY, DCG and GDS, we can see from Tables 3.3D–3.3F that the second lags are negatively significant in the Blundell-Bond two-step estimations. The Wald test rejects the hypothesis that the coefficients of the lagged variables are jointly equal to zero. If the Wald test is not significant, the coefficients might negatively impact patent per capita. The estimates show that the economy and financial institutions are more willing to support innovation activities in the early or initial stages. With the passing of the early-phase of the uncertain stage of technological development, along with the support of the financial institutions, growth in patent output could be lower in the later stage but then falls back to its steady state level.

The Granger-causality test further suggests that growth in the size, activities, and structure of financial development, increase in the availability of credit (DCG) and savings rate (GDS), increases the rate of innovation in economies, and the causality direction reflects that assuming the economies and financial institutions raise their investments in terms of financial support, the rate of innovation accelerates. The findings support the "finance push model" of innovation, which suggests that generation of new ideas pushed through developments in the financial system. Based on the above estimations, the research question of this study, being whether financial development is good for national innovative productivity, has to be answered in the positive. In summary, our results show that after controlling for the period-specific effects, there exists a strong, positive causal direction between indicators of financial development and innovation activities.

Regarding the causality running from patent per capita to the measure of financial development, the estimated results of Equation (2) are shown in Tables 3.4A–3.4F. Similar to the previous estimations, the system GMM specifications include period-specific effects. Lags of the dependent variable from at least two periods earlier, as well as lags of the innovation variable, serve as instruments. In this case as well, the Sargan test does not accept the over-identifying restrictions at 1% significance levels. The AB test accepts the hypothesis of no second order autocorrelation, thus, there is no model misspecification and the moment conditions are valid.

Table 3.4A: Estimation of results

	SIZE	
	Sys 2-step GMM	
SIZE(-1)	0.288***	(0.005)
SIZE(-2)	0.157***	(0.003)
PATAPPPC(-1)	0.129***	(0.006)
PATAPPPC(-2)	0.106***	(0.003)
Number of obs.	640	
Wald test (*p-vlaue*)	0.000	
Sargan test (*p-value*)	0.600	
AB test (*p-value*)	0.384	
Granger causality test	0.0000	

Note: Standard errors are in parentheses.
Estimates for constant term not shown in the table.
AB test: Arellano-Bond test for AR(2) in first differences.
*** indicates significance at the 1% level.

Table 3.4B: Estimation of results

	ACTIVITY	
	Sys 2-step GMM	
ACTIVITY(-1)	0.798***	(0.005)
ACTIVITY(-2)	-0.147***	(0.005)
PATAPPPC(-1)	0.168***	(0.011)
PATAPPPC(-2)	0.093***	(0.005)
Number of obs.	640	
Wald test (*p-vlaue*)	0.000	
Sargan test (*p-value*)	0.710	
AB test (*p-value*)	0.012	
Granger causality test	0.0000	

Note: Standard errors are in parentheses.
Estimates for constant term not shown in the table.
AB test: Arellano-Bond test for AR(2) in first differences.
*** indicates significance at the 1% level.

Table 3.4C: Estimation of results

	STRUCTURE	
	Sys 2-step GMM	
STRUCTURE(-1)	0.321***	(0.009)
STRUCTURE(-2)	-0.019***	(0.005)
PATAPPPC(-1)	0.146***	(0.010)
PATAPPPC(-2)	0.116***	(0.006)
Number of obs.	640	
Wald test (*p-vlaue*)	0.000	
Sargan test (*p-value*)	0.482	
AB test (*p-value*)	0.056	
Granger causality test	0.0000	

Note: Standard errors are in parentheses.
Estimates for constant term not shown in the table.
AB test: Arellano-Bond test for AR(2) in first differences.
*** indicates significance at the 1% level.

Table 3.4D: Estimation of results

	LLY	
	Sys 2-step GMM	
LLY(-1)	1.085***	(0.008)
LLY(-2)	-0.243***	(0.006)
PATAPPPC(-1)	-0.003*	(0.005)
PATAPPPC(-2)	-0.007***	(0.001)
Number of obs.	640	
Wald test (*p-vlaue*)	0.000	
Sargan test (*p-value*)	0.708	
AB test (*p-value*)	0.135	
Granger causality test	0.0000	

Note: Standard errors are in parentheses.
Estimates for constant term not shown in the table.
AB test: Arellano-Bond test for AR(2) in first differences.
***, * indicates significance at the 1%, and 10% levels respectively.

Table 3.4E: Estimation of results

	DCG	
	Sys 2-step GMM	
DCG(-1)	1.109***	(0.003)
DCG(-2)	-0.302***	(0.002)
PATAPPPC(-1)	-0.000	(0.001)
PATAPPPC(-2)	-0.015***	(0.001)
Number of obs.	640	
Wald test (*p-vlaue*)	0.000	
Sargan test (*p-value*)	0.689	
AB test (*p-value*)	0.809	
Granger causality test	0.0000	

Note: Standard errors are in parentheses.
Estimates for constant term not shown in the table.
AB test: Arellano-Bond test for AR(2) in first differences.
*** indicates significance at the 1% level.

Table 3.4F: Estimation of results

	GDS	
	Sys 2-step GMM	
GDS(-1)	0.870***	(0.005)
GDS(-2)	-0.053***	(0.002)
PATAPPPC(-1)	0.001	(0.001)
PATAPPPC(-2)	-0.026***	(0.001)
Number of obs.	640	
Wald test (*p-vlaue*)	0.000	
Sargan test (*p-value*)	0.679	
AB test (*p-value*)	0.816	
Granger causality test	0.0000	

Note: Standard errors are in parentheses.
Estimates for constant term not shown in the table.
AB test: Arellano-Bond test for AR(2) in first differences.
*** indicates significance at the 1% level.

As can be seen from Tables 3.4A–3.4F, the coefficients of lagged patent per capita are positive and significant in the cases of size, activity, structure and GDS. The estimations also find significantly negative coefficients for lagged LLY, and DCG. A possible explanation for this result is that patent per capita Granger-causes size, activities and structure of financial system development and rate of savings in the financial system with a positive sign. This finding suggests that as long as the rate of innovations increases, the size, activities, structure, and liquidity of the financial system keep growing. The results also indicate that, although we cannot confidently suggest the possibility of technological innovations leading to financial development, the preponderance of results encourage the assumption that, patent output leads to financial development positively, supporting the existing finance-innovation literature.

3.4 Conclusion and implications

The literature on endogenous growth theory highlights the effects of financial development on economic growth, and its importance in the process of new knowledge creation (Buera, et al., 2011; Aghion & Howitt, 2009; Aghion, et al., 2005; Galende & Fuente, 2003). Financial development is consistently shown as having a positive effect on growth, whereas the effect, causation and Granger-causality among financial development and innovation activities is investigated less. Using panel data of 64 countries between 2001 and 2012, this paper has explicitly tested the direction of causality among these variables. Although some of the indicators are presented as significantly negative coefficients, this sign can be ignored in the choice of the GMM estimations (Hartwig, 2010; Arellano & Bond, 1991; Podrecca & Carmeci, 2001; Blundell & Bond, 1998). Therefore, the proposed objective of this paper of seeking to understand whether financial development is good for growth in patenting activities, clearly can be answered as positive. The results suggest that financial development Granger-causes innovations and innovation output stimulates the growth of a nation's financial markets. These findings unambiguously indicate that financial support from the national financial systems increases the rate of growth of patenting activities. Also confirmed is that innovation activities have significantly positive effects on measures of financial development. This study suggests that both "finance-push" and "innovation-pull" effects are equally present in the studied research, and the presented models are equally important in explaining the source of national innovative activities. This study is just a beginning; there is much to understand regarding the source and causality direction in finance and innovation in future research.

Appendix 2

List of the countries

Argentina	Greece	Peru
Armenia	Hungary	Philippines
Australia	Iceland	Poland
Austria	India	Portugal
Bangladesh	Iran, Islamic Rep.	Romania
Barbados	Ireland	Russian Federation
Belgium	Israel	Singapore
Brazil	Italy	Slovak Republic
Bulgaria	Japan	South Africa
Canada	Jordan	Spain
Chile	Korea, Rep.	Sri Lanka
China	Latvia	Sweden
Colombia	Lithuania	Switzerland
Croatia	Luxembourg	Thailand
Czech Republic	Macedonia, FYR	Turkey
Denmark	Malaysia	Ukraine
Egypt, Arab Rep.	Malta	United Kingdom
Estonia	Mexico	United States
Finland	Netherlands	Vietnam
France	New Zealand	Zambia
Georgia	Norway	
Germany	Pakistan	

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Chapter 4

National innovation policies, external collaborations and firm innovativeness in India

Abstract: Prior research in this field highlights the significance of national innovation policies and collaboration efforts in enhancing a firm's innovation performance, but largely focuses on developed countries. Using the count data regression model, this chapter examines the influence of innovation support policies and external collaborative efforts have had on the innovation performance of publicly listed Indian firms during the period 2010-12. We develop a conceptual framework by integrating National Innovation System (NIS) and resource-based view (RBV) theories. The results show that international upstream (academic) and downstream (inter-firm) collaborations along with government policies have a positive influence on the ability of emerging-market firms to develop their innovation performance. The findings also indicate that government innovation support policies facilitate firms in strengthening academic as well as international firm collaborations, which has significant impact on patents generation of the Indian firms.

Keywords: government innovation policies, contextual determinants, innovation performance

JEL codes: O31, O38, L14

4.1 Introduction

National governments and policy-makers world-wide are continuously trying to improve firm-level innovation policy in order to improve economic growth. The quest to understand the drivers of innovation performance has also emerged as one of the biggest challenges for firms in developed as well as in emerging economies. The existing research clearly acknowledges the importance of ties with universities and research institutes and inter-firm collaborations in enhancing firms' innovation performance (Ren, et al., 2015; Kafouros, et al., 2015; Wu, 2012; Trigo & Vence, 2012; Vega-Jurado, et al., 2009; Kang & Park, 2012; Tomlinson, 2010; Zeng, et al., 2010). In increasingly competitive global markets, where a widely accessible knowledge-base plays a dominant role, firms across industries and sectors cannot afford to depend entirely on their internal resources to stay ahead of all relevant technological developments (Kafouros, et al., 2012). In an era of open innovation, along with internal ideas, firms increasingly rely on external sources such as collaborations to access advanced technical knowledge, improve patenting success, and to enter into new product

development and technological fields (Chesbrough, 2003a; Perkmann, et al., 2011; Chesbrough, 2006)[21]. Firms do occasionally innovate in isolation, but the probability for and intensity of innovation escalates when external collaborators are involved in the process (Trigo & Vence, 2012; Tomlinson, 2010). Over the last decade the literature acknowledges the growing significance of government innovation policies as a tool to achieve greater levels of innovation success (Samara, et al., 2012). Governments' investments in innovation support programmes in the form of R&D subsidies, grants and other incentives has resulted in enhancing the innovative competitiveness of firms and justifies the continuation of those programmes (Lee & Wong, 2009; Sakakibara, 1997). The policy initiatives also stimulate stronger interaction between universities and firms through strategic programmes for developing the innovative performance of firms (Godin & Gingras, 2000).

Although numerous studies highlight the contributing role of knowledge sources on firms' innovation outcomes (Zhang, et al., 2015; Robin & Schubert, 2013; Tomlinson, 2010), innovation policies resulting in innovative competitiveness (Samara, et al., 2012; Hewitt-Dundas, 2006; Smallbone, et al., 2003; Godin & Gingras, 2000) are largely focused on developed countries (Kafouros, et al., 2015). Few studies have attempted to understand the interaction and relationship between innovation policies and external collaborations and their influence on firm innovation (Lee & Wong, 2009). However, there is a research gap limiting the understanding of the simultaneous impact of innovation policies and external collaborations on the innovativeness of emerging-market firms which remains untapped. To address this issue, in this study we examine this important phenomenon by focusing on one of the most rapidly growing economies and an emerging innovation hub, India. With the increasing innovative efforts of the government and the availability of technical resources and capabilities, India has emerged as a global hub for low-cost R&D and high value innovative products and services, and is ranked as the most preferred location for innovation centres such as Microsoft, IBM, Google and Intel, to name a few (Bowonder, et al., 2006; GoI, 2015). India currently spends about 0.9% of GDP on R&D and has set an objective to increase this to 2% by 2020 (Westmore, 2013; WDI, 2012). Data also show that India has witnessed notable growth in patent filing by

[21] Industries in high-technology sectors have transitioned from closed to open innovation. Research shows that the number of critically important innovations in these sectors has increased drastically. The focus has shifted from a dependence on internal R&D laboratories to one of collaboration with universities, research institutions and external organisations. Following the trend, other industries in low-technology sectors are also adopting open innovation models (Chesbrough, 2003a).

firms (an average 15% increase) during 2005–2011 due to notable changes in patent policy in accordance with the Trade-Related Intellectual Property Rights under the WTO (Ambrammal & Sharma, 2014).

There are a few reasons why India is an ideal subject for this study:

- The *National Innovation Act 2008* was formulated to encourage India to become one of the most competitive knowledge-based economies;
- The Government of India (GoI) has introduced a wide range of innovation support schemes such as the *National Innovation Policy 2008* and the *Decade of Innovation 2010-2020* to provide innovative stimulus to firms, industry and sectors (GoI, 2015);
- The *Science, Technology and Innovation Policy 2013* was introduced to promote innovation-led solutions for sustainable and inclusive growth. Realising the importance of firm-level innovation, the GoI created the *National Innovation Council (NIC)*. To map the innovation opportunities in states and sectors, *State Innovation Councils (SIC)* and *Sectoral Innovation Councils (SeIC)* were established to encourage regional governments and innovation actors to respond to the needs of firms in the respective states and sectors (GoI, 2015); and
- To link the knowledge entities with firms in the national innovation system[22], the GoI developed the *Global Innovation Roundtable (GIR)*, enabling national and international collaborations on innovation.

Given the policy importance around this issue, the current paper studies the interactive effects of government innovation programmes and firms' endogenous and exogenous factors on innovation performance. The main objective of this paper is to understand particularly the importance of domestic and international collaborations, and the role played by government policies in promoting innovativeness in Indian firms. The paper contributes to the literature by

[22] The Indian national innovation system comprises knowledge actors, R&D laboratories, and knowledge users (firms) in the public and private sectors. There are about 280 public universities, including Indian Institutes of Technologies and the Indian Institute of Science, more than 150 self-financing and deemed universities and about 2500 firm in-house R&D centres generating knowledge for the benefit of society. To cater for the different research needs, the GoI established several science structures, which include the Council of Scientific and Industrial Research (39 labs), Indian Council of Agricultural Research (99 institutes and 17 research centres), Indian Council of Medical Research (30 labs), and Defence Research & Development Organisation (48 labs). In addition to the above, there are about 1200 privately- or state-funded Scientific and Industrial Research Organizations (DSIR, 2015).

shedding additional light on (i) whether firms from emerging-market such as India are more likely to be innovative when they work with location-specific collaborators (*national upstream & downstream and international upstream & downstream*)[23], and (ii) how government policies are likely to be more beneficial to the development of firms' innovation performance. This is important in the context of an emerging economy in establishing a link between innovation systems, external collaborations and firm-level innovations, and crucial in enabling emerging-market firms to catch up with firms from developed countries in the global economy in terms of innovativeness. In addition, we extend our analysis to examine the specifics of high-tech and low-tech firms. Although the main focus of the paper is on India, the framework and the analysis could be applied to other emerging economies.

The chapter proceeds as follows. The next section presents the theoretical background and review of the literature along with the hypotheses for analysis. It also presents a conceptual framework that integrates the theories of the National Innovation System (NIS) and the resource-based view (RBV) approaches. Data sources, variables description and methodology are discussed in Section 4.3. We describe the empirical results, analysis and discussion in Section 4.4. The final section discusses the conclusions, implications and directions for further research.

4.2 Literature review and research framework

The seminal articles in endogenous growth literature highlight the significance of the knowledge-based economy and its impact on growth. There is a fairly large consensus on the fact that knowledge- or innovation-based firms achieve higher growth rates and more favourable terms of trade (Romer, 1990). The existing literature in innovation economics focuses on relationships and linkages between innovation actors and firms, which is central to firms' innovative behaviour. Extending this idea, literature on the triple helix model, which is based on set of components such as knowledge transfer, collaboration, substitution and networking, suggest an interaction between university-industry-government relations, identifies the gaps and circulates knowledge flows and resources among the partners (Ranga & Etzkowitz, 2013; Leydesdorff, 2000). This model led to a shift in the boundaries of innovation from a situation where firms' focus mainly on internal R&D activities, to one of external

[23] Park (2006) proposes the value-chain-based innovation system approach where firms are categorised into upstream and downstream enterprises. The upstream alliances include collaboration with universities, R&D institutions and laboratories, whereas downstream includes firms' collaboration with firms.

collaborations and R&D sourcing (Laursen & Salter, 2006; Chesbrough, 2003a; 2003b; 2006). In this new context, firms' internal innovation competencies are complementary, which can be synergetic with innovation actors in exploring new ideas and knowledge, and lead to improved innovative performance (Adams & Marcu, 2004; Hagedoorn & Van Kranenburg, 2003; Cassiman & Veugelers, 2002; Ren, et al., 2015; Zhang, et al., 2015).

A sizable number of past studies provides meaningful insights showing that external knowledge links speed up the innovation process by granting access to resources and expertise (Fukugawa, 2006), enhance firms' patenting success, and provide technological knowledge support for new product development (Mindruta, 2013; Perkmann, et al., 2011; Ponds, et al., 2010; George, et al., 2002). As observed in prior work, not only the transnational corporations but also the small-and-medium-sized enterprises started establishing stronger inter-firm ties in order to achieve economies of scale, to increase market share and to exploit new market opportunities (Bönte & Keilbach, 2005; Hagedoorn, et al., 2000). According to Hewitt-Dundas (2006) external knowledge sources stimulate a firm's capacity to innovate, whereas a lack of collaborations had a negative impact on firm innovativeness. External networking is an important dimension of open innovation and is complementary to firms' internal inputs (Chesbrough, et al., 2006; Chesbrough, 2003a). This complementarity helps in examining the influence of various inter-firm, contextual and inter-related factors on a firm's level of innovativeness (Mohnen & Röller, 2005). There is a significant amount of literature that highlights government support as important in establishing universities and R&D labs to enhance the knowledge and innovation-base of the economy and local enterprises (Zeng, et al., 2010; Doloreux, 2004). Strategic policy measures have had a strong impact on the effectiveness of collaborations with innovation actors, and have enabled firms to make their innovative activities more active and vibrant (Hewitt-Dundas, 2006; Smallbone, et al., 2003; Wong & He, 2003).

Based on this idea, we integrate the National Innovation System (NIS) and resource-based-view (RBV) theories of firms and innovation. To get a fair understanding of usage of the NIS approach (using the terms "*national system of innovation*" "*national innovation system*") in Google Scholar, the search engine finds about 17,800 hits for the period 1980-2014. We observe that the concept has been widely used by researchers, policy-makers, and experts in international organisations (for more literature on NIS see Lundvall, 2007; Samara, et al., 2012). This theory allows governments to intervene in the form of policy for effective

allocation of resources to foster innovation through interactive coordination between different NIS actors, including private firms, public and private universities, and government agencies to produce, diffuse and exploit the knowledge (Kang & Park, 2012). The interaction can be achieved through collaboration and network agreements (Lundvall, 2010; Carlsson, 2006), and is a dynamic tool for formulating and planning socio-economic development with technology and innovation as the main determinants (Wonglimpiyarat, 2011; Lundvall, 2010).

The RBV has emerged as one of most influential and cited theories in the innovation economics literature, which emphasises the idea that a firm must acquire and control valuable, rare, inimitable, and non-substitutable resources and capabilities to achieve sustained competitive advantage (for a more detailed explanation see Kraaijenbrink, et al., 2010). In the RBV approach, a firm's internal resources explains differences in the performance of firms in the same industry, and also focuses on a firm's external environment, which acts as the main determinant of firm performance (Kraaijenbrink, et al., 2010). In innovation studies, RBV theory is used mainly to analyse the effect of a firm's internal resources on innovation performance, however, the approach can be extended to include the effects of external resources because firms require strong in-house capabilities to maintain successful external technological collaborations (Galende & Fuente, 2003).

Building on recent NIS and RBV studies (Ebersberger & Herstad, 2013; Wu, 2012; Trigo & Vence, 2012; Kang & Park, 2012; Tomlinson, 2010; Zeng, et al., 2010; Falk, 2007; Robin & Schubert, 2013), this paper examines the influence of innovation systems and external sources on firm innovativeness. Against this backdrop, it captures the key elements of 707 innovative[24] Indian firms during the period of 2010-2012.

4.2.1 Hypothesis development

4.2.1.1 Past research on the determinants of innovativeness

Prior empirical work uses various streams such as firm-level, external and contextual indicators to explain the innovative behaviour of firms. However, in the context of firms in an emerging market such as India, the interactive relationships between different streams and their

[24] We use the word 'innovative' because the selection of firms is based on the availability of R&D expenditures data for those firms in the CMIE *Prowess* database. Only the firms that reported R&D expenditures in at least three years have been included in the analysis.

impact on innovation outcomes has not been integrated in the previous studies. Hence, the present paper attempts to understand the role played by the various factors in determining innovation performance, with particular reference to the effects of government innovation support policies and external collaborative efforts on firm innovativeness.

4.2.1.2 Government innovation support

The concept of the NIS is macroeconomic by nature, composed of knowledge and skill resources, research activities, market and institutional conditions, financial and innovation systems, and innovation performance (Samara, et al., 2012). Prior empirical work provides evidence and strong economic justification for government policies in the forms of financial support, subsidies, tax incentives, loans, etc. in improving firms' patenting capabilities (Souitaris, 2002; Hadjimanolis, 1999; Freel & De Jong, 2009; Tether, 2002; Falk, 2007; Tang, 2006; Kang & Park, 2012; Ganter & Hecker, 2013). In addition, the networking or partnering complications that cannot be solved by market forces are justified by government involvement (Chaminade & Edquist, 2006). Therefore, world-wide governments in developed as well as in emerging economies encourage firm-level innovation activities by framing conducive R&D policies and supporting innovation-allied projects to generate high social rates-of-return (Feldman & Kelley, 2006; Kang & Park, 2012). Therefore, we propose the following hypothesis:

Hypothesis 1a (H1A): The level of cooperation between strong government innovation support in the form of the State Innovation Council and innovation outcomes of firms is positively associated.

Hypothesis 1b (H1B): The setting up of Sectoral Innovation Councils in the form of government innovation support policy enhances the innovation performance of firms in the respective sectors.

4.2.1.3 Inter-firm collaborations

It has long been established in the literature that inter-firm collaborations tend to have the greatest impact on firm-level innovation capabilities (see Freeman, 1991 for a detailed review). A significant amount of research reveals that collaborations with established firms leads to development of innovative products (Faems, et al., 2005; Loof & Heshmati, 2002; Klomp & Van Leeuwen, 2001), patenting success (Vanhaverbeke, et al., 2002; Ahuja, 2000), and also that the scope of new knowledge is persistently developed by external agents, business

entities, and competitors at a fast pace (Belussi, et al., 2010; Vanhaverbeke, et al., 2008; Romijn & Albaladejo, 2002; Ahuja, 2000). Further, Kang & Lee (2008) and Romijn & Albaladejo (2002) confirm that inter-firm collaborations help firms in overcoming scientific knowledge and resources deficiencies and improving their internal competencies. Inter-firm collaborations contribute to the effectiveness of innovation outcomes in numerous ways (Faems, et al., 2005). First, they provide access to the complementary resources required for the commercialisation of innovations (Hagedoorn, 2002; 1993). Second, they improve the internal competencies of firms through the transfer of codified and scientific knowledge, which results in flows of necessary knowledge and resources (Kang & Lee, 2008; Ahuja, 2000). Lastly, inter-firm collaborations reduce the transaction costs, risks and uncertainties associated with innovation-intensive activities, leading to increased productivity (Mention, 2011; Zeng, et al., 2010; Vega-Jurado, et al., 2009; Hagedoorn, 2002). Therefore, with the introduction of an open innovation model, firms world-wide are in search of efficient external sources to sustain them in the current globalised competitive environment (Qiao, et al., 2014), and because research on the influence of inter-firm collaborations on Indian firms' innovation output is limited (Sasidharan & Kathuria, 2011; Kathuria, 2010), we examine the following hypotheses:

Hypothesis 2a (H2A): Stronger levels of domestic inter-firm collaboration of enterprises are positively associated with their innovation performance.

Hypothesis 2b (H2B): Overseas firm collaborations positively influences firm innovativeness. The higher the level of international firm collaborations, the stronger the effects on innovation performance.

4.2.1.4 Firm-research organisation linkages

Firms' linkages with universities and think-tanks is considered as innovation stimulus. The role of universities and R&D centres as drivers of innovation and change has been emphasised by researchers because collaboration in these networks integrate the firms with partners, reduce the transaction costs and risks, and correct market uncertainties, leading to improved productivity (Zeng, et al., 2010; Vega-Jurado, et al., 2009; Mention, 2011; Leiponen & Byma, 2009; Kang & Park, 2012). Generally, collaboration with research institutions is a vital source of new scientific and technological knowledge for firms in developing countries the reason is they were endowed with strong educational institutions, universities, which has a direct impact on firms' innovation activities (Zeng, et al., 2010; Liefner, et al., 2006). In their study on the role of universities in Malaysia, Razak & Saad (2007) indicate that upstream

collaborations have become the seedbed in providing knowledge and skills to new industries. The industry-university relationship enables firms to achieve sufficient knowledge and competencies to succeed in their patenting activities (Fritsch & Franke, 2004), and a lack of linkages with such institutions could hamper the innovation performance of firms (Kaminski, et al., 2008). Hence, we hypothesise that:

Hypothesis 3a (H3A): The level of collaboration between firms and domestic research and academic organisations is positively related with firms' innovation performance.

Hypothesis 3b (H3B): The level of collaboration between enterprises and international research and academic organisations is positively associated and enhances firms' innovation performance.

4.2.1.5 Interactive role of policies and collaborations

Past research highlights the role of government innovation support in stimulating external collaborations, which firms use to enhance their innovative capabilities. Governments try to promote collaborations between firms and their upstream partners through grants, subsidies, contracts and institutional arrangements, particularly between enterprises and academic and research institutions (U.S. General Accounting Office, 1983). An empirical study by Hong (2008) states that innovation policies positively influence university-industry partnerships. In the context of China, Zeng et al., (2010) averred that the government promotes stronger inter-firm ties and university-industry collaborations through its innovation policies, which positively influence firms' innovation performance. Therefore, we propose hypotheses on the effects of external collaborations on innovativeness interacted by government innovation efforts.

Hypothesis 4a (H4A): That government innovation policy in the form of SIC mediates the relationship between international upstream collaborations and innovation performance.

Hypothesis 4b (H4B): That government innovation policy in the form of SIC mediates the relationship between domestic upstream collaborations and innovation performance.

Hypothesis 4c (H4C): That government innovation policy in the form of SIC mediates the relationship between international downstream collaborations and innovation performance.

Hypothesis 4d (H4D): That government innovation policy in the form of SIC mediates the relationship between domestic downstream collaborations and innovation performance.

Researchers (Kang & Park, 2012; Wong & He, 2003; Kaufmann & Tödtling, 2002) recognise the indirect influence of innovation policies on firms' innovation outputs. The input-output model of a firm's innovative behaviour highlights that external indicators such as innovation support programmes encourage firms to enhance their innovative capabilities through external sources and collaborative activities (Lee & Wong, 2009). Based on this evidence, it is believed that government innovation support is positively related to innovation performance through the positive association of innovation support programmes and external collaborations, and between external collaborations and a firm's innovation performance.

4.2.2 Research framework

Based on the reviewed literature, a conceptual framework is designed by integrating the theories of NIS and RBV. In Figure 4.1, the framework indicates that innovation is a continuous process with separate but interacting, interdependent and inter-related various internal, external and contextual factors. The major thrust of this research is there is a positive relationship between inter-firm collaboration, firm's internal capabilities and external support and innovation performance of the firms. Furthermore, it supposes that influence of government innovation support activities will have a positive influence on cooperation networks and firm's innovative output.

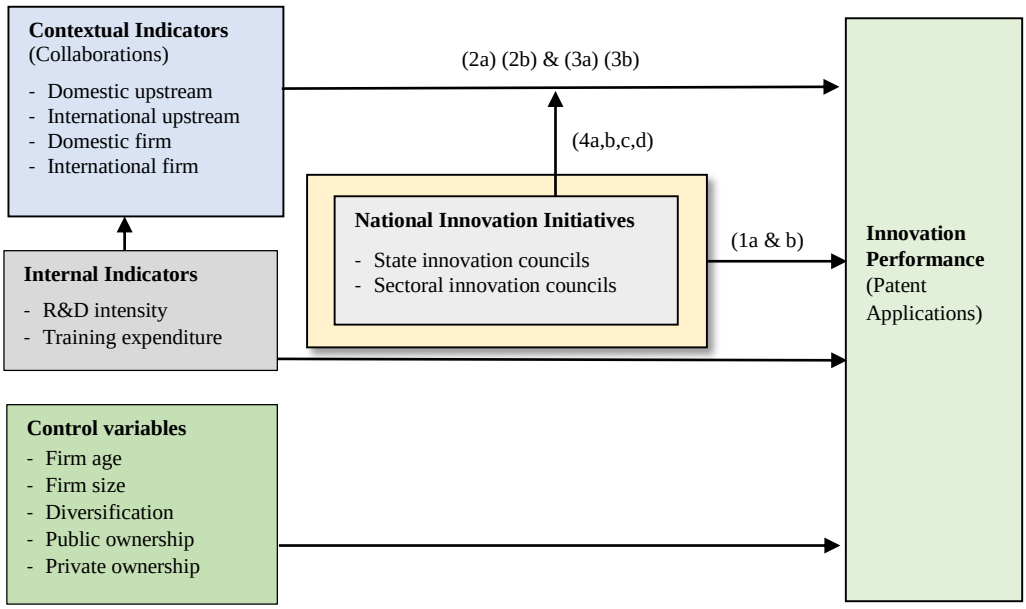

Figure 4.1: National Innovation System (NIS) and resource-based-view (RBV) models of firms' innovative behaviour

4.3 Data sources and variables

We draw our data from the following sources: (i) Indian Patent Office for information on patent applications (http://www.ipindia.nic.in: accessed on 15 January 2015); (ii) Centre for Monitoring Indian Economy's (CMIE) *Prowess* database[25] (for firm-level indicators); (iii) *Capitaline* database[26] (for numbers of external collaborations); and (iv) NIC, GoI on the government innovation support schemes (http://innovationcouncilarchive.nic.in: accessed on 20 January 2015). As indicated in the previous section, the present study uses panel data for the period from 2010-2012. The number of firms in each year is 707, with a total of 2,121 observations for the 3 years, covering industries such as automotive, automobile ancillaries, biotechnology, information technology, petroleum, drugs and pharmaceuticals, electrical and electronics, machinery, equipment, agro products, etc., based on the National Industrial Classification (NIC) 2008 codes.

[25] CMIE's *Prowess* is a firm-level dataset developed by the Centre for Monitoring Indian Economy. It is similar to *Compustat* (the U.S. firms database) and the *Financial Analysis Made Easy* (FAME) database on UK and Irish firms). *Prowess* contains information on around 28,000 firms (manufacturing, services and construction companies) with 3,500 data fields per company. The database has been increasingly used in the literature for firm-level analysis dealing with the issues like determinants of innovativeness, firm performance, etc. (to cite a few (Ghosh, 2012; 2009; Marin & Sasidharan, 2010).

[26] The data in the *Capitaline-2000* database is compiled from the audited annual reports of more than 10,000 enterprises in India listed on the Bombay Stock Exchange.

Table 4.1: Variables, measures and data sources

Variable	Definition	Data Source
Dependent Variables		
PATAPP – Patent applications	Total number of patent applications to Indian Patent Office (IPO)	Controller General of Patents, Designs & Trade Marks, GoI
Independent Variables		
R&DINT – R&D intensity	Ratio of the R&D spending to sales	CMIE-*Prowess*
TRAINEXP – Training & development expenditure	Staff training and development expenditure	CMIE-*Prowess*
SIC – State Innovation Council	Dummy variable capturing the presence of SIC, where (States) the firm is operating – 1 if the state has SIC, 0 otherwise	NIC, GoI
SeIC – Sectoral Innovation Council	Dummy variable capturing the presence of SeIC in which (sectors) the firm is operating – 1 if the sector has SeIC, 0 otherwise	NIC, GoI
DOMUPCOL – Domestic upstream collaboration	Total number of collaborations with domestic upstream partners	*Capitaline*, enterprises websites, annual reports
INTUPCOL – International upstream collaboration	Total number of collaborations with international upstream partners	*Capitaline*, enterprises websites, annual reports
DOMFIRM – Domestic downstream collaboration	Total number of collaborations with domestic firms	*Capitaline*, enterprises websites, annual reports
INTFIRM – International downstream collaboration	Total number of collaborations with international firms (firms outside the country)	*Capitaline*, enterprises websites, annual reports
Control Variables		
AGE – Age of the firm	Number of years since established	CMIE-*Prowess*
DIVERS – Diversification	Dummy variable to capture the presence of the firm in diversified businesses – 1 if diversified, 0 otherwise	CMIE-*Prowess*
SIZE – Size of the firm	Log of total assets	CMIE-*Prowess*
GOVOWN – Public ownership	Dummy variable to capture the government ownership – 1 if government owned, 0 otherwise	CMIE-*Prowess* and *Capitaline*
PRIOWN – Private ownership	Dummy variable to capture the presence of private ownership – 1 if private owned, 0 otherwise	CMIE-*Prowess* and *Capitaline*

Table 4.2: General characteristics of the sample (N=707)

Characteristics	Number	%
Ownership		
Public	123	17.4
Private	584	82.6
Technology intensity		
High-technology	299	42.3
Low-technology	408	57.7
Sectoral information		
Food and beverages	28	4.0
Tobacco and products	4	0.6
Cement	15	2.1
Textiles and wearing apparel	46	6.5
Footwear-leather goods	5	0.7
Pulp, paper products	1	0.1
Publishing, printing	15	2.1
Refined petroleum products	15	2.1
Chemicals	62	8.8
Drugs and pharmaceuticals	88	12.4
Rubber-plastics	36	5.1
Non-metallic mineral products	7	1.0
Basic metals	20	2.8
Fabricated metal products	6	0.8
Machinery	44	6.2
Electronic appliances	13	1.8
Electronic equipment	56	7.9
Transportation means	70	9.9
Computers and Information Technology	25	3.5
Miscellaneous	151	21.4

4.3.1 Measures

In keeping with previous research, variables were drawn on innovativeness, innovation policies, and external collaborations and are considered in further detail below.

***4.3.1.1 Dependent variable*:** Firm innovativeness is difficult to quantify as there is no universally accepted measure (Tomlinson, 2010). Patents count as an appropriate proxy and are easily observable since they are available in the public domain (Akçomak & Ter Weel, 2009; Tomlinson, 2010; Ren, et al., 2015), and are used by number of studies in innovation research (Qiao, et al., 2014; Cruz-Cázares, et al., 2013; Fu, 2012; Kang & Park, 2012; Banerjee & Cole, 2010; Leiponen & Byma, 2009; Álvarez, et al., 2009; Blind, et al., 2006). Patent applications clearly capture information about the technologies and products generated as an outcome of innovation activity (Blind, et al., 2006) and describe a firm's knowledge stock (Wu, 2012). Hence, to measure firm innovativeness, we use the number of patent applications (PATAPP) by the firms to the IPO rather than to U.S. or European patent offices. Using international patent data may favour large firms due to high costs bias involved in the registration processes (Chang, et al., 2006). We measure the $PATAPP_{it}$ as the number of patent applications for firm i in year t. We manually collected the patent applications data for every single company in the sample from the IPO website. Firm selection is done based on the availability of R&D expenditure data, and only those firms are included in the analysis that reported R&D expenditures during the study period.

***4.3.1.2 Explanatory variables*:** By following Kang & Park (2012), Zeng et al., (2010), Hewitt-Dundas (2006), and Smallbone et al. (2003), who stress the importance of the government's role in promoting firm innovation capabilities through supporting firms financially and encouraging networking activities in innovation development, we use government innovation support policies as a proxy variable consisting of two main sources; State Innovation Council (SIC) and Sectoral Innovation Councils (SeIC). If a firm is operating in a state where there is a SIC, the firm is coded 1, and 0 otherwise. Similarly, if the enterprise is operating in a sector which has SeIC, such as cement, textiles, information technology, pharmaceuticals, automotive, electronics, etc., the firm is coded as 1, and 0 otherwise.

R&D expenditure and intensity are often used as measures to represent the R&D investment of the firm. Kang & Park (2012), Griffiths & Webster (2010), Cefis & Marsili (2006), and Romijn & Albaladejo (2002) calculate the R&D intensity as ratio of R&D

expenditure to sales. We use the ratio of R&D expenditure to sales as a measure of R&D intensity (R&DINT). Generally, firms require a pool of qualified human resources, particularly engineers and scientists, to absorb, modify and create new technologies (Romijn & Albaladejo, 2002) and a firm's failure to recruit qualified human capital is a serious concern (Hoffman, et al., 1998). Therefore, firms enrich their human capital through investment in on-the-job and internal or external staff training (Romijn & Albaladejo, 2002). We select the absolute values of the firm's training and development expenditure (TRAINEXP) as one of the internal indicators of innovation.

For researchers, collaborations are important because they integrate firms with partners, reduce transaction costs and risks, and provide access to each other's resources (Zeng, et al., 2010; Vega-Jurado, et al., 2009; Mention, 2011). Recent empirical evidence on the impact of collaborative efforts on firm innovation is a mix of industry- or cross-industry-specific, where researchers focus on vertical or horizontal collaborations through a simple binary variable, merely indicating whether collaborations between firms take place or not (Tomlinson, 2010). To capture the effects of collaboration in a wider context, we followed Kang & Park (2012) by classifying external collaborations into two categories: upstream and downstream; and then further into four sub-categories: domestic upstream and international upstream, and domestic downstream and international downstream. The upstream alliances include a number of collaborations between national and international universities, and R&D centres (DOMUPCOL & INTUPCOL), whereas downstream includes firms' collaborations with domestic and international firms (DOMFIRM & INTFIRM).

***Control variables*:** In order to control for the impact of internal resources on innovation, we include a variety of control variables such as firm age, size, diversification, and ownership status. Firms' experience in knowledge accumulation and learning over a period of time influences innovativeness. The aged firms would have more effective capacity for absorption to innovate than that of younger firms (Martín-de Castro, et al., 2013; Wu, 2012; Love, et al., 2011; Kumar & Saqib, 1996). We calculated the age (AGE) based on the years and months of the firm's operation since its establishment (Qiao, et al., 2014; Rhee, et al., 2010). Firm size is a well-researched determinant. The larger the firm size, the greater the possibility of it using resources for innovative activities than for the smaller firms (Stock, et al., 2002; Beneito, 2003; Kannebley Jr, et al., 2005; Blind, et al., 2006; Coronado, et al., 2008; Banerjee & Cole, 2010;

Galende & Fuente, 2003; Tomlinson, 2010; Clausen, et al., 2013). We compute firm size (SIZE) as the natural log of total assets at the end of the year (Qiao, et al., 2014).

Prior research shows both positive and negative effects of diversification on innovation (Kafouros, et al., 2012; Hitt, et al., 2012; Ahuja, 2000; Hitt, et al., 1994), we control the firm's *diversification* (DIVERS) using a dummy variable coded as 1 if the firm has diversified businesses, and 0 otherwise. Finally, ownership status influences innovation outcomes (Choi, et al., 2011). We construct the variable by including two dummy variables in our estimations. The first dummy variable captures government ownership (GOVOWN); if the firm is government owned, equals 1, and 0 otherwise. The second dummy variable captures private ownership; if the firm is privately owned or a firm with foreign participation (PRIOWN), it is coded as 1, and 0 otherwise.

4.3.2 Econometric model and estimation method

The dependent variable in this study is the count variable (patent applications), which takes only non-negative integer values (i.e., 0, 1, 2….). Estimation of a linear regression model is inappropriate for modelling this type of variable because the distribution of residuals will be heteroskedastic non-normal (Schilling & Phelps, 2007; Ahuja, 2000). Data of this nature is usually modelled using count data (Greene, 2008; 2003; Hausman, et al., 1984), and our analysis is based on the Poisson and negative binomial (NB) models. The unconditional Poisson probability equation is stated as:

$$\Pr(Y_{it} = y_{it}) = \frac{e^{\lambda it}\lambda_{it}^{yit}}{y_{it}!} \qquad \text{for } y_i = 0, 1, 2, \ldots\ldots \qquad (1)$$

Where y is indicating the number of times an event has occurred (number of patents applied in firm i in the year t) and λ is the observable expected (mean) rate of incidences of all i firms during a specific period t (in our study, 2010-2012); the Poisson regression model assumes that the parameter λ_i is characterised by some explanatory variables, X_s. Parameters β_s are estimated by fitting the following equation:

$$\lambda_i = \exp(X_{it}\beta) \qquad (2)$$

Where X_s are the independent variables defined in the Table 4.1 and β_s are the parameters to be estimated. The model may be estimated by the maximum likelihood method. A property of the Poisson distribution is that $\lambda_i = E(y_i) = Var(y_i)$. For cases in which $\lambda_i = \mathrm{E}(y|\mathbf{x}) = \mathrm{Var}(y|\mathbf{x})$ does not hold, quasi-maximum likelihood estimation can be applied to retain some efficiency for certain departures from the Poisson assumption (Wooldridge, 2010). The approach assumes the variance is equal to a multiple of the mean, i.e. $\mathrm{E}(y|\mathbf{x}) = \sigma^2 \mathrm{Var}(y|\mathbf{x})$ and thus adjustments to the standard errors are allowed even $\sigma^2 > 1$ (over-dispersion) and $\sigma^2 < 1$ (under-dispersion).

Patent-related data frequently demonstrate over-dispersion, where the variance is not proportional to the mean (Hausman, et al., 1984). In our case we observe an over-dispersion phenomenon. The presence of over-dispersion leads to spurious high levels of significance because of the consistently estimated coefficients and underestimated standard errors (Cameron & Trivedi, 2013). A negative binomial (NB) model is an alternatively developed model, which is also an extension of the Poisson model that allows estimation of over-dispersed count data. The NB model addresses this issue by assuming that a degree of non-observable heterogeneity exists, which is distributed according to a Gamma function[27]. The NB model relaxes the assumption of the Poisson model by re-specifying $\mathrm{E}(y_i) = \lambda_i$ and $\mathrm{Var}(y_i) = \lambda_i[1 + \left(\frac{1}{\theta}\right)\lambda_i]$. As $\theta \to 0, \mathrm{Var}(y_i)$ is inflated and thus over-dispersion is addressed; as $\theta \to \infty, \mathrm{Var}(y_i) \to \lambda_i$ such that it returns to a simple Poisson model if θ is significantly different from zero. Hence, the NB model is a generalization of the Poisson model that takes into account the problem of over-dispersion. The NB equation is stated as:

$$Y_i \sim NB(\mu_i, \mu_i + \alpha\mu_i^2) \qquad (3)$$

Where α controls for over-dispersion. The NB model is also estimated by the standard maximum likelihood method (Hedeker & Gibbons, 2006). The function is maximised to get coefficient estimates for β and α. The likelihood function is estimated as:

$$L(\lambda_i) = \prod_i \frac{\Gamma((1/\alpha)+y_i!}{\Gamma(1/\alpha)y_i!}\left(\frac{1/\alpha}{(1/\alpha)+\lambda_i}\right)^{1/\alpha}\left(\frac{y_i}{(1/\alpha)+\lambda_i}\right)y_i\,, \quad (4)$$

[27] For more technical details on the NB model see Berk and MacDonald (2008).

In this study, the data are longitudinal with multiple observations for one firm on the same unit over time. The repeated multiple observations on the same firm over time leads to the problem of autocorrelation in the models. The traditional Poisson and NB models generally fail to account for unobserved heterogeneity. To address the issue of firm heterogeneity, the marginal model, generalized estimating equations (GEE) regression[28] is chosen to model the data (Katila & Ahuja, 2002), which can also account for autocorrelation by estimating the correlation structure of the error terms (Liang & Zeger, 1986). The model selection is carried out on the basis of criterion of quasi-likelihood under the independence model (QIC). This criterion compares models with different correlation structures, and the one with the lowest QIC identifies as the best model. We also use McFadden's $pseudoR^2$ statistics to measure the goodness-of-fit[29], and employ *R* software as the statistical tool to execute the econometric computations by using the "MASS", "AER", "pscl", "geepack" packages.

4.4 Results and analysis

4.4.1 Descriptive statistics

Descriptive statistics and inter-correlations of the main variables in the sample are presented in Tables 4.3 and 4.4 respectively. The inter-correlations among the explanatory variables are fairly low, suggesting no serious problem with multicollinearity. As a rule-of-thumb, a multicollinearity problem arises when inter-correlation values are > 0.80 (Hair, et al., 1998; Gujarati, 1995; 2003). We calculate the variance inflation factor (VIF) for each of the predictors, finding that the highest VIF is 8.41 (INTFIRM), indicating well below the acceptable level of 10 (Ryan, 2008). The research finds a high frequency of collaborations with international upstream and downstream partners, which is much higher than the frequency of domestic upstream and downstream collaborators. This implies that Indian firms are more interested in international counterparts to overcome the resource deficiency and to get advanced technology at a competitive price.

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[28] GEE as a marginal strategy, the expected marginal mean, $E(\mathrm{Y_{ij}})$ i=1, ..., and j=1, ..., $\mathrm{n_i}$, is modelled as a function of the explanatory variables. It is an extension of GLMMs and requires that the linear predictor is specified as $n_{ij} = Z_{ij}^T\beta^*$, where $\beta^* = (\beta_0, \beta_1, \ldots\ldots, \beta_{p-1})^T$ is a p-dimensional vector of fixed parameters associated with the covariate vector $Z_{ij=}^T(1, t_{ij}, X_{ij2}, X_{ij3}, \ldots\ldots, X_{ij(p-1)})$. A link function that relates the marginal mean to the linear predictor is specified. In the case of Poisson and NB distributions, the canonical link function is the logarithm, i.e., $\mu_{ij} = \exp(Z_{ij}^T\beta^*)$. In this approach, the variance is written as a function of the mean (Hedeker & Gibbons, 2006).

[29] The most commonly employed formulation to calculate $pseudoR^2$ is the following function:

$$\rho^2 = 1 - LL(\beta)/LL(0)$$

Table 4.3: Descriptive statistics (N=2121)

	Min. value	Max. value	Mean	Var.	Std. Dev.
PATAPP	0.00	302.00	3.41	288.64	16.99
R&DINT	0.00	341.46	1.59	102.25	10.11
TRAINEXP	0.00	1421.20	14.90	4501.91	67.10
SIC	0.00	1.00	0.79	0.17	0.41
SeIC	0.00	1.00	0.89	0.10	0.31
DOMUPCOL	0.00	15.00	0.45	1.60	1.27
INTUPCOL	0.00	7.00	0.16	0.34	0.58
DOMFIRM	0.00	15.00	0.80	2.56	1.60
INTFIRM	0.00	29.00	2.02	9.88	3.14
AGE	1.00	115.00	37.60	450.94	21.24
SIZE	1.39	5.47	2.77	0.63	0.79
DIVERSIFIED	0.00	1.00	0.03	0.03	0.17
GOVOWN	0.00	1.00	0.06	0.05	0.23
PRIOWN	0.00	1.00	0.59	0.24	0.49

Table 4.4: Correlation coefficients of innovation, external and firm internal characteristics

	1	2	3	4	5	6	7	8	9	10	11	12	13
1.PATAPP													
2.R&DINT	0.00												
3.TRAINEXP	0.37[a]	-0.02											
4.SIC	0.05[b]	-0.02	0.05[b]										
5.SeIC	0.00	0.03	0.05[b]	-0.06									
6.DOMUPCOL	0.11[a]	0.02	0.33[a]	-0.03	0.06								
7.INTUPCOL	0.35[a]	0.00	0.39[a]	0.06[a]	0.07	0.29[a]							
8.DOMFIRM	0.22[a]	-0.01	0.51[a]	0.04[c]	0.01	0.37[a]	0.24[a]						
9.INTFIRM	0.40[a]	-0.01	0.35[a]	0.04[b]	0.04	0.21[a]	0.45[a]	0.46[a]					
10.AGE	0.10[a]	-0.09[a]	0.07	0.06[b]	-0.05	0.03	0.03	0.13[a]	0.23[a]				
11.SIZE	0.22[a]	-0.07[a]	0.30[a]	0.04	-0.01	0.29[a]	0.28[a]	0.39[a]	0.40[a]	0.19			
12.DIVERS	-0.02	-0.02	0.00	-0.01	-0.02	0.06	0.02	0.03	0.03	0.02	0.12		
13.GOVOWN	0.00	-0.03	0.34[a]	0.04[c]	0.07	0.31[a]	0.11	0.42[a]	0.14[a]	0.10	0.28[a]	-0.01	
14.PRIOWN	-0.11[a]	-0.05[b]	-0.18	0.05[b]	0.06	-0.30	-0.19	-0.38	-0.4	-0.05	-0.35	-0.01	-0.30[a]

Number of observations = 2121, a, b, and c represent 1%, 5% and 10% significant levels, respectively

It can be seen from Table 4.4 that TRAINEXP is positively correlated to all the forms of collaborative effort. This implies that firms' spending on skill development provides access to the resources and understanding of the scientific codes of the collaborators, which is

inextricably linked to firm innovativeness. Firm size is also positively associated with TRAINEXP and collaborations, implying that the larger the firm's size, the larger the TRAINEXP, and the higher the magnitude of collaborative efforts. Furthermore, the association between innovation policies and PATAPP is positive and statistically significant. Therefore, the hypothesis (H1A) that innovation policies positively influence firm innovativeness is supported.

4.4.2 Regression results

The minimum and maximum values of the dependent variable range from 0 to 302; we note that many firms in the dataset do not have any patent applications in some years. From both the Poisson and NB models the outcomes are quite similar. Our interpretation of the results is based on the GEE-NB link because the tests for over-dispersions for the Poisson models is insignificant ($H_0: \alpha = 0$), indicating that a consideration of NB models may be more appropriate. Table 4.5 reports the GEE-NB regression results for firm innovativeness. Model 1 is the baseline model which includes all control variables. In Models 2 and 3 we introduce R&DINT and TRAINEXP to assess their individual effects on firm innovation. Model 4 is the full model. In order to examine the moderating effects of our theoretical model, we introduce the interaction of SIC with INTUPCOL & INTFIRM and DOMUPCOL & DOMFIRM in Models 5 and 6 to test our hypothesis.

The results indicate that the coefficient of SIC has a significant positive effect on firm innovation, supporting hypothesis H1A ($p < 0.01$), whereas in Models 4, 5 and 6, SeIC is negatively insignificant. The results support Chung (2002) and Malerba (2002; 2005) who argue that the relationship between NIS and regional/sectoral innovation systems is not always positive and their direction of impact on innovation is not the same. Past research shows that sectoral innovation systems are predominant in Western countries, whereas in the context of developing countries, the institutions provide innovative stimuli to certain sectors (Malerba, 2002; Dosi & Malerba, 1996; Nelson, 1993).

Corroborating with other prior work, R&DINT is positive and significant at the 10% level, indicating that innovative firms spend on their internal R&D to draw knowledge and technological know-how successfully from various external sources (Chesbrough, et al., 2006). The TRAINEXP has a significantly positive effect ($p < 0.05$) for innovation, implying most innovative firms train more employees to enhance staff competencies, because in modern

economics innovation and training are intricately linked. Highly trained and qualified staff in firms will have understanding and access to the scientific knowledge from collaborative partners, which enhances the likelihood of successful partnerships and innovativeness (Álvarez, et al., 2009; Gómez & Vargas, 2012; Griffiths & Webster, 2010; Paunov, 2012).

It is notable that Indian firms are indeed attracted to INTUPCOL and INTFIRM collaborations which are positive and significant at the 5% to 1% levels in all models, showing partnering with international collaborators is an important and beneficial factor for innovation, supporting hypotheses H2B and H3B. On the other hand, DOMUPCOL and DOMFIRM have no significant effect, because the coefficient of DOMUPCOL is negatively insignificant, and DOMFIRM is not significant on innovation outcome. The results indicate that international upstream and downstream collaborations are much stronger than domestic ones. Because, in the context of emerging-market firms, international technology dissemination is the major source of innovation (Marsh & Oxley, 2005; Siddharthan & Safarian, 1997; Kumar & Saqib, 1996).

Models 5 and 6 test hypotheses H4A to H4D, indicating the interaction terms between SIC and upstream and downstream collaborations. International partnerships (the interaction terms: SIC*INTUPCOL, SIC*INTFIRM) significantly affect firms' patenting output. The reasons for this finding is: (i) due to the globalisation, the physical and cultural differences are no longer considered to be significant obstacles to the movement of R&D personnel or to the transfer of technical know-how; (ii) knowledge transferred from international partners into emerging markets may be specific and clear so that firms are fully able to understand the logical links between knowledge and its exploitation; and (iii) regular contacts with international partners contribute to the accumulation of network and innovative capabilities, and subsequently enhance firm innovativeness (Kang & Park, 2012). The Wald chi-square statistics suggest that the SIC's interaction with INTUPCOL and INTFIRM significantly improves the model fit over the base model. Model 5's Wald-stat of 131.8, indicates a marginal improvement over the full Model 4 (the difference is 9.0 at 1 degree of freedom). The QIC statistics also suggest that the interaction significantly improves the model fit over the base model, supporting H4A and H4C by showing positive effects of INTUPCOL and INTFIRM partnerships mediated by government innovation policies.

Possible explanations for the insignificance in domestic collaborations (the interaction terms: SIC*DOMUPCOL, SIC*DOMFIRM) are: (i) lack of world-class upstream innovation actors; and (ii) Indian R&D is more adaptive in nature than innovative (Lall, 1986; 1983). These results corroborate with the results of Kang & Park (2012) and Marsh & Oxley (2005), who find a negative effect from domestic collaborations on firm innovativeness, and a significantly positive effect from international firm collaborations. In developing economies, international partnerships enhance the innovation capabilities of firms by providing them with advanced scientific knowledge and the technological support to develop new products and services and to enter into new markets (Kang & Park, 2012).

In this research DIVERS is negatively correlated with innovation outcome. Prior research suggests mixed results, i.e. both positive and negative impacts of diversification on innovative activity (Cohen & Levin, 1989; Ahuja, 2000). With regard to the other indicators of innovation success, firm size is positive and statistically significant ($p < 0.05–0.001$) on PATAPP. This implies that larger-sized firms acquire more innovative capabilities and have significant impact on innovation (Schumpeter, 1942). The coefficient of PRIOWN is significant and positive ($p < 0.05$), indicating that private firms or those with foreign participation are mostly innovative compared to state-owned firms due to the innovative activities carried out by their parent firms and foreign subsidiaries. The likelihood of innovativeness reduces by more than 20% if the firm has government ownership, suggesting that public firms have less incentive to improve innovation performance compared to the private firms owing to their social welfare objectives (Huergo, 2006).

Table 4.5: GEE negative binomial regression analysis

DV: PATAPP	(1)	(2)	(3)	(4)	(5)	(6)
R&DINT		0.026 *	0.028 *	0.030 *	0.034 *	0.028 *
		(0.012)	(0.013)	(0.014)	(0.018)	(0.014)
TRAINEXP			0.068 *	0.068 *	0.092 **	0.065 *
			(0.028)	(0.028)	(0.032)	(0.026)
SIC				0.014 *	0.100 *	0.462 *
				(0.021)	(0.547)	(0.509)
SeIC				-1.493	-0.038	-1.550
				(1.237)	(1.250)	(1.230)
DOMUPCOL	-0.119	-0.126	-0.472 *	-0.439 *	-0.225	0.241
	(0.238)	(0.238)	(0.263)	(0.267)	(0.347)	(0.275)
INTUPCOL	6.202 *	6.203 *	4.259 *	4.278 *	4.617 **	4.180 *
	(2.498)	(2.499)	(1.743)	(1.745)	(1.581)	(1.760)
DOMFIRM	0.731 *	0.730 *	-0.255	-0.268	0.456	2.489
	(0.408)	(0.408)	(0.501)	(0.500)	(0.524)	(1.283)
INTFIRM	1.533 ***	1.532 ***	1.428 ***	1.440 ***	0.381 ***	1.410 ***
	(0.418)	(0.418)	(0.390)	(0.390)	(0.094)	(0.382)
AGE	0.017	0.018	0.022	0.020	0.050 **	0.021
	(0.014)	(0.014)	(0.014)	(0.013)	(0.017)	(0.014)
SIZE	1.934 ***	1.965 ***	1.161 *	1.142 *	1.152 *	1.126 *
	(0.483)	(0.486)	(0.566)	(0.564)	(0.563)	(0.565)
DIVERS	-4.101 ***	-4.088 ***	-3.458 ***	-3.493 ***	-3.540 ***	-3.660 ***
	(0.957)	(0.957)	(0.895)	(0.915)	(0.921)	(0.919)
GOVOWN	-6.457 ***	-6.423 ***	-9.486 ***	-9.321 ***	-13.900	-10.100 ***
	(1.575)	(1.575)	(1.884)	(1.854)	(2.160)	(2.200)
PRIOWN	2.407 **	2.448 **	1.380	1.472	1.320	1.790 *
	(0.914)	(0.919)	(0.953)	(0.986)	(0.903)	(0.910)
Interaction1						
SIC * INTUPCOL					0.683 **	
					(2.661)	
SIC * INTFIRM						
					1.306 **	
					(0.436)	
Interaction 2						
SIC * DOMUPCOL						0.112
						(0.443)
SIC * DOMFIRM						
						-2.381 *
						(1.297)
Intercept	-5.058 ***	-5.197 ***	-3.779 **	-2.774 *	-2.287 *	-3.020 *
	(1.327)	(1.346)	(1.403)	(1.568)	(1.179)	(1.570)
N	2121	2121	2121	2121	2121	2122
Wald chi-square	100.7 ***	106.3 ***	121.9 ***	122.8 ***	131.8 ***	108.1
DF	9	10	11	13	14	14
QIC	11563	11562	11475	11476	11467	11472
Pseudo R-square	0.40	0.41	0.41	0.42	0.39	0.33

Notes: Values in parentheses are std. err. for the coefficient estimates; QIC: Quasi-likelihood information criteria. ***, **, and * represent significance at the 1%, 5%, and 10% levels, respectively

To provide a better illustration, we plot the moderating role of SIC. Figure 4.2a & 4.2b shows quality of collaboration as a key factor in innovation systems. These findings suggest that international upstream and downstream collaborations have significant interaction effects with SIC on innovation performance.

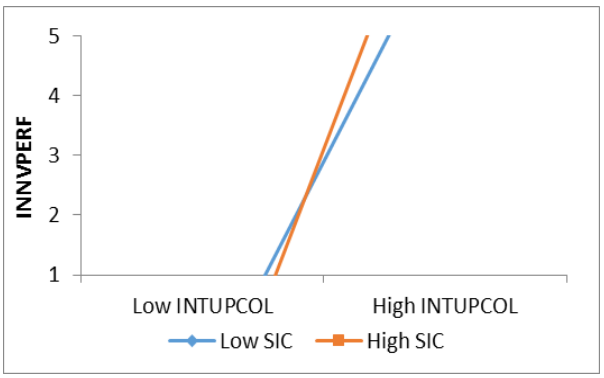

Fig 4.2a: Moderation effect of SIC with INTUPCOL

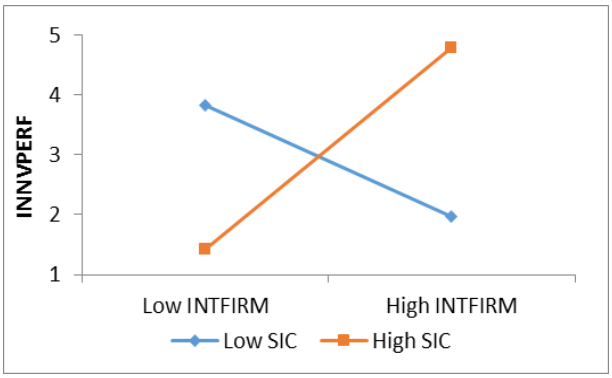

Fig 4.2b: Moderation effect of SIC with INTFIRM

The overall effect of international collaborations on new patent generation is a growth curve shape. The lower the innovation policy efforts by government, the more firms must increase efforts to collaborate and to improve innovative performance (upstream). A possible explanation for this result is that most of the Indian firms are technology adopters rather than technology leaders, and with no government support, firms can be more easily controlled by their partners with regard to the transfer of technical knowledge, access to resources, innovative ideas, payments, etc., which may lead to a decrease in firms' opportunities to learn from international collaborators (downstream). However, when a government introduces R&D policies to support firms in enhancing innovative competitiveness, a moderate level of effort to collaborate is appropriate and the results show SIC positively strengthens the relationship between INTUPCOL and INTFIRM and firm innovation.

In order to check the potential bias of many zero observations for the dependent variable (DV), we tested the data with zero-inflated NB regressions[30]. The results are qualitatively identical, showing the coefficients, signs and significance levels as consistent with those of GEE-NB (Table 4.5), indicating that the findings are stable and consistent across different regression methods.

[30] Results using a zero-inflated NB model can be provided upon request.

4.4.3 Further explorations

We further estimate two sub-samples: high-technology and low-technology[31] firms, to analyse the possible degree of impact from the explanatory variables on firm innovativeness (Tables 4.6 and 4.7). The coefficients INTUPCOL and INTFIRM on innovation are positive and significant for patent generation. INTUPCOL is positive and significant at the 5% level for innovation in high-technology industries, and positive but not significant in low-technology industries. INTFIRM has a significantly positive effect (at the 5% level) on firm innovation in both high- and low-technology industries. Whereas the effect of INTUPCOL appears to be relatively strong in high-technology industries compared to low-technology industries. Further, the results show that TRAINEXP seems to be significant at the 1% level only for low-technology firms. This implies that, in emerging-markets, firms in low-technology sectors are trying to improve their quality of human capital to enhance their absorptive capacity, which subsequently increases the firms' innovativeness.

Finally, the main difference between high- and low-technology firms comes from the selection of type of partner. The interaction between SIC*INTUPCOL and SIC*INTFIRM remains positive and significant ($p < 0.01$) for Indian high-technology firms, whereas for low-technology firms collaborating only with international downstream partners is positively significant ($p < 0.05$). Possible explanations for this result are: (i) advanced technologies are important drivers of innovation competitiveness, and firms in emerging economies such as India, China or Taiwan, are intensifying their efforts at sustainability through continuous innovation; (ii) to facilitate the development and application of advanced scientific technologies, governments in emerging countries are supporting firms by framing a broad spectrum of technology policies (Bauer, et al., 2012). Therefore, the Indian government's innovation policies are more inclined towards international collaborations to make the enterprise more innovative.

[31] We follow the OECD classification of high- and low-technology industries. See www.Oecd.org/sti/ind/48350231.pdf

Table 4.6: GEE-NB regression for PATAPP as DV conditioned on high-technology enterprises

Variables	(1)	(2)	(3)	(4)	(5)
R&DINT		0.033 *	0.035 *	0.034 *	0.037 *
		(0.020)	(0.020)	(0.020)	(0.021)
TRAINEXP		0.061 *	0.061 *	0.060 *	0.063 *
		(0.029)	(0.029)	(0.030)	(0.030)
SIC			0.859	0.074	1.739 *
			(0.610)	(0.808)	(0.912)
SeIC			-4.109 *	-4.096 *	-4.268 *
			(2.374)	(2.381)	(2.377)
DOMUPCOL	-0.002	-0.475	-0.402	-0.372	-0.380
	(0.387)	(0.329)	(0.318)	(0.328)	(0.737)
INTUPCOL	9.287 **	6.882 **	6.858 **	4.581 *	6.724 **
	(3.464)	(2.315)	(2.314)	(2.130)	(2.287)
DOMFIRM	1.032	-0.138	-0.225	-0.258	0.878
	(0.671)	(0.762)	(0.725)	(0.715)	(0.586)
INTFIRM	0.697 *	0.840 *	0.897 **	0.534 *	0.950 **
	(0.396)	(0.333)	(0.343)	(0.234)	(0.343)
AGE	0.040	0.047 *	0.042	0.042	0.042
	(0.028)	(0.028)	(0.027)	(0.027)	(0.027)
SIZE	2.750	1.827	1.761	1.751	1.763
	(1.016)	(1.072)	(1.058)	(1.056)	(1.077)
DIVERS	-3.919 **	-2.518 *	-2.397 *	-2.328 *	-2.449 *
	(1.228)	(1.191)	(1.295)	(1.308)	(1.290)
GOVOWN	-8.772 **	-12.989 ***	-12.491 ***	-12.292 ***	-12.642 ***
	(2.737)	(3.595)	(3.423)	(3.492)	(3.497)
PRIVOWN	2.012	1.588	2.052	1.925	2.371
	(1.569)	(1.581)	(1.725)	(1.692)	(1.756)
Interaction 1					
SIC*INTUPCOL				2.252 *	
				(2.987)	
SIC*INTFIRM				0.406 *	
				(0.324)	
Interaction 2					
SIC*DOMUPCOL					-0.039
					(0.893)
SIC*DOMFIRM					-1.251 *
					(0.708)
Intercept	-9.504	-7.005	-4.104	-3.206	-4.939
	(3.769)	(4.046)	(4.075)	(4.095)	(4.243)
N	897	897	897	897	897
Wald chi-square	28.7 ***	38.0 ***	40.5 ***	61.8 **	57.2 **
DF	7	9	11	14	14
QIC	5074	5041	5039	5039	5039
Pseudo R-square	0.27	0.30	0.30	0.31	0.29

Notes: Values in parentheses are std. errs. for the coefficient estimates. ***, **, and * represent significance at the 1%, 5%, and 10% levels, respectively.

Table 4.7: GEE-NB regression for PATAPP as DV conditioned on low-technology enterprises

Variables	(6)	(7)	(8)	(9)	(10)
R&DINT		-0.006	-0.005	0.013	-0.003
		(0.017)	(0.016)	(0.014)	(0.016)
TRAINEXP		0.118 ***	0.118 ***	0.118 ***	0.123 ***
		(0.029)	(0.029)	(0.028)	(0.029)
SIC			0.301	2.585 **	2.484 **
			(0.788)	(0.915)	(0.883)
SeIC			0.029	-0.221	0.148
			(1.345)	(1.339)	(1.358)
DOMUPCOL	-0.207	-0.572	-0.562	-0.546	-0.887 *
	(0.345)	(0.407)	(0.417)	(0.406)	(0.399)
INTUPCOL	2.385	1.253	1.240	3.136 *	1.259
	(2.260)	(1.937)	(1.940)	(1.811)	(1.965)
DOMFIRM	0.698	-0.261	-0.265	-0.350	2.572
	(0.525)	(0.515)	(0.520)	(0.528)	(2.159)
INTFIRM	2.339 ***	1.882 **	1.881 **	0.244 *	1.895 **
	(0.596)	(0.581)	(0.579)	(0.242)	(0.579)
AGE	0.002	0.004	0.003	0.009	0.004
	(0.017)	(0.016)	(0.015)	(0.015)	(0.015)
SIZE	1.300 ***	0.254	0.249	0.295	0.213
	(0.363)	(0.407)	(0.410)	(0.403)	(0.398)
DIVERS	-2.825 *	-3.057 *	-3.083 *	-3.625 *	-3.054 *
	(1.292)	(1.316)	(1.321)	(1.413)	(1.289)
GOVOWN	-3.558 *	-6.981 ***	-7.024 ***	-7.322 ***	-6.847 ***
	(1.861)	(1.712)	(1.661)	(1.607)	(1.667)
PRIVOWN	1.939 *	0.144	0.112	-0.345	0.335
	(0.991)	(0.941)	(0.945)	(0.936)	(0.948)
Interaction 1					
SIC*INTUPCOL				-2.249	
				(2.593)	
SIC*INTFIRM				1.817 **	
				(0.556)	
Interaction 2					
SIC*DOMUPCOL					0.311
					(0.696)
SIC*DOMFIRM					-3.193
					(2.153)
Intercept	-6.521 ***	-1.845	-2.052	0.756	-4.225 *
	(1.376)	(1.559)	(1.874)	(1.630)	(2.137)
N	1224	1224	1224	1224	1224
Wald chi-square	62.2	104.3 ***	105.7 ***	87.2 ***	105.3 **
DF	7	9	12	14	14
QIC	6429	6361	6365	6352	6365
Pseudo R-square	0.38	0.39	0.39	0.39	0.39

Notes: Values in parentheses are std. errs. for the coefficient estimates. ***, **, and * represent significance at the 1%, 5%, and 10% levels, respectively

4.5 Conclusion and implications

Innovation performance is a long-term target that requires continuous systematic efforts by firms, and is an output of several interrelated independent variables. The NIS and RBV theories help in identifying the innovation determinants in terms of the firm's internal resources and contextual factors. Prior studies have recognised the importance of external knowledge in firms' innovation, but these investigations are limited in emerging markets. In this paper we develop an integrated model that provides an analysis of the impact of policies and knowledge sources on innovation performance. The key findings reveal that international upstream and downstream collaborations enhance innovation performance, since collaboration with distant partners is more beneficial, and increases the probability of firms accessing innovative, up-to-date scientific knowledge and resources (Berchicci, et al., 2013). The present study makes a contribution to the existing literature about the moderating role of innovation policies in strengthening the relationship between distant collaborations and the innovation performance of firms in emerging markets. The relationship between staff training initiatives and international collaborations and innovation performance are strongly inter-related.

These findings have a number of implications for policy-makers in generating change and developing strategies for enhancing the effectiveness of innovation support schemes. These results suggest that there is a need for policy-makers to formulate policies that consider the national, economic, and institutional environments which enhance university-firm collaborations. The results indicate that Indian firms do not show great interest in domestic collaborations, as in most cases the coefficients are insignificant or negatively significant. Therefore, governments should consider implementing policies to improve the research quality of domestic or regional universities and think-tanks by facilitating an environment that links the regional institutions and knowledge-bases in developed countries around the world, which will further enhance the innovativeness of local institutions, enabling firms to utilise the talent of domestic upstream partners (Hess & Rothaermel, 2011; Kafouros, et al., 2015). Government innovation support in terms of SeIC seems to have had no impact on firm innovation, hence, formulation of policies that create favourable sectoral conditions are suggested in order to improve the innovativeness of sectors in general, and firms in particular. In summary, depending on the firm and sector level, internal, external and contextual determinants, firms in an emerging country such as India can enhance their innovative performance to become more competitive in the globally interconnected economy.

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Chapter 5

Linking innovativeness and firm performance: the mediating role of external collaborations

Abstract: The literature on innovation economics examines the innovation-performance nexus and confirms a positive relationship. The present research explores this topic by developing links between absorptive capacity, external collaborations, innovation and performance. A few recently published empirical studies analyse these relationships together, however, this chapter examines those links with a knowledge-based view (KBV) theoretical framework using a sample of 707 Indian enterprises. We test the hypothesised relationships by modelling a system of structural equations using the partial least squares path modelling (PLS-PM) technique. The results show that (i) absorptive capacity directly and indirectly relates to innovation and firm performance respectively, and (ii) supporting the literature, this chapter confirms the positive effect of innovation on business performance. An additional contribution of this research is in showing how, by focusing on external collaborations, light may be shed on this relationship. This chapter also shows that external knowledge collaborations partially mediate the link between innovation and firm performance. Thus suggesting that an increase in the number of external alliances improves firm innovativeness and, in turn, positively affects business performance.

Keywords: innovation, firm performance, external collaborations

JEL codes: L25, O32, P13

5.1 Introduction

The idea that firm performance is linked to innovation has become a sort of axiom among academics, economists, managers and policy-makers in recent years. The empirical literature in industrial economics highlights, both in emerging and developed economies, that firms are operating in an environment characterised by global competition, knowledge-intensiveness, changing customer and supplier expectations, rapid technological developments, and uncertainty (Naranjo-Valencia, et al., 2016; Grünbaum & Stenger, 2013; Serrano-Bedia, et al., 2012). Within the context of a globally competitive environment, innovation has become one of the key determinants influencing the long-term growth and wealth creation of modern organisations (Ko, et al., 2011; Wu, 2011; Srinivasan, et al., 2009; Weerawardena, et al., 2006).

Following the financial meltdown experienced by the world economy in 2009, the OECD (2010; 2015) highlights the potential of innovation to promote quick economic recovery and sustainable growth, and the crucial role of innovation both at the national and firm levels. Since the 1920s, economists have considered innovation as one of the vectors of economic progress (Grupp, 1998) and researchers started linking the relationships between innovation and firm performance after the seminal article by Solow (1957). An innovative firm achieves competitive advantage, which is vital for its survival (Damanpour & Gopalakrishnan, 2001); gains greater market share (Juran, 1993); generates innovative products (Drucker, 1984); and realises better financial performance (Lee, et al., 2015; Liao & Rice, 2010).

Scholars researching the links between innovation and firm performance have long been interested in understanding the crucial role of external collaborations[32], while also considering knowledge-sourcing efforts such as the "locus of innovation"[33] (Ahuja, 2000). Exploring external collaborations is considered to be crucial for firms in emerging economies (Pai, et al., 2012) where infrastructure and institutions are not as efficient or world-class as those of Western countries, hence they mostly rely on external partnerships for modern technologies and knowledge acquisition (Peng, et al., 2008). In the mainstream literature, the influence of *internal* innovation abilities on firm innovativeness and performance have been well researched, and this wealth of empirical research provides support for a positive relationship; while the role of *external* knowledge sources remains under-researched in the context of emerging economies (Chadee & Raman, 2012; Powell, 1998). Technological alliances play an important role in the economic success of several East Asian economies, such as in China and Taiwan, where collaboration with universities and firms from developed countries is seen as a crucial developmental tool (Dodgson, et al., 2006). Lee et al. (2015) argue that there is an inverse relationship between external partnerships and a firm's ability to adopt new technologies and develop new products, which means that firms with more external partnerships are also more likely to adopt advanced technologies from partners and to develop new products, and vice versa. The internationalisation of collaboration activities and increasing global innovation competition pushed firms from one of the emerging countries, India, to look

[32] External collaborations provide access to the new scientific knowledge and technologies that usually reside beyond the firm's boundaries, and this complements the firm's in-house R&D capabilities and innovation base (Wang, et al., 2015).

[33] "…when the knowledge base of an industry is both complex and expanding and the sources of expertise are widely dispersed, the locus of innovation will be found in networks of learning, rather in individual firms" (Powell, et al., 1996, p. 116).

towards developing and maintaining external alliances, which was found to be an integral feature of the competitiveness of Indian enterprises (Chadee, et al., 2011). Due to intensified global competition, Indian enterprises increasingly rely on alliances with international and domestic universities, research centres, and inter-firm collaborations to improve their innovation base. Jacob et al. (2013) show that during the period 2004-08, more than a third of international partnerships involved firms in emerging economies. Researchers (2012) believe that maintaining external collaborations does not necessarily lead to innovation and superior firm performance unless they are properly utilised by a firm's own innovative capabilities. Therefore, we believe that the relationship between innovation and firm performance becomes stronger when firms have more external collaborations.

Despite the importance given to collaborations and their critical role in mediating the relationship between innovation and firm performance, only a little empirical research evidence is available in the literature (Schøtt & Jensen, 2016; Kalmuk & Acar, 2015). For example, Greco et al. (2016), Wang et al. (2015), and Oke and Kach (2012) analyse the effects of external partnerships on firm performance. Lee et al. (2015), Roxas et al. (2014) and Nybakk (2012) examine the links between external knowledge partners, innovativeness and firm performance, but they ignore the mediating role of external collaborations between these two variables. It is evident from the empirical literature that there is a need to address this gap and has been highlighted in some recent studies (López-Nicolás & Meroño-Cerdán, 2011; Oke & Kach, 2012; Jiménez-Jiménez & Sanz-Valle, 2011; Zheng, et al., 2010; Kalmuk & Acar, 2015).

To address this gap in the innovation literature, our main objective in this paper consists of (i) verifying the positive influence of innovation on firm performance; (ii) explaining the mediating effects of external knowledge partnerships on the relationship between firm innovativeness and performance. The examination of the mediating role of external knowledge sources is particularly meaningful in the given research context because previous studies analyse the direct influence of innovation and/or knowledge actors on firm performance; and (iii) this study extends the complementary analysis of external knowledge sources and knowledge-based perspectives to study the influence of external collaborations on firm innovativeness and performance, by incorporating various collaborative factors (domestic and international collaborations) in a coherent model. The influence of external collaborations needs to be fully investigated in relation to its effects on the firm's innovation outputs and financial performance in the context of an emerging economy such as India, due to the

institutional environment where the firms tend to rely on formal or informal partnerships for knowledge and technology acquisition (Pai, et al., 2012; Peng, et al., 2008). Hence, the present research represents a replication with extension by exploring the strategic role of external collaborating partners and their mediating influences on firm innovativeness, which in turn lead to superior firm financial performance. By discussing this, the chapter proposes that when faced with knowledge requirements in the long term, managers should focus on specific knowledge sources and develop respective strategies for the sustainable growth of the organisations.

The remainder of the chapter is structured as follows. The Section 5.2 introduces the theoretical foundations, literature, and hypothesis development. The Section 5.3 presents the research design and data sources. The results are then explained and discussed based on the path analysis method in Section 5.4. The last section concludes the findings and explains their implications for practice and further research.

5.2 Theoretical background and hypotheses development

Changes in the innovation strategies of firms have led to a focus on collaborative efforts to access external knowledge (Jacob, et al., 2013; Kang & Kang, 2010). The prior literature focuses on the fact that firms collaborate to overcome the problem of scarce resources, and that advanced technologies and knowledge obtained from external partners is a key determinant of a firm's technological ability and efficiency (Wang, et al., 2015; Lee, et al., 2015). Results from studies in this context highlight how "open innovation" (external collaborations) complement the firm's in-house R&D activities, which in turn, enhances financial performance (Sisodiya, et al., 2013; Parida, et al., 2012; Powell, et al., 1996; Garriga, et al., 2013; Laursen & Salter, 2006). Given the importance of technological alliances in improving innovativeness and performance, several researchers (Greco, et al., 2016; Lee, et al., 2015; Roxas, et al., 2014; Jacob, et al., 2013; Thornhill, 2006; Darroch, 2005; Kim & Lui, 2015) have attempted to identify the influence of external collaborations in enhancing firm innovation outputs and performance.

The extension of the resource-based view (RBV)[34] (Barney, 1991) led to the emergence of the knowledge-based view (KBV) of the firm, which posits that knowledge is a strategically important intangible resource for sustained competitive advantage (Spender & Grant, 1996). The competence of the organisation depends not only on in-house R&D capabilities but also on the knowledge and technologies acquired from interaction with external academic or research organisations, and inter-firm collaborations (Grant, 1996; Spender, 1996). The KBV theorises that knowledge exploitation (from internal sources) and knowledge exploration (from external sources) are the main pillars for gaining an innovation advantage and achieving superior rates of return (Roxas, et al., 2014). The technologies and resources acquired from external partners come at a cost (Nonaka, et al., 2000), will have negative influence on firm performance in the short-term, but create long-term benefits through innovativeness (Díaz-Díaz, et al., 2008).

A firm's performance depends on how it generates, transfers and applies the developed or acquired knowledge over time (Grant, 1996; Spender, 1996). By extending this idea, in their knowledge-flow model DeCarolis and Deeds (1999) highlight the important contribution of organisational knowledge and demonstrate that external knowledge variables predict firm performance and the firm's absorptive capacity (ACAP)[35]. ACAP is critical for the continuous receiving of both internal and external knowledge-flows (Zahra & George, 2002). Motivated from the research of eminent scholars, such as Kostopoulos, et al. (2011); Mom, et al. (2007), this paper aims to examine the relation between ACAP and the complementary knowledge that a firm acquires from different sources including, for instance, universities, research institutions and competing firms, to accumulate external knowledge. In order to generate commercializable outputs, firms need to identify and exploit knowledge partners (Gottfredson, et al., 2005), whereas ACAP enables firms to recognise the skills and technology of external partners, and to acquire and assimilate the gained knowledge in concert with the firm's own capabilities to produce innovative outputs and experience better performance (Todorova & Durisin, 2007). Therefore, ACAP is considered as a main source of achieving competitive returns and advantage from external collaborations.

[34] A resource-based view highlights the importance of rate, inimitable and non-substitutable resources of the firm to the competitive advantage and performance (Barney, 1991).
[35] Absorptive capacity is a firm's internal capability to innovate by identifying, assimilating and exploiting in-house R&D and knowledge that is available in its own environment. ACAP helps firms in building a bridge between organisational capacity and external knowledge sources (Flatten, et al., 2011).

5.2.1 Absorptive capacity, external partners, and innovation

A firm's exposure to external partners contributes to the development of its future innovation capabilities and resource availability, promotes experiential learning, and improves the decision-making process (Kostopoulos, et al., 2011; Fosfuri & Tribó, 2008). When firms constantly develop and maintain close relationships with competing firms or with specialised research institutions, they are in a better position to assimilate advanced scientific knowledge, and such relationships help firms in understanding each other's unique knowledge competencies (Cohen & Levinthal, 1990). Hence, firms increase their incentives to build internal competencies, knowledge-processing capabilities, i.e. ACAP with the complementarity of the knowledge obtained from knowledge-intensive partners (Lofstrom, 2000; Kumar & Nti, 1998; Cepeda-Carrion, et al., 2012). Furthermore, access to complementary technical and scientific knowledge adds value to output, and enhances growth opportunities (Abecassis-Moedas & Mahmoud-Jouini, 2008; Zahra & George, 2002), which in turn stimulates the firm's ACAP. The discussion on the linkage between a firm's absorptive capacity and its external collaborations underscores the following hypothesis:

Hypothesis 1: A firm's absorptive capacity is positively related to complementary knowledge flows from external collaborators.

A high magnitude of ACAP facilitates a firm's achievement of superior innovation performance by promoting speed and frequency of innovation activities (Fosfuri & Tribó, 2008; Zahra & George, 2002), resulting in quick responsiveness to customers' expectations and thereby avoiding "competency traps" (Zahra & George, 2002). Also, a firm's continuous investment in exploring and exploiting new knowledge partners is more likely to strengthen the internal innovation base and create conditions that meet the requirements of the emerging markets (Lichtenthaler, 2009; Chen & Huang, 2009; Jansen, et al., 2006). In a similar fashion, Nonaka & Takeuchi (1995) suggest that existing internal capabilities coupled with acquired novel ideas and technologies convert into superior innovation products and services. At the same time, via this combination, firms may plan and implement innovative reforms to develop their product portfolio, understand key technologies, learn how to manage human resources, and develop strategies to stimulate creativity, resulting in well-established internal competencies and problem-solving skills. Thus, the high level of the firm's ACAP leads to the generation of higher innovation performance (Wu & Shanley, 2009). ACAP also works as a tool to transfer the necessary knowledge between different organisational units and via inter-

firm connections, contributing to the firm's and its partners' innovation performance (Kostopoulos, et al., 2011). Hence, corroborating the previous studies, we hypothesise that:

Hypothesis 2: A firm's absorptive capacity relates positively to innovation performance.

5.2.2 The collaboration effect on innovation

The last couple of decades have witnessed a substantial increase in the number of studies on collaboration, networks, and inter-firm cooperation in the innovation literature (Lee, et al., 2015; Leyden, et al., 2014; Parmigiani & Rivera-Santos, 2011; West & Bogers, 2014). As mentioned earlier, firms generally collaborate with external entities to overcome limitations of internal resources (Lee, et al., 2015), to strengthen technological ability (Ahuja, 2000), to reduce the risks involved in innovation activities (Tether, 2002), to commercialise products and services (Partanen, et al., 2014), to learn innovation processes (Love, et al., 2011; Love, et al., 2009), and ultimately, to achieve effective innovation performance (Lee & Wong, 2009; Lee, et al., 2001). Researchers and managers believe that scientific knowledge develops faster outside of firms rather inside. Therefore, firms continuously explore external relationships to access new knowledge and exploit new opportunities (Schøtt & Jensen, 2016; Naranjo-Valencia, et al., 2016; Lee, et al., 2015; Lee & Wong, 2009; Lee, et al., 2001). Collaborations also foster shared understanding, experiences and trust, which decrease intellectual barriers to the transfer of knowledge (Jensen & Schott, 2015).

However, innovation performance differences arise due to different kinds of partners (Schott & Sedaghat, 2014; Zeng, et al., 2010; DeCarolis & Deeds, 1999). Heterogeneous knowledge sources for firms are the main determinants of performance differences (Barney, 1991). Studies by Hemmert (2004), Vuola & Hameri (2006), and Nieto & Santamaría (2007) find that collaboration with academic and research institutes benefits innovation, whereas Nieto & Santamaría (2007) argue that partnering with competitors is detrimental. Therefore, firms select knowledge partners with regard to geographic location (national and international) and based on their knowledge requirements (Tödtling, et al., 2009; DeCarolis & Deeds, 1999). Since the economic activities of firms are increasingly globalised, studies on the influence of domestic and international collaborations on innovation have become more frequent (Kang & Park, 2012). A number of recent contributions have yielded inconsistent findings on this topic: Tether (2002) finds that domestic technological collaborations are useful in accessing local

technical expertise and serve as a means for expansion in emerging markets. In contrast, Marsh & Oxley (2005) show that domestic-based collaborations have a strong negative effect, but that international collaborations significantly positively influence a firm's innovation outcomes. In a study of Korean bio-technology small-to-medium enterprises (SMEs), Kang & Park (2012) find that both domestic and international partnerships significantly influence the patenting outcome, whereas the degree of the effect of international collaborations is much stronger than the effect of domestic collaborations. From an emerging economy's perspective, international collaborations can help them expand into new markets and create a common platform for their products and services (Ganesan & Kelsey, 2006; Sirmon & Lane, 2004). Based on these arguments above, we propose the following hypotheses:

Hypothesis 3a: The higher the magnitude of a firm's collaboration with domestic *partners, the higher the level of the firm's innovativeness.*

Hypothesis 3b: The higher the magnitude of a firm's collaboration with international *partners, higher the level of the firm's innovativeness.*

5.2.3 Innovation and firm performance

Innovation enables firms to respond effectively to high-speed change in business environments and changes in inter-firm dynamics (Jiménez-Jimenez, et al., 2008), and to achieve the goal of maintaining and improving firms' performance (Damanpour, et al., 2009). The extant literature on this topic considers innovation as one of the crucial factors for long-term business success. Despite the existence of detrimental effects and some conflicting evidence (Zhang, 2011; Darroch, 2005; Subramanian & Nilakanta, 1996; Capon, et al., 1990; Wright, et al., 2005), most empirical studies and theoretical arguments support the positive relationship between innovation activities and firm performance (Naranjo-Valencia, et al., 2016; Lee, et al., 2015; Roxas, et al., 2014; Kafetzopoulos & Psomas, 2015; Wang, et al., 2015; Camisón & Villar-López, 2014; Rhee, et al., 2010; Damanpour & Gopalakrishnan, 2001; Romijn & Albaladejo, 2002; Love, et al., 2011). Therefore, the hypothesis proposed is:

Hypothesis 4: Firm innovativeness is positively associated with firm performance.

5.2.4 Mediating path of external collaborations

Prior research supports the concept of a direct causal relationship between external knowledge sources and performance and also between external knowledge and innovativeness.

However, the literature shows that interrelations among these constructs have not been modelled yet. In order to study the relationship between external collaborations, innovation and firm performance in greater depth, this paper analyses the likely mediating effect of collaborations on these relationships. The literature on external collaborations not only suggests a positive effect of collaborations on innovation and/or performance, but also argues that external knowledge plays a mediating role in the relationship between organisational innovation strategies, innovativeness, and organisational performance (Jiménez-Jiménez & Sanz-Valle, 2011; Zheng, et al., 2010; Kalmuk & Acar, 2015). No doubt, innovation is an expensive activity and involves a risk of increasing costs and uncertainty (Simpson, et al., 2006), but the firm's existing innovation base, coupled with a proactive external knowledge support, stimulates risk-taking capabilities, creativity and superior performance (Naranjo-Valencia, et al., 2016). Hence, firms can improve long-term business performance with an innovation-oriented knowledge focus. The literature suggests that when firms continuously network with academic and research institutes, R&D labs, and other firms in the value chain, they tend to implement new technologies, in turn improving innovation outcomes and performance. Conversely, when firms do not engage in external partnerships, the chances of exploiting new state-of-the-art knowledge and adopting new technologies will be low (Chang & Cho, 2008; Nonaka, 1994). Thus, coordination with external knowledge partners mediates the relationship between innovation performance and a firm's business performance. Based on these arguments, the hypothesis that we propose is:

Hypothesis 5a: External collaboration (domestic) mediates the relationship between innovativeness and firm performance, in such a way that innovativeness has a positive impact on collaboration, and in turn, has a positive influence on firm performance.

Hypothesis 5b: External collaborations (international) mediates the relationship between innovativeness and firm performance, in such a way that innovativeness has a positive impact on collaboration, and in turn, has a positive influence on firm performance.

Figure 5.1 presents the conceptual model and hypotheses of the study.

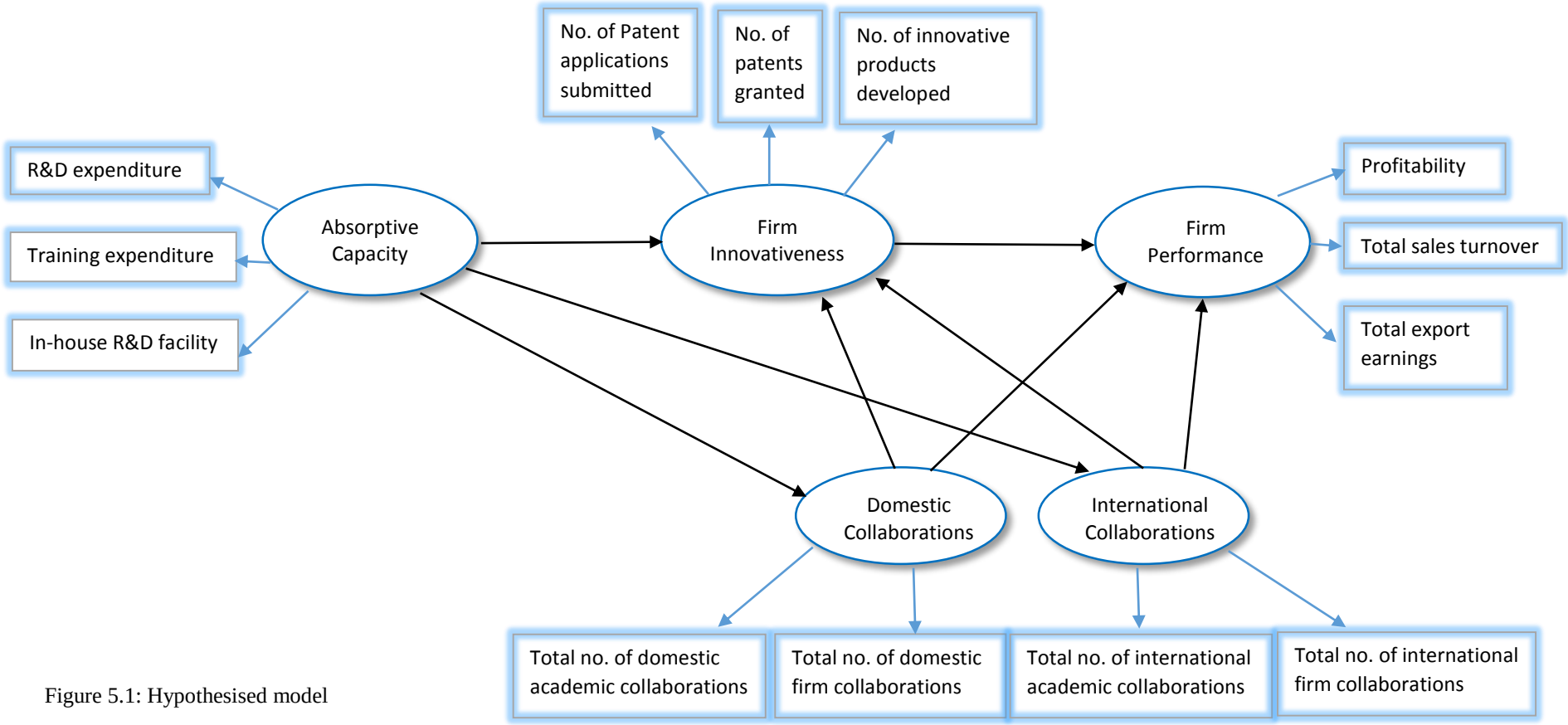


Figure 5.1: Hypothesised model

5.3 Methods

5.3.1 Data and sources

The data employed in this chapter are collected from the following sources: (i) the Indian Patent Office for information on patent applications and patent grants;[36] (ii) the Centre for Monitoring Indian Economy's (CMIE) *Prowess* database[37] (for firm-level indicators); (iii) the *Capitaline* database[38] (for the numbers of external collaborations); and (iv) the Department of Scientific & Industrial Research (DSIR), Government of India (GoI). The chapter uses data for the period 2012–2013, and the number of firms is 707, covering industries such as automotive, automobile ancillaries, biotechnology, information technology, petroleum, drugs and pharmaceuticals, electrical and electronics, machinery, equipment, agriculture & processed products, etc., based on the National Industrial Classification (NIC) 2008 codes. The *CMIE* and *Capitaline* databases contain firm-level data which includes economic and financial data, reports, information on training and development, employment, and so on.

For the analysis, the data were collected in two steps. In stage one, we collected the data for around 5,000 firms listed in the Bombay Stock Exchange, India. In the second stage, within this sample, 707 firms were considered against the following criteria: (i) as the sample comprises innovative firms, only those that reported R&D expenditure or performed R&D activities during the year were selected (Fosfuri & Tribó, 2008; Schmiedeberg, 2008; Cassiman & Veugelers, 2002); and (ii) firms with no missing values in training and development expenditures, profitability, total sales, export earnings, firm age, and total and net assets (Liao & Rice, 2010). By excluding the other firms from the sample that do not meet the selection criteria, we justify our model as one that seeks to investigate the innovation-performance nexus in the firms operating on a relatively sustainable basis. The additional information on the included variables, description and the sources of the data is presented in Table 5.1.

[36] See further at http://www.ipindia.nic.in. Accessed 15 January 2015.
[37] *Prowess* is a firm-level longitudinal database developed by the CMIE. It is similar to *Compustat* (the US firms database) and the *Financial Analysis Made Easy* (FAME) database on UK and Irish firms). *Prowess* contains information on around 28,000 firms (manufacturing, services and construction companies), with 3,500 data fields per company. The database has been increasingly used in the literature for firm-level analysis dealing with such issues as determinants of innovativeness, firm performance, etc. (Ghosh, 2012; 2009; Marin & Sasidharan, 2010).
[38] The data in the *Capitaline* database is compiled from the audited annual reports of more than 10,000 listed and unlisted enterprises in India.

Table 5.1: Description of variables

Dimension	Variables	Description	Source
Absorptive Capacity	Training expenditure (TRAINEXP)	Total expenditure on staff training activities	CMIE
	R&D spending (R&DSPEND)	Total expenditure on R&D activities	CMIE
	In-house R&D facility (INHR&D)	1 if own R&D facility, otherwise 0	DSIR, GoI
Innovativeness	Patent applications (PATAPP)	Number of patents applied to IPO	IPO, GoI
	Patent Grants (PATGRANT)	Number of patents granted by IPO	IPO, GoI
	Innovative products (INNVPROD)	Number of innovative products developed	CMIE
Domestic collaborations	Upstream collaborations (DOMUPCOL)	Total number of collaborations with domestic universities, R&D institutes, and think-tanks	*Capitaline*, Firm's websites & annual reports
	Downstream collaborations (DOMDOWNCOL)	Total number of collaborations with domestic firms	*Capitaline*, Firm's websites & annual reports
International collaborations	Upstream collaborations (INTUPCOL)	Total number of collaborations with international universities, R&D institutes and think-tanks	*Capitaline*, Firm's websites & annual reports
	Downstream collaborations (INTDOWNCOL)	Total number of collaborations with international firms	*Capitaline*, Firm's websites & annual reports
Firm performance	Profitability (PROF)	Firm's profitability (profit after tax)	CMIE
	Turnover (TURN)	Firm's total turnover	CMIE
	Export earnings (EXPREV)	Export earnings ratio	CMIE
Control variables	Age (AGE)	Firm's age in number of years	CMIE
	Size (SIZE)	Logarithm of total assets	CMIE
	Diversification (DIVERS)	1 if diversified, otherwise 0	CMIE

5.3.2 Variables definition and measurement

The theoretical background and hypotheses developed in Section 2 provide the basis for the selection of constructs or latent variables (LVs) and measures. Numerous studies were explored from the innovation, performance, and external collaboration literatures to identify the selected constructs and measures for the study. A list of variables in each construct and measurement is presented in Table 5.1.

5.3.2.1 Absorptive capacity

Researchers have adopted both quantitative and qualitative items to measure the latent variable (LV) absorptive capacity (ACAP). Quantitative measures are, for instance, R&D

expenditures, R&D intensity (i.e. $\frac{R\&D_{expenditure}}{Total\ sales}$) (Tsai, 2001); firm's investment in technical training (Mowery & Oxley, 1995); availability of technical personnel to the total workforce (Spanos & Voudouris, 2009); operational in-house R&D departments as dummy variable, 1 for having in-house R&D, 0 otherwise (Cassiman & Veugelers, 2002); and number of staff having tertiary education (Grimpe & Sofka, 2009). The qualitative approaches used include self-reporting measures (questionnaires or poll surveys) (Jansen, et al., 2005; Lichtenthaler, 2009) to measure the ACAP. In this paper we follow the works of Kostopoulos, et al. (2011) and Escribano, et al. (2009) in developing the LV of ACAP with the principle components being (i) firm's total R&D spending; (ii) investment in human resources skill development training programmes; and (iii) a dummy variable that equals to 1 if the firm has an in-house R&D department, or 0 otherwise. This construct is based on a firm's R&D expenditures, training and innovation activities, which are considered to be the key features of measurement of ACAP (Zahra & George, 2002). The composite reliability coefficient (CRC) and average variance extracted (AVE) of the measure ACAP is shown in Table 4, which covers the abovementioned items: ($\rho_c^{CRC} = 0.66, \rho_c^{AVE} = 0.50$).

5.3.2.2 Firm innovativeness

Prior research measures firm innovativeness in a variety of ways: as output (new products developed, number of patents applied, patents granted) and input (R&D expenditure), and with timing (e.g. pioneers, quick seconds or late followers) (Manu, 1992; Naranjo-Valencia, et al., 2016; Lejpras, 2009; Donate & de Pablo, 2015). This paper measures this LV via the output indicators, such as number of patent applications submitted, number of patents granted and new products developed. The confirmatory factor analysis (Table 4) suggests the use of these three items in measuring firm innovativeness ($\rho_c^{CRC} = 0.80, \rho_c^{AVE} = 0.58$).

5.3.2.3 External collaborations

External collaboration refers to the extent to which firms' collaborate with external knowledge or technology partners, such as universities and institutes, research centres, R&D labs, and with other firms in the same value chain. We use the total number of collaborations as the measure of external collaborations, and further categorise these into two subprocesses: domestic and international. Each category consists of two items, such as academic or research collaborations and inter-firm collaborations, to measure the impact of different external knowledge sources on ACAP, innovation, and performance. The confirmatory factor analysis

shows the CRC and AVE of these subprocesses: ($domestic\ collaborations\ \rho_c^{CRC} = 0.81, \rho_c^{AVE} = 0.68, and\ international\ collaboraitons\ \rho_c^{CRC} = 0.84, \rho_c^{AVE} = 0.72$).

5.3.2.4 Firm performance

The extensive literature on this topic provides a choice of appropriate firm performance measures including profitability, sales growth, market share growth, return on investment, return on assets, export earnings, export growth, exports as a percentage of total sales, firm productivity ($Total\ turnover/Number\ of\ employees$), pre-tax profits or losses, etc. (Roberts & Grover, 2012; Oke & Kach, 2012; Chadee & Raman, 2012; Bong Choi & Williams, 2013). In line with the literature, the following three indicators of firm performance are utilised in this paper to assess the influence of innovation on firm performance: profitability (profit after tax), total sales turnover and export earnings ($\rho_c^{CRC} = 0.67, \rho_c^{AVE} = 0.51$).

5.3.2.5 Control variables

We include measures of firm characteristics as the control variables, with the indicators being: firm's age (years from the firm's inception), size (log of total assets), and business diversification (a dummy variable that equals to 1 if the firm has diversified businesses, or 0 otherwise). Researchers who focus on innovation studies use age as one factor in the studies to derive its impact on innovation and performance. It is believed that firm size affects innovation and performance as larger firms usually have more resources and larger knowledge bases. With regard to diversification, researchers provide both positive and negative results (Jarrar & Smith, 2011).

5.3.3 Methodology

The chapter uses partial least squares path modelling (PLS-PM), a subset of structural equation modelling (SEM), to estimate both the main research model and mediation effects[39]. The PLS method is selected for this chapter for the following reasons: it is a variance-based, distribution free and prediction-oriented method (Fornell & Cha, 1994; Chin, et al., 2003), and can also simultaneously assess the measurement model and the theoretical structural models

[39] The PLS approach to prediction occurs iteratively; each step minimises the residual variance of the observed dependent variables to obtain parameter estimates. The PLS approach calculates the significance of each path in the model using a t-test. PLS does not need to assume that the dependent variables conform to any particular distributions. Bootstrapping is used to evaluate the statistical significance of estimated paths. If a path is found to be statistically significant, then the null hypothesis for that path can be rejected, and the statistical model can be interpreted as providing empirical support for the hypothesis represented by the path (Lowry & Gaskin, 2014).

(Chin, 1998). Furthermore, PLS is an appropriate method for resolving the problems of multicollinearity among the observed variables, as the measurement models are operationalised as formative blocks (Chin, et al., 2003; Kock, 2011; Lowry & Gaskin, 2014). Evaluation of the structural model occurs by the coefficient of determination (R^2) of the LVs and the values of 0.19, 0.33, or 0.67 are classified as weak, moderate, or substantial, respectively (Chin, 1998). Finally, when firms are subprocessed into different industrial sectors to examine how business performance is being influenced by innovation in different sectors, the sample size is considerably low (Agriculture & food processing (n=60); Auto & ancillary (n=70); Electronics (n=46); Machinery & equipment (n=57); Drugs & pharmaceuticals (n=88); and Steel & metals (n=41)) for a covariance-based SEM approach, which works well with more than 200 sample size. PLS works particularly well with the small sample sizes (Henseler, et al., 2016; Reinartz, et al., 2009; Hair, et al., 2013).

The method typically takes place in two stages. The first step is to evaluate the measurement model using confirmatory factor analysis to assess the reliability and validity of the LVs. The second step involves the estimation of the structural model or the path model, which examines the associations between the constructs in the research model. SmartPLS 3.0 was used to analyse the measurement model and structural models. Many studies in the recent literature (Donate & de Pablo, 2015; Roxas, et al., 2014; Liao & Rice, 2010; Santos, et al., 2014; Liao, et al., 2008; Nybakk, 2012; Feng, et al., 2014; Gunday, et al., 2011; Lee, et al., 2015; Zeng, et al., 2010) use this technique in examining the innovation and performance nexus.

5.4 Data analysis and results

The key constructs of this study are absorptive capacity, firm innovativeness, collaborations and firm performance. Tables 5.2 and 5.3 provide the univariate descriptive statistics and correlation matrix respectively for the variables. As observed in the literature, external collaborations are positively associated with absorptive capacity. Furthermore, positive correlations are found between absorptive capacity and innovativeness, and innovation and firm performance.

Table 5.2: Descriptive statistics

Variable	Mean	Std.dev
TRAINEXP	15.67	64.30
R&DSPEND	18.88	89.35
INHR&D	0.61	0.49
PATAPP	2.80	13.22
PATGRANT	0.37	2.56
INNVPROD	5.51	5.67
DOMUPCOL	0.45	1.27
DOMDOWNCOL	0.80	1.60
INTUPCOL	0.16	0.58
INTDOWNCOL	2.02	3.15
PROF	308.00	1560.00
TURN	4330.00	24400.00
EXPREV	796.00	7840.00
AGE	2.25	0.52
SIZE	2.81	0.84
DIVERS	0.03	0.17

Table 5.3: Correlation matrix

	(1)	(2)	(3)	(4)	(5)
1.Dom Col					
2.Innovativeness	0.36				
3.Firm Perform	0.39	0.41			
4.ACAP	0.56	0.57	0.62		
5.Int Col	0.44	0.55	0.41	0.51	

5.4.1 Measurement model

Prior to testing the hypotheses, we assessed the validity of the measurement model in Tables 5.4 and 5.5, which show the convergent and discriminant validity of all values, indicating acceptable reliability (Hair, et al., 2013). The measurement model fits the data well, indicating the positively significant t-values of items in their corresponding constructs at $p < 0.05$. The test for convergent validity examines the average variance extracted (AVE), showing that the values of AVE, which range from 0.52 to 0.72, are all above the evaluation criteria of 0.50, suggesting that the items are suitable to explain the variance in the constructs. In addition, the weights and loading of all the measures display significant loadings at $p < 0.05$. The composite reliability coefficients (CRC) for the constructs are considered acceptable at 0.60 (Hair, et al., 2013; Fornell & Larcker, 1981), suggesting that high internal reliability exists in the constructs (Fornell & Larcker, 1981; Kock, 2011). The model fit criterion implemented for

PLS-PM is the standardized root mean square residual (SRMR). A value of 0 indicates a perfect fit and a cut-off value of 0.08 is considered adequate (Hu & Bentler, 1999). The results in the measurement model show a SRMR value of 0.072 indicating an acceptable fit.

The discriminant validity shows the extent to which measures of a particular construct differ from others in the same model. For adequate discriminant validity, the diagonal elements of the correlation matrix should be greater than the off-diagonal elements in the corresponding rows and columns (Fornell & Larcker, 1981; Roldán & Sánchez-Franco, 2012). Table 5.5 shows that the measurement model demonstrates adequate discriminant validity, implying that the various constructs used in the model belong to distinct and separate entities. As a check for multicollinearity between the items, we calculate variance inflation factor (VIF) scores for all manifest variables. Table 5.4 shows that all VIF scores were below 2, suggesting that they are within the acceptable threshold of 5 (Hair, et al., 2011).

Table 5.4: Results of the measurement model[a]

Construct	VIF	Weights	SL	SE	t-value[b]	CRC	AVE
Absorptive capacity	1.47					0.66	0.50
Training expenditure		0.77****	0.87****	0.02	44.35		
R&D spending		0.26****	0.45****	0.10	4.30		
In-house R&D facility		0.40****	0.54****	0.03	17.46		
Firm innovativeness	1.54					0.80	0.58
Patent applications		0.54****	0.83****	0.03	24.17		
Patent Grants		0.33****	0.74****	0.07	10.08		
Innovative products		0.44****	0.70****	0.07	10.24		
Domestic collaborations	1.16					0.81	0.68
Academic collaborations		0.48****	0.74****	0.05	14.16		
Firm collaborations		0.72****	0.90****	0.02	40.07		
International collaborations	1.26					0.84	0.72
Academic collaborations		0.53****	0.82****	0.05	16.96		
Firm collaborations		0.64****	0.88****	0.04	23.82		
Firm performance						0.67	0.51
Profitability		0.91****	0.95****	0.07	14.37		
Turnover		0.28****	0.57***	0.14	2.96		
Export earnings		0.26**	0.45**	0.17	1.97		
Control variables							
Age	1.03	1.00	1.00	0.00	0.00	1.00	1.00
Size	1.48	1.00	1.00	0.00	0.00	1.00	1.00
Diversification	1.01	1.00	1.00	0.00	0.00	1.00	1.00

Notes: VIF-variance inflation faction; SFL- standardized loading; SE-standard error; CRC-composite reliability coefficient; AVE-average variance extracted; ****P<0.001, ***P<0.01, **P<0.05, *P<0.1

[a] See Table 1 for a detailed description of items; [b] Absolute t-values greater than 1.96 are two-tailed significant at the 5% level; [d] Percentage of variance of item explained by the latent variable.

Table 5.5: Discriminant Validity[a]

	Dom Coll	Innovat	Firm Perf	ACAP	Int Coll
Dom Coll	**0.825**				
Firm Innovat	0.364	**0.758**			
Firm Perf	0.387	0.413	**0.623**		
ACAP	0.565	0.573	0.621	**0.646**	
Int Coll	0.444	0.553	0.411	0.515	**0.851**
Size	0.480	0.421	0.414	0.491	0.441

[a] Discriminant validity $= \frac{(\sum \lambda_k^2)}{(\sum \lambda_k^2)+\sum \mathrm{var}(\varepsilon_k)}$

The predictability of the structural model is evaluated by means of the R^2 values of the endogenous variables. Figure 5.2 shows that the R^2 value for the endogenous constructs exceeds the minimum value of 0.1 recommended by Falk & Miller (1992); Innovation $R^2 = 0.43$, and Performance $R^2 = 0.31$. The PLS method does not require the use and estimation of traditional goodness-of-fit (GoF) measures (Hulland, 1999), however, different software packages such as EQS, LISREL, WarpPLS, SmartPLS, and AMOS, have promoted the development of such criteria (Camisón & Villar-López, 2014). The GoF index is calculated by taking the square root of the AVE of the latent constructs and the R^2 values of the endogenous variables, where the index varies between the values of 0-1 and a minimum threshold value of >0.31 is recommended (Tenenhaus, et al., 2005). In this analysis, the estimated GoF index value of 0.320 is above the minimum recommended value, ensuring the globally accepted quality of the model (Hair, et al., 2013). Furthermore, the blindfolding procedure in SmartPLS (shown in Table 5.6) estimates the cross-validation (CV) communality and redundancy indices to assess the predictive validity and fit, showing all the latent constructs statistics were >0, with positive values for CV-communality and redundancy indexes (Tenenhaus, et al., 2005).

Table 5.6: Quality of structural equation

	CV-communality	CV-redundancy
Innovation capabilities	0.05	0.10
Firm innovativeness	0.16	0.20
Domestic collaborations	0.11	0.21
International collaborations	0.19	0.18
Firm performance	0.03	0.09

5.4.2 Structural model

After estimating the predictive validity and fit of the structural equations, the proposed hypotheses were tested and the results of the analyses and path coefficients are presented in Table 5.7. Bootstrapping (5000 subsamples) provides the p-values to evaluate the statistical significance of relationships in the model (Tenenhaus, et al., 2005). The findings for (H_1) $(\text{ACAP} \rightarrow \text{Collaborations}; \beta = 0.39 \text{ \& } 0.43 \text{ for dom. coll and int. coll respectively}, p < 0.001)$ suggest that firm absorptive capacity has a positive, direct and significant relationship with external collaborations. The RBV theory provides support for external resources exploitation and the combination of existing capabilities, with the acquired external new knowledge more likely stimulates the firm's absorptive capacity. In addition, improving absorptive capacity is a dynamic process of learning from external knowledge partners and are not substitutes (Pai, et al., 2012).

The findings also provide support for (H_2) $(\text{ACAP} \rightarrow \text{Firm innovativeness}; \beta = 0.37, p < 0.001)$ showing the positive association between absorptive capacity and firm's innovation performance. Prior research on this topic indicated that although external technological relations are crucial for innovation performance, a large number of studies emphasise the importance of an in-house innovation base and internal technological inputs as vital factors to influence on firm innovativeness (Love & Roper, 2001). The results also provide empirical evidence supporting the significant indirect effect of absorptive capacity on firm performance $\beta = 0.22, p < 0.001$. This finding indicates that collaboration-orientation with ACAP (H_1), which has been theorised to contribute firm innovation, in turn accelerates sustainable competitive advantage.

The findings with regard to (H_{3a}) $(\text{Domestic collaborations} \rightarrow \text{Firm innovativeness}; \beta = -0.05, p < 0.791)$ and (H_{3b}) $(\text{International collaborations} \rightarrow \text{Firm innovativeness}; \beta = 0.33, p < 0.001)$ show a negative non-significant effect of domestic-based alliances on innovation performance but a significantly positive effect of international alliances on the firm innovativeness in the Indian context. The results corroborate the findings of Marsh & Oxley (2005). In addition, the magnitude of the influence of international collaborations on firm performance is higher than the effect of domestic partnerships. Taking into account the fact that collaborations also improves performance along with innovativeness, these results seem to reflect that knowledge collaborations mediate the relationship between innovation and performance.

Finally, the results for (H_4) (Innovation $\rightarrow$ Firm performance; $\beta = 0.19, p < 0.05$) suggest that innovation has a positive and significant effect on performance (profitability, turnover and export earnings), as it explains approximately 31% of the variation in firm performance (Figure 5.2), corroborating the widespread idea in the literature that in practice innovation is a key driver of competitiveness and superior performance.

With regard to the control variables, firm size is the most influential factor, positively and significantly related to collaborations, firm innovation, and performance. The significantly positive effect of firm size suggests that bigger firms usually have more resources and capabilities to invest in innovation, collaborations, therefore, obtain better performance.

Figure 5.2: Estimated coefficients of the hypothesised model

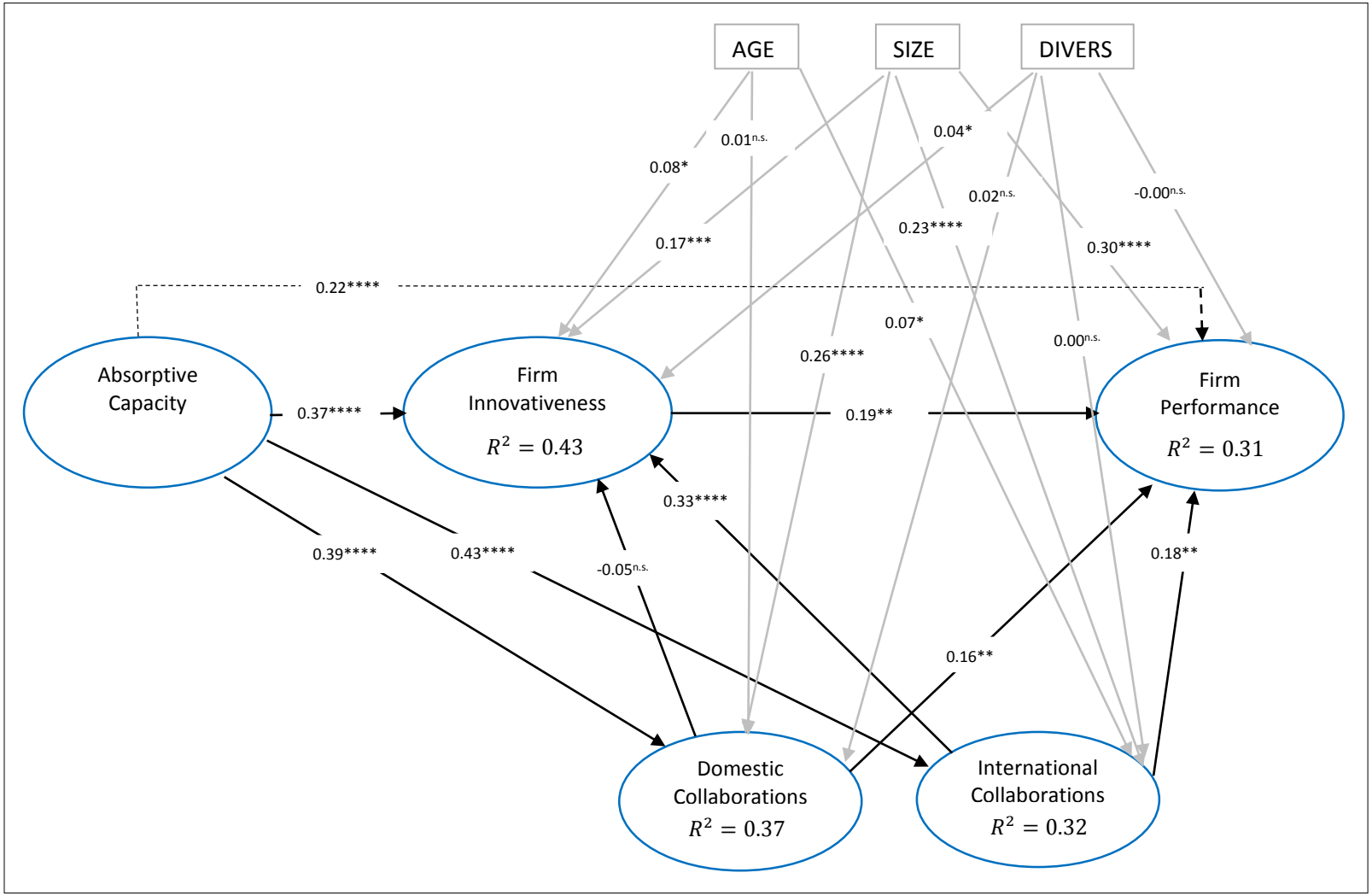


Table 5.7: Results of the structural equation model

	Decomposition of effects					
	Total effects		*Direct effects*		*Indirect effects*	
Structural path	**Standardized coefficient**	**t-value**	**Standardized coefficient**	**t-value**	**Standardized coefficient**	**t-value**
Hypothesised relationships						
Absorptive capacity → Domestic collaborations	0.39****	4.58	0.39****	4.58		
Absorptive capacity → International collaborations	0.43****	6.13	0.43****	6.13		
Absorptive capacity → Firm innovativeness	0.48****	5.27	0.37****	4.18	0.11***	2.28
Absorptive capacity → Firm performance	0.22****	3.55			0.22****	3.35
Domestic collaboration → Firm innovativeness	-0.05 n.s.	0.79	-0.05 n.s.	0.79		
Domestic collaboration → Firm performance	0.15**	2.08	0.16**	2.31	-0.01 n.s.	0.64
International collaboration → Firm innovativeness	0.33****	5.43	0.33****	5.43		
International collaboration → Firm performance	0.24**	2.25	0.18**	2.39	0.06**	2.04
Firm innovativeness → Firm performance	0.19**	2.06	0.19**	2.06		
Non-hypothesised relationships (control variables)						
Age → Firm innovativeness	0.08*	1.82	0.05 n.s.	1.37	0.02*	1.76
Age → Firm performance	0.03*	1.96			0.03*	1.96
Age → Domestic collaboration	0.01 n.s.	0.42	0.01 n.s.	0.42		
Age → International collaboration	0.07**	2.10	0.07**	2.10		
Size → Firm innovativeness	0.17****	3.38	0.10***	2.52	0.06**	2.95
Size → Firm performance	0.30****	7.62	0.19****	4.21	0.11****	4.46
Size → Domestic collaboration	0.26****	5.28	0.26****	5.28		
Size → International collaboration	0.23****	5.42	0.23****	5.42		
Diversification → Firm innovativeness	0.04*	1.70	0.04*	1.65	0.00 n.s.	0.04
Diversification → Firm performance	-0.00 n.s.	0.04	-0.01 n.s.	0.22	0.01 n.s.	1.20
Diversification → Domestic collaboration	0.02 n.s.	0.61	0.01 n.s.	0.61		
Diversification → International collaboration	0.00 n.s.	0.13	0.00 n.s.	0.13		
Goodness-of-fit statistics						
R squares (Innovation & Performance)	0.432 & 0.310					
GoF	0.320					

Notes: ****P<0.001, ***P<0.01, **P<0.05, *P<0.1, n.s.-non-significant at the 10% level.

To shed more light on the mediated relationships hypothesised in the (H_{5a}) and (H_{5b}), we examined the mediating role of external collaborations in the link between innovation and performance. We used the method recommended by Preacher & Hayes (2008), which estimates the indirect effect between the predictor and the criterion variables through the mediator using a bootstrapping technique. Table 5.8 reports the findings from Sobel (1987) test, Goodman and Arion tests[40] indicate that the model presented is a partially significant mediated model confirming hypotheses (H_{5a}) and (H_{5b}). The results of this analysis are presented in Figures 5.3 and 5.4. These findings provide support that international collaborations is most important element among the constructs domestic and international collaborations, which found to have a stronger effect in linking firm innovativeness and performance.

Table 5.8: Mediation effect of external collaborations

Hypothesis		**Decision**
H_{5a}	Sobel t-Test: $SE_{\text{indirect effect}} = 0.031, z-score = 2.863; p < 0.01$ Goodman test: $SE_{\text{indirect effect}} = 0.030, z-score = 2.879; p < 0.01$ Arion test: $SE_{\text{indirect effect}} = 0.031, z-score = 2.847; p < 0.01$	Partial Mediation
H_{5b}	Sobel t-Test: $SE_{\text{indirect effect}} = 0.053, z-score = 3.258; p < 0.001$ Goodman test: $SE_{\text{indirect effect}} = 0.052, z-score = 3.274; p < 0.001$ Arion test: $SE_{\text{indirect effect}} = 0.053, z-score = 3.242; p < 0.001$	Partial Mediation

[40] Sobel proposed an approximate test of the standard error using the following formula:

$$z_{value} = a * b / \sqrt{b^2 s_a^2 + a^2 s_b^2}$$

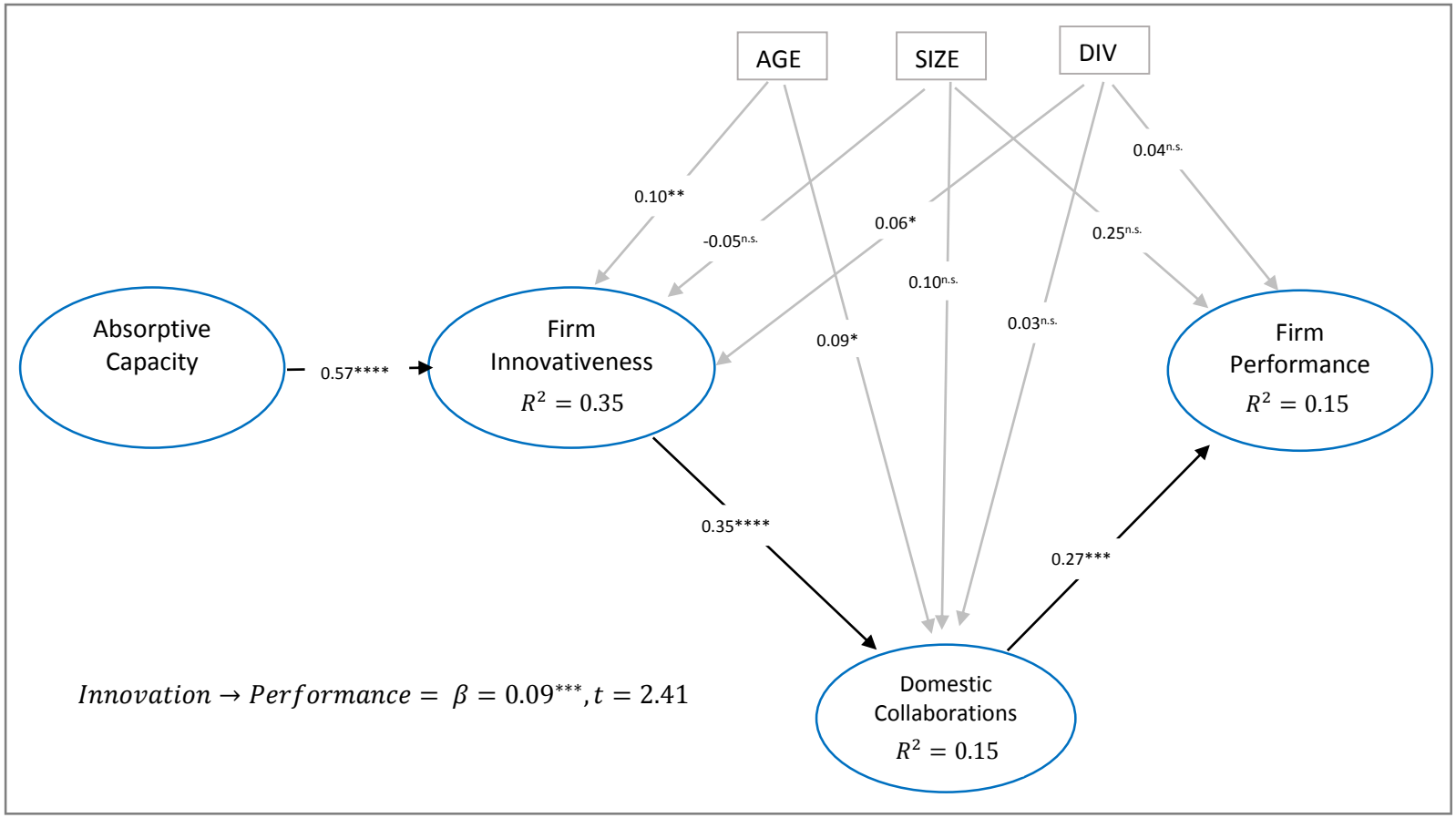
Goodman test equation:

$$z_{value} = a * b / \sqrt{b^2 s_a^2 + a^2 s_b^2 - s_a^2 s_b^2}$$

Arion test equation:

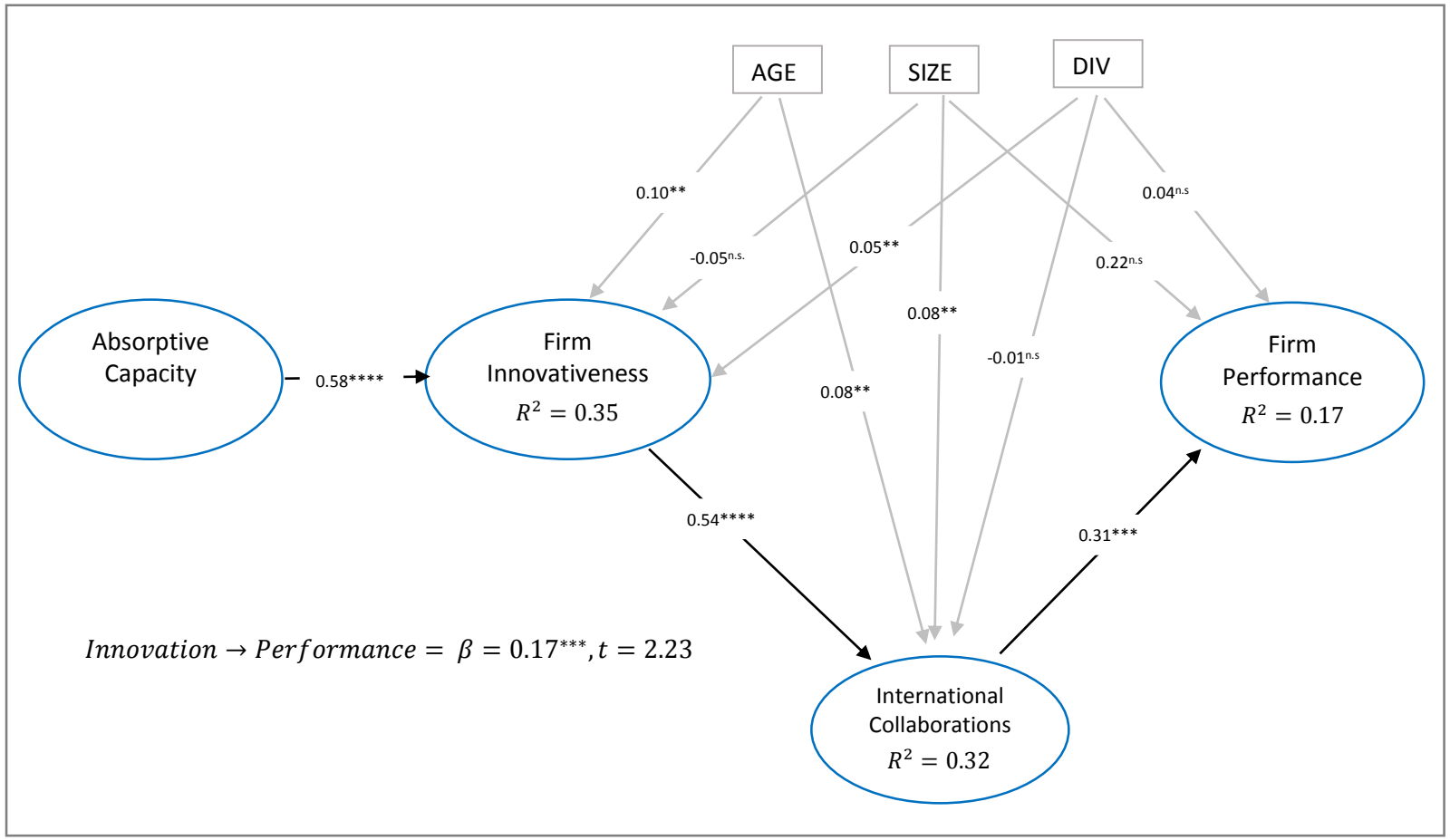
$$z_{value} = a * b / \sqrt{b^2 s_a^2 + a^2 s_b^2 + s_a^2 s_b^2}$$

Figure 5.3: Mediated model with domestic collaborations



Note: ****P<0.001, ***P<0.01, **P<0.05, *P<0.1, n.s.- non-significant

Figure 5.4: Mediated model with international collaborations



Note: ****P<0.001, ***P<0.01, **P<0.05, *P<0.1, n.s.- non-significant

5.4.3 Sectoral analysis

The sectoral analysis provides key information that economists and policy-makers can use to examine the innovative activities and competitiveness of firms, which can lead to the development of public policy (Oltra & Saint Jean, 2009). Turning now to the sectoral analysis aspect of this study, firms are chosen from different industrial sectors, with particular focus on how performance is influenced by firm innovativeness in the following identified sectors: Agriculture & food processing (n=60); Auto & ancillary (n=70); Electronics (n=46); Machinery & equipment (n=57); Drugs & pharmaceuticals (n=88); and Steel & metals (n=41). Table 5.9 shows the PLS estimation results of the structural model for different sectors.

Table 5.9: Sub-sector analysis

Variable	Agriculture & food processing (n=60)	Auto & ancillary (n=70)	Electro-nics (n=46)	Machinery & equip-ment (n=57)	Drugs & pharma (n=88)	Steel & metal (n=41)
Absorptive capacity → *Domestic collaborations*	0.52**** (4.82)	0.45*** (3.01)	0.79**** (3.87)	0.37** 2.19)	0.60**** (4.54)	0.64*** (3.25)
Absorptive capacity → *International collaborations*	0.46**** (3.41)	0.81**** (5.31)	0.38 n.s. (1.43)	0.25 n.s. (1.42)	0.61**** (5.21)	0.60**** (3.55)
Absorptive capacity → *Firm innovativeness*	0.18 n.s. (0.69)	0.57 n.s. (1.67)	-0.23 n.s. (0.69)	0.18 n.s. (0.69)	0.13 n.s. (0.52)	0.09 n.s. (0.30)
Domestic collaboration → *Firm innovativeness*	0.32* (1.65)	-0.01 n.s. (0.06)	0.37 n.s. (0.85)	0.42** (2.59)	-0.07 n.s. (0.28)	0.03 n.s. (0.11)
Domestic collaboration → *Firm performance*	0.24 n.s. (1.05)	-0.11 n.s. (0.53)	0.15 n.s. (0.38)	0.16 n.s. (0.62)	0.25 n.s. (1.34)	0.25 n.s. (1.01)
International collaboration → *Firm innovativeness*	0.11 n.s. (0.53)	0.24 n.s. (1.21)	0.83* (1.80)	0.40* (1.88)	0.44* (1.80)	0.45 n.s. (1.21)
International collaboration → *Firm performance*	-0.12 n.s. (0.40)	0.37** (2.02)	0.63* (1.69)	0.16 n.s. (0.86)	0.10 n.s. (0.57)	0.26 n.s. (0.70)
Firm innovativeness → *Firm performance*	0.11 n.s. (0.33)	0.42** (1.98)	0.19 n.s. (0.38)	-0.10 n.s. (0.33)	0.44** (1.89)	-0.18 n.s. (0.61)

Note: ****P<0.001, ***P<0.01, **P<0.05, *P<0.1, n.s.-non-significant; t-stats in brackets

It is evident from the findings that absorptive capacity is significantly and positively associated with external collaborations in these sectors, indicating the technology and knowledge adapted from the external partners are being tailored to improve the existing innovation capabilities and competitive advantage in the Indian scenario. As expected, the magnitude of the relationship between absorptive capacity and international collaboration is greater in high-technology sectors ($Auto\ \&\ ancillary$: $\beta = 0.81, p < 0.001$), ($Drugs\ \&\ pharmaceuticals\ \beta = 0.61, p < 0.001$) than in low-technology sectors (Agriculture & food processing, Machinery & equipment, etc.) (Oltra & Saint Jean, 2009; Garcia-Morales, et al., 2008). We also verify the positive relationship between innovation and performance as proposed in (H_4) in the sectoral context. Firm performance appears to be positively and

significantly influenced by innovation in high-technology sectors such as Auto & ancillary ($\beta = 0.42, p < 0.05$), and Drugs & pharmaceuticals ($\beta = 0.44, p < 0.05$). In the empirical studies, Coad & Rao (2008) and Engel et al. (2004) focus on investigating this link in German and US high-tech sectors. The estimated results emphasise a positive relationship between innovation output and sales turnover.

The results also show that in the Agriculture & food processing, Electronics, Machinery and Steel & metal sectors, the innovation-performance relationship appears to be non-significant. The results here corroborate the prior research to some extent (Baldwin & Johnson, 1995). Particularly in the low-technology sectors (e.g., Agriculture and food processing, Steel and metals, etc.) firms' initiatives to collaborate with research organisations and firms in the same value chain allows them to further strengthen their processes and mechanisms in the short run. Such short-run developments transform into organisational innovativeness and sustainable competitive advantage in the long run (Garcia-Morales, et al., 2008). In the Indian context, the non-significant relationship in these sectors could be due to the relatively small sample size used in this study.

5.5 Conclusions and implications

Using a sample of Indian enterprises, a context in which prior empirical research on this topic is especially limited, this study serves as a reference for fostering firm innovativeness and business performance through improvement in external knowledge or technological collaborations. In the knowledge-competitive economy, effective external alliances create an environment in which innovative firms must have a collaborative orientation in order to maintain sustainable competitive advantage and a leadership position (Senge, 2014). Building upon recent research on the KBV theory of the firm, this study tests a model of the impact of innovation on firm performance and presents an extension on how knowledge-flows from external collaborators mediate the relationship between firm innovativeness and performance. This study is important in the context of an emerging economy such as India because there is a gap in the mainstream literature in terms of how innovation and performance improves through external knowledge sources within these economies. The results of this research may also apply to other emerging economies such as China, Turkey and Korea, to name a few.

The contributions of this study to the literature are many. First, the results of the PLS analysis provide additional support to existing literature that maintains that innovation is a key determinant and has a positive effect on a firm's performance.[41] Second, the findings provide evidence of a positive relationship between a firm's absorptive capacity, innovativeness and performance, which suggests that the effect of absorptive capacity on innovativeness is stronger than its effect on firm performance. The results imply that absorptive capacity enables improvement in firm performance by facilitating innovativeness (Kostopoulos, et al., 2011; Cohen & Levinthal, 1990; Nonaka & Takeuchi, 1995; Baker & Sinkula, 2002; Zahra & George, 2002). Third, there is strong evidence to suggest that collaborative orientation improves innovativeness and performance. Taking into account the finding for external collaborations, we find that the magnitude of influence of international collaborations is larger than that of domestic collaborations. Generally, emerging economies such as India are characterised by relatively less world-class research and academic institutions, R&D infrastructure, technologies, etc., compared to developed countries. Hence, international collaborative orientation is better than domestic collaborations, but it must be combined with "Science-Technology-Innovation" and "Doing-Using-Interacting" modes of innovation (Jensen, et al., 2007) to have a positive influence on existing innovation capabilities and performance.

Furthermore, this study adds to the literature by examining the mediation effect of external collaborations on the relationship between firm innovation outcomes and performance. We find a partial mediation of external collaborations on the innovation and performance link, indicating that an increase in the number of external alliances moderately improves the positive relationship between innovation and performance. Finally, the findings of this study have important managerial and policy implications. The widespread idea that innovation improves performance has attracted the attention of managers, but how the process works remains unclear (Han, et al., 1998). This study suggests that external knowledge-flows, coupled with a firm's absorptive capacity, facilitate innovation and lead to superior firm performance. On the policy front, governments can foster the inflow of technological knowledge from external partners, facilitating firms in collaborative arrangements and R&D partnerships to enhance business performance through innovation. These implications are

[41] See, for example, Naranjo-Valencia, et al. (2016); Lee, et al. (2015); Roxas, et al. (2014); Kafetzopoulos & Psomas (2015); Wang, et al. (2015); Camisón & Villar-López (2014); Rhee, et al. (2010); Damanpour & Gopalakrishnan (2001); Romijn & Albaladejo (2002); Love, et al. (2011); Weerawardena, et al. (2006); Thornhill (2006)

especially important for the non-innovators who are operating in this current globally competitive environment.

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Chapter 6

Conclusion

This thesis consists of four essays on the determinants of innovation and firm performance with a consideration of the role of financial development, innovation policies and external collaborations. This chapter summarises the major research findings and contributions of this thesis, and also highlights future research directions. The discussion in the preceding chapters highlights firm innovativeness as one of the most important driving forces for attaining superior firm performance. Prior research shows that there are various factors that mediate this relationship to a greater or smaller degree, such as absorptive capacity, knowledge base, financial system, availability of trained and skilled workers, external knowledge collaborations, and innovation policies designed to promote firm innovativeness and performance. Previous research in this field has not been focused in the context of an emerging economy such as India. In order to address this gap, the present study applies the resourced-based view (RBV), knowledge-based view (KBV) and national innovation system (NIS) approaches to examine the relationship between innovation and the performance of firms in an emerging economy. The integrated RBV and NIS theoretical framework provides an understanding of how a firm's internal capabilities, along with government innovation support, contributes to sustained innovative advantage and a firm's long-run performance. The KBV posits that knowledge exploitation and knowledge exploration are the main pillars for gaining an innovation advantage and achieving superior rates of return.

6.1 Synthesis of research findings

This thesis has developed investigative conceptual frameworks to study the drivers of firm innovativeness on one hand, and the influence of innovation on the performance of innovative Indian enterprises on the other, based on a systematic review of the literature. This review unites the fragmented literature on the determinants of innovation by covering the majority of topics in this field such as firms' general characteristics (size, age, R&D expenditure, ownership status), culture and organisational strategies (innovation culture, innovation orientation, innovation strategies), functional resources (in-house R&D, trained and qualified workers, training and skill development programmes), external factors (competition environment, export intensity, internationalisation and diversification), and contextual factors

(collaboration and networking, government policies and regulations) and studies how they all contribute to explaining firms' innovation outcomes.

The first key finding is the uncovering of the most important determinants of innovation performance. The internal, external and contextual factors are inter-linked and this interaction determines innovation performance. The local and international institutional dynamics, which include collaborations, industrial parks/districts, regional and national innovation systems, and national innovation policies contribute significantly to explaining higher innovation output.

The second key finding is that financial development is good for growth in patenting activities. The results show unambiguous evidence of two-way Granger-causality between financial market development and innovation. Financial development shows Granger-causality on innovation, and on average, improvement in innovation output stimulates the growth of a nation's financial markets. Specifically, both "finance-push" and "innovation-pull" effects are equally present in the studied research. The hypotheses developed in this thesis propose that certain identified types of external collaborations are conducive to firm innovativeness, that the effects of external collaborations are distinguished by a partner's location (national and international), and to assess the role of government innovation support policies in enhancing the firm innovativeness. This is particularly important because the Indian economy and its enterprises are in transition, where firms must develop their internal idiosyncratic capabilities in order to improve their innovative competitiveness and performance.

The third key finding provides support for the hypothesis that the effect of international academic and firm collaborations is stronger than that of domestic collaborations. Within the RBV and NIS frameworks, government innovation support policies favourably affect the innovativeness of Indian enterprises. Furthermore, the moderation effect of innovation policies suggests that these policies positively strengthen the relationship between international academic and firm collaborations and firm innovation capabilities.

The thesis examines the relationship between innovation and performance by considering the mediating role of external collaboration factors. The fourth key finding suggests that there is a strong positive relationship between innovation and performance. The results also demonstrate that a firm's absorptive capacity has significant effects on internal innovation capabilities and performance. In other words, absorptive capacity enables

improvement in firm performance by facilitating innovativeness. Taking into account the mediation effect, external collaborations partially mediate the link between innovation and performance, indicating that an increase in the number of external partnerships moderately improves the positive relationship between innovation and the performance of Indian enterprises. The literature finds strong evidence of emerging market firms' dependence on external collaborations because these markets have relatively fewer world-class research and academic institutions, R&D infrastructure, technologies, etc., compared to those of developed countries. Hence, international collaborative orientation has a positive influence on firms' internal innovation capabilities and performance.

6.2 Recommendations and policy implications

An understanding of the significance of the research on firm innovativeness and its impact on business performance within the context of Indian economy is the need of the hour. In contributing to the broader picture of the Indian innovation, the thesis recommendations and policy implications are derived from the four interwoven essays that encourage and open more avenues for policy makers and managers, which are discussed below. The provided recommendations and policy implications would be useful for managers and government policy makers in other emerging or developing economies.

The findings from the first essay (Chapter 2) recommends that firm's internal, external and contextual factors are inter-linked in explaining their relationship with innovation. A key takeaway for the managers is to recognise the value of their own internal resources and capabilities, the competences of the competitors and the benefits accrued from the innovation environment while making any strategic decisions. For Indian enterprises, the challenges for channelling their resources and capabilities towards the improvement of firm innovation capability rely upon ability to deploy and develop an appropriate combination of crucial resources. The message to policy makers and managers is very clear that in order to achieve superior firm performance they should emphasise developing strong innovation capabilities. Most significantly, the innovation capability is determined by four key resources that are internal innovation capabilities, learning orientation, external collaborations and government support.

Findings from the second essay (Chapter 3) imply that better access to finance is important for the innovation activities of firms as this reduces the costs of innovation and gives firms incentives to innovate. One promising route to generate innovative ideas is the development of the implications for resource allocation at the level of the firm, the industry and the economy. The study of the financial instruments for promoting innovations in the economies shows that innovation financing system and innovativeness have direct causal relationship. Therefore, the government policies should increase attention and financial resources to the enterprises, especially in the emerging economies like India.

The recommendations from Chapter 4 points to the need for government involvement to improve support and to coordinate innovation activities for enterprises in the emerging Indian economy. The results recommend that the government consider programmes to facilitate international linkages. The innovation policies should help the firms in finding appropriate partners with specific technology and knowledge capabilities that the developing firm needs is important. Also, policies should be strengthened to provide assistance and education on management of international partnerships, which are likely to be lacking among the enterprises in the developing countries, would help the firms to be active in international collaborations.

Furthermore, recommends collaboration with regional and international R&D and educational institutions and training bodies is important as it increases the opportunities and enhances the innovation capabilities. The firms should also focus on increasing the amount of firm-to-firm networking and collaboration, new technology sourcing, and awareneness of relevant external knowledge to reduce the constraints that affect their ability to innovate and improve the mechanism through which R&D inputs are transformed into innovation outcome.

Innovation is shown to improve the firm performance. The results from essay four (Chapter 5) imply that firms with developed networking and interacting with other organisations is an effective way for improving firm performance. The sectoral analysis provides recommendations for policy makers to design innovation and technology policies which should highlight different policy measures for different sectors. In fact, sectoral needs are need to be closely identified with regard to the specificity of knowledge, boundaries, actors and networks.

6.3 Future research directions

The results discussed in this thesis regarding the determinants of innovativeness and performance offer a range of issues that can be investigated in future research. The main focus of the present study is to develop a comprehensive model by combining external knowledge collaborations with academic and research institutions and highly innovative firms, government policy regulations, firms' internal innovation capabilities, and performance all in the context of an emerging economy. These functions are rarely studied simultaneously. Consequently, some of the important aspects of the determinants of innovation and performance measures could not be discussed extensively in this thesis, and this area needs further investigation. The most important future research directions identified can be summarised as follows:

- This study uses data on product and process innovations. Future studies may take into consideration the roles other types of innovation such as organisational, managerial, cultural and marketing innovations have in modelling the relationship between collaborations, innovation and performance.
- Modelling the source and direction of causality between finance and innovation among different sectors in the economy, and across countries, geographic regions, and income groups allows us to understand not only the positive outcomes generated by the relationship, but also the negative outcomes.
- The model that integrates government policy, collaborations and their relationship with a firm's innovative competitiveness and performance as hypothesised in this study, should be investigated in the context of other emerging economies and relevant industries.
- Further longitudinal investigations of overall causal paths between policies, collaborations, internal innovation capabilities, and performance would allow an understanding of the sources and determinants.
- The investigation of causal models can also be applied to different sectors of the economy, to and comparative studies of both developed and emerging economies.
- Research on innovation capabilities and modelling their relationship with performance is not only important to large firms in any economy, but are also vital and add value to the competitiveness and survival of small- and medium-sized enterprises (SMEs),

especially in the case of emerging economies. Hence, an examination of the influence of policies, collaborations and innovation on firm performance in the context of SMEs will provide in-depth insights for managers and policy makers.

- Finally, future studies that examine the impact of various individual-level determinants of open innovation (external knowledge sources, collaborative partners, and networks) and their contribution to firm innovation and performance, will deepen our understanding of decision-making processes at the firm level, which provide important insights into the firm's internal idiosyncratic capabilities for managing external partners.