OPERATIONALISING SUSTAINABILITY IN SUPPLY CHAINS: A CASE OF THE AUSTRALIAN FOOD INDUSTRY

by

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ABSTRACT

Sustainability has opened up new growth avenues for the corporate sector, even during the times of global recession. Firms are now aiming to incorporate the concept of sustainability in their supply chains. However, lack of practical measures, which could address all three dimensions of sustainability - social, environmental and economic - is the main obstacle in achieving this objective. Thus, it is imperative to develop a reliable and valid scale for sustainable supply chain management (SSCM) which can further theory construction.

This PhD study treated SSCM as a broader phenomenon and developed valid and reliable scales for sustainable planning, procurement, manufacturing, transportation, and warehousing. Qualitative data analysis (QDA) techniques and methodologies were used to review SSCM material consisting of 349 academic articles, books, industry publications and company reports. Various dimensions and measures were developed for SSCM sub-constructs and translated in the form of a questionnaire. Data was collected from 215 firms in the Australian food industry, and subjected to rigorous quantitative analysis using structural equation modelling (SEM) to ensure validity and reliability of each SSCM scale.

The study has made five major contributions: (1) it has developed a valid and reliable sustainability scale for each process of a focal firm’s supply chain; (2) it presents a set of best practices for each stage of the food supply chain; (3) it has developed an inventive framework for construct conceptualisation and measures identification; (4) it has conducted a thorough review of SSCM literature through the lens of the Supply Chain Operations Reference (SCOR) process model; (5) it also shows that the use of qualitative data analysis (QDA) software makes it possible to organise and analyse voluminous data in a strategic manner.

DECLARATION OF CANDIDATE

I hereby certify that the work in this thesis, submitted for fulfilling the requirements of the degree of Doctor of Philosophy (PhD) of the Macquarie Graduate School of Management (MGSM) at the Macquarie University, is original and entirely the outcome of my contribution except as acknowledged by general and specific references.

I also certify that this thesis has never been submitted for a higher degree to any other university or institution. The research presented in this thesis was approved by the Macquarie Graduate School of Management, Human Research Ethics Sub-Committee (reference number: 5201300017) on 14th February, 2013.

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List of Abbreviations

AMOS .... Analysis of Moment Structures

AVE .... Average Variance Extracted

CFA .... Confirmatory Factor Analysis

CFI .... Comparative Fit Index

CITC .... Correlated Item Total Correlation

CMB .... Common Method Bias

DFD .... Design For Disassembly

DFE .... Design For Environment

EFA .... Exploratory Factor Analysis

GFI .... Goodness of Fit Index

GSCM .... Green Supply Chain Management

IFI .... Incremental Fit Index

JIT .... Just-In-Time

KMO Measure .... Kaiser-Mayer-Olkin Measure

LCA .... Life Cycle Analysis

NFI .... Normed Fit Index

NRB .... Non-Response Bias

OECD .... Organization for Economic Cooperation and Development

PCA .... Principal Component Analysis

QDA .... Qualitative Data Analysis

RL .... Reverse Logistics

RMSEA .... Root Mean Square Error of Approximation

SC .... Supply Chain

SCM .... Supply Chain Management

SCOR Model .... Supply Chain Operations Reference Model

SDB .... Social Desirability Bias

SEM .... Structural Equation Modelling

SM... Sustainable Manufacturing

SMC .... Squared Multiple Correlation

SP .... Sustainable Procurement

SPlng .... Sustainable Supply Chain Planning

SPSS .... Statistical Package for the Social Sciences

SRMR.. Standardised Root Mean Square Residual

SSCM .... Sustainable Supply Chain Management

ST .... Sustainable Transportation

STV Ratio .... Subject to Variable Ratio

SW.. Sustainable Warehousing

TQM .... Total Quality Management

UNCTD .... United Nations Conference on Trade and Development

CHAPTER 1: INTRODUCTION

1.1 Background and Aims of the Research Study

The concept of supply chain management (SCM) has received tremendous attention from researchers and practitioners since its first introduction in the early 1980s (La Londe, 1998; Oliver & Weber, 1992). It is a multi-disciplinary concept that is based on many different fields such as organisational theory, logistics, strategic management, marketing, quality management, information and communication technology, materials management and procurement (Carter & Price, 1993; Dale, Lascelles, & Lloyd, 1994). Consequently, there are numerous concepts in supply chain management which are inherently confounding and therefore difficult to operationalise for any statistical analysis, such as customer satisfaction, total quality management, collaboration, trust, supply chain risk, supplier selection, transparency, green supply chain management, agility, performance, lean and sustainability. These variables (or constructs) are not directly measurable and are termed as 'latent'. Kerlinger (1986, p. 37) described a latent variable as 'an unobserved entity presumed to underlie observed variables.' He further remarked that 'in science our real interest is more in the relations among latent variables than it is in the relations among observed variables because we seek to explain phenomena and their relations.' Even though a lot of progress is made in advancing the field of SCM, many experts have stressed the need to clearly define the latent supply chain constructs and their theoretical underpinnings (Cooper, Lambert, & Pagh, 1997; Saunders, 1998).

In this regard, researchers have made efforts to operationalise the latent supply chain constructs so that theory construction and validation can be furthered, and unknown phenomena in SCM are comprehended. For example, *risk management* in supply chains, which aims to decrease a firm's vulnerability to disruption in operations, is defined by Punniyamoorthy, Thamaraiselvan, and Manikandan (2011) as a function of risks pertinent to supply, manufacturing, demand, environment, information and logistics; *supply chain agility*, which is reflected in the ability of a firm's supply chain to be vigilant and responsive to changes, is described and validated by Li, Goldsby, and Holsapple (2008) as alertness and response capability at strategic, operational and episodic levels; *performance measurement in transport logistics* is analysed by Lai, Ngai and Cheng (2002) through service effectiveness for shippers and consignees, and operational efficiency of transport logistics service providers; and Zhu, Sarkis, and Lai (2008) empirically confirmed that the *green supply chain management (GSCM)* construct, which promises ecological efficiency and reduction in environmental risks, can be operationalised by implementing practices pertinent to internal environmental management, green purchasing, cooperation with customers, eco-design and investment recovery.

Despite of all these efforts, the construct of 'sustainable supply chain management (SSCM)' is still in an embryonic stage. Measures have been proposed by the European Logistics Association (ELA) in a recent book by Cetinkaya et al. (2011), and are subsequently used by researchers for sustainability assessment (Soosay, 2013). However, the ELA sustainability metric is very broad, and the association provides no evidence of psychometric properties. Also, the ELA metric is not based on any literature review and only consists of nine high-level sustainability elements which are quality, efficiency, responsiveness, health and safety, noise, employees, emissions, natural resources, and waste. The broader literature review conducted in this PhD study (Chapter 2) showed that the ELA metric is incomplete and fails to recognise numerous sustainability elements suggested in literature such as local communities, corruption free operations, business continuity plan, collaboration with suppliers, training, workplace standards, regulatory compliance, etc. Hence, the ELA metric cannot be used to operationalise sustainability in supply chains. Consequently, theory development that will advance knowledge in the field of SSCM is not possible without a valid and reliable scale, as erroneous scales lead to invalid and flawed theories (Lewis, Templeton, & Byrd, 2005; Venkatraman, 1989). Therefore, there is a dire need to develop an SSCM scale with valid and reliable measures.

Since reliability and validity testing is based on data collected from industry, a decision had to be made regarding the scope of data collection. In this regard, the researcher of this PhD study selected the 'food industry', mainly because of two reasons: (1) the researcher has professionally worked in the supply chain department of a multi-national firm in the food industry and is intrinsically motivated to further explore this industry, and (2) the food industry has one of the most critical and crucial local supply chains in Australia, and it is considered that this needs the implementation of sustainability practices. It seems important at this juncture to provide some background of the Australian food industry. The Australian Food and Grocery Council [AFGC] (2010, 2011a) considers this industry as the backbone of the Australian economy with its own dynamics and set of challenges. The industry employs more than five million people throughout the food supply chain including the farmers to the final distributors, and provides 24 million meals to all Australians every day. Overall, it is Australia's largest employer (~ 8 million people), major exporter of value added products ($25 billion in 2008-09), Australia's largest manufacturing sector (28 percent of total manufacturing), a significant investor ($3.8 billion spent on capital expenditure in 2006-07), and with an annual turnover of around $130 billion (AFGC, 2010, 2011a, 2011b). Unfortunately, this pivotal industry was severely hit by the global financial crisis. According to AFGC (2011b), the industry is passing through turbulent times because of factors such as high prices of raw materials, unpredictable legislation, natural catastrophes, inflation and declining consumer confidence. Repeated calls are made for the adoption of sustainable practices that could ensure profits in addition to communal welfare and environmental preservation (DAFF, 2012). However, companies are extremely wary of any investment in this sector, mainly because there is no comprehensive framework or a list of best practices that could help to operationalise sustainability for a focal firm in the Australian food industry (Delforce, Dickson, & Hogan, 2005; DEFRA, 2006).

Hence, the overall aim of this PhD study is to develop a valid and reliable SSCM scale that could also help to identify the best practices for a firm in the Australian food industry.

This study primarily investigated the SSCM literature and identified dimensions and measures for the SSCM scale. However, it also adapted them to the Australian food industry so that the questionnaire survey, used for validity and reliability testing of the SSCM scale, is more relevant to the target industry. Adaptation was mainly done by using publications from a number of industry organizations such as the Australian Food and Grocery Council (AFGC), Department of Agriculture, Fisheries and Forestry (DAFF), Department of Environment, Food and Rural Affairs (DEFRA), Australian Conservation Foundation (ACF), and Commonwealth Science and Industrial Research Organisation (CSIRO). The adaptation process, discussed later in the thesis, incorporated many elements of the food industry such as food safety, Australian packaging covenant, traceability, food grade packaging, food labelling, Hazard Analysis and Critical Control Point (HACCP) standards, and avoidance of cross-contamination. Consequently, the entire scale development process in this research study resulted in a set of sustainability 'best-practices' for a firm in the Australian food industry along with many other interesting insights and contributions.

1.2 Research Gaps and Questions

Various gaps were identified in the supply chain and sustainability literature and these are as follows:

First, there is a dearth of empirical studies in sustainability literature that simultaneously examine all three dimensions, namely, economic, social and environmental (Seuring & Müller, 2008). Scholars have acknowledged this deficiency and calls have been made to fill the gap (Boyd, Spekman, Kamauff, & Werhane, 2007; Diniz & Fabbe-Costes, 2007; Linton, Klassen, & Jayaraman, 2007; Matos & Hall, 2007). **Second**, as mentioned before, in supply chain and operations management literature there is no comprehensive scale that could highlight the measures for operationalising sustainability in a firm's supply chain. Consequently, theory development is limited and there is a dire need to develop a valid and reliable scale for sustainable supply chain management (SSCM). **Third**, the literature review shows that several organizations have attempted to implement sustainability in their business processes (Baumgartner & Ebner, 2010), as there is a general agreement that sustainable operations can help to achieve competitive advantage in the market (Carter & Easton, 2011; Flint & Golicic, 2009). However, even the most sincere efforts have only resulted in cursory solutions with insignificant improvement in the social and environmental performance of the firm (Ramus & Montiel, 2005). One of the main reasons is that these implementations lack the supply chain perspective (Baumgartner & Ebner, 2010; Lubin & Esty, 2010). Despite the fact that the relationship between sustainability and competitive positioning is well researched, the literature lacks the insights into how a firm can operationalise sustainability in its supply chain. In fact, researchers have concluded that 'the state of SSCM [Sustainable Supply Chain Management] implementation in practice can still be considered low' (Brockhaus, Kersten, & Knemeyer, 2013). In this regard, some researchers are of the view that sustainability can only be realised if initiatives are taken along different stages (or processes) of a firm's supply chain (Green, Morton, & New, 1996; Nathan, 2005). Thus, it is imperative to analyse the current status of sustainability research for each stage of a focal firm's supply chain – supply chain planning, procurement, manufacturing, transportation, warehousing and reverse logistics. Presently, no SSCM literature review provides this insight in a comprehensive manner. Therefore, it was considered necessary that a meticulous literature review focusing on each supply chain process is performed for the SSCM scale development. **Fourth**, investigation into scale development literature showed that scales are not 'developed' carefully, and are rather 'assembled'. This is due to the absence of a systematic framework that could explain all the primary and secondary steps related to the conceptualisation and identification of scale measures (DeVellis, 2003). **Finally**, both academic literature and industry publications do not provide a set of empirically tested sustainability practices, with sound psychometric properties, for each stage of a firm's supply chain in the Australian food industry (AFGC, 2010; DAFF, 2012).

In order to fill the above-mentioned gaps, this thesis develops a reliable and valid scale for sustainable supply chain management, with a special focus on the Australian food industry. Towards this end, the following research questions are identified:

1. What are the sustainability 'best practices' for supply chain planning, procurement, manufacturing, transportation, warehousing and reverse logistics for a firm in the Australian food industry?
2. How have sustainability challenges been addressed in the academic literature to date for each supply chain process?
3. Which steps should be followed for systematic construct conceptualisation and measures identification during the scale development process?

1.3 Contributions of the Research Study

This PhD research study and thesis has contributed to four major fields or domains of knowledge. These are: sustainability, supply chain management, qualitative data analysis and food industry.

1.3.1 SSCM Scale Development

The research study has developed a valid and reliable scale for each major stage of a focal firm's supply chain such as sustainable supply chain planning, sustainable procurement, sustainable manufacturing, sustainable transportation and sustainable warehousing. Even though the scale is adapted to the Australian food industry, most of the steps, techniques, methodologies and findings are generic and can be applied to any industry.

This research treats SSCM as a broader phenomenon or meta-construct that is a combination of six separate **sub-constructs**, namely, sustainable supply chain planning (SPlng), sustainable procurement (SP), sustainable manufacturing (SM), sustainable transportation (ST), sustainable warehousing (SW) and reverse logistics (RL).

Qualitative data analysis (QDA) techniques and methodologies were used through the NVivo software to review the SSCM material: 349 academic articles, industry publications and company reports for each SSCM sub-construct. Various dimensions and measures were developed and translated in the form of a questionnaire. This questionnaire was used to collect quantitative data from 215 firms in the Australian food industry and the data were subjected to exploratory and confirmatory factor analysis (EFA and CFA). Rigorous examination was done using structural equation modelling (SEM) with the help of the AMOS software tool. A number of quantitative tests were done to ensure unidimensionality, reliability, convergent validity and discriminant validity of the EFA and CFA models. An effort was made to avoid social desirability bias (SDB) and the results were also analysed for non-response bias (NRB) and common method bias (CMB).

1.3.2 Best Practices for the Australian Food Industry

The scale development process resulted in a scale for each SSCM sub-construct (sustainable supply chain planning, sustainable procurement, sustainable manufacturing, sustainable transportation, and sustainable warehousing). The dimensions and measures of each scale were adapted to the Australian food industry, for reliability and validity testing, during the first stage of the scale development process.

Consequently, the entire SSCM scale development process resulted in a set of best practices for each stage of a firm's supply chain in the Australian food industry, and these are discussed in the final chapter of this thesis. These best practices were provided to the industry experts who were requested to identify the primary impact of each practice on various dimensions of sustainability (social, environmental and economic). Accordingly, the practices were grouped together, based on each sustainability dimension, and presented in the form of a holistic and graphical model for each supply chain process. These models for sustainable supply chain planning, sustainable procurement, sustainable manufacturing, sustainable transportation and sustainable warehousing have been presented at major supply chain conferences around the world, where they were very well received. The feedback from reviewers is incorporated to make them more relevant and concrete. *Details of all the papers based on this PhD study, and presented at various conferences, are provided collectively in **Table 1**.*

1.3.3 Construct Conceptualisation and Measures Identification Framework

A construct conceptualisation and measures identification framework is developed for Stage I of the scale development process. It is based on extensive academic literature related to sustainability, SCM, management theories and scale development. It defines a step-by-step procedure for construct conceptualisation and measures identification. It also incorporates expert feedback at different steps to develop measures with sound psychometric properties and high industry relevance. It includes a unique four-phased methodology for 'item generation' which is usually the weakest aspect of the scale development research studies. The four-phased methodology, which is a part of the complete framework, was presented in the form of a conference paper at the 8th Annual

Symposium of the Institute of Sustainable Leadership (ISL) in Nice, France in 2013, and it received **the best paper award** after double-blind review by a panel of ISL experts.

Overall, the construct conceptualisation and measures identification framework presents the first stage of the scale development process in a cohesive and coherent manner. Also, the framework can be adapted to disciplines other than SCM to generate relevant sustainability dimensions and measures. Some of the steps might change accordingly, but a major portion of the framework (coding methodology; techniques; and strategies) will remain the same. In addition, the framework clearly shows that content and thematic analyses are powerful techniques that could be effectively applied to embryonic fields such as sustainable supply chain management. The complete framework was recently presented in the form of a conference paper at the 9th Annual Symposium of Institute of Sustainable Leadership (ISL) in Salzburg, Austria in 2014, and it also received **the best paper award** after double-blind review by a panel of ISL experts. *Details of all the papers based on this PhD study, and presented at various conferences, are provided collectively in **Table 1**.*

1.3.4 Review of the SSCM Literature with the Lens of the SCOR Model

Even though many literature reviews have recently been published that analysed various aspects of the research done in the field of sustainable supply chain management (SSCM), this PhD research study also carried out a detailed review of the SSCM literature and separately analysed the sustainable supply chain literature for planning, procurement, manufacturing, transportation, warehousing and reverse logistics.

It was noted that most of the SSCM review papers broadly discussed the research methodologies, modelling techniques, performance metrics and supply chain drivers, which help to improve the sustainability performance of a supply chain. However, no review has been conducted via the lens of the Supply Chain Operations Reference (SCOR) process model that could separately analyse the status of sustainability research for each major stage of supply chain, so that specific gaps are identified and practices can be developed accordingly.

Therefore, this PhD study conducted a comprehensive SSCM literature review for each major stage of supply chain (planning, procurement, manufacturing, transportation, warehousing and reverse logistics). It devised a unique four-phased methodology, as a part of the construct conceptualisation and measures identification framework, to review and analyse the SSCM academic material consisting of 349 peer-reviewed academic articles. This meticulous SSCM literature review found that the purview of sustainable supply chain is very broad, as there are 74 journals from various disciplines that contributed either one or two papers to the publication sample of 349 papers. In addition, the top contributing journals such as Greener Management International and Business Strategy and the Environment, which contributed 21 papers each, are not typical supply chain and operations management journals. This clearly showed that any sustainable supply chain management study focusing only on operations research (OR) and supply chain management (SCM) journals could be extremely deficient in terms of the credibility and validity of its findings.

Various other findings of this comprehensive review activity that formed the basis of further research in this PhD study, are discussed in Chapter 3 (section 3.1). The review of SSCM literature, via the lens of the SCOR process model, along with its findings, was presented at the 74th Annual Meeting of the Academy of Management (AoM), Philadelphia, PA, USA in 2014 and it received a good review.

1.3.5 Inventive Use of the Qualitative Data Analysis Software (NVivo)

This PhD study also shows that the use of qualitative data analysis (QDA) software makes it possible to organise and analyse voluminous data in a strategic manner. Even though it is the decision of the researcher to select the relevant tools and optimally exhaust the capabilities of the software to achieve the research objectives, the software enhances the validity of the results through use of a rigorous and transparent coding mechanism. It is believed that brainstorming, deliberations, critical analysis, close examination of literature, and constant review and comparison are still at the core of the entire analysis process, but computer programs for textual analysis increase the rigour of the research study. This research study chalked out a ‘unique four-phased qualitative methodology’ to analyse the publication sample of 349 peer-reviewed research articles with the help of QDA software – NVivo.

Coding is done and themes are developed through NVivo tools such as word frequency query, text search query, tree maps, tag clouds, broadbrush coding and constant review and comparison of the selected literature. Details of NVivo qualitative data analysis software are provided in Chapter 3 (section 3.2). NVivo assisted the researcher of this study in making more informed decisions in the analysis process by providing deep insights into literature through its flexible and robust data arrangement mechanism, its searching and querying tools, and graphical modelling techniques. It eased the laborious task of manual analysis by providing features pertinent to annotations and memos, and thus enabled researchers to concentrate mainly on identification of themes and exploration of trends that could lead to sound judgement and conclusions. This PhD study clearly shows that the use of the software relieves the researchers from the worries of data organisation, storage and presentation, and enables them to focus more on the analytical part of the research.

1.3.6 Blind Peer Review of the Thesis by Domain Experts

A major strength of this PhD thesis is that all parts and sections of this study are written in the form of eight conference papers that have been presented at credible management and supply chain conferences around the world. Two of these papers won the best paper award, and one paper reached the final round of the best paper contest. A list of these papers, along with the conferences, is provided below in **Table 1**.

Table 1: List of all the Papers based on this PhD Study

Sr. No.	Title of the Papers	Conferences
	Papers on Sustainability Models for each Supply Chain Process	
1.	Sustainable Supply Chain Planning: A framework to facilitate economic, environmental and social responsibility	Presented at the 25th Annual Conference of the Production and Operations Management Society (POMS), Atlanta, Georgia, USA in 2014
2.	Sustainable Procurement Model: A strategic tool for responsible decision-making	Presented at the 24th Annual Conference of the Production and Operations Management Society, Denver, Colorado, USA in 2013
3.	Sustainable Manufacturing Model: A Step Towards Operationalising Sustainability in Supply Chains	Presented at the 11th ANZAM Operations, Supply Chain and Service Management Symposium, Brisbane, Australia in 2013
4.	Sustainable Transportation Model: A Guide for Safe and Environment-Friendly Operations in the Logistics Industry **(Finalist)**	Presented at the 7th International Conference on Operations and Supply Chain Management, Shanghai, China in 2013
5.	A Model for Sustainable Warehousing: From Theory to Best Practices	Presented at the 12th International Decision Sciences Institute Conference, and the 18th Asia Pacific DSI Conference, Bali, Indonesia in 2013
	Methodology Papers	
6.	Sustainability Determinants for the Food Supply Chain: Developing a Qualitative Methodology **(The Best Paper Award)**	Presented at the Institute of Sustainable Leadership (ISL) 8th International Symposium, Nice, France in 2013
7.	Sustainable Supply Chain Construct Development: Developing a Conceptual Framework **(The Best Paper Award)**	Presented at the Institute of Sustainable Leadership (ISL) 9th International Symposium, Salzburg, Austria in 2014
	Review Paper	
8.	Review of Sustainable Supply Chain Management Literature: Using the SCOR Process Model	Presented at the 74th Annual Meeting of the Academy of Management (AoM), Philadelphia, PA, USA in 2014
	Paper on the Use of QDA Software	
9.	Using QSR-NVivo to Develop a Taxonomy of Supply Chain Sustainability Themes	Finalising for submission to MIS Quarterly.

1.4 Scope of the Research Study

This research study has effectively developed five scales (sustainable supply chain planning, sustainable procurement, sustainable manufacturing, sustainable transportation, and sustainable warehousing) to operationalise Sustainable Supply Chain Management (SSCM) in a focal firm. However, **reverse logistics**, which is identified as one of the SSCM sub-constructs, has not been covered in a comprehensive manner due to 'time constraints'. Nevertheless, it is covered to some extent under other SSCM sub-constructs, such as supply chain planning, procurement, manufacturing, transportation and warehousing.

As discussed before, this research study planned only to review the SSCM literature for 'each stage of the supply chain' to identify dimensions and measures for the SSCM construct. The food industry literature is not thoroughly reviewed, due to time constraints, and mainly industry publications are used to adapt the questionnaire to the Australian food industry. However, face validity is ensured through testing the questionnaire against: (1) sustainability reports of the top firms in the food industry, and (2) the Global Reporting Initiative (GRI) reporting standards. Also, content validity is confirmed through experts currently working in the food industry. Both face and content validity assured that no important element of the food industry was overlooked in the questionnaire.

Furthermore, this thesis will not discuss the minute procedural details related to the coding process in the NVivo software for literature review and analysis. For example, it will not provide step-by-step information on how to execute a word frequency query, text search query or perform creation of nodes based on tag clouds and tree maps. In addition, the detailed process of converting conceptual taxonomies into visual models will not be covered. The NVivo manuals and online tutorials can be easily accessed to understand these procedural details. The academic discussion on the subtle differences between various analytical techniques used in this research study (such as content and thematic analysis) based on their epistemology, aims and application, is also beyond the scope of this thesis. Nevertheless, an effort is made to provide operational details of literature analysis through the NVivo software in a comprehensive and succinct manner. Screenshots are provided, features of the software are discussed, and a four-phased methodology, used for literature analysis and item pooling, is explained in a concise manner.

Furthermore, this thesis will not cover technical discussions pertinent to very specific concepts and techniques used in supply chain planning, procurement, manufacturing, transportation, warehousing and reverse logistics.

In the sustainable supply chain planning (SPlng) sub-construct, the thesis will not debate particular strategies and models for inventory management, postponement, vendor managed inventory (VMI), supply contracts, product design, safety stock, ERP (Enterprise Resource Planning) solutions and integration of supply chain factors, as these might change from one firm to another. Similarly, for the sustainable procurement (SP) sub-construct, the thesis will not discuss techniques and mathematical models related to supplier selection, contract management, spend analysis, supplier assessment, and e-procurement. In the case of the sustainable manufacturing (SM) sub-construct, the thesis will not cover discussion areas such as criteria for new product development (NPD); theory of industrial ecology; pros and cons of sub-contracting or outsourcing; advantages of lean manufacturing, just-in-time (JIT) strategy, Kaizen and total quality management (TQM); importance of recycling and remanufacturing strategies; and adoption of ISO (International Standards Organization) standards. For the sustainable transportation (ST) sub-construct, the thesis will not discuss issues related to engine design, vehicle performance indicators, vehicle space utilisation calculations, and vehicle routing and scheduling.

Finally, it must be noted that special attention is paid to the sustainable warehousing (SW) sub-construct as the literature review recognised it as an overlooked area. Therefore, each dimension and measure of SW is discussed in detail. However, many of them are vast areas of research within themselves and it is not possible to cover their technical specifics. For example, 'facility design' is an extensively researched domain and several key experts have contributed to it in the last four decades, such as Firth et al. (1988), Mulcahy (1994), Oxley (1994), Hassan (2002) and Rushton, Croucher, and Baker (2006). They have elucidated the design process, outlined steps, identified inter-relationships among various design activities and debated optimal solutions and trade-offs. The domain has matured and evolved into several sub-domains.

Thus, various technical details pertinent to building design, lighting, thermal materials and building architecture are left to the experts of those sub-domains and not covered in this thesis (Treloar, Fay, Ilozor, & Love, 2001). Also, the advantages and disadvantages of different operational strategies and the application of the life cycle assessment (LCA) tool are not discussed (Tsoulfas & Pappis, 2006). In addition, this research study will not address problems related to various warehouse concepts such as zone picking, cross-docking, storage location assignment, unit-load replenishments, level of automation, optimal storage and handling equipment, and operational policies. Its scope is restricted to the development of best practices that could be used for operationalising sustainability in warehouses.

1.5 Structure of the Thesis

The structure of this thesis follows the scale development process that is typical for any scale development research study. The researcher of this study looked at many scale development theses in the 'ProQuest Dissertations and Theses Database' and found that most of the scale development theses have followed the logical flow of the scale development steps. Therefore, it was decided to pursue this tradition in this thesis.

Consequently, there is no separate chapter for **'Literature Review'** as it was a constant activity that was done not only during the content domain specification and the item pool generation, but also played a key role in the scale refinement and validation steps. Thus, this thesis has creatively tried to present broader sustainability and supply chain literature review in a chronological manner in Step 1 of the scale development process; detailed SSCM literature review with thorough descriptive analysis in Step 2 (sections 3.1 and 3.3); brief review of qualitative data analysis and software in Step 2 (section 3.2); pilot testing and sample size literature review in Step 4; EFA literature review in Step 5; and CFA and SEM literature review in Step 6. The thesis has effectively connected all these reviews with the scale development steps and other elements of the research study.

Similarly, there is no exclusive chapter for **'Methodology'** as all the qualitative and quantitative methods, techniques, and strategies used in various steps of the scale development process are discussed in detail in those parts of the thesis. Different methodologies are employed for literature collection, literature analysis, descriptive analysis, coding, content analysis, item pooling, face validity, content validity, pilot study, large scale data collection, exploratory factor analysis, and confirmatory analysis.

In brief, this thesis takes the reader on a **'scale development journey'**, moving from one step to another and using the output of one step as the input of the next step. It provides deep insights of each step that is supported by relevant literature review, methodology, and analysis; along with developing further on the work done in the previous steps.

It must be noted that Chapter 1 and Chapter 8 consist of Introduction and Conclusion respectively while Chapter 2 to Chapter 7 cover different stages and steps of the scale development process.

This PhD study divided the scale development process into two main stages – **Stage I** (conceptualisation and development of measures), and **Stage II** (scale refinement and validation). In Stage I, the domain of the construct is outlined, a formal definition is presented, an item pool is generated and adapted to the Australian food industry, and the content validity of the measures is assessed. In Stage II, a pilot study was conducted on a small scale to further refine and screen (purify) the items through exploratory factor analysis. Consequently, the questionnaire was finalised and then circulated to the target population for data collection. Finally, the collected data was subjected to confirmatory analysis to assess dimensionality, reliability and validity of the SSCM sub-constructs. Various stages and steps of the scale development process are presented in **Figure 1**.

Stage I, which consists of three steps, is covered by three corresponding chapters of the thesis (Chapters 2, 3 and 4).

Chapter 2 presents Step 1, and mainly discusses the content domain specification. It develops a definition of sustainable supply chain management (SSCM) based on a broad literature review germane to sustainability, supply chain and operations management; review of already existing SSCM definitions; feedback received from industry experts; and analysis of relevant theories. It also presents the research framework for the SSCM scale development based on the understanding that it is a broad phenomenon that is a combination of six supply chain sub-constructs (planning, procurement, manufacturing, transportation, warehousing and reverse logistics).

Chapter 3 provides details of Step 2 (item pool generation), and is divided into three sections (3.1, 3.2 and 3.3). **Section 3.1** – 'SSCM Literature Collection and Descriptive Analysis', presents the step-by-step procedure that was adopted to collect the most relevant SSCM academic literature from library services and digital databases. It also provides in-depth descriptive analysis of the collected academic literature that laid down the foundation for further research in this PhD study. It presents a number of interesting new findings and highlights the gaps and overlooked areas in the field of SSCM. **Section 3.2** – 'SSCM Literature Analysis: Four-Phased Qualitative Methodology', provides extensive details about the methodology that was devised to review and analyse the SSCM material consisting of 349 peer-reviewed academic articles, and miscellaneous carefully selected industry publications and company reports. The overall aim was to develop a sustainability questionnaire for each stage of a firm's supply chain in the Australian food industry. The questionnaire was later used for data collection and scale validation. **Section 3.3** – 'SSCM Literature Analysis: Results and Research Hypotheses', is based on sections 3.1 and 3.2 and presents the results of the SSCM material analysis. It elaborates on each SSCM sub-construct (planning, procurement, manufacturing, transportation, warehousing and reverse logistics) and provides a comprehensive discussion on each dimension and measure finalised through the systematic analytic process that was covered in section 3.2.

Chapter 4 discusses the third and last step (Step 3) of Stage I and is pertinent to content validity assessment (CVA). Content validity for any construct is ensured when the identified items adequately represent the construct. In order to ensure that various elements or items of SSCM sub-constructs (sustainable planning, sustainable procurement, sustainable manufacturing, sustainable transportation, sustainable warehousing and reverse logistics) identified in Chapter 3 adequately represent SSCM, Lawshe's (1975) technique is used. This chapter presents the assumptions, rules and results of CVA, for each SSCM sub-construct, as per the response received from 14 different industry experts.

Stage II of the scale development process also consists of three steps (Steps 4, 5 and 6) and is correspondingly presented by Chapters 5, 6 and 7.

Chapter 5 discusses Step 4 of the scale development process and presents mainly pilot testing and the results of exploratory factor analysis (EFA). The data gathered through the pilot survey was used for exploratory factor analysis that helped to purify the items of the scale for each SSCM sub-construct. This chapter presents the methodology that was used for pilot testing and also reviews the literature to justify the sample size used for pilot testing. It also delineates the strategy that was employed to either reject or retain items based on correlation and reliability testing, and factor loadings of the items for each SSCM sub-construct. **Chapter 6** provides the details of Step 5 of the scale development process and discusses the sampling and data collection methodology. It elaborates various challenges faced during the data collection process and discusses techniques that were adopted to avoid non-response bias (NRB), common method bias (CMB) and social desirability bias (SDB). **Chapter 7** discusses the sixth (and final) step of the scale development process that is related to the validation of SSCM sub-constructs. The data collected in Step 5 is subjected to structural equation modelling (SEM) through confirmatory factor analysis (CFA) in the AMOS software. The results of first-order and second-order CFA models, reliability, convergent validity, discriminant validity and common method bias are discussed in this chapter for each SSCM sub-construct – sustainable planning, sustainable procurement, sustainable manufacturing, sustainable transportation, sustainable warehousing and reverse logistics. The final validated models, along with the SEM fit statistics (such as GFI, NFI, IFI, CFI, RMSEA, SRMR and AVE), are presented in this chapter. The structure of the thesis, based on above discussion, is summarised in **Table 2**.

Table 2: Structure of the Thesis

Structure of the Thesis – SSCM Scale Development		
Stages and Steps of the Scale Development Process		**Chapters of the Thesis**
		CHAPTER 1: INTRODUCTION
Stage I: Conceptualisation and Development of Measures	Step 1	**CHAPTER 2:** STEP 1 – CONTENT DOMAIN SPECIFICATION
	Step 2	**CHAPTER 3:** STEP 2 – ITEM POOL GENERTION
		Section 3.1: SSCM Literature Collection and Descriptive Analysis
		Section 3.2: SSCM Literature Analysis: Four-Phased Qualitative Methodology
		Section 3.3: SSCM Literature Analysis: Results and Research Hypotheses
	Step 3	**CHAPTER 4:** STEP 3 – CONTENT VALIDIITY ASSESSMENT
Stage II: Scale Refinement and Validation	Step 4	**CHAPTER 5:** STEP 4: PILOT TESTING AND EXPLORATORY ANALYSIS
	Step 5	**CHAPTER 6:** STEP 5 – SAMPLING AND DATA COLLECTION
	Step 6	**CHAPTER 7:** STEP 6 – LARGE SCALE CONSTRUCT VALIDATION
		CHAPTER 8: CONCLUSION

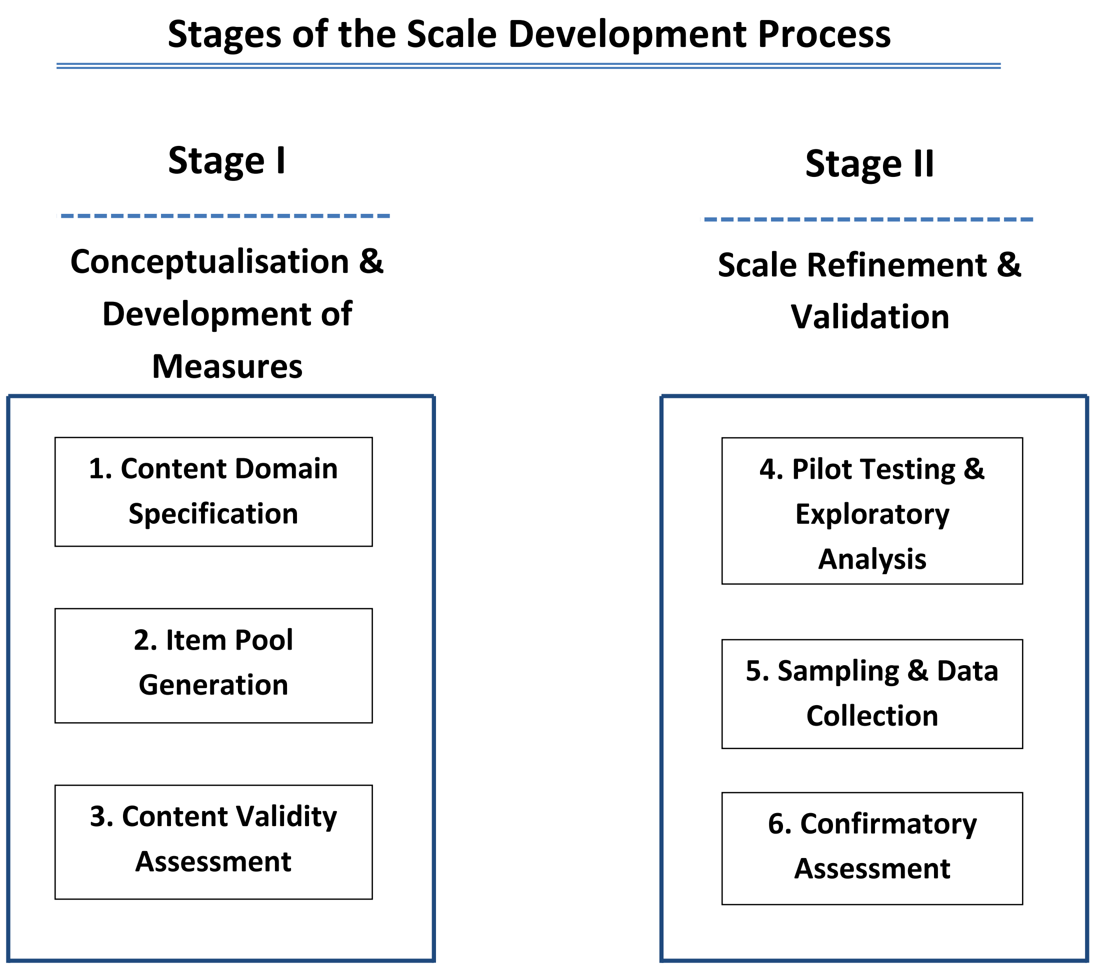

Figure 1 - Stages of the Scale Development Process

SUSTAINABLE SUPPLY CHAIN MANAGEMENT (SSCM) SCALE DEVELOPMENT

STAGE I – Conceptualisation and Development of SSCM Measures

Overview of STAGE I

The first stage is the most pivotal juncture in this entire process as it sets the platform for the remaining stages. DeVellis (2003, p. 60) investigated the rigour of Stage I in various studies and observed that 'many researchers think they have a clear idea of what they wish to measure, only to find that their ideas are more vague than they thought. Frequently, this realization occurs after considerable effort has been invested in generating items and collecting data – a time when changes are far more costly than if discovered at the outset of the process.' The situation is quite the same in Supply Chain Management (SCM) regarding Stage I of the scale development process. Most of the research inadequately explains the content domain specification **(Step 1)** and it is generally considered equivalent to simple literature search; details about item pool generation **(Step 2)** are usually neglected, and content validity of items **(Step 3)** is often overlooked. Similar findings were presented by Slavec and Drnovšek (2012) in their recent 'review-paper' focusing on the scale development process in entrepreneurship research. They calculated that only 16.9 percent of the papers specified the domain of the construct and proposed a relevant definition; about 24.7 percent omitted the item pool generation process; and only 16.9 percent of the articles evaluated measures for content validity. The lack of emphasis on **'Stage I'** results in irrelevant measures with no practical significance. Also, constructs represented by such erroneous scales (measures and dimensions) lead to invalid and flawed theories. DeVellis (2003) is of the view that scales are not 'developed' carefully, and are rather ‘assembled’. This is due to the absence of a systematic framework that could explain all the primary and secondary steps related to Stage I. Therefore, this PhD research study developed a ‘construct conceptualisation and measures identification’ framework. Even though the framework is used to identify the dimensions and measures for the sustainable supply chain management (SSCM) phenomenon, it is intended to be generic in nature, and therefore, easily adaptable to any domain.

The Conceptualisation and Measures Identification Framework

The framework consists of five steps, as shown in **Figure 2**. In **Step 1.1,** a definition of the SSCM concept was developed based on broad literature review germane to sustainability, supply chain and operations management; review of already existing SSCM definitions; feedback received from industry experts; and analysis of relevant theories. In **Step 1.2,** the SSCM domain was carefully assessed and it was decided to treat SSCM as a broad phenomenon that is a combination of six supply chain sub-constructs (planning, procurement, manufacturing, transportation, warehousing and reverse logistics). The first two steps resulted in construct definition and a high-level research framework, as shown in **Figure 3**.

In **Step 2.1,** literature pertinent to SSCM was collected in a systematic manner from library services and digital databases. An in-depth descriptive analysis was carried out that laid down the foundation for further research in this PhD study. An analysis of the existing literature reviews on SSCM helped to identify the focus areas of current SSCM research and assisted in delineating the strategy for further literature analysis. Overall, this step resulted in a number of interesting new findings and highlighted the gaps and overlooked areas in the field of SSCM. In **Step 2.2,** SSCM material is analysed using NVivo. A four-phased methodology was devised to review and analyse the SSCM material consisting of 349 peer-reviewed academic articles, miscellaneous carefully selected industry publications and company reports. The overall aim was to develop a sustainability questionnaire for each stage of a firm's supply chain in the Australian food industry. The questionnaire was later used for data collection and scale validation. The material analysis was completed in four phases that used thematic and content analysis for coding. It was an iterative and non-linear process based on constant review and comparison, and rigorous perusal of the material. It was facilitated by the qualitative data analysis software – NVivo.

In **Step 3.1**, the content validity of the identified measures was analysed by using the technique suggested by Lawshe (1975). The finalised measures were circulated among 14 industry experts who had prior experience in procurement, logistics, customer services and supply chain planning at both operational and strategic levels. First, they were asked to review each dimension of SPlng, SP, SM, ST, SW and RL. Second, they were requested to rate each measure (or item) as 'essential' (E), 'useful but not essential' (NE) or 'not necessary' (NN) to a dimension on the scale. The responses were used to calculate the content validity ratio according to the formula CVR = (n – N/2) / (N/2) where 'N' is the total number of industry experts and 'n' is the frequency of 'essential' responses. The CVR for each measure was checked against the table published by Lawshe (1975) to determine its statistical significance. As a result, some of the statistically insignificant measures were dropped. A number of other recommendations by experts were incorporated in the questionnaire.

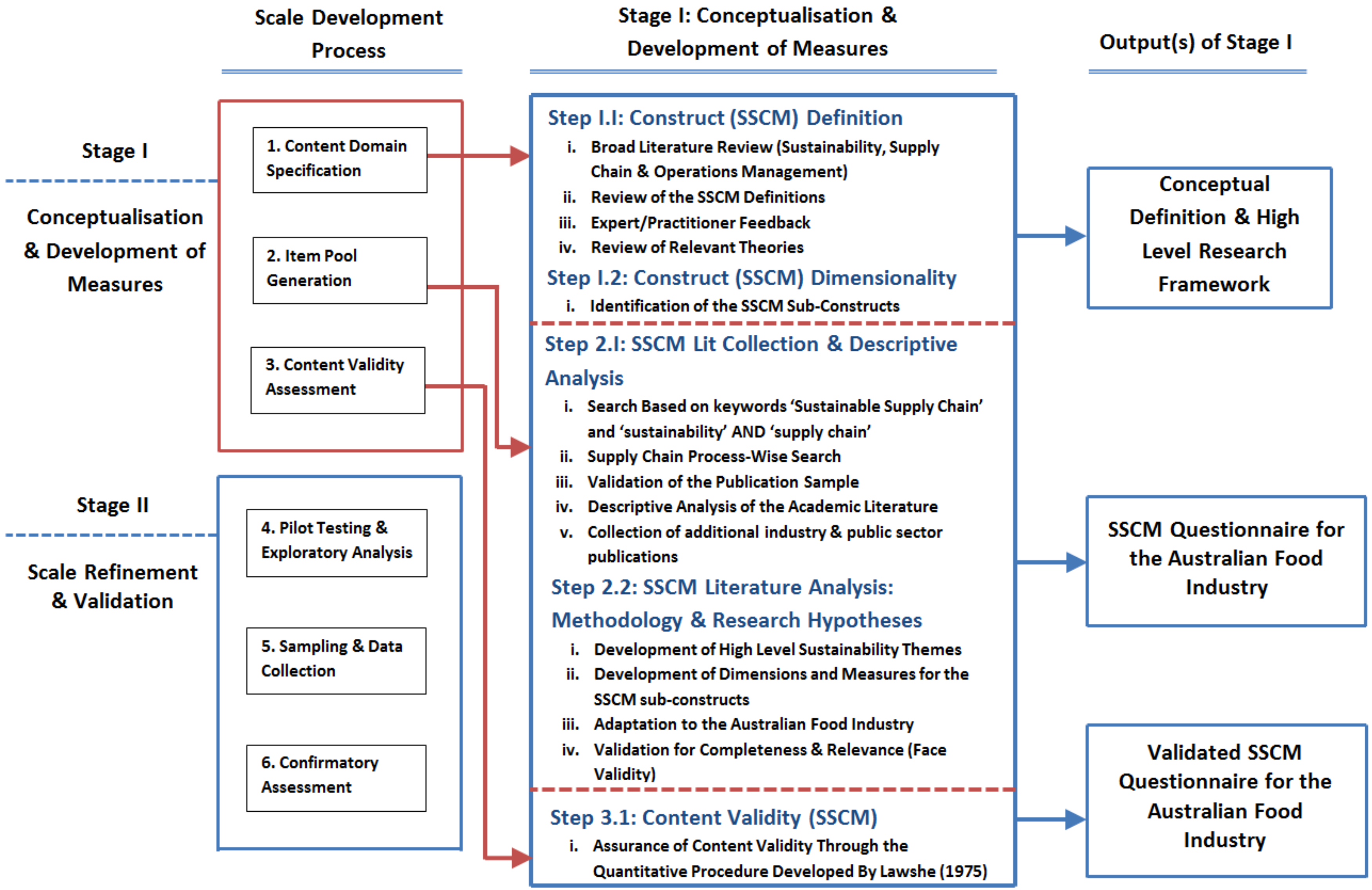

Figure 2: Stage I – Conceptualisation and Measures Identification Framework

CHAPTER 2: STEP 1 – CONTENT DOMAIN SPECIFICATION

Specification of the content domain is the basis for all remaining steps (Netemeyer, Burton, & Lichtenstein, 1995), as it identifies the conceptual purview of the construct (Nunnally & Bernstein, 1994) and also helps the researcher in understanding the boundaries of the construct, its underlying sub-constructs, associated fields of knowledge, previous and current definitions, and its evolution over time.

The content domain for sustainable supply chain management (SSCM) is identified by broader literature review of the field focused on sustainability, supply chain management and operations management. The keywords were entered into Google Scholar and seminal papers were identified for review. The timeframe was kept in consideration and literature analysis was synthesised in a chronological manner, as shown in later sections of this chapter. This broad literature review exercise reinforced the fact that sustainability is not a new concept as the concerns about environmental degradation and social injustice started decades ago. It also clarified the evolution of sustainability through corporate agendas, and its ingress in the field of supply chain management. The review of the SSCM definitions identified the perceptions of the research community pertinent to sustainability in supply chains. It was found that various authors have adopted the triple bottom line (TBL – economic, social and environmental) approach, but mostly, SSCM is still considered equivalent to green supply chain management (GSCM) (Pullman, Maloni, & Carter, 2009).

Furthermore, the initial framework that mainly looked at SSCM from a TBL perspective was discussed with the industry experts but they had a different opinion. They preferred an approach that could specifically focus on each supply chain process rather than develop high level and generic social, economic and environmental supply chain practices. At this stage, the researcher of this PhD study realised that a process-based approach for the SSCM scale development would result in a more pragmatic and realistic scale, where TBL can be used as a secondary lens for each supply chain process (or stage) (planning, procurement, manufacturing, transportation, warehousing and reverse logistics). The literature also provided the basis for the process approach, as discussed in later sections. **Table 3** shows the difference between the two approaches. Relevant management theories were also analysed and the Resource Based View (RBV), stakeholder theory (ST) and institutional theory (IT) were identified as the main theories that should be considered while identifying the sustainability practices for each supply chain process. In addition, the dimensionality of the SSCM construct was brainstormed in the light of expert feedback, literature and review of relevant theories. It was finally decided to consider it as a high-level phenomenon (or meta-construct) that consists of multiple sub-constructs such as sustainable supply chain planning, sustainable procurement, sustainable manufacturing, sustainable transportation, sustainable warehousing and reverse logistics. Consequently, the output of Step I was a conceptual definition for the SSCM phenomena and a high-level research framework for the scale development process, as shown in **Figure 3**.

Table 3: Approaches for the SSCM Scale Development

Approaches for the SSCM Construct Development	
TBL Approach	**Supply Chain Management (SCM) Process Approach**
High level and generic economic, social and environmental practices for a focal firm's supply chain	Sustainability measures for supply chain planning
	Sustainability measures for procurement
	Sustainability measures for transportation
	Sustainability measures for manufacturing
	Sustainability measures for warehousing
	Sustainability measures for reverse logistics

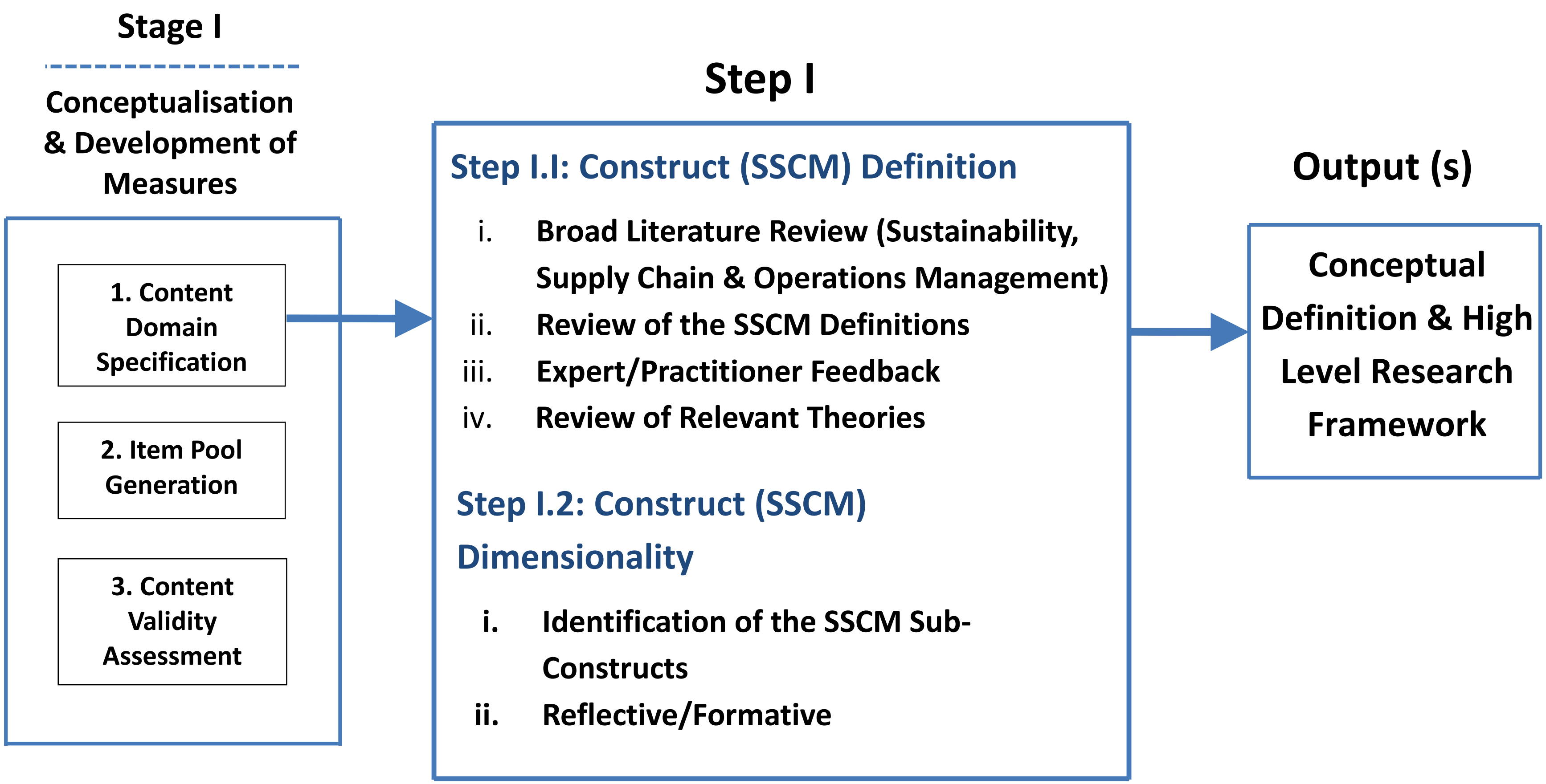

Figure 3: Stage I – Framework for Content Domain Specification

2.1 Construct Definition

2.1.1 Broader Literature Review of the SSCM Domain

The first and foremost step in item generation is to develop a broader understanding of the construct under consideration. The main purpose is to comprehend how the construct evolved over time; how was it used in the past by different researchers; what is the current description of the construct generally agreed on by researchers and practitioners in academic literature and industry publications, respectively; contexts in which it is applied, and different fields that contributed to its development. In this study, the broader review helped to understand the boundaries of the sustainable supply chain management (SSCM) construct which subsequently assisted in developing relevant measures that adequately captured only the SSCM domain and not the factors of other constructs (Netemeyer, Bearden, & Sharma, 2003).

In addition, a broader understanding of the literature also ascertained that no important dimension of SSCM is overlooked – an important criterion for thorough scale development identified by Nunnally and Bernstein (1994). Therefore, following the guidelines of construct validation experts such as DeVellis (2003) and Netemeyer et al. (2003), a broad understanding of SSCM domain is achieved through a thorough inter-disciplinary review of literature. The suggestions of Parahoo (2006) were used for this purpose, and a systematic review of the SSCM domain was carried out. The timeframe of the literature was kept in consideration, pertinent techniques were employed to assess and synthesise the findings, and maximum attention was paid to research done in the last 5 – 10 years, with an exception of seminal works. The results of this methodical process were synthesised and framed in chronologically structured themes as per the recommendation of Carnwell and Daly (2001). A snapshot of these themes is presented below:

2.1.2 Concerns about Sustainability (1867 – 1987)

It is usually considered that sustainability made its debut through the Brundtland Report (Brundtland, 1987) but abhorrence to social injustice, rising levels of poverty and unequal distribution of wealth was voiced even centuries before the report. Evidences can be easily found towards the latter part of 18^{th} century when Karl Marx (1867), in *Das Kapital*, commenting on capitalism stated that it has exploited human labour and earned surplus value and profits through their unpaid work. He wrote: *'capital is dead labor that, vampire-like, lives only by sucking living labor, and lives the more, the more labor it sucks.'* The struggle was intensified after the Second World War, and Carson (1962), wrote the book *Silent Spring* and revealed the real face of the chemical industry. She argued that every human being, from the time of conception till death, comes in contact with dangerous chemicals. She pointed out:

> *'We have allowed these chemicals to be used with little or no advanced investigation of their effect on soil, water, wildlife, and man himself. Future generations are unlikely to condone our lack of prudent concern for the integrity of the natural world that supports all life.'*

She further commented on the hazardous impact of newly-developed biocides and insecticides (at that time) that caused the destruction of wildlife on a massive scale:

> *'This is an era of specialists, each of whom sees his own problem and is unaware or intolerant of the larger frame into which it fits. It is also an era dominated by industry, in which the right to make a dollar at whatever cost is seldom challenged.'*

Later on, Nicholson (1970), co-founder of the World Wildlife Fund (now the Worldwide Fund for Nature), noted in his book *The Environmental Revolution'*, that public awareness is increasing regarding ecological issues caused by the corporate world. He reflected the public sentiment in the book as follows: *'The pride of having reached the moon is cancelled out by the humiliation of having gone so far towards making a slum of our own native planet.'* However, after a series of disasters, a rise in poverty, climatic changes, environmental degradation, human rights protests and increased public awareness, corporate sector and world-order craftsmen started paying heed to the voices raised in the last four decades. This resulted in a wave of environmental legislation throughout the 1970s that swept across the Organisation for Economic Co-operation and Development (OECD) region, and industry went into compliance mode. Afterwards, the 'Green' wave began in 1988 with the publication of *Our Common Future* by the Brundtland Commission (Brundtland, 1987), and injected the term 'sustainable development' in the political circuit. It defined sustainability as: '*Development that meets the needs of the present world without compromising the ability of future generations to meet their own needs.'*

2.1.3 Sustainability on Corporate Agendas (1987 – 1997)

The decade of the 1990s brought sustainability onto the corporate agenda. The publication, *Beyond the Limits* by Meadows, Meadows, and Randers (1992) came up with a very decisive statement:

> *'The present way of doing things is unsustainable. The future, to be viable at all, must be one of drawing back, easing down, healing. Poverty cannot be ended by indefinite material growth; it will have to be addressed while the material human economy contracts.'*

In addition, the 1992 United Nations (UN) Earth Summit in Rio de Janeiro further strengthened the public pressure on companies such as Nike, Shell and Monsanto to address issues of child labour, genetically modified foods, etc. Later in 1995, the United Nations Conference on Trade and Development (UNCTD) explained the links between corporate activity, sustainability and accounting. It eloquently articulated that sustainability should combine eco-justice (inter and intra-generational social equity) and eco-efficiency (environmental) over the short and long term. It added that a sustainable economic model is one that safeguards the Earth's critical and renewable natural capital and resolves inequalities between countries. In addition, it suggested that sustainability should evaluate global commercial activity not only by economic capital but also by social and natural capital (UNCTAD, 1996). In 1997, the sustainability agenda, especially focusing on the social dimension, became the spotlight of the Harvard Business Review. Hart (1997) mentioned that *'Beyond greening lies an enormous challenge — and an enormous opportunity. The challenge is to develop a sustainable global economy: an economy that the planet is capable of supporting indefinitely.'*

2.1.4 Interdisciplinary Sustainability Research

The Brundtland report, UN Earth Summit and Harvard Business Review showed the vagaries of the concept of sustainability. Clearly, sustainability has an extensive purview which makes it hard for organisations to adopt practices that could realise the desired vision. Naturally, many approaches to sustainable development are debated and many questions are raised concerning the kind and quantity of future resource requirements by mankind and other inhabitants of the planet Earth; the levels of emissions and pollutants that might not be detrimental for any living being; exploitation levels of renewable resources so that they remain renewable; the role of technology and market forces; and required changes in lifestyles (Linton, Klassen, & Jayaraman, 2007). Also, the wide-ranging concept of sustainability makes it difficult for organisations to determine their role and responsibility towards internal stakeholders such as shareholders and employees, and external stakeholders that include customers, supply chain partners, environment and society at large (Hart, 1995; Starik & Rands, 1995). A broader look into the literature shows that the Brundtland Report and the Rio Declaration proved to be the foundation stones for stimulating sustainability research across many disciplines such as materials science, engineering, energy, medicine, agriculture, environmental sciences, economics, business, and management (Linton, Klassen, & Jayaraman, 2007). However, the ecological dimension has always been under the investigation spotlight and researchers suggested several frameworks, models, indicators, classifications, systems and practices for controlling and preventing environmental degradation (Adriaanse, 1993; Bergstrom, 1993; Gauthier, 2005; Gilbert & Feenstra, 1994; Klassen & Whybark, 1999; Levy, 1995; Zhu & Sarkis, 2004). Although some effort was made to bring society into the limelight, and sustainability indicators focused on the relationship between society and ecosystems were formulated (Azar, Holmberg, & Lindgren, 1996), still, environmental issues took precedence over societal concerns.

2.1.5 Sustainability Research in Management Studies

Similarly, management scholars also paid attention to organisational sustainability but it was mainly considered equivalent to operations and processes that do not negatively impact the environment (Starik & Gribbon, 1993; Throop, Stark, & Rands, 1993). Shrivastava defined sustainability as 'the potential for reducing long-term risks associated with resource depletion, fluctuations in energy costs, product liabilities, and pollution and waste management' (Shrivastava, 1995, p. 955). However, Gladwin, Kennelly, and Krause (1995) argued that sustainability is not synonymous with eco-efficiency, and that socio-economic factors are equally important. In more recent literature, Sikdar considered sustainability from a macro-viewpoint and according to him, it is '*a wise balance among economic development, environmental stewardship, and social equity*' (Sikdar, 2003, p. 1928). Later on, Carter and Rogers (2008, p. 361) clearly stated that the term sustainability refers *'to an integration of social, environmental, and economic responsibilities.'*

2.1.6 Sustainability in Supply Chain Management

Literature review reveals that the end of the 20th century witnessed the marriage of environment and business. This bond evolved and matured into industrial ecology or ecosystem research where sustainability was considered equivalent to limiting the impact of manufacturing and engineering processes on the environment. The concept of supply chain management was budding at that time even though the jargon such as Materials Logistics Management (MLM), Materials Requirements Planning (MRP), Just-in-Time (JIT), Total Quality Management (TQM), Theory of Constraints (TOC), Customer Relationship Management (CRM) and many more had been around for decades. It was only in this era that the notion of Supply Chain Management absorbed all these ideas in order to manage and improve the overall supply chain of a firm (Fredendall & Hill, 2001). Gradually, firms have been adopting the broader concept of supply chain, but still, the integration of product development, finance and marketing with logistics functions is not a common phenomenon. While firms are grappling with these challenges, the new millennium has dawned with an added mandate of sustainability from governments, the general public, employees and above all, consumers. They are demanding transparency about the conditions under which products are manufactured and distributed. They are aware that it is not only the final product but the entire value creation process that needs to be scrutinised (Seuring, Sarkis, Müller, & Rao, 2008). In addition, immense pressure is exerted by mass media and environmental legislation (like EU law) posing multiple new challenges to approaches such as human rights and workers' safety issues, reduction in carbon footprint and cost minimisation in the wake of financial crisis (Teuteberg & Wittstruck, 2010). Thus, in order to remain competitive in an increasingly aware world, firms are now aiming to impart the concept of sustainability in their supply chains. Researchers are also of the view that the goals of sustainable development can only be realised if appropriate and timely initiatives are taken along the supply chain of a firm (Green, Morton, & New, 1996; Nathan, 2005)

2.1.7 Evolution of Sustainable Supply Chain Management (SSCM)

Within Supply Chain literature researchers have separately investigated various environmental, social and economic issues in the domain of supply chain management, such as impact of corporate logistics management on environment (Murphy, Poist, & Braunschweig, 1995); economic benefits of green supply chain (Rao & Holt, 2005, p. 912); significant negative impact of various processes on the environment, such as long-distance sourcing (Garnett, 2003); just-in-time replenishment (Bleijenberg, 1996; Rao, Grenoble, & Young, 1991; Whitelegg, 1995) and inventory centralisation (Matthews & Hendrickson, 2008); safety issues in motor carrier, airline, and rail industries (Cantor, Corsi, & Grimm, 2006; Crum, Dooley, & Morrow, 1995; Weener & Wheeler, 1992); hiring and promotion issues among logistics personnel (Lynagh, Murphy, & Poist, 1996); environmental criteria for supplier selection (Min & Galle, 2001); collaboration between vendors and suppliers to improve environmental performance (Bowen, Cousins, Lamming, & Faruk, 2001); use of life cycle analysis (LCA) to assess environmental impacts on supply chains (Browne, Rizet, Anderson, Allen, & Keita, 2005; Faruk, Lamming, Cousins, & Bowen, 2001). More recently, work by Carter and Jennings (2002, 2004) interconnected concepts of environment, safety, human rights, community, diversity and philanthropy into broader constructs of logistics social responsibility (LSR) and purchasing social responsibility (PSR). Also, Carter and Rogers (2008) developed a conceptual high-level framework for sustainable supply chain management based on triple bottom line and four important dimensions of sustainability – strategy, culture, transparency and risk management. They defined SSCM as *'the strategic, transparent integration and achievement of an organisation's social, environmental, and economic goals in the systemic coordination of* *key interorganisational business processes for improving the long-term economic performance of the individual firm and its supply chains.'* In addition, Seuring et al. (2008) also defined sustainable supply chain management as *'the management of material and information flows as well as cooperation among companies along the supply chain while taking goals from all three dimensions of sustainable development, i.e., economic, environmental and social, and stakeholder requirements into account.'*

Furthermore, an industry guide by Smart Steps (2009) recommended that sustainability should be instilled in all supply chain functions of a firm to maximise social, environmental and economic benefits. However, other than that, SSCM is usually considered equivalent to green supply chain management (GSCM) and no comprehensive scale is developed to measure it (Seuring & Müller, 2008). The European Logistics Association (ELA) has proposed a scale (Cetinkaya et al., 2011) that is subsequently used by researchers for sustainability assessment (Soosay, 2013). However, the scale is generic and lacks psychometric properties. A broader review of the literature showed that SSCM must take into consideration the end-to-end supply chain which encompasses suppliers, vendors, customers and local communities. It also clarified that within a firm, SSCM stretches horizontally and encourages collaboration of supply chain function with other departments, and vertically by encompassing intra-organisational practices within supply chain processes that range from high level policies to operational procedures. Thus, SSCM measures can be developed in two ways: (1) *TBL approach* can be adopted and measures pertinent to environmental, social and economic sustainability can be broadly developed irrespective of supply chain processes; or (2) *Supply Chain Operations Reference (SCOR) model* can be used, and each supply chain process (planning, procurement, manufacturing, transportation, warehousing and reverse logistics) can be separately analysed for various ecological, communal and financial measures (TBL) that could help to instil sustainability into that process and ultimately the entire supply chain of the firm. These two approaches are shown in **Table 3**.

2.2 Analysis of the SSCM Definitions

An analysis of SSCM definitions was done and it was found that experienced SCM researchers have narrowly defined it as 'the management of supply chains where all the three dimensions of sustainability, namely the economic, environmental, and social ones, are taken into account' (Ciliberti, Pontrandolfo, & Scozzi, 2008, p. 1580) and broadly described it as 'the set of supply chain management policies held, actions taken, and relationships formed in response to concerns related to the natural environment and social issues with regard to the design, acquisition, production, distribution, use, reuse, and disposal of the firm's goods and services' (Haake & Seuring, 2009, p. 285).

Clearly, in many definitions, researchers adopted the process-based perspective emanating from their insights and understanding of the SSCM domain.

2.3 Expert Feedback

Initially, this research study decided to perceive sustainability from a social, environmental and economic perspective as this is the norm in the SSCM literature (Carter & Rogers, 2008). A preliminary research framework was developed and it was decided to get 'expert feedback' from the practitioners since a major emphasis of this study was to develop realistic sustainability dimensions and measures that are highly relevant to the corporate world and also have sound psychometric properties. Discussions with professionals in the field of logistics, supply chain planning and manufacturing made it clear that the TBL perspective is generic in nature and has a strong tendency to overlook the unique requirements and setting of each supply chain process. For example, the TBL view would result in environmental practices such as reduction in emissions and use of non-toxic materials, but these practices cannot be directly operationalised in different supply chain processes and would require further adaptation for manufacturing, procurement and transportation. Similarly, training is highly recommended by researchers as it helps to develop the human capital within an organisation and contributes towards social sustainability (Carter & Jennings, 2002, 2004), but training requirements for procurement personnel would be very different from those in transportation or warehousing. Therefore, it seemed that a process-based approach to supply chain sustainability would be more appropriate, as it would result in more specific and relevant dimensions and measures for each supply chain process, and that would improve the sustainability performance of the end-to-end supply chain.

The Supply Chain Operations Reference (SCOR) model in literature also supports this view. The Supply Chain Council (SCC) developed the model which states that a process-based perspective of the supply chain is more helpful in improving the overall performance of a firm's supply chain. Firms use it extensively and, in the past decade, IBM, Intel, Airbus, General Electric (GE) and DuPont adopted the SCOR model. According to the SCC's website, 'While remarkably simple, it [the SCOR model] has proven to be a powerful and robust tool set for describing, analysing, and improving the supply chain' (as cited in Zhou, Benton, Schilling, & Milligan, 2011). The model takes an operational process perspective of a supply chain and outlines processes, namely: plan, source, make, deliver and return. In addition, researchers are also of the view that sustainability can only be realised if initiatives are taken along different stages (or processes) of a firm's supply chain (Green, Morton, & New, 1996; Nathan, 2005). Also, various SSCM definitions have adopted the process-based perspective, as mentioned before (section 2.2), which also supports the Expert Feedback.

2.4 Review of Relevant Theories

A thorough review of management and supply chain theories was done and it was decided to use the Resource Based View (RBV), stakeholder theory (ST) and institutional theory (IT) for this research study.

2.4.1 Resource Based View (RBV)

RBV suggests that a firm can achieve competitive advantage due to its distinct resources that are rare, inimitable, valuable and non-substitutable (Barney, 1991, p. 117; Penrose, 1959). According to the recent research on RBV, a firm's resources include its assets, policies, culture, knowledge, strategies, products, processes, information technology systems, human resource, equipment, and corporate relationships (Capaldo, 2007; Rai, Patnayakuni, & Seth, 2006). Researchers have discussed RBV from the perspective of a supply chain. It is used as a theoretical lens to develop a conceptual framework to explain, describe, and predict the benefits of a firm's linkages with entities in its supply chain (Rungtusanatham, Salvador, Forza, & Choi, 2003). Also, supply chain experts are of the view that in today's global arena, competition is usually based on 'supply chain vs supply chain' and thus it can be a source of long-term competitive advantage (Gold, Seuring, & Beske, 2010b; Soler, Bergstrom, & Shanahan, 2010). A firm's supply chain can develop a unique blend of the above-mentioned resources which will prove to be a stronger security shield against any imitation by competitors (Kleindorfer, Singhal, & Wassenhove, 2005; Lee & Klassen, 2008; Pullman, 2012; Pullman, Maloni, & Carter, 2009). According to the literature, implementation of sustainability in the supply chain facilitates the development of high-level organisational capabilities which are very specific to a firm, and thus hard to imitate by other market players (Carter & Jennings, 2002, 2004).

In addition, the Resource Based View (RBV) also recommends focusing on processes to improve an organisation's performance. The modern school of thought in

RBV believes that the ultimate goal of firms is to ensure their growth by improving business processes. They consider the seminal work of Penrose (1959) – *The Theory of the Growth of the Firm* – as the main origin of this view. According to this RBV perspective, 'Penrose never aimed to provide useful strategy prescriptions for managers…rather she tried to rigorously describe the processes through which firms grow' (Rugman & Verbeke, 2002). Therefore, this research study will further extend the RBV and develop sustainability measures for each supply chain process that could provide a unique competitive advantage to the firm in the Australian food industry.

2.4.2 Stakeholder Theory (ST)

The stakeholder perspective has gained central importance in organisations in terms of devising new strategies, designing new products, setting up routes to market, planning business expansion, and tackling competitors' moves. It was originally put forward by Freeman (1984) in his book *Strategic Management: A Stakeholder Approach,* and identified various stakeholder groups and how management of a corporation can ensure that its interests are safeguarded. Traditionally, shareholders (owners of the company) were the centre of attention for all strategic, tactical and operational decisions. However, stakeholder theory argued that there are other entities to be considered, such as employees, customers, government, consumers, suppliers, society, unions, regulatory authorities, and environment, and that a firm must make efforts to maximise value for all its stakeholders (Jensen, 2001; Roberts, 1992).

The stakeholder theory explains and guides both the operations and structure of a firm. It views a firm as an organisational entity through which different participants accomplish multiple and diverse goals. The theory goes beyond just stating that 'organizations have stakeholders'. It is used to describe the nature of the firm (Brenner & Cochran, 1991), managers' approach towards running an organisation (Brenner &

Molander, 1977), and how board members conceptualise the interests of various corporate constituencies (Wang & Dewhirst, 1992). Thus, the theory helps to elucidate the connections between stakeholder management and typical corporate objectives such as growth and profitability (Donaldson & Preston, 1995). The theory also helps to interpret the function of a firm relevant to its philosophical and moral responsibilities towards its stakeholders, such as employees and customers (Kuhn & Shriver, 1991; Marcus, 1993).

Recently, the theory has been used to accentuate the corporate social responsibility of a firm, and studies have made implicit and explicit references to stakeholders' perspective (Preston & Sapienza, 1990; Preston, Sapienza, & Miller, 1991). Researchers have observed that many highly successful companies such as Wal-Mart, Dayton Hudson and Hewlett-Packard share the stakeholder perspective, despite operating in different industries. Kotter and Heskett (1992, p. 59) mentioned that 'almost all [their] managers care strongly about people who have a stake in the business – customers, employees, stockholders, suppliers, etc.' In a similar vein, the stakeholder theory provides the basis for identification of all stakeholders for every process of a focal firms' supply chain, so that social, environmental and economic value can be maximised for them leading to long-term sustainability.

2.4.3 Institutional Theory (IT)

Institutional theory explains how external pressures impact an organisation (DiMaggio & Powell, 1983; Roberts & Greenwood, 1997). According to institutional theory 'firms operate within a social framework of norms, values, and taken-for-granted assumptions about what constitutes appropriate or acceptable economic behaviour' (Oliver, 1997, p. 699). Social factors related to geographical norms, customs, tabos, and religious traditions are important concerns while making strategic decisions. The theory suggests that social factors, such as communal obligation and societal justification, are the key influences on an organisation's adoption of innovative practices (Rogers, Purdy, Safayeni, & Duimering, 2007). Thus, with the lens of institutional theory, various actions and initiatives taken by a firm can be explained as attempts to establish their legitimacy among their stakeholders (Rogers et al., 2007).

Organisations and individuals 'are assumed to be approval seeking, susceptible to social influence, and relatively obstinate creatures of habit and tradition' (Oliver, 1997, p. 699). Organisations try to comply with the expectations of the stakeholders, such as employees, customers, regulatory authorities and suppliers, as their success and survival is based on how responsive and agile they are towards them (Baum and Oliver, 1991; Dacin, Goodstein, & Scott, 2002). In addition, firms also conform to stakeholders' requirements 'because they are rewarded for doing so through increased legitimacy, resources, and survival capabilities' (Scott, 1987, p. 498).

Scholars have used institutional theory as a lens for studying the adoption of innovative practices in the supply chain (Heugens & Lander, 2009; Rogers et al., 2007; Teo et al., 2003). They are of the view that institutional pressures originating from the external environment can strongly affect a firm's decision to adopt innovative supply chain practices. Rogers et al. (2007) have contended, 'Arguments from institutional theory can contribute to a better understanding of the social context of OM [Operations Management] and SCM [Supply Chain Management] strategies' (p. 569). Further, Teo et al. (2003) argued that the supply chain innovations enabled by the internet are more driven by institutional motivations than technical requirements. Currently, governments, the general public, employees and, above all, consumers, are demanding organisations to become sustainable. These stakeholders want organisations to be transparent about the conditions under which products are manufactured and distributed. They are aware that it is not only the final product but the entire value creation process that needs to be scrutinised (Seuring, Sarkis, Müller, & Rao, 2008). In addition, immense pressure is exerted by mass media and environmental legislation posing multiple new challenges to organisations, such as human rights and workers' safety issues, reduction in carbon footprint, and cost minimisation in wake of financial crisis (Teuteberg & Wittstruck, 2010). Thus, institutional theory is a pivotal perspective for studying the adoption of sustainability practices by different functions within a focal firm's supply chain.

Based on Step 1.1, this research study defined SSCM as:

> *'the strategic collaboration and coordination between a firm's supply chain processes – planning, procurement, manufacturing, warehousing, transportation and reverse logistics and those of its customers, suppliers and service providers with an aim to maximise the environmental, social and economic value of the end-to-end supply chain.'*

It must be noted here that even though the scope of this research is limited to a firm, the concept of end-to-end supply chain is used. This is because a firm has the ability to not only ingrain sustainability in its internal supply chain, but it can also influence decisions regarding its external supply chain. It can force its suppliers to use recyclable packaging, ensure that basic human rights are not violated by its vendors, and that fuel efficient transportation modes are used by its service providers. Therefore, SSCM is a multifaceted meta-construct that comprises sustainable planning, procurement, manufacturing, warehousing, transportation and reverse logistics.

2.5 Construct (SSCM) Dimensionality

Once the SSCM phenomenon was defined, its dimensions were assessed as per the recommendations by MacKenzie, Podsakoff, & Podsakoff, (2011). After much deliberation, literature review and consultation with experts, it was finally agreed to treat SSCM as a broader phenomenon that is a combination of six different sub-constructs, namely: sustainable planning (SPlng), sustainable procurement (SP), sustainable manufacturing (SM), sustainable transportation (ST), sustainable warehousing (SW) and reverse logistics (RL). Each of them was considered as a separate and standalone sub-construct, as shown in **Figure 4**.

This approach also supports the fact that different sectors of industry have different combination of these processes in their supply chain. For instance, third-party logistics providers (3PLs) mainly deal with transportation or warehousing with a small percentage of procurement functions, while manufacturing companies have extensive procurement and manufacturing and they usually outsource logistics to 3PLs. Thus, it makes sense to treat each sub-construct as a discrete entity and then determine its sustainability dimensions and measures based on TBL.

Finally, the extensive literature review and analysis implicitly suggested that all dimensions for a particular SSCM sub-construct are reflective in nature (further discussed in section 3.3). This means that a sub-construct is made up of many dimensions, and eliminating any one of them would impact the sustainability performance of that particular supply chain process. Also, the guidelines provided by Freeze and Raschke (2007) were used to ensure the reflective nature of the sub-constructs. The Table used for this purpose is provided in Appendix 6 at the end of this thesis. All the elements identified by Freeze and Raschke (2007) were checked for the SSCM sub-constructs and it was finally decided that the sub-constructs should be reflective and not formative.

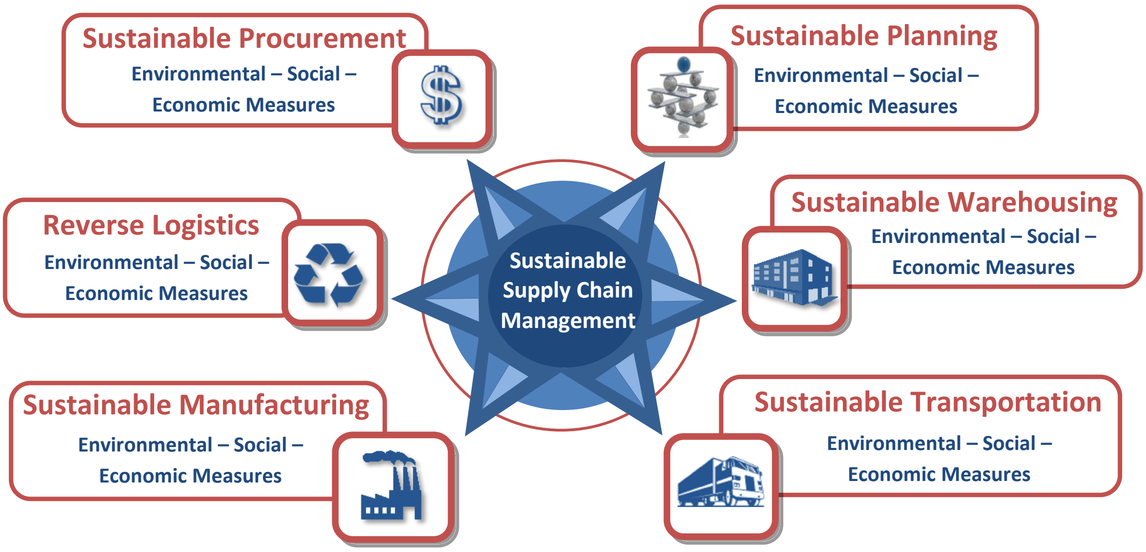

Figure 4: High Level Research Framework based on the SCOR model, TBL, RBV, ST & IT

CHAPTER 3: STEP 2 – ITEM POOL GENERATION

Reynolds (2010) emphasised that item pool generation is a crucial step and it is not appropriate to present only a limited number of items in the research study. DeVellis (2003) observed that:

> '*researchers often "throw together" or "dredge up" items and assume that they constitute a suitable scale. These researchers may give no thought to whether the items share a common cause, share a common consequence, or merely are examples of a shared superordinate category that does not imply either a common causal antecedent or consequence.'*

Such an approach results in invalid theories with no practical significance. In the arena of Supply Chain Management (SCM), it has been repeatedly stressed to develop constructs that have strong theoretical underpinnings (Babbar & Prasad, 1998; Cooper, Lambert, & Pagh, 1997; Saunders, 1995, 1998). Therefore, this PhD research study thoroughly explains the 'item pool generation' process. All the details are provided in a comprehensive manner to clearly articulate the generation of items for each Sustainable Supply Chain Management (SSCM) sub-construct. All the strategies, methodologies, procedures, and analytical techniques are described in a simple and lucid manner. Step 2 (item pool generation) of the scale development process was divided into two steps (steps 2.1 and 2.2), as shown in **Figure 5**, and details of these steps are covered in the next three sections (sections 3.1, 3.2 and 3.3). These sections are briefly discussed below:

Section 3.1 – 'SSCM Literature Collection and Descriptive Analysis', provides details of the step-by-step procedure that was adopted to collect the most relevant SSCM academic literature from library services and digital databases. It also provides in-depth descriptive analysis of the collected academic literature that laid down the foundation for further research in this study. It presents a number of interesting new findings, and highlights the gaps and the overlooked areas in the field of SSCM. At the start, an analysis of the already existing literature reviews on SSCM was also carried out so as to benefit from the expert insight of seasoned SSCM researchers. This analysis helped to identify the focus areas of current SSCM research and assisted in delineating the strategy for a systematic literature review. **Section 3.2** – 'SSCM Literature Analysis: Four-Phased Qualitative Methodology', provides extensive details in a succinct manner about the methodology that was devised to review and analyse the SSCM material consisting of 349 peer-reviewed academic articles and miscellaneous carefully selected industry publications and company reports. The overall aim was to develop a sustainability questionnaire for each stage of a firm's supply chain in the Australian food industry. The questionnaire was later used for data collection and scale validation. The material analysis was completed in four phases that used thematic and content analysis for coding. It was an iterative and non-linear process based on constant review and comparison, and rigorous perusal of material facilitated by NVivo, the qualitative data analysis software. **Section 3.3** – 'SSCM Literature Analysis: Results and Research Hypotheses', presents the results of the SSCM material analysis (section 3.2). It elaborates on each SSCM sub-construct (planning, procurement, manufacturing, transportation, warehousing and reverse logistics) and provides a comprehensive discussion on each dimension and measure, finalised through the systematic analytic process that was covered in section 3.2. In addition, for each SSCM sub-construct, it separately provides details of key literature used for analysis. A summary of all the material used for each sub-construct is also provided in a tabular form to show the extent of material studied in order to finalise the dimensions and measures. Furthermore, research hypotheses are developed for each SSCM sub-construct and presented in the form of conceptual models.

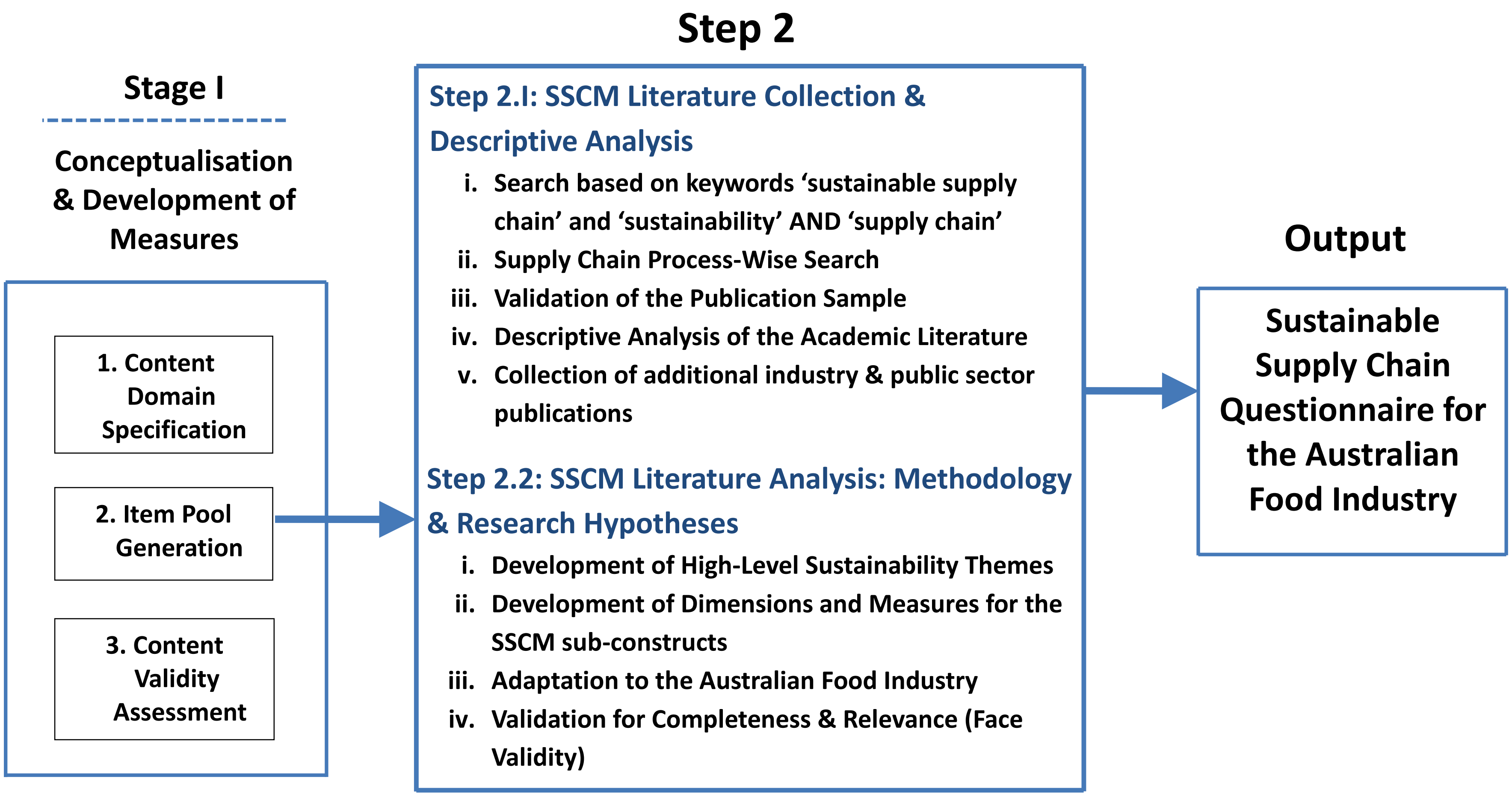

Figure 5: Stage I – Framework for Item Pool Generation

3.1 SSCM Literature Collection and Descriptive Analysis

The research framework requires that a separate comprehensive scale should be developed for each SSCM sub-construct. Therefore, in order to generate items for each sub-construct, it was decided to critically analyse the literature through the lens of the SCOR process model. Current SSCM review papers were also studied and it was found that reviewers have broadly investigated the research methodologies, modelling techniques, performance metrics and supply chain drivers which help to improve the sustainability performance of a supply chain. However, no review has been conducted through the lens of the ***SCOR process model*** that could explicitly analyse the status of sustainability research for each supply chain process, so that gaps are identified and practices can be developed accordingly. Therefore, the review of academic literature in this PhD study was aimed to address the research question 2 (mentioned in the Introduction). This research question is further divided into the following sub-questions to attain meaningful results from the review activity:

1. How have sustainability challenges been addressed in each SCOR process to date?
    a. Which methodologies dominate the research in each process?
    b. Which aspects of sustainability (social and environmental) are focused on in each process?
    c. What are the key categories of knowledge developed in each process?
    d. What are the major themes (or topics) covered with regard to each process?
2. What are the major gaps and research opportunities regarding operationalisation of sustainability in each supply chain process?

These questions are answered through descriptive analysis in this section, and analysis of the SSCM material in sections 3.2 and 3.3.

3.1.1 Analysis of Existing Literature Reviews

The analysis of already existing SSCM reviews proved to be a time-consuming activity in itself; however, it provided noteworthy insights into the SSCM literature and focus areas of the SSCM research to date. It established the platform for carrying out an extensive review of the SSCM literature through the lens of the SCOR process model and with the knowledge of what is already being done. The findings of this analysis, briefly discussed below, can also be considered as a contribution of this PhD study in their own capacity.

It was found that earlier reviews on SSCM mainly focused on greening of the supply chain, and identified green product and process development as the basis for incorporating environmental issues into the supply chain without any concern for social matters (Gungor & Gupta, 1999; Kleindorfer, Singhal, & Wassenhove, 2005). The applications of operations research (OR) and categorisation of related methods was done by Bloemhof-Ruwaard, van Beek, and Hordijk (1995) and Daniel, Diakoulaki, and Pappis (1997) in the context of environmental management (EM) and planning. ReVelle (2000) provided a synopsis of the OR techniques pertinent to the management of solid waste, water resources and air quality. Most of the reviews in the last ten years are mainly general or focused on quantitative models or empirical research. **Table 4** presents a brief summary of these reviews. Those by Srivastava (2007), and Min and Kim (2012) are limited only to green supply chain management (GSCM), but other researchers have targeted the entire gamut of SSCM. Overall, the reviewers are of the opinion that sustainability is usually driven by customers, governments or other stakeholders (Gold, Seuring, & Beske, 2010a, 2010b; Seuring & Müller, 2008) and most of the empirical research is mainly focused on a single firm and the manufacturing sector (Carter & Easton, 2011; Hassini, Surti, & Searcy, 2012). Seuring and Müller (2008) are also of the view that the primary focus of the SSCM research is still ‘environment’, while social issues are broadly overlooked in analytical modelling (Tang & Zhou, 2012) and empirical research (Gold, Seuring, & Beske, 2010a).

Whereas Tang and Zhou (2012) observed that the social factors analysed in quantitative SSCM papers are limited only to customers and producers, and the environmental factors are mostly concentrated on pollution and emissions. It must also be noted that most of the reviews have restricted their literature search and scope only to logistics and SCM journals. However, Ashby, Leat, and Hudson-Smith (2012) and Teuteberg and Wittstruck (2010) have also included other relevant journals in their reviews. They are of the opinion that since sustainability is in an embryonic stage, therefore many other journals that may fall outside of the typical SCM research arena still reasonably inform SSCM, and thus should be included in the review to analyse the advancement in the field.

Table 4: Summary of the SSCM Reviews

Sr No.	Authors and Year	Research Focus of Review	No. of Reviewed Papers/Books	Time Horizon
1.	Kleindorfer et al. (2005)	General	353	1992 – 2004
2.	Srivastava (2007)	General	227	1994 – 2007
3.	Carter and Rogers (2008)	General	166	N/A
4.	Seuring and Müller (2008)	General	191	1994 – 2007
5.	Gold et al. (2010a)	Empirical	70	1994 – 2007
6.	Gold et al. (2010b)	Empirical	70	1994 – 2007
7.	Teuteberg and Wittstruck (2010)	General	142	1995 – 2008
8.	Carter and Easton (2011)	Empirical	80	1991 – 2010
9.	Min and Kim (2012)	General	519	1995 – 2010
10.	Hassini et al. (2012)	Quantitative Models	87	2000 – 2010
11.	Seuring (2012)	Quantitative Models	36	1994 – 2010
12.	Tang and Zhou (2012)	Quantitative Models	56	N/A
13.	Sarkis (2012)	Empirical	~100	2000 – 2010
14.	Ashby et al. (2012)	General	134	1983 – 2011

Previous reviews have observed that the empirical testing is more prevalent in SSCM studies when compared to conceptual or modelling techniques. Reviewers have also provided classification of the SSCM literature with regards to supply chain drivers and partners (Hassini et al., 2012), supply chain design (Srivastava, 2007) and research methodology (Ashby et al., 2012; Seuring & Müller, 2008; Teuteberg & Wittstruck, 2010). Few researchers, such as Carter and Rogers (2008) and Seuring and Müller (2008), have used the literature review to develop a conceptual framework for SSCM. Overall, the perusal of these reviews made it clear that in SSCM literature the conceptual models, theoretical frameworks, empirical analysis, case studies and quantitative techniques that address all three dimensions of sustainability are very rare or extremely limited in their scope (Seuring & Müller, 2008). In addition, major review papers helped in understanding the overall status of the sustainability research in the field of SCM. Various aspects of SSCM are discussed with a broader perspective, however, reviewers have not specifically analysed the publications with a focus on supply chain processes. This could be extremely useful as it would highlight specific areas that need to be investigated within each supply chain process. Consequently, the resulting research would develop targeted solutions, metrics, practices and models which would assist the corporate sector in truly operationalising sustainability in their supply chains.

This research study made an effort to fill this gap. It collected and analysed the SSCM material separately for each supply chain process (planning, procurement, manufacturing, transportation, warehousing and reverse logistics). It carried out an extensive descriptive analysis to understand which methodologies are prevalent and which sustainability dimensions are mostly focused in each area. This effort led to interesting findings, discussed later in this section through descriptive analysis.

The basic reasoning and logical argument behind this extensive activity was that SSCM is in an embryonic stage, and research output has exponentially increased in the last decade with deviant, similar or contradictory findings. Thus it is very important for the SSCM scale development that an extensive review is carried out and its findings are used as a stepping stones towards the identification of dimensions and measures for the SSCM sub-constructs. It must also be noted that this was not a futile activity, as the continuously increasing knowledge makes literature reviews crucial tools for excavating the 'nuggets of knowledge that lie buried underneath' (Kirca & Yaprac, 2010, p. 306). They are a scholarly contribution in themselves as they synthesise and refine scattered knowledge, map and consolidate the existing research, and identify further research opportunities (Meredith, 1993). According to Fink (2010), 'A literature review is a systematic, explicit, and reproducible design for identifying, evaluating, and interpreting the existing body of recorded documents.' Thus, the aim of this review was twofold: first to encapsulate, consolidate and evaluate the territory of the SSCM literature with respect to each supply chain process; and second to identify the gaps to further develop the body of knowledge (Meredith, 1993; Tranfield, Denyer, & Smart, 2003).

3.1.2 Literature Review Methodology

Recent supply chain reviews have been criticised for lacking rigour in terms of the description of research methodology and procedure (Seuring & Gold, 2012). Kolbe and Burnett (1991, p. 250) also accentuated the significance of elaborative documentation of the applied methods and the entire research process. They are of the opinion that reporting of methodology is 'critical for discerning the quality and usefulness of content analysis studies as well as for allowing replication.' Therefore, an effort is made in this thesis to provide sufficient details regarding each stage of the literature review based on the steps suggested by Mayring (2002, 2008).

3.1.3 SSCM Literature Collection

Initially, the literature review was limited to including the research published in peer-reviewed journals during the 20–year period from 1992 to 2012. Since journal articles are the main mode of communication within academia and between academia and practitioners, they are considered as the ‘unit of analysis’ for this review study. The following inclusion/exclusion or filtration criteria, adapted from seminal works of Ashby et al. (2012) and Seuring and Müller (2008), was used for literature collection.

1. Manuscript must be written in English.
2. Papers focusing on pure mathematical approaches such as geometric clustering, equilibrium problems and algorithmic game theory should be excluded.
3. Papers with very specific focus on technical aspects of supply chain, such as end-of-pipe equipment, material processing technologies, automated warehousing, remanufacturing techniques, simulation methods, inventory management strategies, ERP optimisation and pollution prevention should not be included in the publication sample.
4. Papers with non-management focus, and with a main emphasis on human psychology, political science, organisational governance, and industrial ecology should not be considered.

It was clear to the researcher of this study that an inappropriate selection would limit the quality of results (Fettke, 2006; Swanson & Ramiller, 1993; Webster & Watson, 2002). So in this review, the keyword-based search was used for material collection as it is the most widely used mechanism for acquiring relevant publications from library services and electronic databases (Seuring & Gold, 2012). It was completed in the following three steps.

3.1.3.1 Step I: General Search

A general search using the term ‘sustainability’ in Google Scholar resulted in 848,000 hits and about 59,500 hits when restricted to only the ‘article title’ in the advanced search options. This shows that it is critical that the selected literature deals specifically with the concept in the context of supply chain management. Initially, the search was conducted in

Emerald, ScienceDirect, Wiley and Springer. A broad search of the term ‘sustainable supply chain management’ resulted in more than 11,000 hits. The search was then limited to only the title, keywords or the abstract of the articles, which reduced the number of hits to 447. The abstracts were examined, filtration criteria were applied, and only 178 articles were found relevant. Similarly, broadly searching for ‘sustainability’ AND ‘supply chain management’ resulted in about 8,200 hits and when restricted to title, keywords or abstract, hits reduced to 186, out of which only 53 papers were found relevant. Most of these papers broadly covered supply chain rather than focusing its processes. Therefore, the search criteria were expanded, as described in Step II (process-wise search).

3.1.3.2 Step II: Process-Wise Search

In this phase, more search terms were used that focused specifically on different supply chain processes. A combination of search strings consisting of (sustainable OR ethical OR green) AND (purchasing OR procurement OR sourcing OR transportation OR mobility OR logistics OR warehousing OR storage OR manufacturing OR production) was entered in the electronic databases and library services mentioned in Step I. The search was again restricted to only article title, keywords and abstract. This process was also repeated for the terms related to supply chain planning and reverse logistics. This searching exercise resulted in a total of 561 papers. The perusal of abstracts, application of filtration criteria, and elimination of duplications reduced the number to 115 relevant papers.

3.1.3.3 Step III: Validation Check

Finally, a validation check was performed by comparing the publication sample of 346 papers with relevant articles already identified by high-quality sustainable supply chain literature reviews. This further ensured that credible work by researchers in the field of SSCM is not missed out, and consequently enhanced the credibility of the search process. Only three reviews were used for this purpose, which included the work done by Seuring and Müller (2008), Cater and Easton (2011) and Teuteberg and Wittstruck (2010). Consequently, three more papers were added to the sample, leading to a final sample size of 349 papers. In this entire search process about 2,100 papers were considered and only 349 met the selection criteria for this review. Even though the extensive search process, used across multiple databases, ensured that the major proportion of the literary work related to SCM and sustainability is represented by this publication sample of 349 articles, it was recognised that the search methodology would inevitably exclude some of the related work.

3.1.4 Descriptive Analysis

This section deals with the descriptive analysis of the reviewed literature. First of all, it will broadly examine the entire publication sample (349 papers) and present (1) the distribution of papers across the time period from 1992 till 2012; (2) the methodologies used to conduct the research; (3) the journals which published these articles; and (4) dimensions of sustainability that were addressed in these papers. Second, it will discuss the categorisation and analysis of the publication sample with respect to SCOR processes.

3.1.4.1 Year-Wise Distribution of Publications

In total, 349 papers were reviewed that were published in the researched period (1992 – 2012) as shown in **Figure 6**. The Brundtland Report, published in 1987, was taken as the starting point for paper search even though environmental and social issues were raised many times before, but it was the Brundtland Report that brought them under the spotlight on the international stage. It can be clearly seen that the number of publications has dramatically increased in the last ten years. Only 84 papers were published from 1992 to 2001, and 255 were published from 2002 to 2012 – almost triple the number. A substantial increase in 2001 and 2003 is due to special issues of the journal Greener Management International containing seven papers each. Later on, typical supply chain and operations management journals (International Journal of Production Research, International Journal of Cleaner Production, International Journal of Production Economics and Journal of Operations Management) also covered SSCM in their special issues which show wide acceptability of the subject in the research community. A peak in 2007 is also because of two special issues that appeared in that year.

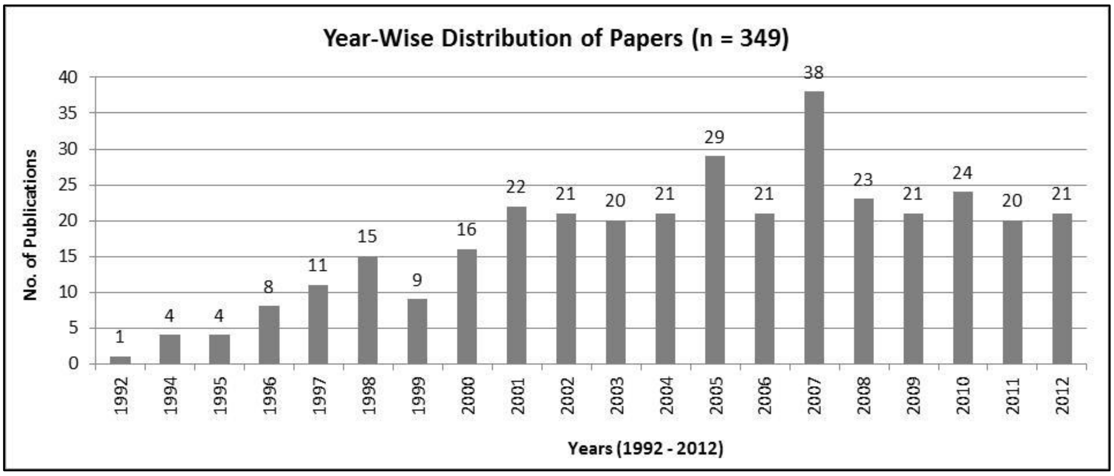

Figure 6: Year-Wise Distribution of Publication Sample for the SSCM Literature

3.1.4.2 Journal-Wise Distribution of Publications

The traditional operations management journals represent about 95 papers (28 percent) while environmental management journals also represent almost the same number of papers (105) which is about 30 percent of the sample; and journals that focused on ethics and corporate social responsibility contributed 20 papers.

It must be noted that literature search was not limited to typical SCM and OR Journals, and other relevant journals were also included. Ashby, Leat, and Hudson-Smith (2012) and Teuteberg and Wittstruck (2010) have also adopted the same strategy in their SSCM reviews. They are of the opinion that since sustainability is in an embryonic stage, therefore many other journals that may fall outside of the typical SCM research arena still reasonably inform SSCM, and thus should be included in the review to analyse the advancement in the field. The researcher of this study agrees with their viewpoint.

It can be seen that many top contributors such as ‘Greener Management International’ and ‘Business Strategy and the Environment’ are not typical operations management journals. **Figure 7** shows the distribution of papers across journals. This graph displays only 263 papers out of 349, and it represents journals that contributed at least 3 papers. The remaining 86 papers were contributed by 74 journals and it was not possible to show all of them in the same graph. Twelve journals contributed 2 papers each, while 62 journals contributed only one paper each. In total, contributions from 102 journals made up the publication sample for this review. This clearly shows that SSCM is a multi-disciplinary field and is very extensive in terms of its scope and application.

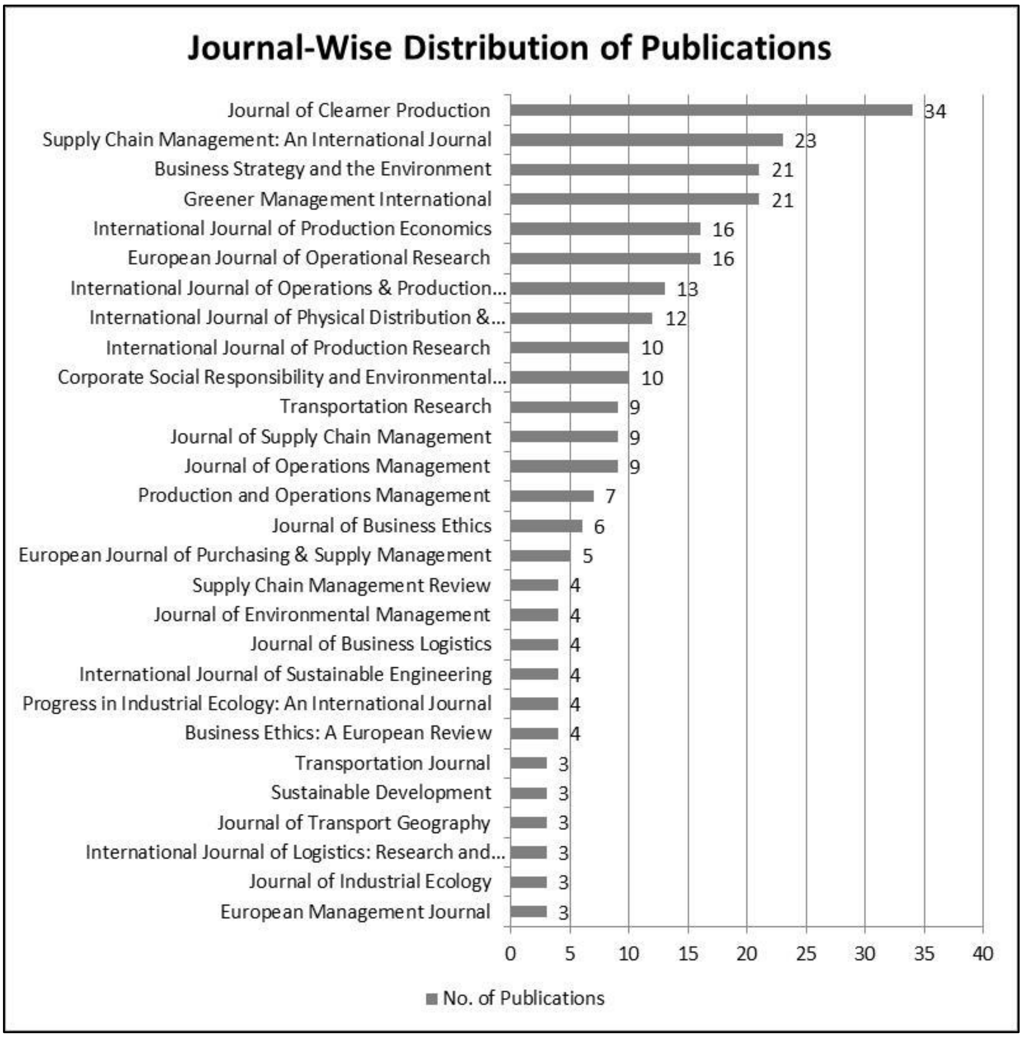

Figure 7: Journal-Wise Distribution of Publication Sample for the SSCM Literature

3.1.4.3 Research Methodologies

Papers were categorised into five main groups based on the research methodologies broadly employed to conduct the research. These are (1) case studies; (2) conceptual and theoretical papers; (3) papers that used quantitative models; (4) research done through surveys; and (5) review papers. . This classification is based on the work done by Seuring and Müller (2008). About one-fourth (26 percent) of the sample employed case study research methodology as it allows in-depth contextual analysis of complex issues within the field of SSCM, while almost the same number of papers (84) used a survey approach to produce results that could be generalised across the field. It must be noted that for the sake of simplicity the rigour of methodology is not considered in this review, and many papers that just used corporate practices or methodologies as examples to answer research questions without any attempt at theory construction were also classified as case studies.

In addition, 74 papers did not have any empirical component and were either theoretical or conceptual in nature. This is not surprising for an evolving field which is still trying to lay down its foundations and mark out its intellectual territory. Also, 66 papers (19 percent) used mathematical models based on variables and their causal relationships that are a depiction of reality. This is in contrast to Seuring and Müller's (2008) findings where modelling papers were only 10 percent of the SSCM paper sample. The reason is that they excluded the reverse supply chain papers and only considered the forward supply chain, while this review found that reverse logistics has employed mathematical models more than any other supply chain process.

Lastly, 35 (10 percent) of literature reviews are produced by researchers in the field of SSCM. Reviews are the backbone of any academic field as they highlight major research contributions and identify gaps to pave the way for further research. **Figure 8** summarises the above discussion.

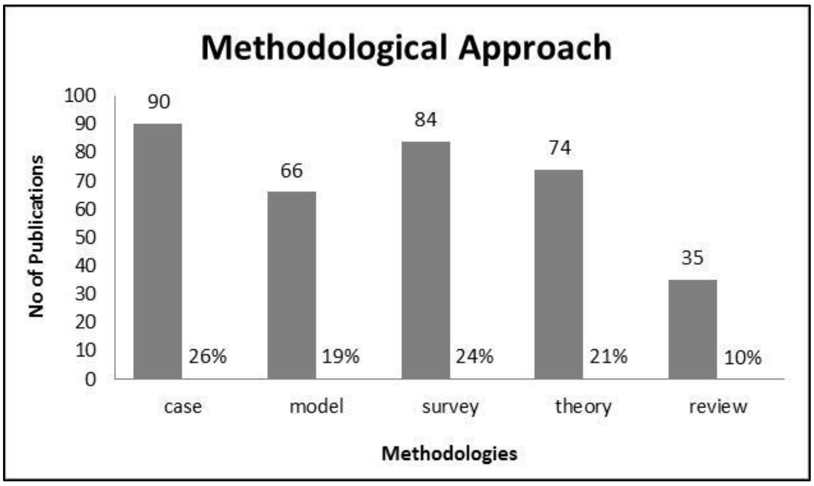

Figure 8: Methodology-Wise Distribution of Publication Sample for the SSCM Literature

The paper sample for this review is also analysed for research methodologies used across the time period (1992 – 2012). The following **Table 5** clearly shows that mathematical modelling is rarely used during the first decade (1992 – 2001) and only 12 papers proposing and testing quantitative models were published during these ten years. However, this number has dramatically increased to 54 in the last decade. This is an extremely positive development as it will allow the field to expand further on solid grounding.

Another interesting finding is that only 11 review papers were published from 1992 till 2006 (15 years) while 24 were published in just the last five years. This really shows that SSCM is evolving, and researchers are critically analysing the field to identify the themes and important domains that need to be focused for future research.

Table 5: Year-Wise Distribution of Publication Sample for Research Methodologies

Research Methodology	No. of Papers	1992 - 1996	1997 - 2001	2002 - 2006	2007 - 2012
Case Study	90	3	20	34	33
Model	66	2	10	18	36
Survey	84	7	21	25	31
Theory	74	4	16	31	23
Review	35	1	6	4	24

3.1.4.4 Sustainability Dimensions

The paper sample for this review was also analysed for sustainability dimensions (environment and social). The strategy employed by Seuring and Müller (2008) in their seminal SSCM review paper is also used in this review, and it is assumed that an economic dimension is present in all the papers. Subsequently, papers were categorised as (1) environmental – if ecological and environmental issues and strategies were mainly discussed; (2) social – if societal, communal or employee related matters were analysed, and (3) sustainable – if it covers both environmental and social dimensions. **Table 6** shows the overall distribution of the publication sample for these dimensions. Clearly, environmental issues have been dominating the sustainability arena and it is the main theme in about 60 percent of the papers as compared to only 12 percent focusing on social issues.

Table 6: Overall Distribution of Publication Sample for Sustainability Dimensions

Sustainability Dimension	No. of Publications (N = 349)	Publication Percentage
Environmental	209	60
Social	41	12
Sustainable	99	28

Table 7 shows the year-wise distribution of papers. Again, it can be seen that in each year the environment-related publications are almost double the number of those focusing on both environment and social matters. However, an interesting and encouraging finding is that the number of papers addressing social dimensions has increased three-fold (31) in the last decade (2002 – 2012) as compared to only 10 papers in the earlier decade. Similarly, sustainability papers, focusing on both environment and social topics, have increased seven times (87 papers) in the latter decade as compared to only 12 papers in the former decade. Another important observation is that 'sustainability' consistently started

appearing only since 2002, which implicitly shows a consensus among the researchers that sustainability in supply chains is not related only to environmental sustainability; it must also take into consideration the social issues (both internal and external) relevant to the firm. In addition, a large number of papers in a specific year can be explained by the special issues of a journal during that particular year. For example, a high publication output for environment related papers in 2001 and 2007 can be attributed to special issues of Greener Management International and International Journal of Production Research, respectively.

Table 7: Year-Wise Distribution of Publication Sample for Sustainability Dimensions

Year of Publication	Sustainable (99)	Env (209)	Soc (41)
1992	1		
1994		1	3
1995		4	
1996	2	6	
1997	2	8	1
1998	1	12	2
1999	2	6	1
2000	2	11	3
2001	2	20	
2002	4	11	6
2003	5	10	5
2004	6	12	3
2005	8	19	2
2006	4	14	3
2007	11	26	1
2008	10	9	4
2009	8	11	2
2010	8	12	4
2011	12	8	
2012	11	9	1

3.1.4.5 SCOR Process-Wise Paper Distribution

The publication sample of 349 papers was also classified with regard to each supply chain process (planning, procurement, manufacturing, transportation, warehousing and reverse logistics). Papers that did not focus on any specific supply chain process, and generically discussed sustainability at firm or industry level, were categorised as general sustainable supply chain management (GSSCM) papers. **Figure 9** shows the distribution of paper sample with respect to the above categories.

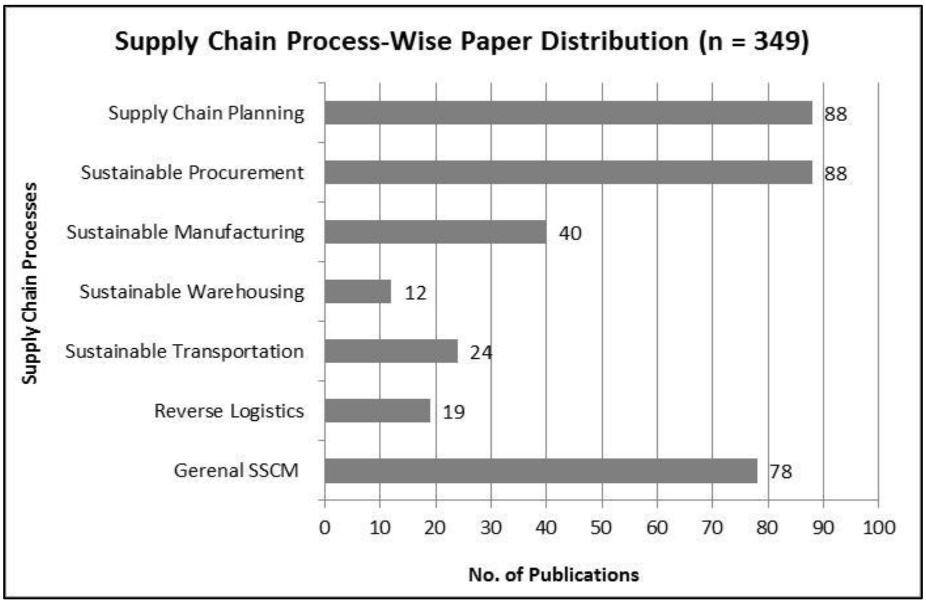

Figure 9: Supply Chain Process-Wise Distribution of Publication Sample

3.1.4.6 Sustainable Supply Chain Planning (SPlng) Paper Sample

Papers that discussed issues related to environment, society (or both) with regards to supply chain planning related to risks in supply chain, product development, supply chain design, supply chain performance metrics, management information systems, decision making, institutional factors, integration issues, supply chain partnerships and optimisation models were categorised as 'sustainable planning' papers.

A total of 88 papers matched the above criteria, which is about 25 percent of the sample. Some 56 research articles (64 percent) focused on the environmental dimension of sustainability, and only five papers (six percent) discussed social issues, while 27 papers (31 percent) were categorised as sustainable. Also, about 58 percent of the papers either used a survey or case study approach to provide in-depth analysis of the firms with regards to their sustainability efforts (**Figure 10**).

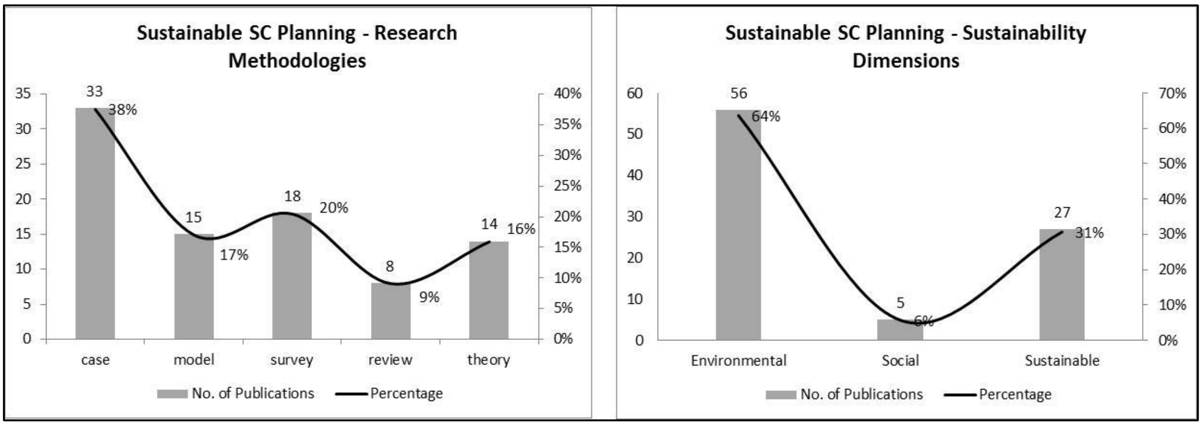

Figure 10: Distribution of Sustainable Supply Chain Planning (SPlng) Papers Regarding Research Methodologies & Sustainability Dimensions

3.1.4.7 Sustainable Procurement (SP) Paper Sample

Papers that focused on procurement policies, green buying, contract management, supplier management and e-procurement in the context of sustainability were categorised as 'sustainable procurement' papers. Again, a large number of papers (88), about 25 percent of the sample, focused on purchasing, which shows the strategic importance of the function and likewise efforts of the researchers to make it more environment-friendly or sustainable. Again, 50 percent of the sample (44 papers) focused on environmental issues and only 21 papers (24 percent) addressed social issues, while 23 papers (26 percent) focused on both, which is an encouraging number for an evolving field like SSCM. Again, survey and case study were the preferred methodologies, as they were used in about 64 percent of the papers. **Figure 11** summarises the above discussion.

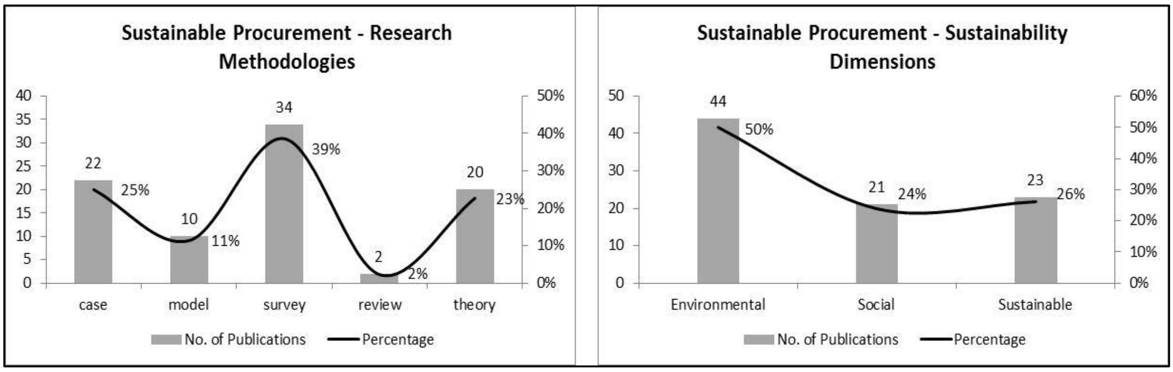

Figure 11: Distribution of Sustainable Procurement (SP) Papers Regarding Research Methodologies & Sustainability Dimensions

3.1.4.8 Sustainable Manufacturing (SM) Paper Sample

Papers that discussed environmental or social issues in the context of manufacturing processes, workers' safety, production strategy, lean and cleaner production and manufacturing waste were grouped together as 'sustainable manufacturing' papers. Even though manufacturing is a mature field and researchers have been debating issues related to industrial ecosystems, ecology and life cycles for a long time, the focus on sustainable manufacturing seems to be very recent as only 40 papers (11 percent) were published in the last two decades, and most of them (29 papers, ~ 73 percent) mainly focused only on environmental issues. The prevalent research methodologies include case studies, surveys and mathematical modelling as shown in **Figure 12.**

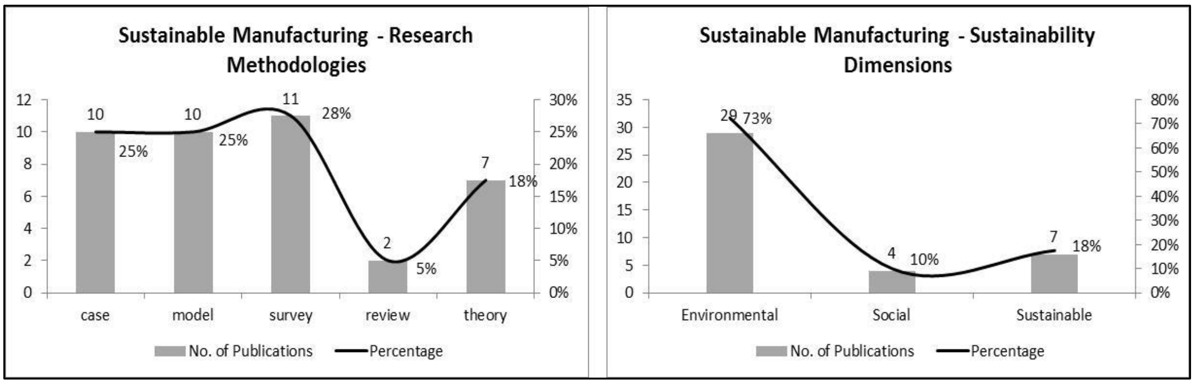

Figure 12: Distribution of Sustainable Manufacturing (SM) Papers Regarding Research Methodologies & Sustainability Dimensions

3.1.4.9 Sustainable Transportation (ST) Paper Sample

Transportation and mobility in itself is a highly-developed and mature field and researchers from many disciplines have contributed to network structures, capacity management, pricing, transportation modes, fuel efficiencies, inter-continental and urban transportation. A general search on Google Scholar with the keyword 'sustainable transportation' resulted in 1,190,000 hits which were reduced to only 74 articles when the search was done with 'sustainability' AND 'transportation' restricted to the title of the article. The abstracts were carefully perused and only those papers that particularly addressed the sustainable transportation (ST) issues with regard to the supply chain of an organisation were considered. Consequently, 24 articles were selected and most of them (12 papers – 50 percent) addressed both social and environmental issues in the context of a firm's supply chain. *It must be noted that a large number of these papers were published in **'Journal of Transport Geography'** and **'Transportation Research'** which are not considered typical operations management journals.* **Figure 13** shows the descriptive analysis of these 24 papers with respect to research methodologies and sustainability dimensions.

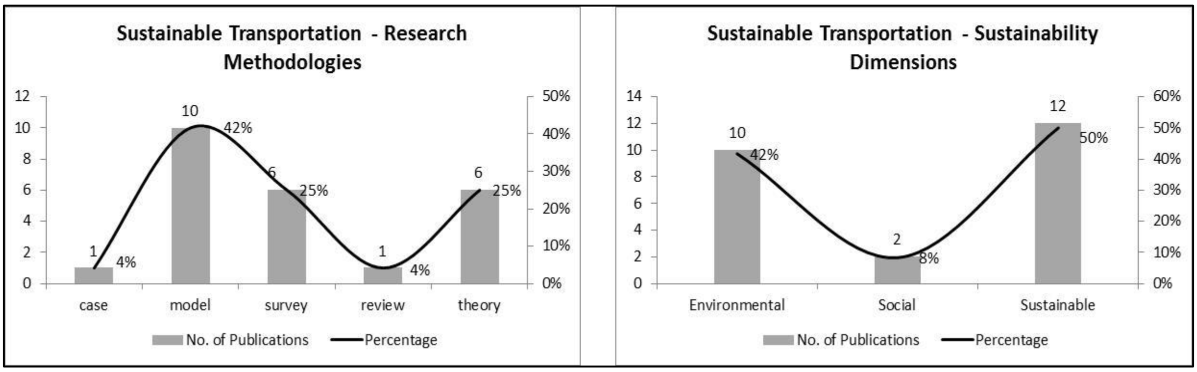

Figure 13: Distribution of Sustainable Transportation (ST) Papers Regarding Research Methodologies & Sustainability Dimensions

3.1.4.10 Sustainable Warehousing (SW) Paper Sample

The keyword search for sustainable warehousing during material collection did not produce any paper. This shows that even though storage or warehousing is mandatory at some stage of a supply chain, it has received relatively less attention from researchers and academics as compared to other supply chain processes in the context of sustainability. Consequently, combined keyword strings such as ‘warehouse layout’, ‘warehouse design’ AND ‘energy conservation’, ‘worker safety’ were used to find pertinent articles that were not typically focused on sustainable warehousing, but indirectly addressed environmental and social matters in a warehouse. As a result, 12 papers were selected that indirectly focused on various issues pertinent to sustainable warehousing (SW). *However, it appears to be the most neglected process within a supply chain in the context of sustainability and calls out for due attention and prioritisation from the research community.* **Figure 14** shows the descriptive analysis of these 12 papers with respect to research methodologies and sustainability dimensions.

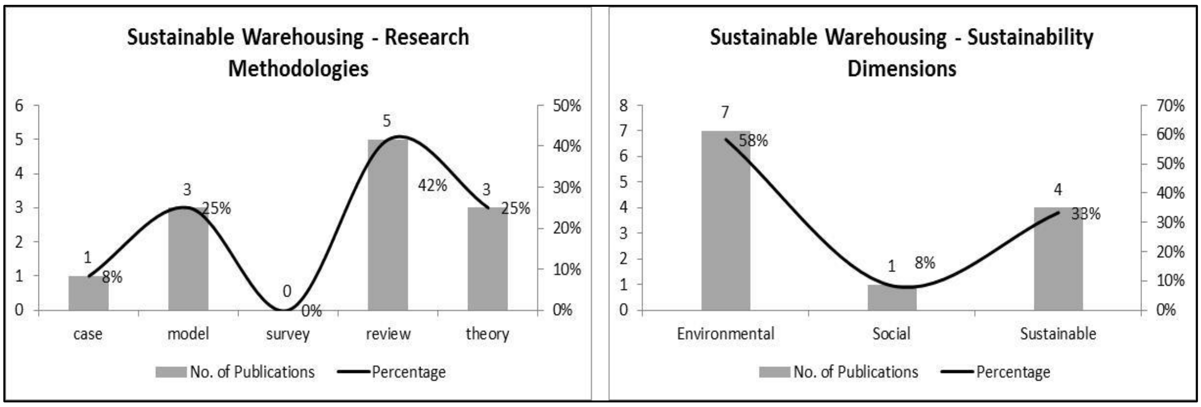

Figure 14: Distribution of Sustainable Warehousing (SW) Papers Regarding Research Methodologies & Sustainability Dimensions

3.1.4.11 Reverse Logistics (RL) Paper Sample

Reverse logistics (RL) is an established domain and a general search on Google Scholar with the keyword ‘reverse logistics’ produced an output of 127,000 papers, which reduced to 2,760 hits when the keyword was searched only in the title of the articles. Further filtering by using the combined keyword strings of ‘reverse logistics’ AND ‘supply chain sustainability’ resulted in only 63 papers which were studied to find the most suitable articles that focused on reverse logistics in the context of sustainable supply chains. Finally, 19 papers met the stringent criteria set by this research study. All those papers that generically discussed remanufacturing, design for disassembly, modular production techniques and recovery strategies were excluded from the sample. The selected papers showed that researchers have used various methodologies; however, mathematical modelling is still a preferred choice in this domain, followed by conceptual and theoretical papers, as shown in the **Figure 15.**

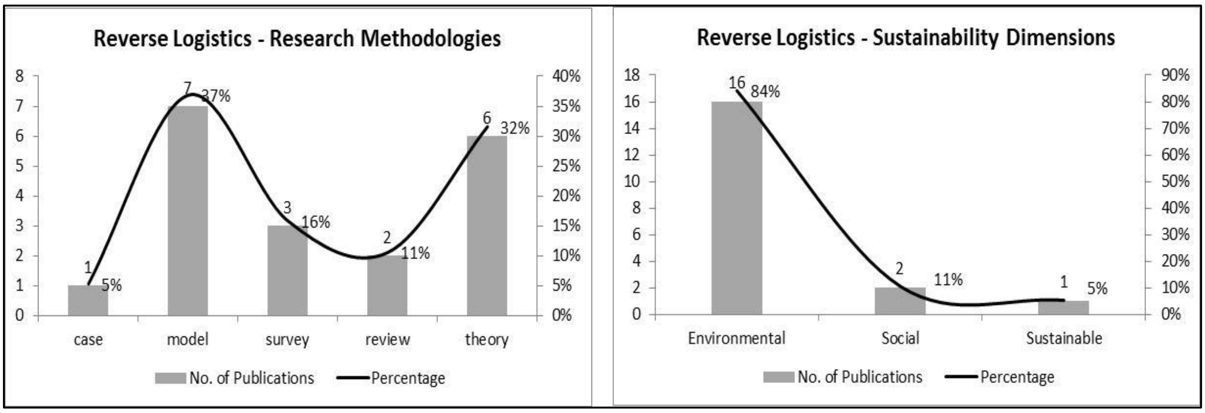

Figure 15: Distribution of Reverse Logistics (RL) Papers Regarding Research Methodologies & Sustainability Dimensions

3.1.4.12 General Sustainable Supply Chain Management (GSSCM) Paper Sample

Finally, all the papers that did not specifically focus on any supply chain process, but generically discussed environmental and social issues in the context of sustainability at firm, industry or country level, were grouped under the category of general supply chain management (GSSCM) papers. As a result, 78 papers were found that discussed ethics, corporate social responsibility, greening and sustainability with respect to supply chain. Again, case study was found to be the preferred research methodology with about 22 papers (~ 28 percent) followed by a large number of theoretical and conceptual research output (18 papers – 23 percent) as shown in **Figure 16**.

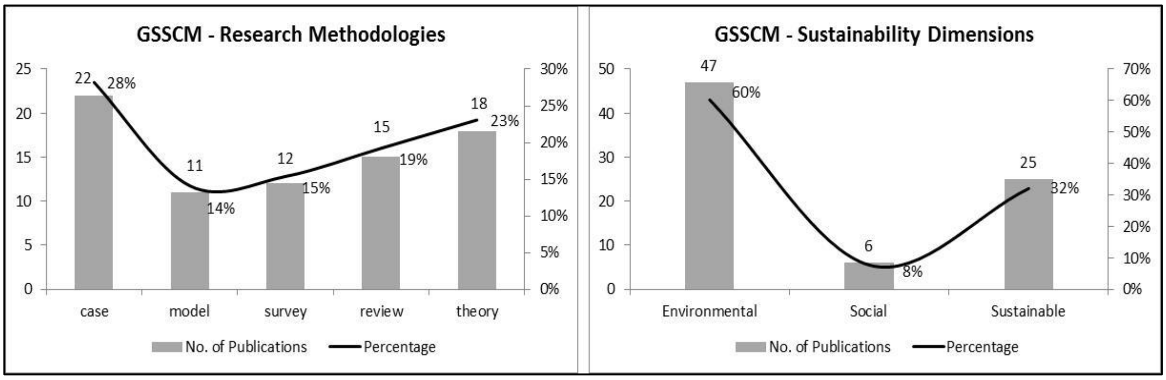

Figure 16: Distribution of General SSCM (GSSCM) Papers Regarding Research Methodologies & Sustainability Dimensions

Collectively, an analysis of all SCOR processes across sustainability dimensions is presented in the following **Table 8** and **Figure 17**. It can be clearly seen that environmental dimension is the main area of investigation in all the processes, while social dimension is least considered. However, there is a growing trend towards considering both social and environmental issues.

Table 8: Process-Wise Distribution of Publication Sample for Sustainability Dimensions

Sustainability Dimension	SPlng	SP	SM	SW	ST	RL	GSSCM
Environment	56	44	29	7	10	16	47
Social	5	21	4	1	2	2	6
Sustainable	27	23	7	4	12	1	25

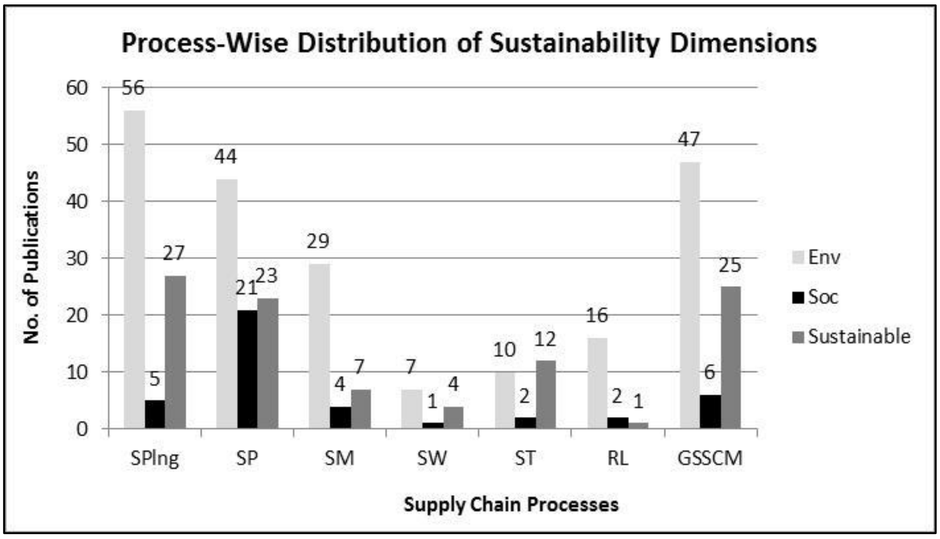

Figure 17: Process-Wise Distribution of Publication Sample for Sustainability Dimensions

A year-wise analysis of publications across all the processes shows a substantial focus on sustainability after 2000. However, the primary focus is on sustainable supply chain planning and sustainable procurement, and reasonable number of research outputs for sustainable manufacturing, as shown in **Table 9**. However, sustainable transportation and reverse logistics, in the context of supply chain sustainability, seem to be overlooked and sustainable warehousing is completely ignored by researchers. Even though general SSCM papers have been increasing over the years, specific attention must be paid to address particular environmental and social issues in warehousing, transportation and reverse logistics.

Table 9: Process-Wise Distribution of Publication Sample from Year 1992 – 2012

Year	SPlng	SP	SM	SW	ST	RL	GSSCM
1992				1			
1993							
1994		1	1	1		1	
1995	1		2			1	
1996	1	2	2		2	1	
1997		6	1		1	1	2
1998	6	6	1	1		1	
1999	2		3	1		1	2
2000	4	6		1	1		4
2001	4	10	3		2		3
2002	6	6	1	1	1	2	4
2003	5	3	2	1	2		7
2004	4	8	5		2		2
2005	13	7	4		3		2
2006	6	3		2	1	1	8
2007	11	5	6	1	1	2	12
2008	4	5			2	2	10
2009	6	4	2	1		3	5
2010	4	8	2	1	4	2	3
2011	7	4	3		1		5
2012	4	4	2		1	1	9

In total, the research methodologies used across various supply chain processes show that most of the researchers have preferred the use of the case study approach, followed by theoretical papers, as shown in **Table 10.** This is understandable, as the field of SSCM requires an in-depth contextual analysis to establish its foundations.

Table 10: Process-Wise Distribution of Publication Sample for Research Methodologies

Research Methodology	SPlng	SP	SM	SW	ST	RL	GSSCM
Case Study	33	22	10	1	1	1	22
Model	15	10	10	3	10	7	11
Survey	18	34	11	0	6	3	12
Review	8	2	2	5	1	2	15
Theory	14	20	7	3	6	6	18

3.1.5 Collection of Industry and Public Sector Publications

The descriptive analysis of academic peer-reviewed journal papers showed that material needed to analyse each supply chain process in the context of sustainability is not adequate. Therefore, a number of books were consulted to further understand the dynamics of sustainable supply chain. **Table 11** shows the list of general supply chain **'books'** and those specifically consulted for each supply chain process (planning, procurement, manufacturing, transportation, warehousing and reverse logistics).

Also, the lens of the SCOR process model clearly showed that literature is scarce when it comes to the nexus between sustainability and supply chain processes. This is surely due to the fact that sustainable supply chain management is in its infancy, and little effort is made to analyse the facets of sustainability in each individual process of a firm's supply chain. Therefore, it was decided to also collect publications from credible and reputable government institutions, consultancy organisations, independent freelance professionals and autonomous industry research centres. The tables on the following pages show the list of **'industry and public sector publications'** collected to further substantiate the academic literature used for each supply chain process. **Table 12, Table 13, Table 14, Table 15** and **Table 16** present the industry and public sector publications for sustainable procurement, sustainable transportation, sustainable warehousing, sustainable manufacturing and sustainable supply chain planning respectively.

Table 11: General & Specific Books Consulted for Each Supply Chain Process

Title of Books	Sources
Procurement	
E-Procurement in Emerging Economies Theory and Cases	Pani and Agrahari (2007)
Strategic Procurement	Booth (2010)
Procurement Strategies - A Relationship Based Approach	Walker and Hampson (2003)
Lean Supply Chain Management : A Handbook for Strategic Procurement	Wincel (2004)
Handbook of Procurement	Dimitri, Piga, and Spagnolo (2006)
Purchasing and Supply Chain Management: Strategies and Realities	Quayle (2006)
Transportation	
Introduction to Transportation Engineering	Mathew and Rao (2006)
Global Logistics - New Directions in SCM	Waters (2010)
Sustainable Transportation - Problems and Solutions	Black (2010)
Manufacturing	
Sustainable Manufacturing	Davim (2010)
Warehousing	
Warehousing in the Global Supply Chain	Manzini (2011)
Green Logistics	McKinnon, Browne, and Whiteing (2010)
Warehouse and Distribution Science	Bartholdi and Hackman (2008)
Green Building with Concrete - Sustainable Design and Construction	Sabnis (2012)
Introduction to Materials Handling	Ray (2008)
Reverse Logistics	
Value Recovery from the Reverse Logistics Pipeline	Diener, Peltz, Lackey, Blake, & Vaidyanathan (2004)
Supply Chain Planning	
Basics of Supply Chain Management	Fredendall & Hill (2001)
Essentials of SCM	Hugos (2003)
Managing Product Life Cycle in a SC	Kumar & Krob (2005)

Table 11: General & Specific Books Consulted for Each Supply Chain Process (continued)

Title of Books	Sources
General	
Supply Chain Management - New Perspectives	Renko (2011)
Sustainable Supply Chain Management	Cetinkaya et al. (2011)
Green Logistics	McKinnon, Browne, and Whiteing (2010)
The Lean Sustainable Supply Chain	Palevich (2011)
Greening the Supply Chain	Sarkis (2006)

Table 12: Industry and Public Sector Publications: SP

Title of Publications (Procurement)	Sources
Best Practices in Spending Analysis	Aberdeen Group (2004)
The State of Green Procurement in Australia	Australian Environmental Labelling Association [AELA] (2004)
Green Purchasing - The Supplier Questionnaire	Australian Procurement and Construction Council [APCC] (2010)
CPO Rising 2012 - Keeping Score	Ardent Partners (2012a)
CPO Rising 2011 - The State of Spend Analysis	Ardent Partners (2011)
The Importance of Procurement in a Global Environment	The Boston Consulting Group [BCG](n.d.)
Purchasing Management	Chalmers University (2008)
Sustainable Procurement Practice Guidelines	Government of Western Australia - Department of Finance [DoF] (2011)
Electronic Payments 2012: It Pays to Pay Electronically	Ardent Partners (2012b)
Australian and New Zealand Government Framework for Sustainable Procurement	Australian Procurement and Construction Council [APCC] (n.d.)
Sustainable Procurement Strategy	NHS Purchasing and Supply Agency [NPSA] (2006)
Procure-to-Pay: The Best in Class Blueprint	Ardent Partners (2012c)
Value of Sustainable Procurement Practices	PwC, EcoVadis and INSEAD (2010)
Sustainable Procurement Guidelines	Government of South Australia - State Procurement Board [SPB] (2012)
Sustainable Procurement - Making it Happen	UK Government - The Waste and Resources Action Programme [WRAP] (2003)
Model Procurement Policy	Municipal Association of Victoria [MAV] (2011)
Building Sustainability into Your Supply Chain Through e-Procurement	Dimension Data (2011)

Table 13: Industry and Public Sector Publications: ST

Title of Publications (Transportation)	Sources
Sustainable Transportation Monitor	The Centre for Sustainable Transportation [CST] (2005)
Smart Steps– Transportation	Smart Steps (n.d.a)
Developing Indicators for Sustainable and Liveable Transport Planning	Victoria Transport Policy Institute [VTPI] (2013)
Guide to Sustainable Transportation Performance Measures	US Environmental Protection Agency [EPA] (2011)
Towards Sustainable Transportation– The Vancouver Conference	OECD (1996)
Sustainable development and sustainable transportation: strategies for economic prosperity, environmental quality, and equity	Institute of Urban and Regional Development [IURD] (2001)
Sustainable Transportation – Conceptualisation and Performance Measures	Texas Transportation Institute [TTI] (2002)
The future of Automobile in an Environmentally constrained world	The University of California Transportation Centre [CTC] (2010)

Table 14: Industry and Public Sector Publications: SM

Title of Publications (Manufacturing)	Sources
OECD Sustainable Manufacturing Toolkit	Organization for Economic Cooperation and Development [OECD] (2011)
Sustainable Manufacturing Initiative Sector Focus Study Series	US Department of Commerce [USDoC] (2010)
Economic Incentives for Sustainable Production	World Resource Institute [WRI] (2001)
Smart Steps - Manufacturing	Smart Steps (n.d.c)
Reducing Machine Setup & Changeover Times	Lean Solutions Group [LSG] (2008)
Lean Manufacturing	Aberdeen Group (2009)
Sustainable Manufacturing – manufacturing for sustainability	Manufacturing Skills Australia [MSA] (2008)
What does sustainable manufacturing mean to Australia?	Commonwealth Science and Industrial Research Organisation [CSIRO] (2012)
Sustainable Manufacturing Initiative	Commonwealth Science and Industrial Research Organisation [CSIRO] (2011)
Sustainable Manufacturing for the Future	Geelong Manufacturing Council [GMC] (2006)

Table 15: Industry and Public Sector Publications: SW

Title of Publications (Warehousing)	Sources
Warehousing and Logistics	Logistics Training Council [LTC] (2010)
Smart Steps– Warehousing	Smart Steps (n.d.b)
Five Steps to Optimizing Warehouse Management	Aberdeen Group (2009)
The Warehouse Productivity Benchmark Report	Aberdeen Group (2006)
Managing the Work Environment and Facilities - Code of Practice	Safe Work Australia (2011)
Workplace amenities and work environment - Compliance Code	Work Safe Victoria (2008)
ACCPAC Warehouse Management System	ACCPAC (2003)
Inventory Accuracy through Cycle Counting	Supply Chain Consortium (2012)
Inventory Cycle Counting	REM Associates (1999)
Inventory Optimization - A Necessity Turning to Urgency	SETLabs (2007)
Development of the World's First Engine/Battery Hybrid Forklift Truck	Mitsubishi Heavy Industries [MHI] (2010)
Workplace Health and Safety Handbook	Safe Work South Australia (2012)
Safe Stacking and Storage	Department of Labour New Zealand [NZDoL] (1999)
Forklift safety – reducing the risks	Safe Work South Australia (2010)
Lighting - Bright ideas for efficient illumination	Carbon Trust (2011)
ECO TEMPLATE a framework for increasingly environmental and socially responsible logistics development	Gazeley (2004)
Life Cycle Assessment in Green Star	Green Building Council of Australia [GBCA] (2012)
Innovative Warehouse Design	Kennesaw Advisory Group [KAG] (2009)
Ceiling Systems	Armstrong (2007)
Managing Shift work to minimise workplace fatigue	Department of Labour New Zealand [NZDoL] (2007)
The Case for Work-Life Balance - Closing the gap between Policy and Practice	Hudson (2005)
Warehouse Management Guide	SAP AG (2001)

Table 16: Industry and Public Sector Publications: SPlng & General

Title of Publications	Sources
Supply Chain Planning	
Sustainable Supply Chain - The Supplier Questionnaire	Metcash Limited (1999)
Supply Chain Sustainability	Australian Research Institute in Education for Sustainability [ARIES] (2009a)
Sustainability in Food Distribution Systems	Australian Research Institute in Education for Sustainability [ARIES] (2009b)
General	
Supply Chain Sustainability: A Practical Guide for Continuous Improvement	United Nations [UN] (2010)
Sustainable Supply Chain Logistics Guide	Smart Steps (2009)
Business Guide to a Sustainable Supply Chain	New Zealand Business Council for Sustainable Development [NZBCSD] (2003)

All these books (as listed in Table 11), industry publications and public sector reports (as listed in Table 12 to Table 16) were used, in addition to the 349 academic peer-reviewed journal articles, to identify dimensions and measures for each SSCM sub-construct, as discussed in sections 3.2 and 3.3. These dimensions and measures were translated into questions that were later used to collect data for the validation of scales for each SSCM sub-construct.

3.2 SSCM Literature Analysis: Four-Phased Qualitative Methodology

This section will cover an overview of the four-phased methodology used for the analysis of academic literature and industry publications. The analysis through this methodology ultimately resulted in dimensions and measures for each process of a firm's supply chain in the Australian food industry. These were translated into a questionnaire for subsequent data collection and validation of the SSCM sub-constructs. Initially, this section will present a thorough discussion to elucidate: (1) the use of qualitative data analysis (QDA) software rather than manual techniques for the analysis of the SSCM material; (2) the strategy employed for the qualitative analysis of the SSCM material; (3) differences between thematic and content analysis; (3) coding methodology; (4) role of qualitative analysis software (NVivo); and (5) details of the four analytic phases.

This section also clearly shows the inventive way of using qualitative data analysis software (QDA) for the review and analysis of the academic literature and industry publications. It demonstrates how powerful features of the software can be used, with the researcher in the driving seat, to systematically investigate all aspects of the literature in an efficient and structured manner. It also shows that how software can be strategically used in the coding process, and how data can be stored in any possible format that relieves the researchers from the worries of data organisation, storage and presentation, and enables them to focus more on the analytical part of the research.

Therefore, NVivo was used in this study, which made it possible to organise and analyse voluminous data (349 articles and industry publications) in a strategic manner, but it was the decision of the researcher of this study to select the relevant tools and optimally exhaust the capabilities of the software to achieve the research objectives. It cannot be denied that the use of the software enhanced the validity of the results through a rigorous and transparent coding mechanism, but brainstorming, deliberations, critical analysis, close examination of the literature, and constant review and comparison were still at the core of the entire analysis process and their value cannot be underestimated.

3.2.1 Qualitative Analysis of the SSCM Material

The analysis of qualitative material (or data) is usually the most demanding aspect of a research study. Miles (1979) argued this several decades ago but the statement is still valid today. There are no shortcuts, and sufficient energy and time is required to perform the analysis (Delamont, 1992). According to Dey (1993), coding is the most crucial part of the analysis as it involves division of data into manageable and meaningful units. This organisation and interpretation of data results from vigorous conversations between the researcher and the data, and encapsulates the voluminous information into a nutshell of themes, categories or codes. Tesch (1990) termed this as ‘data condensation’, implying that the huge body of knowledge is captured in manageable codes through constant deliberation, comparison and analysis (Glaser & Strauss, 1967). Previously, this laborious job was performed manually. Bogdan and Bilken (1982) are among the few researchers who explained the basics of manual coding, such as note cards and cut-and-paste.

However, in the last two decades, software supporting the electronic method of coding has replaced the manual techniques. The software provides searching options which are very fast compared to the slow process of manual filing and searching, but still many researchers are quite apprehensive about their application and effectiveness (Weaver & Atkinson, 1994). There are polarised opinions in favour or against the use of software – one group believes that they are abhorrent and limit the depth and breadth of the findings because of their stringent procedures, while others consider them as a heavenly miracle which made it possible to analyse voluminous data and present insights in a structured and timely manner that is not possible through manual techniques (Crowley, Harre, & Tagg, 2002; Glesne & Peshkin, 1992; Strauss, 1987).

The main concern from the research community is regarding the ‘loss of data’ that occurs by putting the words into a computer and through the resulting abstraction (Crowley et al., 2002). Data loss is not a unique thing in qualitative research, and it also takes place when field notes are typed or interview tapes are transcribed. Previously, software could only accept ‘plain text’ and all the thoughts ingrained in the underlined, italicised and highlighted text were lost. But contemporary software not only accepts rich text documents but can also process data in any format (video, audio, podcasts, images, spreadsheets, databases and pdfs). Another main concern that still exists even today is that the Qualitative Data Analysis (QDA) software drives the analysis process in an inadvertent manner through its rigid procedures and thus limits the thought process of the researcher and subsequently the research findings (Crowley et al., 2002). Again, this is not true about modern cutting-edge QDA software. Even though it provides a standard process for novice users that guides the analysis, it can be altered by the researchers depending upon their insights, experience, perception and comprehension of the underlying concepts (Siccama & Penna, 2008). Also, the latest software provides a number of general purpose tools and modelling techniques to assist and enrich the analysis, and eventually it is the decision of the researchers to select the most relevant options and use the capabilities of the software to further their research (Bazeley, 2007).

During the last decade, the number of QDA software packages used to conduct textual data analysis has increased (Ulin, Robinson, & Tolley, 2005). Onwuegbuzie and Leech (2007) stated that the use of computer programs for textual analysis increases the rigour of the research study. Bazeley (2007) agrees with this opinion and further points out that computer programs provide much deeper insights into data when compared to manual techniques. These days, the volume of data in qualitative research is extremely large, and it is quite an arduous task to handle it manually. Therefore, many qualitative theorists have also recommended the use of computer-assisted qualitative data analysis software (CAQDAS) (Berg, 2001; Denzin & Lincoln, 1998; Krueger, 1998; Merriam, 2001; Miles & Hueberman, 1994; Morse & Richards, 2002; Patton, 2002; Silverman, 2000, 2001; Taylor & Bogdan, 1998; Tesch, 1990).

Consequently, this study used a software package to analyse voluminous academic literature and industry publications pertinent to sustainability and supply chain management. The following sub-sections will provide a detailed account of a 'unique four-phased qualitative methodology' that assisted in developing sustainability dimensions and measures for each SSCM sub-construct using the NVivo software package.

3.2.2 Selection of Qualitative Data Analysis (QDA) Software

A review of the available software such as QDA Miner, QSR NVivo, Ethnograph and Atlas/ti showed that they have many similar features and some unique strengths that separate them from each other (Fielding & Lee, 1998; Tesch, 1990). However, QSR NVivo is considered as the most specialised analysis package in the market (Weitzman & Miles, 1995), and its tenth release is used in this research study. NVivo has state-of-the-art features that help to both organise and analyse unstructured information. Its ability to handle loads of versatile data in various file formats, powerful queries, user-friendly interface and modelling tools made it a preferred choice for this research study (Bazeley, 2007). The software developers at QSR have designed NVivo in an open-ended fashion so that it can assist the research process in multiple ways. In the same manner that a word processor can be used to either write a poem or a company report or a novel, the NVivo software does not dictate a specific analysis procedure, but rather provides basic conceptual elements, robust and versatile tools and rigorous processing capabilities to carry out the analysis in a structured and organised way (Crowley et al., 2002; Richards, 1999). NVivo does not force the researchers to arrange the data in a particular way; instead, the researchers have the discretion to organise the data in whatever manner they want, and use its very simple, logical and fluid mechanism to lead to richer analysis and insights (Bazeley & Richards, 2000).

3.2.3 Overview of the Four-Phased Methodology

The identification of sustainability themes for each supply chain process was done through NVivo in four phases. In **phase I**, generic sustainability themes were identified through 'thematic analysis' of high-level sustainability frameworks. In **phase II**, sustainability themes from phase I were used as a guiding principle to perform 'content analysis' of academic literature related to supply chain planning, procurement, manufacturing, warehousing, transportation and reverse logistics. Coding was done to develop dimensions and measures for each SSCM sub-construct, which was then translated into a questionnaire. NVivo tools such as word frequency query, text search query, tree maps, tag clouds and broad-brush coding were used along with constant review and comparison of the SSCM material.

In **phase III**, the dimensions and measures of each SSCM sub-construct (from phase II) were adapted to the Australian food industry. Finally, in **phase IV**, the output of phase III was compared and tested against GRI reporting standards and annual sustainability reports of the top 10 firms in the food industry. Again, content analysis was used and dimensions and measures were added, modified and sometimes deleted to ensure the face validity of the results.

3.2.3.1 Strategy for Qualitative Analysis

Researchers and practitioners have enumerated many strategies to carry out qualitative research through software tools. Richards (2004) recommends four steps through which a researcher, using NVivo, can ensure that the best possible results are achieved through apposite use of data in a methodical and systematic manner. The four steps of his strategy are (1) interrogate interpretations; (2) scope data for profound analysis; (3) achieve saturation to ensure completeness; and (4) maintain audit trails. All these steps help to enhance the validity of the results and increase the credibility, transparency and replication of the findings. This strategy governed the analysis process in all the four phases but will only be discussed with respect to the second phase for the sake of brevity.

3.2.3.2 Thematic and Content Analysis

It is considered important at this point to clarify the choice of techniques and methods used in the four phases. It was decided to use thematic analysis in **phase I** as it is *'a method for identifying, analysing and reporting patterns (themes) within data'* (Braun & Clarke, 2006, p. 79) and this is exactly what was intended in this phase – to identify sustainability themes regardless of the field or industry so that broader purview of sustainability could be captured for further investigation into the supply chain literature.

In **phase II**, content analysis was used as the main technique for textual analysis. Vaismoradi, Turunen, and Bondas (2013) defined it as *'a systematic coding and categorising approach used for exploring large amounts of textual information unobtrusively to determine trends and patterns of words used, their frequency, their relationships, and the structures and discourses of communication.'* In this phase, the frequency and occurrences of the SSCM concepts were examined and critically analysed in the context of the sustainability themes identified earlier. Consequently, dimensions and measures were developed and translated into a questionnaire for each SSCM sub-construct.

In **phase III**, content analysis was used to identify important elements of the Australian food industry supply chain which were then used to adapt the general sustainable supply chain questionnaire (from phase II).

In **phase IV**, content analysis was again used to identify major concepts in the sustainability reports and the GRI standards. These were then compared with the output of phase III to ensure face validity.

Content analysis and thematic analysis are categorised as descriptive approaches in the qualitative world. Many research studies have used them interchangeably without making any distinction between them (Sandelowski & Barroso, 2003; Sandelowski & Leeman, 2012). It seems that the main reason is the considerable overlap between their epistemology, aims and analysis process. Vaismoradi, Turunen, & Bondas, (2013) also agree with this observation in their recent review paper on this subject. Even though the philosophical discussion regarding the similarities and differences between them is beyond the scope of this paper, it is required to clearly differentiate between them in order to justify their use in different phases.

The analysis in this research study is based on the understanding that **content analysis** is similar to **thematic analysis**, as both allow for the qualitative analysis, but content analysis also focuses on the descriptive analysis of the attributes of the selected text while thematic analysis concentrates only on the qualitative dimensions of the text (Gbrich, 2007). Both of them support deductive and inductive approaches, and use the coding process to transform large amount of data into manageable and understandable codes (or categories) and themes.

3.2.3.3 Coding through the NVivo Software

In this research study, content and thematic analyses are used to code data in each phase through the NVivo software. Coding is simply transforming data into understandable form or organising data into categories/classes/codes that could facilitate analysis. According to Lockyer (2004), coding is *'a systematic way in which to condense extensive data sets into smaller analyzable units through the creation of categories and concepts derived from the* *data.'* A code is a word or short phrase that symbolically represents the essence or the central idea of the selected data (or text). Coding requires close analysis and deep understanding of the domain by the researcher. It is a taxing and time-consuming activity, but it is at the heart of the entire analysis. Strauss (1987) rightly said that 'the excellence of the research rests in large part on the excellence of the coding.'

In NVivo software, coding is done through **'nodes'** which may be understood as material containers or objects representing an idea or a concept. Initially, a researcher develops **'free nodes'** which represent emerging themes and these could be later grouped into **'tree nodes'**. Simply put, a tree node is like a parent node with various child nodes. It is similar to creating a hierarchy or taxonomy of related concepts grouped under relevant categories. Earlier versions of NVivo forced the users to create either a 'case node', 'free node' or 'tree node' and the node classification structure was also very stringent. For example, in NVivo 8, case nodes were the only nodes that could have some attributes related to demographic information.

However, in NVivo 10, nodes can represent just about anything – such as a person, place, an organisation or a topic with their own unique set of attributes or demographic information. They can be created as a researcher needs them and can be classified straight away, or at a later stage. It is at the discretion of the researcher to place them in a hierarchical structure and define attributes for them, or not. This flexibility in the latest NVivo places the researcher in the driving seat and enables him/her to fully utilise the capabilities of the software as per the requirements of the research study.

In addition, NVivo provides many tools, such as word frequency query, text search query, tree maps, tag clouds and cluster analysis. These tools help to explore, arrange, sort, classify and examine data through searching, linking, shaping and modelling. **Word frequency query** has multiple options to determine words that occur most frequently in the textual sources. It helps to extract possible themes or concepts in the earlier phases of the research project. The results are displayed in the form of tag clouds, tree maps and cluster analysis. Tag clouds are extremely helpful as they visually show the frequency of various words on a relative basis where frequently occurring words are in larger font size. **Figure 18** shows a **'tag cloud'** resulting from word frequency query executed on the 'sustainable procurement' literature.

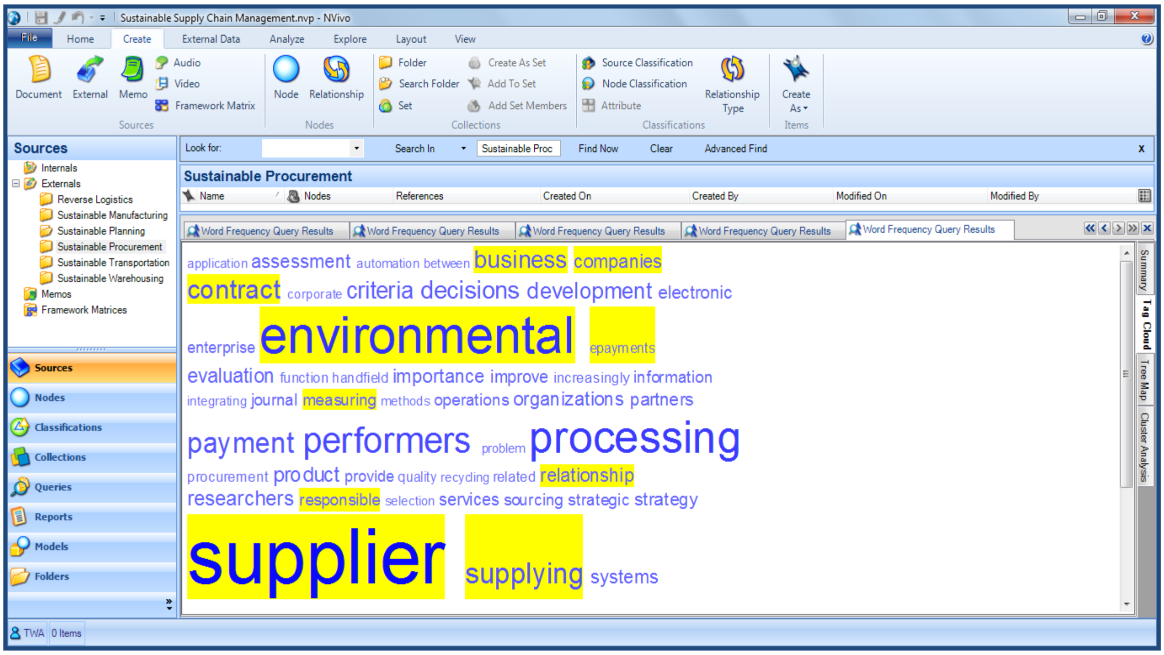

Figure 18: Tag Cloud from Word Frequency Query Executed on the SP Literature

In addition, **cluster analysis** presents results in the form of a tree map that shows taxonomic relationships between the words, also called a dendrogram. The cluster analysis in NVivo can be viewed in many ways, which is extremely helpful to understand basic relationships between the frequently-occurring concepts. These views include horizontal or vertical dendrogram, a 2D or 3D cluster map, and a circle graph. Furthermore, a simple **text search query** is also an extremely powerful tool as it helps to find exact words in the selected source text, or similar words or concepts. The results of text search query can be viewed in the form of a **'word tree'** to identify the concepts related to that word (or phrase) in the literature under investigation. **Figure 19** shows a word tree for the 'transportation mode' concept resulting from a text search executed on the 'sustainable transportation' literature.

Also, the results of 'word frequency query' and 'text search query' can be saved in new nodes for later investigation. For example, if pollution or air quality occurs frequently in the text, then all their occurrences can be stored in a new node. This process provides a useful starting point and helps to develop initial themes in the literature. It is called as **'broad-brush coding'** in the NVivo terminology. Later on, these new nodes can be further analysed through the syntax and semantic analysis of the narrowed-down text in order to identify themes that represent more underlying and less explicit concepts. This is called as **'scoping of data'** in the NVivo literature.

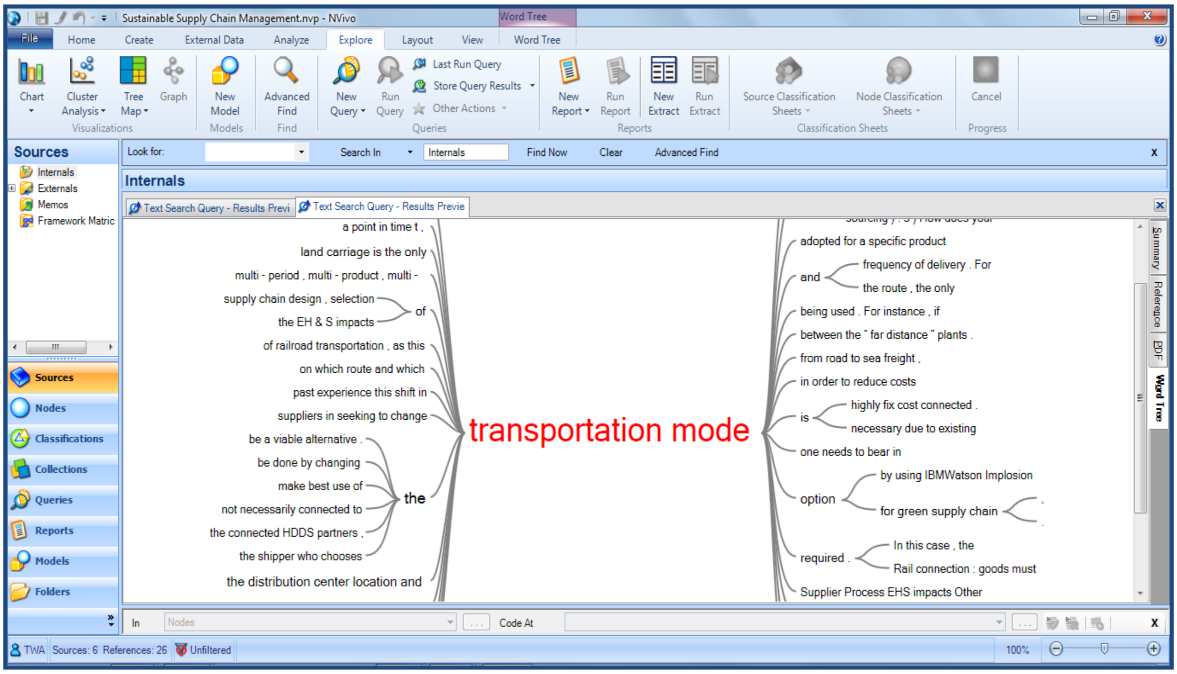

Figure 19: Word Tree from Text Search Query Executed on the ST Literature

3.2.4 Phase I – Development of High-Level Sustainability Themes

Initially various high-level sustainability frameworks were studied to comprehend the purview of sustainability, compatibility of these approaches, commonalities and differences, strengths and weaknesses, measurement techniques and underlying philosophies. These include Natural Capitalism, Biomimicry, Cradle to Cradle, Life Cycle Analysis, Social Return on Investment, The Natural Step, Sustainability Helix and Triple Bottom Line (Cook, 2004; McDonough & Braungart, 2010; Shedroff, 2009). The advocates of these frameworks claim that their model is complete and truly represents sustainability. However, our thematic analysis reveals that these are lenses to view sustainability from different perspectives and help to develop a deep insight of the approaches, issues, measures and the domain of sustainability. The selection was based on the decision that there should be a good blend of 'futuristic' and 'currently applicable' frameworks so that realism and vision can go hand-in-hand.

Natural capitalism, which focuses on natural, human, financial and manufactured capital, is also known as eco-efficiency. It prioritises efficiency for all forms of capital and proposes the utilisation of current technologies to achieve it. But the supporters of Biomimicry and Cradle to Cradle still perceive Natural Capitalism as a cradle-to-grave model, as it does not eliminate waste. Both Biomimicry and Cradle to Cradle try to imitate nature where output of one process is the input of the other process, and waste does not exist. They focus on re-imagining the product design, materials and the development process so that no waste is generated and all materials are reused at the end of a product's lifecycle (Shedroff, 2009).

On the other hand, Life Cycle Analysis (LCA) is prevalent in industry as it provides quantitative assessment of solutions. Even though it is very accurate, the cost and the time required to complete LCA makes it unaffordable for small firms (Shedroff, 2009). Also, it does not sufficiently analyses social and financial performance. Additionally, Social Return on Investment is a framework that only focuses on social and economic performance. It is recently developed and has no model for industry application, but it does provide an approach to assess social performance within an economic framework.

The Natural Step supports a systems perspective like Natural Capitalism and suggests four conditions to achieve ecological balance and preserve human life on the planet Earth (Cook, 2004). Lastly, Triple Bottom Line (TBL) approach, which formed the basis for the Global Reporting Initiative (GRI) guidelines, has become a standard in the corporate sector. It proposes that there should be three separate bottom lines prepared by a firm – economic, environmental and social. The main rationale of TBL is to further the implementation of sustainability in business practices. All these frameworks provide a very strong conceptual basis for operationalising sustainability in supply chains.

Thematic analysis helped to develop a basic taxonomy of themes discussed in these frameworks. It became evident that at its core, sustainability is about 'efficiency'. It preaches elimination of any kind of waste and better utilisation of resources. It enforces 'risk mitigation' to help avoid vulnerabilities related to financial, political, operational, social and environmental hazards. It encourages taking the 'systems perspective', so that impacts of decisions and strategies can be evaluated on a broader scale.

Also, sustainability promotes 'resilient enterprises' that are stable, flexible, accessible, adaptable and have a learning attitude. It endorses 'diversity' of workforce, ideas, solutions and approaches because a diverse enterprise is more capable of facing a challenging situation related to market trends, unprecedented catastrophes and financial crunch. It discourages 'centralisation' of power, control, resources and decision-making as this is unresponsive and devoid of local knowledge and expertise. It institutionalises a blend of 'cooperation, collaboration and competition' among the stakeholders, providing the opportunity for continuous innovation.

Thorough analysis showed that all the frameworks focused on the three main dimensions of sustainability – economic, social and environmental. The terminology used in them might be different but the focal themes were almost the same, such as biodiversity, air quality, water contamination, toxic materials, hazardous emissions, renewable resources, recycling, freedom of speech, work-life balance, child labour, regulatory compliance, transparency, accountability, risk management, cost-reduction, product design, etc. **Figure 20** shows these themes along with number of references and sources. Identification of general sustainability themes served as a roadmap for further investigation into the supply chain literature.

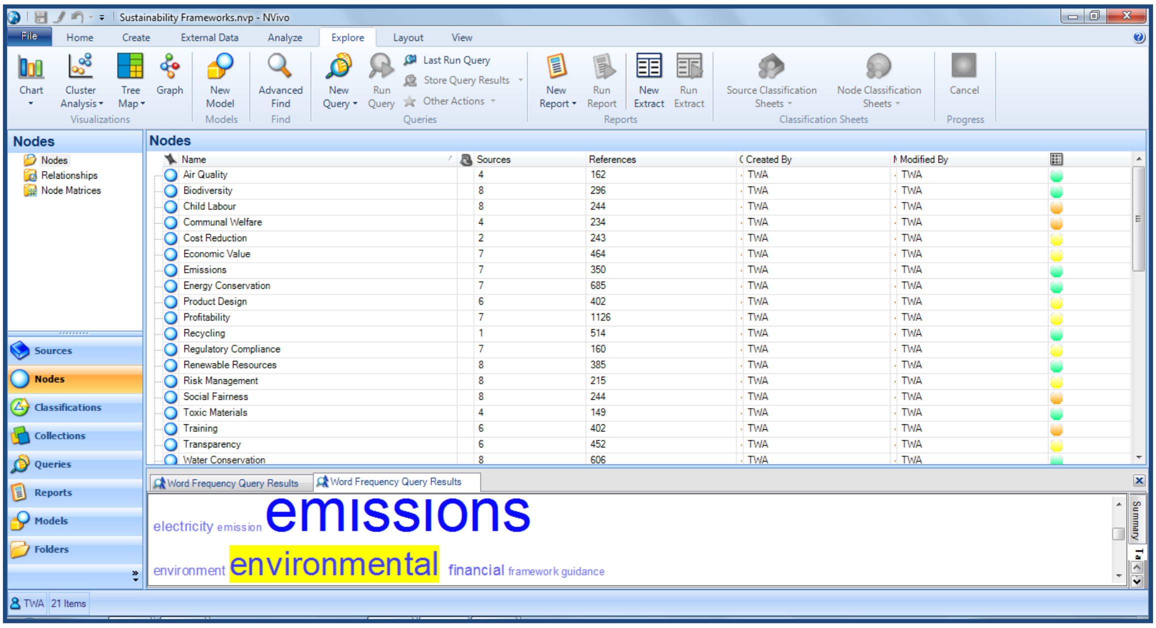

Figure 20: Sustainability Themes from General Sustainability Frameworks

The above discussion related to the phase I of this ‘four-phased methodology’ is graphically presented in **Figure 21.** Figure shows the inputs (sustainability frameworks), which were coded through thematic analysis in NVivo. Free nodes, representing general sustainability themes, were developed through the NVivo tools which were later grouped into tree nodes until saturation was achieved, and no new theme could be identified. This thematic analysis was supported by the NVivo tools, and constant review and comparison of the frameworks, leading to general sustainability themes that were used as an input for phase II.

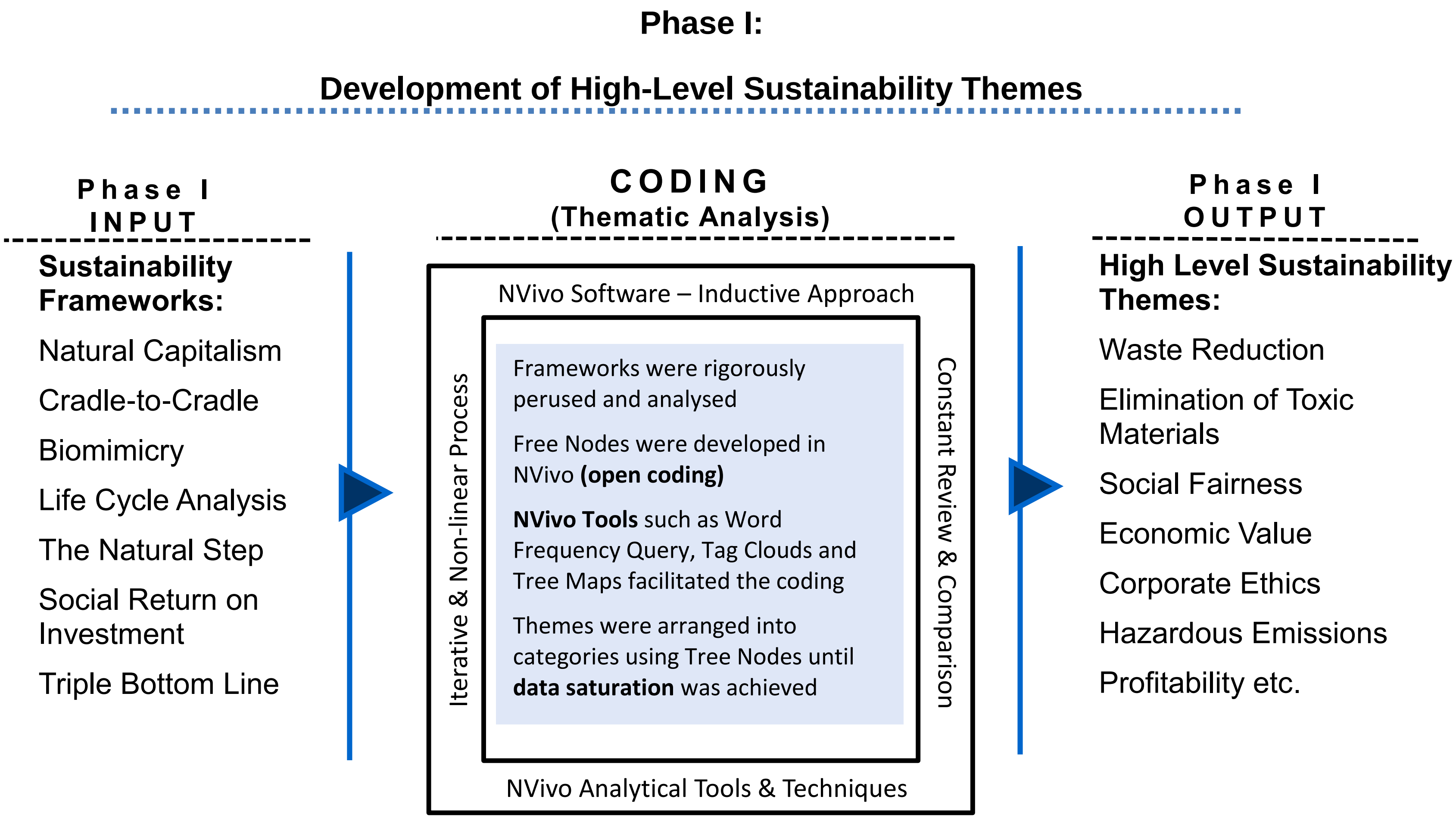

Figure 21: Phase I – Development of High-Level Sustainability Themes

3.2.5 Phase II – Development of Sustainable Supply Chain Themes

The output of Phase I was used for further analysis of the selected academic literature related to supply chain planning, procurement, manufacturing, warehousing, transportation and reverse logistics. The publication sample of 349 papers related to sustainable supply chain management (SSCM) was segregated into seven groups after review of their abstracts, and in many cases, the entire research article. These categories were based on the SCOR process model consisting of papers focusing on sustainable supply chain planning (SPlng), sustainable procurement (SP), sustainable manufacturing (SM), sustainable transportation (ST), sustainable warehousing (SW) and reverse logistics (RL). Also, all those papers that 'generally' focused on various aspects of a sustainable supply chain at firm or industry level were grouped as general sustainable supply chain management (GSSCM) papers.

Since the aim of the analysis was to investigate each supply chain process and identify key sustainability themes pertinent to the unique requirements of that process, seven folders were created in NVivo – one for each of the above categories. For example, all papers pertinent to sustainable supply chain planning (88 papers) were imported into its specific folder and the same action was repeated for all the other folders. It was a very simple process and only required a few mouse clicks. Once all the data (papers) were imported, analysis was conducted according to the strategy recommended by Richards (2004), that consists of the following four steps.

3.2.5.1 Step I: Interrogate Interpretations

This step refers to a thorough investigation into the data to interpret preliminary themes that could later be used for more targeted and narrowed-down analysis. In this step, all papers imported for a particular process were initially coded on a node named after that process, along with GSSCM papers because of their generic nature. For example, papers related to SP and GSSCM were coded onto the 'sustainable procurement' node. The themes identified in phase I were used as a guiding principle to extract the 'sustainability related concepts' in the SP literature through text search query and word frequency query. Tree maps, tag clouds, cluster analysis and summary tables were used for analysis. The resulting main ideas were carefully studied from the literature, thoroughly debated, critically analysed and continually compared with each other. The resulting broad themes were again coded onto new 'free nodes' and named accordingly. This 'broad-brush coding' of the SP literature revealed that main themes were related to suppliers, sourcing policies, procurement processes, contracts and training. Afterwards, the same 'open coding' procedure was repeated for the SPlng, SM, ST, SW and RL literature and numerous free nodes were generated representing broader sustainability concepts specific to sustainability for each SSCM sub-construct.

3.2.5.2 Step II: Perform Scoping of Data

Scoping refers to deeper and profound analysis of a specified subset of data (Gibbs, 2002; Richards, 2004). Each of the broader themes identified in Step I, coded onto free nodes, were meticulously studied and each free node was refined, which resulted in the creation of many new free nodes (or codes) for each supply chain process. This conceptualisation of data was based on close analysis and examination of the literature. During this step, word frequency query, text search query and tag clouds were used to facilitate this iterative and non-linear procedure based on 'constant review and comparison'.

3.2.5.3 Step III: Achieve Data Saturation

It was achieved by constant scoping of data until a clear repetition was observed in the new nodes by the researcher. This actually meant that 'saturation' is achieved and all the new free nodes sufficiently cover the domain of the process under examination. Saturation is considered as a point in analysis when a researcher only comes across already known concepts and no new codes are generated from further data analysis (Seldén, 2005). Once saturation was achieved, free nodes that represented similar technical domain of supply chain or emerging sustainability themes were connected with each other to form ‘tree nodes’ (or categories). This was also achieved through constant review and comparison so that each tree node represents a unique category and there is no overlapping between the tree nodes. For example, for sustainable warehousing, **free nodes** that represented block stacking, selective racks, double-deep racks, mobile racks, push back racks and flow through racks were later connected together to form a tree node of ‘storage system’. Later on, **tree nodes** of storage system, layout configuration, aisle design and departmentalisation were grouped together in the ‘warehouse layout’ category. **Figure 22** shows the warehouse layout category and themes, represented by tree nodes in NVivo, along with the number of sources and references in the literature.

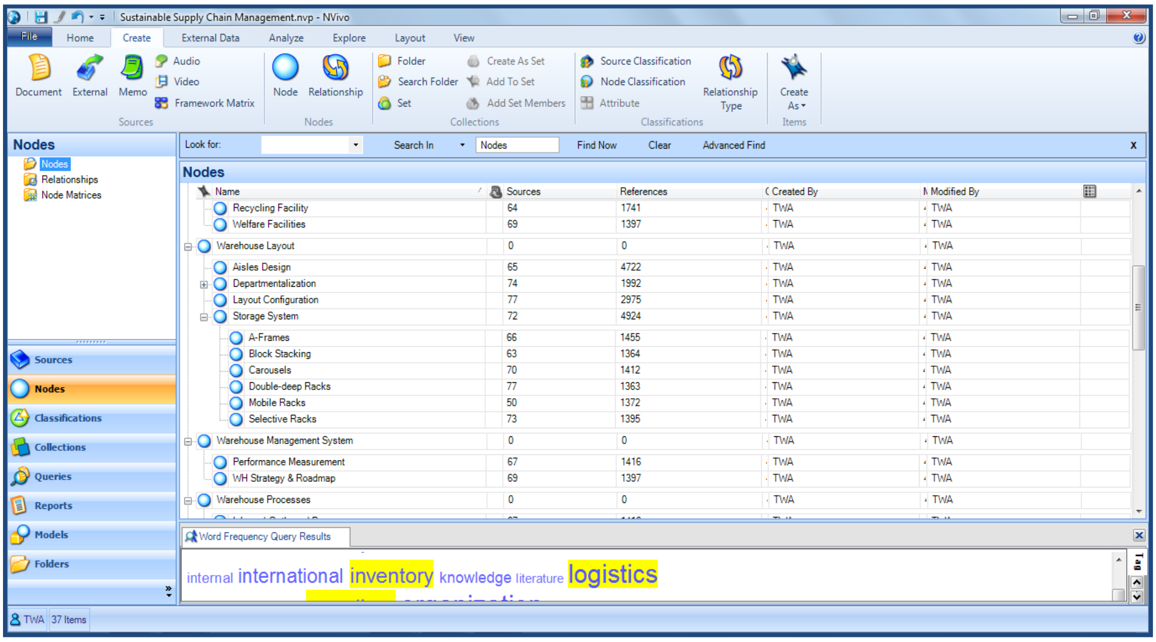

Figure 22: Warehouse Layout Category Along With its Tree Nodes

A graphical model constructed from the warehouse layout taxonomy in NVivo is shown in **Figure 23**. The visual form makes it easy to understand the underlying themes and related concepts that could help to ingrain sustainability in a warehouse. It clearly shows that in order to instil sustainability in a warehouse, the Logistics Managers should focus the ‘Warehouse Layout’ in which the ‘Aisles Design’ can be improved for faster and safer operations; ‘Departmentalisation’ can be optimised so that fast moving goods are near the exit gates of the warehouse; ‘Configuration’ can be designed in such a way that the travelling time is minimal for order picking and storage; and ‘Storage System’ should optimally use the warehouse space while providing maximum storage capacity. All these practices will lead to safer, cheaper and environment friendly warehouse operations.

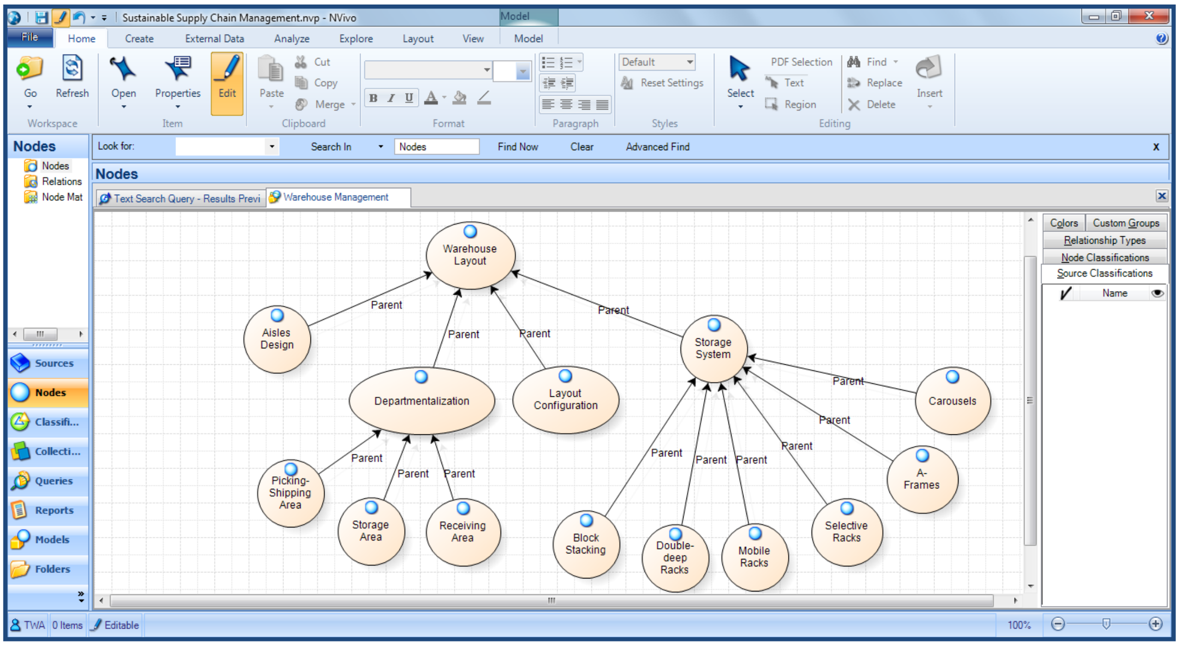

Figure 23: Graphical Model of Warehouse Layout Category & Themes for Sustainable Warehousing

NVivo facilitated all the above three steps, but it was actually the judgement, understanding, perception and deep analysis of the researcher that determined the final set of dimensions and measures for each SSCM sub-construct. It must also be noted that ‘constant review and comparison’ was carried out within and across all the three steps. For instance, any conflicts appearing at Step III forced the researcher to go back to Step II and Step I, again analyse the literature, re-examine the concepts, recode the nodes and harmonise the data and the resulting taxonomy. This was a highly iterative and non-sequential process that was effectively supported by the NVivo software.

3.2.5.4 Step IV: Maintain Log and Audit Trails

Lastly, log and audit trails were maintained in each phase. They helped in tracking various decisions made during the analysis process. They can show how various decisions evolved during the course of the research analysis and they will make it easier for others to appraise and replicate the results of this research (Siccama & Penna, 2008). The 'Memos' option in NVivo was used to maintain the audit trails which contained a date and time stamp and other important reminders for researcher of this study. Thematic memos were also created to maintain the log and clarify why certain themes were created or deleted or merged. In addition, a physical notebook was used during the entire process to graphically draw the hierarchies for each supply chain process and for comparison of free nodes, tree nodes and the resulting categories.

Thus phase II resulted into general dimensions and measures for each process (or stage) of a firm's supply chain, as shown in **Figure 24**. It was a time consuming phase as dimensions and measures were extracted, for supply chain planning, procurement, manufacturing, transportation, warehousing and reverse logistics, through rigorous perusal of literature, brainstorming and constant review and comparison. Figure 24 shows that the output of phase I was used as an input in phase II and acted as a guideline for identifying various dimensions and measures of each SSCM sub-construct. Content analysis was used to code data through the NVivo tools and constant review and comparison leading to the phase II output (dimensions and measures of SPlng, SP, SM, ST, SW and RL). This output was used as an input for phase III.

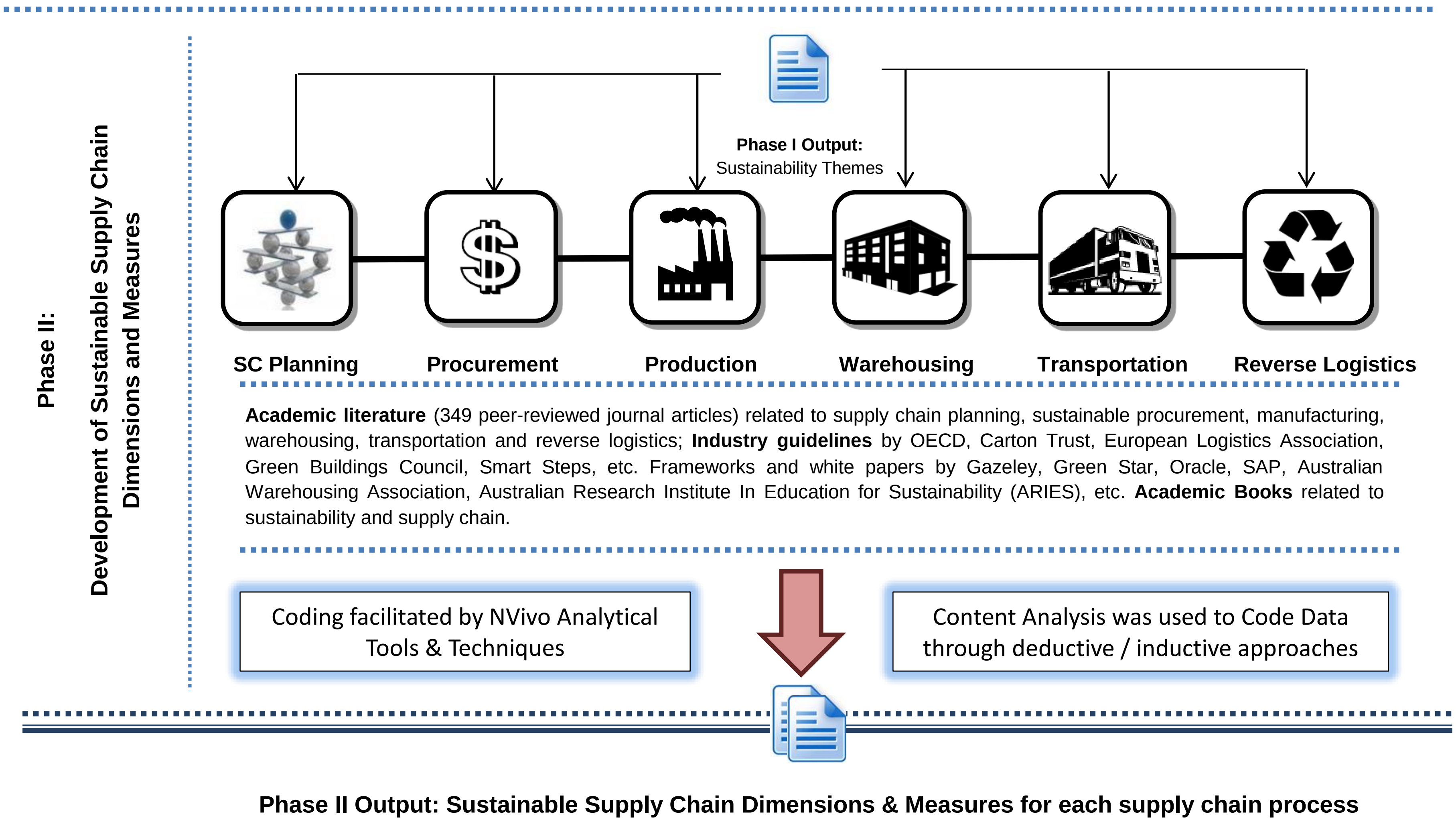

Figure 24: Phase II – Development of Sustainable Supply Chain Dimensions and Measures

3.2.6 Phase III: Adaptation of the SSCM Questionnaire to the Australian Food Industry

Phases I and II resulted in a questionnaire based on generic sustainable supply chain dimensions and measures. Since this PhD study categorically aimed to focus on the Australian food industry, it was decided to incorporate industry and country-specific variables.

3.2.6.1 Analysis of the Industry-Specific Literature: Food Industry

The analysis of the industry literature helps to identify the unique set of sustainability criteria specific to that industry. All the frameworks analysed in phase I were generic, and do not cater to the industry requirements (Farneti & Guthrie, 2007). However, organisations have recognised the significance of considering the industry setting for sustainability issues. Global Reporting Initiative (GRI, 2002) stated in their guidelines: '…the GRI recognises the limits of a one-size-fits-all approach and the importance of capturing the unique set of issues faced by different industry sectors'. Zhu and Sarkis (2006) also reported that different industries present differing barriers and drivers to companies. Also, the Department of Environment and Health [DEH] (1999) acknowledged that most of the sustainability frameworks are generic in nature and thus there is a need to develop industry specific sustainability criteria.

The environmental and social factors vary from one industry to another because of the mandatory reporting requirements, expectations of stakeholders and corporate strategies (Pullman, Maloni, & Dillard, 2010; Pullman & Wu, 2012). To date, there are very few studies that consider the industry imperative for sustainability analysis (Guthrie, Petty, & Ricceri, 2007). This generic nature of most of the sustainability instruments also impacts the accuracy of results of empirical studies (Guthrie et al., 2004), thus it is important to investigate the industry setting to close this gap.

This research study focused on the Australian food industry and analysed both academic literature and industry publications to extract the industry-specific sustainability variables. The study found that consumers want be confident that the food on their table is 'safe, wholesome and nutritious.' Changing lifestyles and increased awareness levels have led to new trends in the food industry, such as 'organic, convenience and ethnic food (Kosher, Vegan or Halal).' It is also found that 'procurement' is of paramount importance in the food supply chains, as these are spread all over the globe and involve numerous intermediaries, and therefore inherently carry the risk of social and environmental degradation (Polonsky, Bhaskaran, & Cary, 2005; Tabeau, Banse, Woltjer, & Van Meijl, 2009). In addition, the use of 'genetically modified (GM)' foods is a contentious issue. In 2010, GM crops were grown on a record area (148 million hectares) by 15.4 million farmers in 29 countries (Anthony & Ferroni, 2011). The four main crops were canola, cotton, soybean and corn, which are used in thousands of products consumed daily all across the globe. An examination of Codex Alimentarius (Latin for Book of Food) shows that industry experts are very conscious about food labelling, additives, pesticides, hygiene and food safety. It suggests the use of the hazard analysis and critical control point (HACCP) approach for prevention of any possible hazards to human health (Mayes & Mortimore, 2001).

3.2.6.2 Analysis of the Country-Specific Literature: Australia

The analysis of the country-specific literature helps to further contextualise the scope of the research. A study conducted by Christmann, Day, and Yip (1999), with 99 observations of foreign subsidiaries across 37 countries, showed that country-specific attributes were the most significant determinant of subsidiary performance.

Also, the regulatory requirements, consumer lifestyles, health issues, inflation, purchasing power, political situation and cultural/religious values are different all over the world. Obesity and food wastage are common issues in developed countries. Australians waste about $5.2 billion worth of food every year (The Australia Institute [TAI], 2009) while starvation is a norm in Africa, and access to clean water is still a luxury in many parts of Asia. This simply means that firms need to adapt their operations and processes according to local dynamics (Makino, Isobe, & Chan, 2004).

In this research study the sustainability criteria for food supply chain is contextualised for the Australian market. Therefore, various guidelines, standards, industry reports and research publications were reviewed and indicators relevant to the Australian context were added to the questionnaire. The focus on utilisation of energy and water, recycling of waste, emissions, packaging and sourcing were further accentuated in the questionnaire. Phase III is graphically shown in **Figure 25** while the food industry publications used for adaptation are shown in **Table 17**.

Table 17 clearly shows that a number of publications were used from the Australian Food and Grocery Council (AFGC), Department of Agriculture, Fisheries and Forestry (DAFF), Department for Environment, Food and Rural Affairs (DEFRA), New Zealand Business Council for Sustainable Development (NZBCSD), Australian Conservation Foundation (ACF), Australian Packaging Covenant (APC) and various other departments of the Australian Government to adapt the questionnaire to the Australian food industry. Figure 25 shows that the output of phase II (dimensions and measures of SPlng, SP, SM, ST, SW and RL) was used as an input for phase III and an effort was made to incorporate the elements of the Australian food industry in the questionnaire. This phase was also completed with the help of the NVivo software. Major food industry elements from these publications were extracted through the NVivo tools and constant review and comparison. The output of this phase was used as an input for phase IV.

Table 17: Food Industry Publications Used for Phase III (Adaptation)

Title of Publications	Sources
AFGC Sustainability Supplement	Australian Food and Grocery Council [AFGC] (2010)
AFGC State of the Food Industry	Australian Food and Grocery Council [AFGC] (2011a)
AFGC – 2020: Industry at a crossroads	Australian Food and Grocery Council [AFGC] (2011b)
AFGC Sustainability Report	Australian Food and Grocery Council [AFGC] (2009)
DAFF – FOODmap: An analysis of Australian Food Supply Chain	Department of Agriculture, Fisheries and Forestry [DAFF] (2011)
Resilience in Australian Food Supply Chain	Department of Agriculture, Fisheries and Forestry [DAFF] (2012)
Food Industry Sustainability Strategy	Department for Environment, Food and Rural Affairs [DEFRA] (2006)
KPMG Sustainability Reporting Guide	KPMG (2008)
Sustainable Development Reporting Guidelines	New Zealand Business Council for Sustainable Development [NZBCSD] (2003)
UN Supplier Code of Conduct	United Nations [UN] (2011)
The Key Sustainability Challenges Facing Australian Food Industry	Australian Conservation Foundation [ACF] (2003)
Australian Packaging Covenant	Australian Packaging Covenant [APC] (2011)
Australian Food Industry – Recent Changes and Challenges	Delforce, Dickson, and Hogan (2005)
Australian Functional Food	Commonwealth Science and Industrial Research Organisation [CSIRO] (2004)
Australia's National Framework for Environmental Management Systems in Agriculture	Natural Resource Management Ministerial Council [NRMMC] (2002)
Alternative policy approaches to natural resource management	Australian Bureau of Agricultural and Resource Economics [ABARE] (2001)
Agribusiness and Sustainable Agriculture Innovation	Department of Agriculture, Fisheries and Forestry [DAFF] (2000)
Energy Efficiency Report	The Allen Consulting Group [ACG] (2010)
Future of Packaging White Paper	Australian Food and Grocery Council [AFGC] (2012)
The Analysis of Food Related Health Risks	Food Standards Australia and New Zealand [FSANZ] (2011)
Sustainable Development Guidelines	Government of South Australia (2007)
Sustainable Packaging Guidelines	Australian Packaging Covenant [APC] (2010)
Green Skills	Department of Education, Employment and Workplace Relations Australia [DEEWRA] (2010)

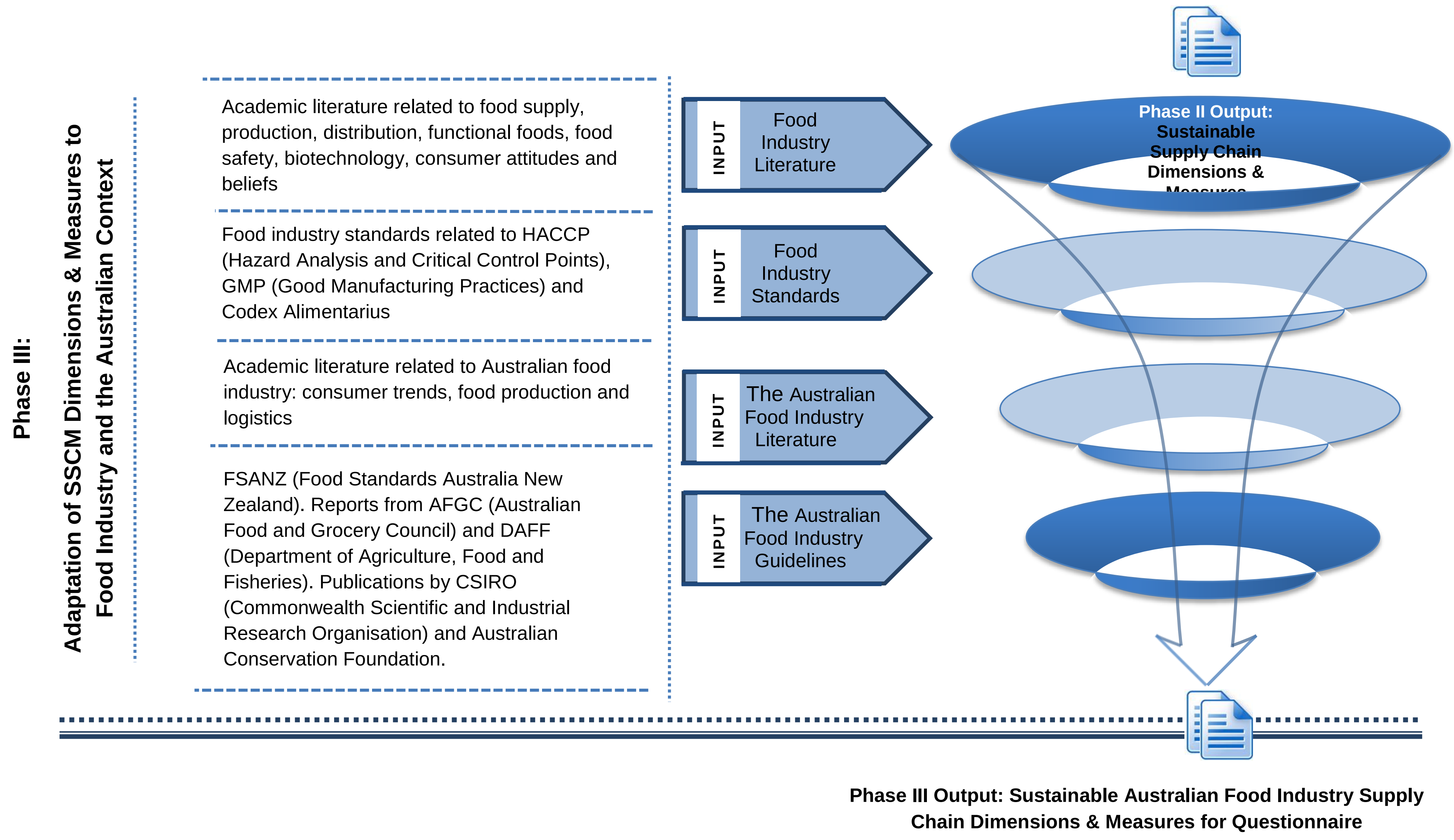

Figure 25: Adaptation to the Food Industry & the Australian Context

3.2.7 Phase IV: Validation for Completeness and Relevance (Face Validity)

Face validity is an estimate of the degree to which a measure is unambiguously and clearly tapping the construct it purports to assess (Gravetter & Forzano, 2011). It refers to the transparency, relevance and completeness of the dimensions and measures that represent a specific scale. It is not very concrete and rigorous as content validity and construct validity but it provides a general valuation of the appropriateness of constructs. In order to ensure face validity of the dimensions and measures of each SSCM sub-construct, triangulation is used. Altrichter, Feldman, Posch, & Somekh (2008) state that triangulation 'gives a more detailed and balanced picture of the situation.' According to O'Donoghue (2003), triangulation is a *'method of cross-checking data from multiple sources to search for regularities in the research data.'*

The results of phase III were compared with the Global Reporting Initiative (GRI, 2011) guidelines which is the most relevant industry standard for sustainability. It is inherently operational in nature and outlines key indicators to measure each dimension of sustainability. It is currently used by more than 5,000 companies worldwide. In addition, results of phase III were also tested against the annual 'sustainability reports' of the top 10 firms in the food sector (Table 18) to ensure industry relevance of all the SSCM dimensions and measures. These top 10 firms are selected by the Sustainable Asset Management (SAM) – a firm which focuses on sustainability investments. SAM uses its extremely reliable set of criteria and conducts thorough reviews of the environmental, social and economic performance of firms. Thus, testing the output of phase III against GRI standards **(Gate 1)** and sustainability reports of the top 10 sustainability firms **(Gate 2)** ensured the face validity of the dimensions and measures of each SSCM sub-construct.

Table 18: Company Reports Used for Face Validity

Sr. No.	Corporate Sustainability Reports	Sources
1.	Unilever Sustainable Living Plan Progress Report	Unilever (2011)
2.	Danone Sustainability Report: Strategy and Performance	Danone (2011)
3.	Nestle Annual Sustainability Report	Nestle (2011)
4.	Campbell Corporate Responsibility Report	Campbell Soup Company (2012)
5.	Growing for Good – Corporate Responsibility Report	ConAgra Foods (2011)
6.	Annual and Sustainability Report	Grupo Nutresa (2011)
7.	Creating a more delicious food – Our 2010 Report	Kraft Foods (2010)
8.	General Mills Global Responsibility Report	General Mills (2012)
9.	Corporate Social Responsibility Report	Heinz (2009)
10.	Corporate Social Responsibility Progress Report 2011	Hershey (2011)

In Phase III, a separate categorisation of material was developed through coding onto NVivo nodes. Major themes discussed in GRI and highlighted by companies in their annual sustainability reports were determined through content analysis and tools provided in the NVivo software (Figure 26). Data triangulation was applied which revealed contradictions and spurred further analysis, review and comparison, coding and re-coding of the data. Some measures were added, modified or even deleted after thorough analysis. Literature was drilled to find evidence in order to support these decisions. Consequently, taxonomies emerged for each SSCM sub-construct consisting of highly valid dimensions and measures. **Table 18** lists the top 10 sustainability companies in the food sector and **Figure 26** outlines the sustainability themes or practices that emerged from the GRI guidelines and annual sustainability reports.

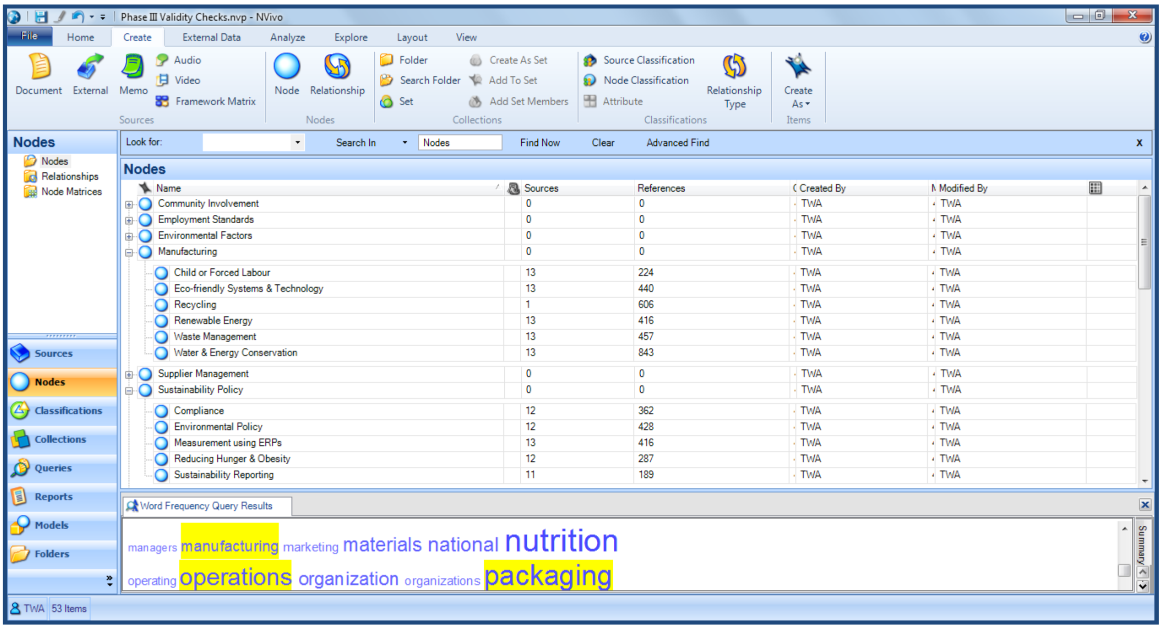

Figure 26: Sustainability Themes from the GRI Framework and Corporate Sustainability Reports

In addition, Siccama and Penna (2008) are also of the view that visual presentation (or screenshots) of NVivo representing important aspects of the research study is also a means of providing insight into the data analysis and counters validity threats. It demonstrates the rigour of the research process (Bringer, Johnston, & Brackenridge, 2006). Therefore, screen captures of the analysis, as it unfolded in NVivo, are also provided in this thesis to counter any validity threats. It could be seen that best possible results are achieved by making sound inquiry into appropriate datasets.

Figure 27 shows the above discussion of phase IV in a graphical manner while Figure 28 shows a collective summary of the four phases of this qualitative methodology.

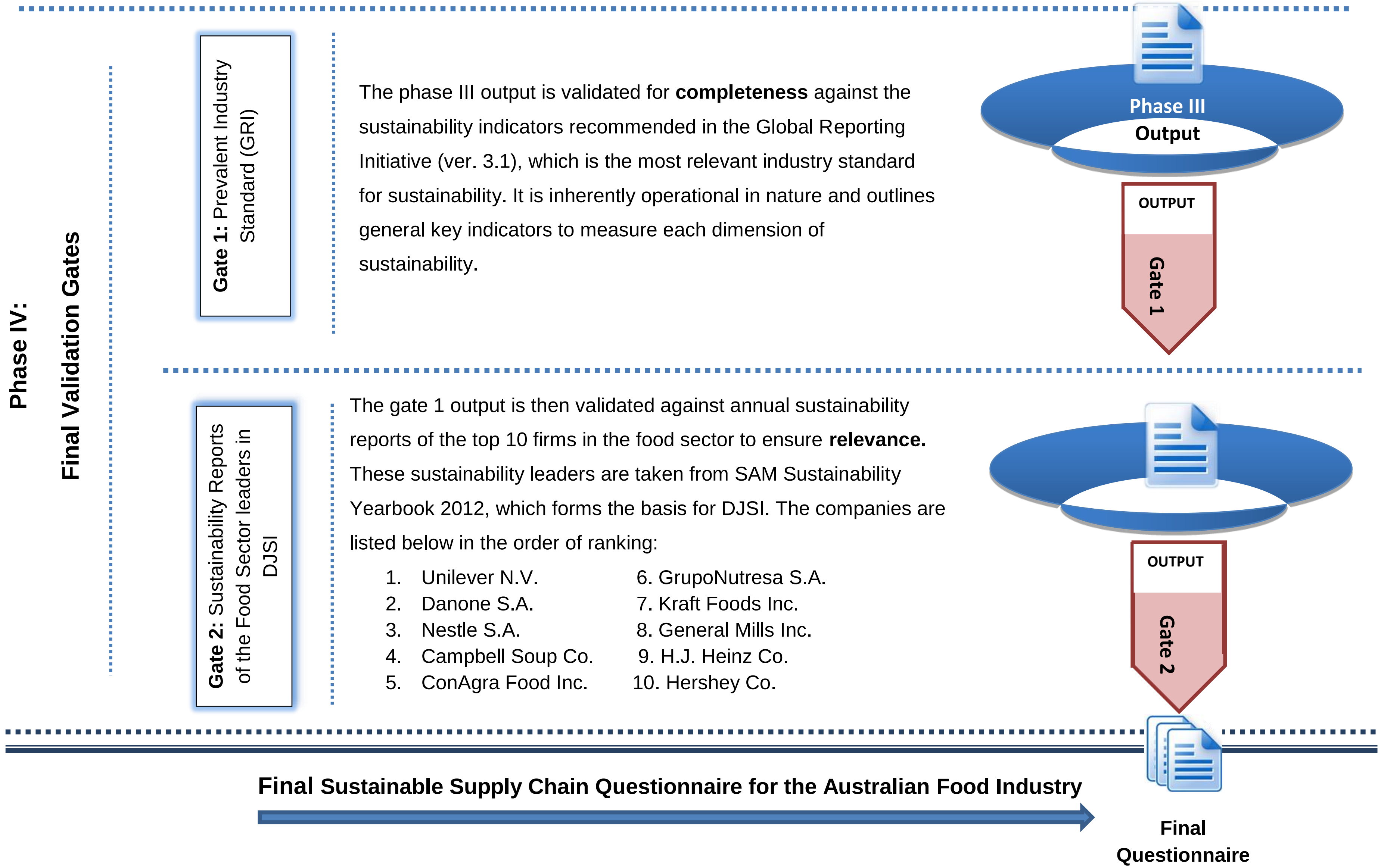

Figure 27: Face Validity of the SSCM Dimensions and Measures

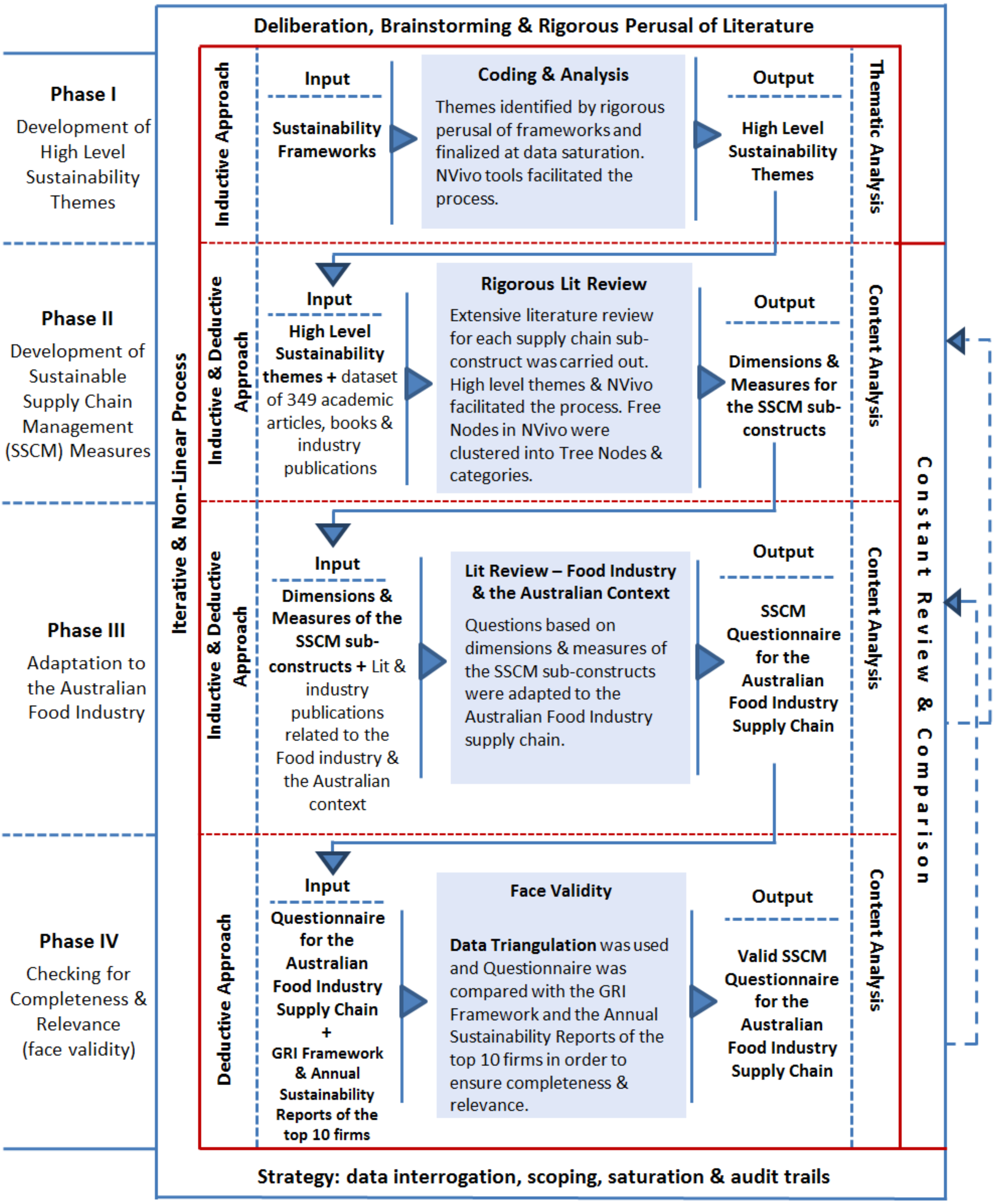

Figure 28: The Four-Phased Qualitative Data Analysis Methodology

3.3 SSCM Literature Analysis: Results and Research Hypotheses

This section will discuss the output of sections 3.1 and 3.2. The dimensions and measures of sustainable supply chain management (SSCM), that were finalised after extensive review and analysis of the SSCM material (academic articles and industry publications) through a four-phased methodology, are discussed in detail in this section. These dimensions and measures were transformed into questions for the ultimate data collection, from companies in the Australian food industry, in order to validate the scales for SSCM sub-constructs.

This section elaborates on each SSCM sub-construct (planning, procurement, manufacturing, transportation, warehousing and reverse logistics) and provides a comprehensive discussion on each dimension and measure along with the key literature used for literature review and analysis. A summary of all the material used for each sub-construct is also presented in a tabular form to show the extent of documents studied in order to finalise these dimensions and measures. Furthermore, based on the discussion, research hypotheses are developed in this section for each SSCM sub-construct and presented in the form of conceptual models. Also, the research questions that the researcher posed for each sub-construct are also mentioned explicitly.

In short, every sub-construct is discussed in extensive depth and breadth in order to justify the SSCM dimensions and measures finalised for this PhD research. However, an effort is made to separately discuss each and every measure of sustainable warehousing in more detail. This is only to show the sustainability potential of this SSCM sub-construct, which is almost overlooked in the academic literature. Therefore, a number of industry publications are used to highlight warehousing practices that can contribute towards sustainability.

3.3.1 Sustainable Supply Chain Planning (SPlng)

Badurdeen et al. (2009, p. 57) defined SSCM as ’Involvement of the planning and management of sourcing, procurement, conversion and logistics activities involved during pre-manufacturing, manufacturing, use and post-use stages in the life cycle in closed-loop through multiple life-cycles with seamless information sharing about all product life-cycle stages between companies by explicitly considering the social and environmental implications to achieve a shared vision.’ Clearly, planning is one of the most important but challenging areas in a supply chain (SC).

In the last two decades the focus of SC planning has shifted from shop floor to an holistic view of various logistics, production and procurement activities within a focal firm. A major driver of this shift is the consumer call for environment-friendly and socially responsible operations. Hence, cooperation has increased between suppliers, focal firm and logistics providers (Fredendall & Hill, 2000; NZBCSD, 2003). This has mounted enormous pressure on the ‘planning’ function to expand its purview from a factory floor activity to a strategic function that could oversee operations in other supply chain processes and initiate, monitor and implement ‘sustainable practices’ (Renko, 2011).

However, the literature lacks the insight into how supply chain planning can help to realise the goal of sustainable development. The following research questions were considered while reviewing the SSCM material for SPlng:

RQ1: How can supply chain planning play a role in achieving sustainability objectives?

RQ2: What are the major dimensions and measures of the SPlng sub-construct?

These research questions are answered by developing a theoretical and conceptual model for sustainable supply chain planning (SPlng) through a rigorous and systematic methodology discussed in the previous section. Literature review showed that the planning process is at the core of a sustainable supply chain as it furnishes high level institutional policies, chalks out risk mitigation strategies, performs accurate demand and supply planning activities, and contributes towards sustainable new product development. These dimensions of SPlng, along with their measures, are discussed below and the hypothesised conceptual model is shown in **Figure 29.**

Institutional Policies (IP) – Institutional supply chain policies are defined as a set of detailed protocols that apply to all supply chain processes (procurement, production, transportation, warehousing and reverse logistics) within a focal firm (ARIES, 2009a). The institutional policies are mainly related to stakeholders (internal and external) and operations (Hartman, Hofman, & Stafford, 1999; Zhu & Sarkis, 2007). These policies must ensure that internal stakeholders are satisfied, they are fully motivated to perform their job, and their skillset is optimally utilised. This is possible only if the planning department ensures diversity of workforce **(WDI)**; provides equal opportunities to everyone **(EOE)**; eliminates discrimination and harassment from the workplace **(WDS)**; periodically trains the employees **(ETD)**; ensures fair remuneration and working conditions **(FRWC)**; and performs backup/replacement planning **(EBP)** for all critical positions (Mintcheva, 2005; Yakovleva, 2007).

In addition, prior research shows that institutional policies should also take care of external stakeholders (customers, consumers and society at large) by ensuring that all SC departments contribute towards communal projects **(CWP)** related to health, education, sports and infrastructure, and conduct customer satisfaction surveys **(CSS)** on a periodical basis (Fossgard-Moser, 2003; Winstanley, Clark, & Leeson, 2002).

It must also ensure that all SC operations are free of corruption **(CFO)**, bribery or any kind of illegal activities **(TMP)**. In addition, it should devise strategies that could stimulate continuous improvement **(CI)** in processes pertinent to material acquisition, production, delivery and reverse logistics (Closs, Speier, & Meacham, 2011; Sharfman, Shaft, & Anex, 2009; Svensson, 2009). Industry publications showed that the planning department should keep its employees up to date regarding any developments in the Australian food industry **(AFIK)** and it should carry out research and development **(R&D)** related to the Australian food supply chain (ARIES, 2009a; DAFF, 2011).

Risk Mitigation (RM) – Risk mitigation in the supply chain is a very broad field and researchers have debated the different kinds of risks and mitigation strategies. Punniyamoorthy et al. (2011) noted that typically risks are related to supply, manufacturing, demand, logistics, information and environment. However, as most of these risks are tackled by respective supply chain departments, the literature does not explicitly articulate the role of the planning department in risk mitigation. Nevertheless, consultation with industry experts and literature review revealed that the planning department acts a central headquarter for the remaining supply chain functions and should deal with high-level risks that have a firm-wide impact (Teuscher, Grunninger, & Ferdinand, 2006).

Thus, the planning department must ensure that the organisation has (1) a documented and periodically tested Business Continuity Plan **(BCP)** to ensure smooth operations in the wake of any IT Issues (e.g. server crash, data viruses, cyber-attacks and hacking); (2) a survival plan to mitigate risk of any natural disasters (e.g. floods, earthquakes and bushfires) **(NDSP)**; (3) an emergency plan, to minimise harm to employees and local community, in the event of any site disaster **(EP)**; and (4) backup suppliers **(BS)** in case the deliveries from the primary suppliers are disrupted due to bad crops, flooding and pests (Chen & Fan, 2012; Cousins, Lamming, & Bowen, 2004; Foerstl, Reuter, Hartmann, & Blome, 2010; Norrman & Jansson, 2004).

Demand and Supply Planning (DSP) – Demand and supply planning is one of the crucial functions in any organisation. It mainly encompasses forecasting (or demand planning) and production planning that forms the basis for materials requirements planning (MRP) (Smart Steps, 2009). It also helps in decision-making at various planning levels (e.g. strategic, tactical and operational) consisting of different planning horizons (long, medium and short-term) (Caldelli & Parmigiani, 2004; Pun, 2006).

Another important aspect of this dimension is the collaborative planning with internal corporate functions (such as sales and marketing) and external partners (such as customers and suppliers) which can lead to low inventory levels through vendor managed inventory (VMI), and reduced costs due to better visibility for all supply chain partners (Kovacs, 2004). This dimension of planning must focus on improving demand forecast accuracy **(DFA)**, accuracy of production schedules **(APS)**, and collaborative planning **(CP)** (Hugo & Pistikopoulos, 2005; Partidario & Vergragt, 2002).

New Product Development (NPD) – New product development is a full-fledged field that mainly consists of eight stages, namely: idea generation, screening, conceptualisation, business analysis, market testing, technical implementation, commercialisation and pricing (Kumar & Krob, 2005). Organisations usually consider NPD as the first step in the overall process of product lifecycle management. Studies have shown that 80 percent of any product's ecological costs and impacts are established during its design phase (Hagelaar, van der Vorst, & Marcelis, 2004; Karna & Heiskanen, 1998; Shedroff, 2009; Tsoulfas & Pappis, 2006). Thus, members of the supply chain planning function must contribute to 'product design' and collaborate with the Brand team and suppliers **(CBS)** so that the long-term environmental and social impacts of the product can be minimised. Elimination of toxic materials **(PD-NTM)**, reduction in weight and size of the product so that it is optimised for logistics operations **(PD-OL)**, and minimisation of product resource requirements (water, energy and materials) **(PD-MRR)** would certainly ameliorate the supply chain's sustainability outlook (Boons, 1998; Seuring, 2011).

In addition, the supply chain department can utilise the expertise of their sourcing suppliers, supply chain partners and vendors to help the Brand team in the development of products that are easily recyclable **(PD-RP)**, expire over a long time period **(PD-LE)**, address consumer needs **(PD-CN)** and provide functional benefits **(PD-FB)** at competitive prices **(PD-CP)** (Cramer, 2000; Vermeulen & Ras, 2006).

Content analysis of industry publications showed that the supply chain can play a pivotal role in assuring that all products have a 'take-back' strategy for reusability or recycling **(PD-TBS)**, they comply with the Australian food safety regulations **(AFSR)** and use raw materials that are locally sourced **(PD-LS)**. This would support local business and also generate local employment opportunities (DAFF, 2012; DEFRA, 2006; NZBCSD, 2003).

3.3.1.1 SSCM Material Used for SPlng

Key academic literature used for SPlng is presented in **Table 19** separately for each SPlng dimension – Institutional Policies (IP), Risk Mitigation (RM), Demand and Supply Planning (DSP), and New Product Development (NPD). Also, the summary of all the SSCM material (academic literature, books, and industry publications) used to determine the SPlng dimensions and measures is presented in **Table 20.**

Table 19: Key Literature Used for the SPlng Dimensions and Measures

Sustainable Supply Chain Planning (SPlng) Dimensions and Measures	Key Literature
Institutional Policies (IP)	
Corruption Free Operations (CFO), Transparent Market Practices (TMP), Communal Welfare Projects (CWP), Customer Satisfaction Survey (CSS), Employee Training & Development (ETD), Workforce Diversity (WDI), Equal Opportunity Employer (EOE), Workplace Discrimination (WDS), Employee Backup Planning (EBP), Continuous Improvement (CI) and Research & Development (R&D), Fair Remuneration & Working Conditions (FRWC), Australian Food Industry Knowledge (AFIK)	Hartman et al. (1999); Zhu and Sarkis (2007); Closs et al. (2011); Sharfman et al. (2009); Svensson (2009); Winstanley, Clark and Leeson (2002), Fossgard-Moser (2003); Hutchins and Sutherland (2008); Auroi (2003); Hamprecht, Corsten, Noll, and Meier (2005); Mintcheva (2005); Yakovleva (2007); Apaiah, Hendrix, Meerdink, and Linnemann (2005); Baumann, Boons, and Bragd (2002); Albino, Balice, and Dangelico (2009).
Risk Mitigation (RM)	
Business Continuity Plan (BCP), Natural Disaster Survival Plan (NDSP), Backup Suppliers (BS), Emergency Plan (EP)	Punniyamoorthy et al. (2011); Chen and Fan (2012); Cousins et al. (2004); Foerstl et al. (2010); Norrman and Jansson (2004); Seuring, Goldbach, and Koplin (2004); Teuscher, Grunninger, and Ferdinand (2006); Sharfman, Shaft, and Anex, Jr. (2009).
Demand and Supply Planning (DSP)	
Demand Forecast Accuracy (DFA), Collaborative Planning (CP), Accurate Production Scheduling (APS)	Kovacs (2004); Hugo and Pistikopoulos (2005); Partidario and Vergragt (2002); Tsai and Hung (2009); Caldelli and Parmigiani (2004); Pun (2006); Gold, Seuring, and Beske (2010a).
New Product Development (NPD)	
Collaboration with Brand & Suppliers (CBS), NPD – Minimum Resource Requirements (PD-MRR), NPD – Non-Toxic Materials (PD-NTM), NPD – Optimised for Logistics (PD-OL), NPD – Local Sourcing (PD-LS), NPD – Take Back Strategy (PD-TBS), NPD – Recyclable Products (PD-RP), NPD – Competitive Pricing (PD-CP), NPD – Long Expiry (PD-LE), NPD – Functional Benefits (PD-FB), NPD – Address Consumer Needs (PD-CN), Australian Food Safety Regulations (AFSR)	Shedroff (2009); Boons (1998); Seuring (2011); Yakovleva, Sarkis, and Sloan (2012); Jones (2002); Tsoulfas and Pappis (2006); Badurdeen et al. (2009); Hagelaar, van der Vorst, and Marcelis (2004); Karna and Heiskanen (1998); Warren, Rhodes, and Carter (2001); Cramer (2000); Vermeulen and Ras (2006); H'Mida and Lakhal (2007); Hu and Bidanda (2009); Andersson, Hogaas Eide, Lundqvist, and Mattsson (1998); Baumann, Boons, and Bragd (2002).

Table 20: Summary of the SSCM Material Used for SPlng

Category	No. of Sources	Description
Peer-Reviewed Journal Articles		
Sustainable Supply Chain Planning (SPlng) Articles	88	Papers that discussed issues related to environment, society, or both, with regards to supply chain planning related to risks in supply chain, product development, supply chain design, supply chain performance metrics, management information systems, decision-making, institutional factors, integration issues, supply chain partnerships and optimisation models
General sustainable supply chain management (GSSCM) Articles	78	Papers that did not specifically focus on any supply chain process but generically discussed environmental and social issues in the context of sustainability at firm, industry or country level
Supply Chain Planning Articles	4	Papers that discussed supply chain planning regardless of sustainability perspective
Miscellaneous		
Books	4	Books related to basic and strategic supply chain management and product life cycle approaches in supply chain
Industry and Public Sector Publications	6	Publications by ARIES, AFGC, DEFRA, NZBCSD and DAFF
Sustainability Frameworks	7	Frameworks used for the development of basic sustainability themes: Natural Capitalism, Cradle to Cradle, Biomimicry, Life Cycle Analysis, The Natural Step, Social Return on Investment and Triple Bottom Line
Corporate Sustainability Reports and Sustainability Guidelines	11	Material used for face validity – Annual sustainability reports of Unilever, Danone, Nestle, Campbell Soups, ConAgra, GrupoNutresa, Kraft Foods, General Mills, Heinz and Hershey and GRI guidelines

3.3.1.2 Sustainable Planning Research Hypotheses

From the above discussion it is clear that "Sustainable supply chain planning deals with institutional policies related to stakeholders (internal and external) and operations. It focuses on risk mitigation, demand and supply planning and new product development in order to reduce uncertainty, streamline operations and satisfy customers."

The systematic and detailed literature review and analysis led to four hypotheses for the sustainable supply chain planning (HSPlng) sub-construct. The conceptual model along with the hypotheses is presented below:

HSPlng1: Supply chain planning is driven by institutional policies that have positive impact on stakeholders (internal and external) and operations.

HSPlng2: Supply chain planning is positively associated with risk mitigation as it can help to moderate the negative impacts of natural disasters, cyber-attacks, fire emergencies and supply uncertainty.

HSPlng3: Supply chain planning can reduce inventory costs through accurate demand forecasting and production (supply) planning in collaboration with other corporate functions.

HSPlng4: Supply chain planning is positively related to product development as it can engage suppliers and provide invaluable insights to brand team related to ingredients that are non-toxic and locally available.

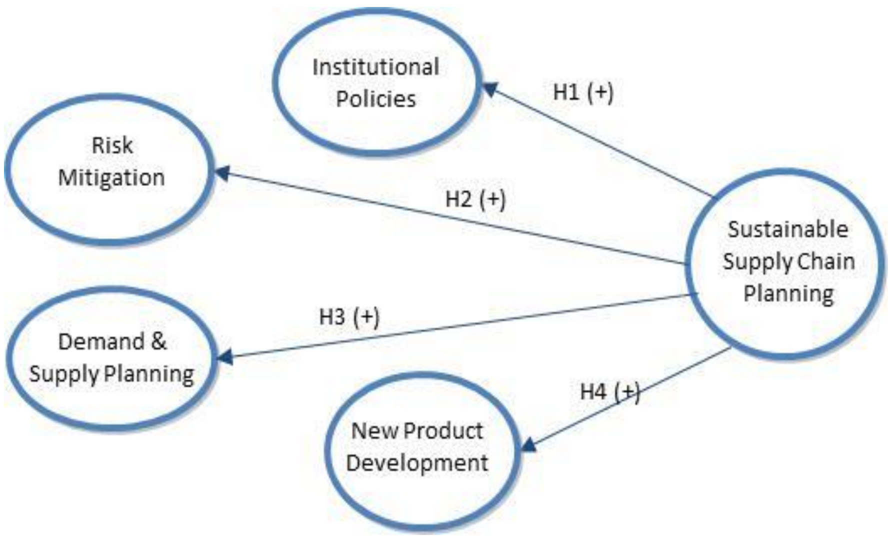

Figure 29: Conceptual Model of Sustainable Supply Chain Planning

3.3.2 Sustainable Procurement (SP)

Carter and Rogers (2008) defined sustainable supply chain management (SSCM) as 'the strategic, transparent integration and achievement of an organization's social, environmental, and economic goals in the systemic coordination of key inter-organizational business processes for improving the long-term economic performance of the individual company and its supply chains.' The need to analyse inter-organizational processes accentuated the importance of procurement. Thus firms must work with their suppliers to reduce the negative environmental and societal impacts of poisonous ingredients, emissions of greenhouse gases (GHG), contamination of waterways and exploitation of low cost labour markets (Sharfman et al., 2009). According to practitioners, '*sustainable procurement means taking into account economic, environmental and social impacts in buying choices. This includes optimizing price, quality, availability… but also environmental life-cycle impact and social aspects linked to product/services origin'* (PwC, EcoVadis, & INSEAD, 2010). However, the literature lacks the insight into how procurement can help to realise the goal of sustainable development. The following research questions were considered while reviewing the SSCM material for SP:

RQ1: How can procurement play a role in achieving sustainability objectives?

RQ2: What are the major dimensions and measures of the SP sub-construct?

These research questions are answered by developing a theoretical and conceptual model for sustainable procurement (SP) through a rigorous and systematic methodology discussed in the previous section. Literature review showed that procurement is a strategic function in any supply chain and its key dimensions are: procurement policy, operational efficiency, supplier selection and assessment, supplier workplace standards, supplier operations and supplier regulatory compliance. These dimensions of SP along with their measures are discussed below, and the hypothesised conceptual model is shown in **Figure**

30. It must be noted that the terms 'procurement', 'purchasing' and 'sourcing' are used interchangeably in both academic literature and industry publications. For this thesis, 'procurement' will be considered as the over-arching concept that includes a range of different activities undertaken to ensure that economic, social and environmental value is obtained from the sourced goods and services. While 'purchasing/sourcing' will be considered as just one of the steps in procurement, where supplier/vendor renders services or supplies goods in response to customer orders.

Procurement Policy and Processes (PPP) – Van Weele (1984), Easton, Murphy, & Pearson (2002) and Sitar (2012) identified that initially in the 1970s procurement was considered as an administrative arm of materials management and gradually its commercial orientation was realised as it helped to negotiate and select suppliers with lowest offers. However, in the 1990s, procurement assumed a logistics orientation as the entire process was structured and optimised so that the total cost of sourcing is reduced. Currently, in many organisations it is recognised as a strategic department that assists in the formation of corporate strategy (Booth, 2010; Van Weele, 1984; Walker & Hampson, 2008). However, companies where procurement is still treated as a clerical, commercial or logistics function must make relevant changes to ensure the cross-functional role of strategic procurement **(SP)**. Otherwise, sustainability objectives of the firm will not be realised (NZBCSD, 2003). Literature review revealed that the procurement function should be able to anticipate changes and trends in the external environment related to competitor moves, legal requirements, commodities pricing and cutting-edge technologies (Green, Morten, & New, 1996; Meehan & Bryde, 2011). According to Burt and Soukup (as quoted in Ferguson, Hartley, Turner, & Pierce, 1996) 'the greatly accelerated rate of change in social, political, and economic variables as well as in technology forces companies to monitor their environments constantly' and thus procurement intelligence has great importance in corporate planning. This knowledge must be combined with expected future demand to reduce uncertainty of supply (Kruger, 1997). In addition, procurement should liaise with marketing in order to get consumer insight and also assist the design department so that unsustainable materials could be eliminated at early stages of product development (Quayle, 2006). Combing all the three elements leads to a procurement function with an extremely extensive and strategic scope to achieve corporate sustainability objectives.

In addition, to ascertain that sustainable procurement has a solid footing in the firm, a written procurement policy **(WPP)** based on economic value, environmental preservation and communal welfare must be approved by the management (APCC, 2010; AELA, 2004). The policy should encompass procurement principles, procurement guidelines, procurement departmental structure and procurement rules and procedures. Procurement principles are usually related to high-level policies such as resistance to any form of corruption (e.g. extortion or bribery); support for initiatives that could improve environmental quality; and elimination of any kind of forced, compulsory or child labour (NPSA, 2006; UN Global Compact, 2011). These principles are usually realised through tactical procurement guidelines which might detail the processes related to spend analysis, stakeholder study, impact assessment, supply market examination, contract management and supplier relationship management (GWA, 2011). Procurement departmental structure forms the layout of the function within the organisation. It usually covers centralisation or decentralisation decisions, an authorisation system for various procurement personnel, identifies teams for different product categories and layout roles and responsibilities of the strategic and operational buyers (BCG, n.d.; MAV, 2011). Any layout can be adopted that supports open communication channels and fosters friendly discussions. Also, procurement procedures should cover purchasing rules for various categories of materials. These may be direct (materials used to make finished products) or indirect (materials used to support the operations) or categorisation may be based on the value and criticality of the product. Thus, a written procurement policy (**WPP**) will lay down the foundation for sustainable procurement within an organisation (APCC, 2010).

The procurement policy should guide procurement processes from source-to-settle, encompassing need analysis **(NA)**, procurement plan **(PP)**, purchasing **(PUR)** and procurement evaluation **(PE)**. Initially, for any procurement, spend analysis and demand forecast is carried out to identify the need (NPSA, 2006; MAV, 2011; SPB, 2012). This is followed by business case development which encompasses several steps such as supply market research, procurement approach, contract planning, finalisation of terms and condition (usually in the form of RFX documents) and funding approval. Afterwards, tendering/bidding/e-auctions or simple supplier selection is done, services or goods are delivered by supplier, contract monitoring and management is continuously done and, finally, payments are transacted to close the purchasing process (Ardent Partners, 2011). Later on, procurement evaluation is carried out to investigate the impact of sourcing activity on the firm's performance. All these steps in the procurement process from source-to-settle must be governed by the procurement principles, guidelines, rules and procedures that are aligned with the corporate sustainability objectives (Ardent Partners, 2012c).

Finally, the procurement policy should also govern the contract management process **(CMP)** in the procurement function. Almost 60-80 percent of all business-to-business deals/transactions are done through formal contracts and most of the global corporations have at least 20,000 to 40,000 contracts active at any given time. Research has found that most enterprises poorly manage this important component of procurement (Aberdeen Group, 2004b; SPB, 2012; WRAP, 2003). Literature review also revealed the significance of this process in operationalising sustainability. Generally, contract management includes elements such as contract planning, contract management practice and post-contract evaluation. *Contract planning* takes input from procurement planning and deals with specification development, contract length, role of sub-contractors, risks identification and mitigation strategy (Quayle, 2006). While *contract management practice* focuses on the execution phase and encompasses contract mobilisation; record-keeping and administration; managing relationships; contract monitoring; performance management; managing and negotiating contract variations and disputes; ensuring ethical practices and contract completion (CDFD, 2012; Dimitri, Piga, & Spagnolo, 2006;). Contract completion should be followed by *post-evaluation* of actual versus planned specifications, timelines and benefits outlined in the planning phase. It is a vital element, but usually overlooked by the companies. Literature review has shown its great worth as it can help in continuous improvement of the procurement policies and guidelines through lessons learned (EU, 2011).

Operational Efficiency (OE) – Literature review showed that operational efficiency is the key to sustainability, and the most pivotal element in operational efficiency is the development of procurement personnel. During the last four decades, procurement personnel, especially buyers/purchasers, were trained to achieve lowest possible prices with acceptable quality standards (Pani & Agrahari, 2007; Van Weele, 1984; Wincel, 2004). They are the front-line players as they carry out negotiations with suppliers, develop goodwill with partner organisations, gather market intelligence, identify upcoming trends, analyse company spend, find ways to eliminate the gap between expected demand and supply and secure future supplies (Bowen, Cousins, Lamming, & Faruk, 2001). All these tactical and operational activities provide input for strategic corporate decisions, thus effective personnel training **(PT)** is essential. Garrambone (as quoted in Sroufe, 2003) commented that 'one of the biggest challenges for purchasing will be how to turn an individual accustomed to transactional purchasing into a skilled strategic sourcing professional'. The challenge is now more pressing as the sustainable mindset also needs to be inculcated into procurement personnel. Literature review revealed three types of training for the procurement personnel: strategic, operational and general**.** *Strategic training* should enable personnel to revamp and continuously improve the procurement principles and guidelines related to contract management, supplier management, vendor-based management, total cost of ownership, pricing approaches and market intelligence, in such a way that organisational sustainability objectives are satisfied. *Operational training* should be focused on traditional areas such as communication and presentation skills, accounting, book-keeping, critical thinking and negotiation techniques. In addition, regulatory compliance, procurement policies, environmental legislation, international human rights and labour standards should also be explicitly taught to operational buyers/purchasers. The output of this training should be a purchasing officer who could buy goods that not only satisfy the conventional cost and quality criteria but also support the local economy, contribute to communal welfare and have minimum impact on the environment (DoF, 2011; SPB, 2012). Furthermore, *general training* related to emotional intelligence, stress management and self-control should be a mandatory component of the annual training schedule.

According to the literature, another important element that will ensure operational efficiency is supply base development **(SBD)**, which may be defined as securing supplies for the firm through a range of sourcing options which can be used as a backup (Li, 2011). Literature review has shown that researchers have thoroughly discussed various aspects of robust supply-base management through optimal number of suppliers (Nam, Vitton, & Kurata, 2011) and global supply chain adaptations (Liao, Marsillac, Johnson, & Liao, 2011). Firms are mainly looking for competitive pricing, quality conformance and better designs. Also, as natural catastrophes have become a regular event in a calendar year, it is important to have backup suppliers that could be used to prevent supply disruptions and ensure on-time deliveries to customers. This will help to improve the economic sustainability of the firm.

In addition, literature review also showed that any computerised procurement system can also help to improve operational efficiency and transparency (Pani & Agrahari, 2007). The procurement management system **(PMS)** can be a standard procurement system or an electronic procurement system, as both of them can support sustainability. The *standard system* automates conventional purchasing processes that include requisitions, purchase orders, receipts and invoices. In addition to core functionalities, it has reporting options, workflow management, and tools for funds management and spend analysis (Ardent Partners, 2011, 2012b). All these tools can be very helpful in improving social and environmental performance. On the other hand, *e-procurement system* is an internet-based system where buyers access suppliers' catalogues, select materials, specify accounts for charging, and purchasing orders are automatically created in the system (Pani & Agrahari, 2007). In such a system, the entire procurement process is completed electronically which improves efficiency and reduces paperwork. E-procurement was identified by Barua, Konana, Whinston, & Yin, (2001) as '…the most important element of e-business operational excellence for large corporations.' In addition, purchasing tools based on e-commerce and internet help to maximise benefits for both buying and selling companies (Boyer & Olson, 2002). Therefore, organisations still using manual record-keeping books and Excel spreadsheets, should upgrade themselves to PMS.

Supplier Selection and Assessment (SSA) – Supplier Selection and Assessment focuses on the most critical entity in the procurement process – suppliers. According to Gartner Inc., purchasing costs represent 30 – 65 percent of sales in most industries. It estimated that Fortune 500 companies spend about 45 cents for purchase of either goods or services for each dollar made in revenue (as cited in PeopleSoft, 2002). Literature review highlighted the traditional elements such as supplier selection **(SS),** supplier assessment/audits **(SA),** supplier financial strength **(SFS)** and supplier involvement **(SI)** (Holt, 2004; Rao, 2005). *Supplier selection* is well-researched and researchers have chalked out several methods based on price, quality, delivery, historical performance, production capacity, service levels and location (Dempsey, 1978; Shipley, 1985; Verma & Pullman, 1998). Some researchers also proposed linear weighting models (Timmerman, 1987), hierarchical process models (Nydick & Hill, 1992) and total cost of ownership approach (Ellram, 1995). Recently, researchers have also started considering sustainability issues for supplier selection and assessment (Bai & Sarkis, 2010) and they have emphasised the importance of periodical supplier audits to ensure that they comply with the standards. The text search query in NVivo for the keyword 'supplier' and the related 'word trees' showed that the suppliers' operations should be free of corruption or any illegal activity, and they should be financially sound. This will ensure long-term economic, social and environmental sustainability of the supplier and will decrease the costs for the focal firm, as it will not be required to change the supplier on a frequent basis (Bai & Sarkis, 2010; Lee & Kim, 2011; Simpson & Power, 2005).

Supplier Workplace Standards (SWS) – This dimension emphasises the importance of elements such as occupational health and safety **(OHS)**, child or forced labour **(CFL)**, workplace discrimination **(WD)**, employee working hours **(EWH)**, employee wages **(EW)** and freedom of association **(FA)** (Graafland, 2002; Leire & Mont, 2010; Nyaga, Whipple, & Lynch, 2010). An organisation can include these in its supplier selection and assessment criteria. Generally *occupational health and safety* is concerned with workplace illness and injuries and covers all forms of unpaid or paid work in all environments. Literature does provide evidence that good OHS management improves productivity (Massey, Lamm, & Perry, 2006). In addition, International Labour Organization (ILO) Declarations do not allow any form of workplace discrimination or child/forced labour. Thus, both suppliers and the focal firm must comply with the ILO Declarations. Employee wages and working hours should also be as per the market standards and the *freedom of association* must be respected by both parties (GRI, 2011).

Supplier Operations (SO) – This dimension dictates that supplier operations should be based on practices such as energy conservation **(EC)**,water conservation **(WC)**, reduction in emissions **(RE)**, preservation of biodiversity **(PB)**, waste reduction **(WR)**, recyclable packaging **(RP),** traceability **(TR)** and specific industry requirements **(SIR).** Energy should be consumed efficiently so that greenhouse gas (GHG) emissions can be reduced. Also, *renewable energy sources* (e.g. biofuels, biomass, solar, wind, etc.) should be used. Their selection can be based on market factors, regulatory compliance and operational costs (Fichtner, Frank, & Rentz, 2004; Saint Jean, 2008; Marchant, 2010). Use of daylight should be maximised and it should be optimally combined with an artificial lighting scheme as improved visibility has a proven positive impact on workforce alertness and productivity (Carbon Trust, 2007*). Water conservation* can be done through latest roofing technology, modern sanitation fixtures, drainage techniques, and air-cooled compressors and chillers. Some of the ecological benefits of water conservation include reduction in distribution piping, and lesser burden on municipal water supply (Gazeley, 2004).

In addition, procurement literature seems to be alien to *biodiversity* but content analysis of latest standards (GRI, 2011) showed that it is integral to sustainability as it is important to both business and society. Research has shown that organisations with greener surroundings and settings have more motivated employees and about 8 percent higher property value as compared to those far away from parks and green spaces (CABE, 2005; NEN, 2008). A focal firm can impress on its suppliers to take care of biodiversity as research has found that suppliers are very responsive to customers' environmental performance requirements (Simpson, Power, & Samson, 2007). In addition, reduction of waste through recycling and reuse should be promoted by suppliers and this can be best done by using recyclable packaging in their products. A *recycling facility*, that can process the stock that is damaged, expired, returned by customers and rejected by quality, is also recommended by the industry guidelines and the top researchers in the field of supply chain management (NZBCSD, 2003; Simpson, 2010).

A very important factor accentuated by corporate sustainability reports is *traceability*. It is considered as a key element in tracking down issues that hamper the environmental and social sustainability in the food supply chains. Thus, suppliers must ensure that their entire production is traceable and also complaint to the *specific food industry requirements* which might include animal welfare, fair-trade recognition, ISO compliance, Halal or Kosher certification, etc. All these elements should be added to supplier selection and assessment criteria and development programs (MAV, 2011; WRAP, 2011).

Suppliers' Regulatory Compliance (SRC) – The review of academic literature and industry publications related to the Australian food industry led to the addition of this dimension to the sustainable procurement model. Two main elements that resulted from the literature review are local and international compliance **(LIC)** and food products labelling **(FPL)** according to the Australian standards (AELA, 2004; APCC, 2010). In addition, it was also decided to add an element or measure related to the compliance with the Australian Packaging Covenant **(APC),** even though it is voluntary. These elements were extracted from the analysis of publications by the Australian Food and Grocery Council (AFGC), CSIRO reports, DAFF publications and FSANZ standards (AFGC, 2010; CSIRO, 2004; DAFF, 2011; FSANZ, 2011).

3.3.2.1 SSCM Material Used for SP

Key literature used for SP is presented in **Table 21** while summary of all the SSCM material used to determine the SP dimensions and measures is presented in **Table 22.**

Table 21: Key Literature Used for the SP Dimensions and Measures

Sustainable Procurement (SP) Dimensions and Measures	Key Literature
Procurement Policy and Processes (PPP)	
Strategic Procurement (SP), Written Procurement Policy (WPP), Need Analysis (NA), Procurement Plan (PP), Purchasing (PUR),Procurement Evaluation (PE), Contract Management Practice (CMP)	Van Weele (1984), Easton et al. (2002); Sitar (2012); Ferguson et al. (1996); Kruger (1997); Votta, Broe, Johnson, and White (1998); Corbett and DeCroix (2001); Green, Morten, and New (1996); Meehan and Bryde (2011); Krause, Vachon, and Klassen (2009); UN Global Compact (2011); GWA (2011); MAV (2011); Aberdeen Group (2003); EU (2011)
Operational Efficiency (OE)	
Personnel Training (PT), Supply Base Development (SBD), Procurement Management System (PMS)	Bowen, Cousins, Lamming, and Faruk (2001); Harland et al. (2006); Davila et al. (2003); Barbieri and Zanoni (2005); Angeles and Nath (2007); Bartolini (2012)
Supplier Selection and Assessment (SSA)	
Supplier Selection (SS), Supplier Assessment/Audits (SA),Supplier Financial Strength (SFS), Supplier Involvement (SI)	Beske , Koplin, and Seuring (2008); Theyel (2001); Zhu and Geng (2001); Holt (2004); Rao (2005); Cousins, Lamming, and Bowen (2004); Simpson and Power (2005)
Supplier Workplace Standards (SWS)	
Occupational Health and Safety (OHS), Child or Forced Labour (CFL), Workplace Discrimination (WD), Employee Working Hours (EWH), Employee Wages (EW), Freedom of Association (FA)	Carter (2005); Harwood and Humby (2008); Drumwright (1994); Graafland (2002); Leire and Mont (2010); Nyaga, Whipple, and Lynch (2010); Cooper, Frank, and Kemp (2000); Carter (2000, 2004, 2005); Carter and Jennings (2002); Eltantway, Fox, and Giunipero (2008); Bernardes (2010); Carter and Jennings (2004); Svahn and Westerlund (2009); Sitar (2012)
Supplier Operations (SO)	
Energy Conservation (EC),Water Conservation (WC), Reduction in Emissions (RE), Preservation of Biodiversity (PB), Waste Reduction (WR), Recyclable Packaging (RP),Traceability (TR), Specific Industry Requirements (SIR)	Fichtner, Frank, and Rentz (2004); Jean (2008); Dawson and Probert (2006); Koplin, Seuring, and Mesterharm (2007); Giunipero, Hooker, and Denslow (2012); Roberts (2003); Wolf and Seuring (2010); Verschoor and Reijnders (1997); Stoughton and Votta (2003).
Supplier Regulatory Compliance (SRC)	
Local and International Compliance (LIC), Food Products Labelling (FPL), Australian Packaging Covenant (APC)	AELA (2004); GWA (2011); APCC (2010); GSA (2012); MAV (2011); Aberdeen Group (2004); Ardent Partners (2011, 2012); BCG (n.d.)

Table 22: Summary of the SSCM Material Used for SP

Category	No. of Sources	Description
Peer-Reviewed Journal Articles		
Sustainable Procurement (SP) Articles	88	Papers that focused on procurement policies, green buying, contract management, supplier management and e-procurement in the context of sustainability.
General sustainable supply chain management (GSSCM) Articles	78	Papers that did not specifically focus on any supply chain process but generically discussed environmental and social issues in the context of sustainability at firm, industry or country level.
Procurement Articles	10	Papers that generally discussed procurement, buyer-supplier relationship, purchasing strategies, supply management and e-procurement.
Miscellaneous		
Peer-Reviewed Conference Papers	4	These four papers focused on literature review, emerging issues, supply strategies and purchasing portfolio in the context of sustainability.
Books	6	Books mainly discussed strategic and e-procurement and their role in supply chain management.
Industry and Public Sector Publications	19	These publications provided industry views and information on spend analysis, green procurement, procurement policy and e-procurement.
Sustainability Frameworks	7	Frameworks used for the development of basic sustainability themes: Natural Capitalism, Cradle to Cradle, Biomimicry, Life Cycle Analysis, The Natural Step, Social Return on Investment and Triple Bottom Line
Corporate Sustainability Reports and Sustainability Guidelines	11	Material used for face validity – Annual sustainability reports of Unilever, Danone, Nestle, Campbell Soups, ConAgra, GrupoNutresa, Kraft Foods, General Mills, Heinz and Hershey and GRI guidelines.

3.3.2.2 Sustainable Procurement Research Hypotheses

The systematic and detailed literature review and analysis led to six hypotheses for the sustainable procurement (HSP) sub-construct. The conceptual model along with the hypotheses is presented below:

HSP1: Sustainable procurement is positively associated with a written procurement policy that aims to impart sustainability in all procurement functions.

HSP2: Sustainable procurement depends on operational efficiency driven by personnel training, backup suppliers and use of technology.

HSP3: Sustainable procurement must establish supplier selection and assessment mechanism encompassing economic, social and environmental criteria along with regular audits.

HSP4: Sustainable procurement is positively related to supplier workplace standards focusing on employee wellbeing and communal welfare.

HSP5: Sustainable procurement is positively related to supplier operations based on efficient utilisation and conservation of resources, recycling and traceability mechanisms.

HSP6: Sustainable procurement should ensure that suppliers comply with the Australian and international standards for food safety, labelling, and packaging.

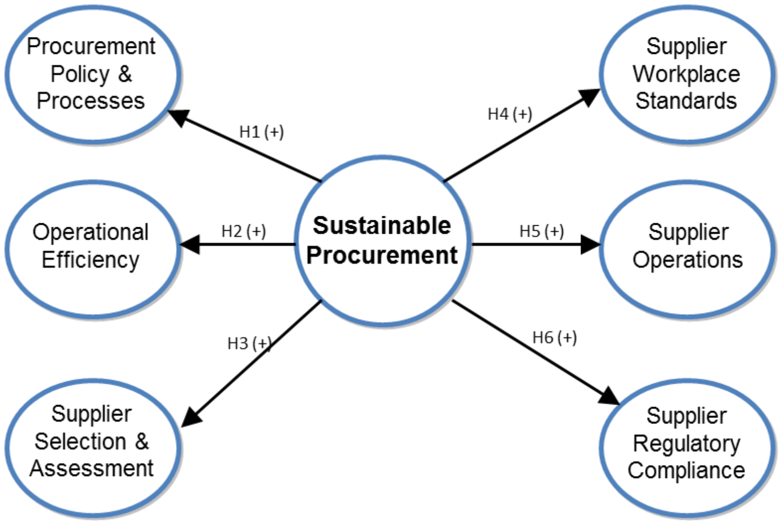

Figure 30: Conceptual Model of Sustainable Procurement

3.3.3 Sustainable Manufacturing (SM)

Manufacturing processes require high inputs of energy and materials for value creation. Electric power generation and fuel combustion for facility heating during production processes, are estimated to contribute 9 percent and 25 percent of GHG emissions, respectively (Smart Steps, n.d.c). The waste generated from production centres and plants highly contaminate the local and the global environment. It usually contains various heavy metals discharged in waste-water such as Cu, Pb, hexavalent chromium, cadmium, Zn, Ni and Hg; organic pollutants and pesticides; oil and grease; pathogens; suspended solids; and nitrogen and phosphorous (Nasr, Hilton, & German, 2011). Therefore, socially and environmentally responsible manufacturing is not an option any more, but is a business imperative. Sustainable manufacturing is defined as *'systems of production that integrate concerns for the long-term viability of the environment, worker health and safety, the community, and the economic life of a particular firm'* (Quinn, Kriebel, Geiser, & Moure-Eraso, 1998). More recently, the US Department of Commerce [USDoC] (2010) defined sustainable manufacturing as *'the creation of manufactured products that use processes that minimize negative environmental impacts, conserve energy and natural resources, are safe for employees, communities, and consumers and are economically sound.'* However, comprehensive and holistic criteria for operationalising sustainability in manufacturing are not available. The following research questions were considered while reviewing the SSCM material for SM:

RQ1: How can manufacturing play a role in achieving sustainability objectives?

RQ2: What are the major dimensions and measures of the SM sub-construct?

These research questions are answered by developing a theoretical and conceptual model for sustainable supply manufacturing (SM) through a rigorous and systematic methodology discussed in the previous section. Literature review showed that the manufacturing process is at the core of a sustainable supply chain and its key dimensions are: manufacturing policy, pollution control and prevention, resource conservation, manufacturing strategy, production staff, cleaning and sanitation and production regulatory compliance. These dimensions of SM, along with their measures, are discussed below and the hypothesised conceptual model is shown in **Figure 31.** It must be noted that the terms *'production'* and *'manufacturing'* are used interchangeably in both academic literature and industry publications. In this thesis, the term 'manufacturing' will be used as the over-arching concept that includes a range of different activities undertaken to ensure that economic, social and environmental value is obtained from the products. Whereas 'production' will be considered as only one of the steps in the manufacturing process where machines or plants assemble/fabricate goods in response to customer orders.

Manufacturing Policy and Processes (MPP) – This dimension ascertains that the ideology of sustainable manufacturing is ingrained in the culture and processes through a written manufacturing policy **(WMP)** that should encompass manufacturing principles, manufacturing guidelines, environmental and communal policy and regulatory compliance (Davim, 2010; Ray, 2008). The manufacturing function should not have a subordinate strategic position within the firm and must play a proactive role in strategic decision making (Ward, Leong, & Boyer, 1994). Manufacturing principles are usually pertinent to high-level policy decisions such as increased usage of renewable energy sources; procurement of cleaner production technologies; commitment to reduce resource consumption; fiscal support for initiatives related to preservation of environment; zero-accident and zero-emissions targets; stance against any kind of corruption; eradication of forced or child labour; and worker benefits scheme. (UN Global Compact, 2011; WRI, 2001). Literature review showed that these policies can be realised through guidelines, action-plans and standard operating procedures (SOPs) for recycling, handling of hazardous/toxic materials, treatment of waste water, cleaning-up of spills, noise-control, evacuation (in case of emergencies), pollutants and waste control (Black, 2010; Mathew &

Rao, 2006). In addition, the sustainable manufacturing policy should explicitly articulate a comprehensive strategy that could effectively tackle and neutralise the negative impacts of production processes on the local environment and community. This might encompass minimal use of groundwater, employment opportunities for locals, communal welfare projects and preservation of biodiversity (CSIRO, 2012).

Furthermore, content analysis of contemporary industry publications, latest sustainability standards (GRI, 2011) and annual sustainability reports of firms revealed that manufacturing policy should explicitly focus on biodiversity preservation **(BP)** through control of hazardous materials. Biodiversity (or biological diversity) refers to various life forms that exist in a particular area consisting of natural vegetation, animals, forests, waterways, micro-organisms and eco-systems (OECD, 2011; WRI, 2001; Smart Steps, n.d.c). It is necessary for sustaining life on the planet Earth and is important for individuals, communities and businesses. Thus, the broad purview of biodiversity must be kept in consideration while designing or revamping products and processes. The life cycle analysis (LCA) tool can be very helpful in this regard. One way of preserving biodiversity is to minimise the use of hazardous materials/chemicals/solvents or replace them with safer alternatives (Portney, 1990).

In addition, food industry literature and industry reports related to the Australian food industry showed that manufacturing departments should follow the principles of HACCP (Hazard Analysis and Critical Control Point) in food production processes to ensure food safety **(FS),** and this should be guided by the manufacturing policy. HACCP is a preventive system that ensures food safety and saves cost for the organisation in the long run, and thus it supports both social and economic sustainability. It identifies, evaluates and prevents all sorts of chemical, biological and physical hazards related to food processes (DAFF, 2012; DEFRA, 2006). Also, literature showed that manufacturing policy will be handicapped and processes would not become sustainable without an environmental management system **(EMS)**. EMS is a systematic tool that helps to monitor the impact of manufacturing operations on the environment and consequently helps in planning, resource allocation and strategy development. Various thresholds and functionalities in EMS should also be guided by the manufacturing policy (NRMMC, 2002; NZBCSD, 2003).

Pollution Control and Prevention (PCP) – This dimension aims to control and prevent the harmful impacts of pollutants on the environment and local communities. Pollution control is a reactive strategy that comes into action at the end of a process and thus includes the remedial action plan **(RAP)** and end-of-pipe controls **(EPC)**. The remediation plan should be focused on neutralising, tackling or cleaning any ecological damage from previous operations (or crises). It requires deep understanding of pollutants and their harmful impacts (both short and long-term) (Davim, 2010). Literature review shows that it is usually driven by the environmental legislation but it must be in place in case of any emergency or unprecedented situation. On the other hand, end-of-pipe control encompasses the equipment that is usually installed at the end of a process, such as an effluent pipe or a discharge stack to capture or treat pollutants and waste (Hugos, 2003; Renko, 2011). Manufacturing plants using such equipment must ensure compliance to regulatory standards that specify limits for emitted pollutants on the basis of commercially available end-of-pipe equipment (Portney, 1990). Researchers have discussed the financial implications of these controls but surely the long-term benefits outweigh the costs. Even though 'cleaner technologies' are a much recommended option for manufacturing plants, still end-of-pipe equipment provides an additional layer of protection against any possible polluting substance (Gray & Shadbegian, 1993; Walley & Whitehead, 1994). Therefore, the pollution control practices play a vital role in realising the sustainable manufacturing policy in an organisation.

On the other hand, pollution prevention is a proactive approach. Literature review has shown that it outlines all possible measures and strategies that could assist in curbing the production of any substance that might be harmful to the environment and society. Literature has further categorised pollution prevention into practices such as product adaptation **(PTA)** and process adaptation **(PRA)** (Utterback & Abemathy, 1975). Product adaptation deals with designing eco-friendly products, while process adaptation takes into account changes that help to reduce negative impacts of manufacturing processes, mainly material acquisition, production and delivery (Klassen & Whybark, 1999). Also, literature review showed that there are three main categories of emissions which should be monitored and controlled **(EMC)**. These are greenhouse gases, ozone depleting substances, and toxic pollutants. The most effective strategy to reduce production of air pollutants and toxic materials is to use ‘clean technologies’ rather than using cleaning mechanisms to remove pollutants that are already generated by the production system (O’Brien, 1999).

Waste management **(WM)** also comes under pollution control and prevention. Usually, unusable materials generated by a production process or facility are considered as waste. However, literature review shows that researchers have outlined many types of waste in manufacturing facilities such as: (1) waste from over-production; (2) waste of waiting time; (3) transportation waste; (4) inventory waste; (5) processing waste; (6) wasted motion; and (7) waste from product defects (Suzaki, 1987). Rigorous review of literature, comparison with the GRI framework and testing against the corporate sustainability reports showed that waste can be minimised by efficient materials-handling techniques. Also, lean manufacturing practices and concepts, such as single minute exchange of die (SMED), can be effectively used to reduce machine setup and changeover time (LSG, 2008). This should be done in parallel with investments focusing on the training and development of the workforce in order to be successful (Boyer, 1996). In addition, one of the biggest material inputs in any manufacturing process is packaging. A lot of packaging material is wasted during the setup process and this can be reduced by effectively implementing total quality management (TQM) principles (Sarkis, 2001). Also, waste management is unimaginable without recycling and reuse. According to academics and industry experts, a recycling facility is a must in a production plant, and reuse of materials must be ingrained in product design, procurement and manufacturing strategies (Kahhat et al., 2008; Fernandes & Rocha, 2011).

Furthermore, pollution control and prevention is not possible without state-of-the-art and best-of-the-breed production management system **(PMS)** having top-notch enterprise resource planning (ERP) modules. It will lead to operational efficiency and transparency. Palevich (2011) has reported 10 percent savings, through implementation of PMS, which avoids direct and indirect labour costs. EMS, discussed under the policy dimension, should be a core module of PMS that could help to manage and monitor environmental data in a systematic manner. It will help to fulfil the reporting requirements of the most established EM frameworks – ISO 14001 and European Union's Eco-Management and Audit Scheme (EMAS) (Lu et al., 2011; NOHSAC, 2006).

Other important modules of PMS that could help in performance measurement and developing future production strategies are capacity requirements planning (CRP), engineering change management (ECM), staff productivity monitor (SPM), shop floor control (SFC), master production scheduling (MPS), material requirements planning (MRP), product data management (PDM) and quality management and assurance (QMA) (Fredendall & Hill, 2000; Palevich, 2011). The latest PMS also supports 'digital manufacturing' which is an integrated suite of features that support designing of plant layout and production processes. It can run powerful simulations that can help a plant/production engineer to optimise the manufacturing operations. Thus, organisations still using manual record-keeping books or Excel spreadsheets should upgrade themselves to at least a basic production management system. It must be noted that these days acquisition of technology is not an issue but implementation that could realise full benefits of the advance manufacturing technology takes years. Thus, firms must make an effort to attain both technical and business success (realisation of full benefits) while implementing any advance manufacturing technology (Voss, 1988).

Resource Conservation (RC) – This dimension dictates that the consumption of resources should be minimised and production operations should be based on elements such as energy conservation **(EC)**, water conservation **(WC)**, minimal raw materials usage **(RMU1)** and maximum recycled materials usage **(RMU2)**. Currently, major energy inputs are oil, gas, coal and electricity, and they all produce gases such as CO_2, CH_4, and N_2O. Every effort should be made to use 'renewable energy sources' such as solar thermal, solar photovoltaic, wind, biofuels, biomass (wood chips or other waste), geothermal resources and energy recovered from process waste (such as heat from air compressors). In addition, biodiesel and natural gas, which are low carbon alternatives, can also be used (GMC, 2006; Ilgin & Gupta, 2010; OECD, 2011; Schlosser, Klocke, & Lung, 2011). The choice and mix of renewable energy sources should be made prudently, keeping in consideration operational cost, market factors and regulatory compliance (Marchant, 2010).

Optimal combinations of daylight and artificial lighting scheme should be employed, as improved visibility has a proven positive impact on workforce alertness and productivity (Carbon Trust, 2007). Furthermore, water can be conserved through state-of-the-art roof design which can help to collect rainwater for later use in the production plant and other areas of the manufacturing facility. Brown and green roofs, water irrigation technology, roof drainage techniques and modern sanitation fixtures can also be used to conserve water. In addition, usage of water for cooling compressors, chillers and steam boilers can be avoided by considering air-cooled equipment.

Gazeley (2004) reported that some of the key ecological benefits of water conservation include lesser burden on municipal water supplies, reduction in distribution piping and decrease in release of chlorine into the environment. In addition, Gazeley's eco-template mentions that collection of rainwater in a large facility (e.g. warehouse or production centre) fulfils about 89 percent of the water requirements in toilets, saves water required for nearly 89,000 flushes and, if purified, about 25,000,000 cups of tea per year. Finally, efforts should be made to decrease the usage of raw materials and increase the usage of recycled materials during each stage of production. This should include the recycling and reuse of water **(RRW)** for production operations, as water is a finite resource. Also, a report by Organisation for Economic Cooperation and Development (OECD) showed that the use of recycled materials could result in 20 – 40 percent performance improvement over a period of three years (OECD, 2011).

Manufacturing Strategy (MS) – Literature review shows that the manufacturing strategy is inherited from the broader dimensions of manufacturing policy, and pollution control and prevention. In the last 20 years, many different approaches are developed in the field of manufacturing strategy which can be divided into three distinct paradigms such as competing through manufacturing; strategic choices in manufacturing; and the best practice (Voss, 1995). MS should mainly focus on eco-friendly processes **(EFP)**, product design **(PD)** and manufacturing practices **(MP).** A sustainable production process should integrate concepts of waste minimisation, TQM's ultimate goals of zero-waste and zero-emissions, and adoption of the ISO 14000 standards based on Deming's continuous improvement cycle (PDCA – Plan, Do, Check and Act). The final objective is to ensure a micro-industrial eco-system, with a closed-loop production process, which can reuse any waste or by-products produced during the operations (Sarkis, 2001). In addition, product strategy should mainly revolve around the philosophies of design for environment (DFE) and design for disassembly (DFD). Also, manufacturing strategy should focus on understanding the impact of products during the production process by using the lifecycle analysis (LCA), which is a prevalent industry technique standardised as the ISO 14040 series (Kumar & Krob, 2005; Reich-Weiser et al., 2008).

Execution and implementation of all the practices discussed earlier would only be possible if production personnel are engaged; therefore, manufacturing strategy should encourage empowerment of workers and make them responsible for quality and performance enhancement. This can be done through many contemporary management philosophies and principles, such as TQM, Kaizen, Just-in-time (JIT) and lean manufacturing, whichever is more suitable to their particular context (Hanna & Newman, 1995; O'Brien, 1999; Voss & Robinson, 1987). Literature review has shown that manufacturing strategy should also focus on production facility and location **(PFL).** Decisions related to location and facility design can severely impact local environment and community. Thus, any expansion decision should consider the facility's waste-generation and waste-handling capacity, energy usage of future technologies and proximity of 'complementary' organisations such as logistics providers (Dutton, 1998; Scott, 1997).

Production Staff (PS) – The production staff dimension focuses on shift management **(SM)**, work-life balance **(WLB)**, child or forced labour **(CFL)**, occupational health and safety **(OHS)**, workplace discrimination **(WD)**, employee wages **(EW)**, employee working hours **(EWH)** and freedom of association **(FA)**. Pollution control, waste minimisation and pollution prevention can only be ensured if production staff are happy and satisfied. The elements of this particular dimension highlight the significance of social aspects of sustainability. Contemporary supply chain books (or literature) do not comprehensively focus on the production staff. The keyword search of 'work-life balance' in many different forms resulted in zero occurrences of the word in 10 supply chain books. The word 'balance', when investigated discretely, showed up in the perspective of ‘balanced scorecard’, ‘balance sheet’, ‘balance between competing objectives’, ‘balance between supply and demand’, and so forth. However, comparison with the GRI and corporate sustainability reports (during face validity) confirmed that policies for ensuring work life balance of production staff need to be a priority for management and not a superfluous agenda item (Caproni, 1997; Crompton et al., 2006; Gregory & Milner, 2009; GRI, 2011).

Also, latest research has shown that shift work, especially night work, is a major contributor to fatigue which leads to mental and physical impairment. The human vigilance varies with the time of the day, as individuals are programmed to sleep at night and to be awake during the daytime. Shift work is defined as ‘any work pattern that causes a change in normal sleep patterns (NZDoL, 2007).’ Irregular shift patterns impact the mental health, immune system, cardiovascular health and productivity of an individual (Dawson & McCulloch, 2005). Supply chain and manufacturing literature again seems to be quiet about management of shift work and its impacts on productivity and safety. However, analysis of corporate sustainability reports clearly highlighted that some manufacturing companies have attained higher staff productivity and reduced accident rates by implementing employee-friendly shift rosters and management practices (Smith et al., 2000).

In addition, OHS is a very well-researched domain and companies seem to be very concerned about it due to legal requirements. Generally, occupational health and safety is concerned with workplace injuries and illness, and covers all forms of paid or unpaid work in all environments (Safe Work Australia, 2011; Work Safe Victoria, 2008). Literature does provide evidence that good OHS management improves productivity (Massey, Lamm, & Perry, 2006). Literature review shows that there are substantial social and economic costs attached to OHS (NoHSAC, 2006). Also, workplace discrimination and harassment should be rooted out and employees found guilty of misbehaviour should be sufficiently punished to set an example for others. Finally, employee wages and working hours should also be as per the market standards, and freedom of association must be respected by all manufacturing firms (GRI, 2011).

Literature review showed welfare of production staff is not possible without proper onsite facilities related to elements such as washing, drinking water, showers, change rooms, toilets for males and females, dining room, canteen and personal storage. These are the minimum requirements as per the national and state laws in most of the developed countries (Safe Work Australia, 2011). In addition, special facilities for staff working on night shifts should be provided. These might include a workout area, a common room with television, rest room and a sports area with games such as table football, table tennis and chess. Personal hygiene standards must be reinforced at all times, such as disinfection of toilets, proper seating in dining rooms and cleanliness of shower and change rooms. First-aid services should also be available at all times. It is preferred to have a medical/emergency room staffed with a trained nurse and a doctor during the day (CSIRO, 2011; GMC, 2006). Some employees should be nominated as ‘wardens’ and should be trained in various first-aid and cardiopulmonary resuscitation (CPR) techniques. The emergency room should be big enough to accommodate at least few cupboards for storage of dressings, linen and medicaments; two beds; proper disposal system; workbench or dressing trolley; a stretcher; and a wash basin with cold and hot water (Work Safe Victoria, 2008). Palevich (2011) reported that many workers who are involved in heavy manual labour or work with vibrating tools, usually develop carpal tunnel syndrome. Thus, a properly maintained emergency room and wellness program can provide temporary relief.

Cleaning and Sanitation (CS) – Literature review showed that sustainable production facilities; where pollution is not only controlled but prevented, all types of waste is minimised, emissions are monitored and controlled, and all toxic pollutants are neutralised; are not possible if proper cleaning, sanitation, temperature and pest control **(CSTPC)** is not ensured on daily basis (Davim, 2010; Ray, 2008). Thus, cleaning and sanitation are the very foundation of a sustainable production facility and manufacturing processes leading to safe and hygienic food. In the same context, it should be ensured that all detergents, disinfectants or cleaning aids are environment and human friendly **(EHFDD)** (OECD, 2011; USDoC, 2010).

Production Regulatory Compliance (PRC) – Analysis of industry literature showed that all the manufacturing equipment and materials used in production should be food graded as per the Australian standards **(ASFG),** and all the food products should be labelled according to the Australian Regulations **(ARFL)** (AFGC, 2010; FSANZ, 2011). Also, it is very important that manufacturers follow the Australian Packaging Covenant **(APC)**, even if it is only voluntary, to ensure that their products have least impact on the environment and society (APC, 2010, 2011). Finally, the labour and workplace management policies **(WMP)** should be aligned with the international standards set by institutions such as United Nations and International Labour Organization (ILO) (NZBCSD, 2003).

3.3.3.1 SSCM Material Used for SM

Key literature used for SM is presented in **Table 23** while summary of all the SSCM material used to determine the SM dimensions and measures is presented in **Table 24.**

Table 23: Key Literature Used for the SM Dimensions and Measures

Sustainable Manufacturing (SM) Dimensions and Measures	Key Literature
Manufacturing Policy and Processes (MPP)	
Written Manufacturing Policy (WMP), Biodiversity Preservation Policy (BP), Environmental Management System (EMS), Food Safety Mechanisms (FS)	Porter and van der Linde (1995); Liyanage (2011); Rusinko (2007); Hill (1997); Zhu and Sarkis (2004); Labuschagne and Brent (2005); Newman and Hanna (1996); Sarkis (2001); Black (2010); Mathew and Rao (2006); Waters (2007); UN Global Compact (2011); GRI (2011)
Pollution Control and Prevention (PCP)	
Remedial Action Plan (RAP), End-of-Pipe Controls (EPC), Product Adaptation (PTA), Process Adaptation (PRA), Emission Monitoring and Control (EMC), Waste Management (WM), Production Management System (PMS)	Kjaerheim (2005); Narayanaswamy, Scott, Ness, and Lochhead (2003); Tseng, Lin, and Chiu (2009); Liu, Leat, and Smith (2011); Zanoni and Zavanella (2011); Davim (2010)
Resource Conservation (RC)	
Energy Conservation (EC), Water Conservation (WC), Raw Materials Usage (RMU1), Recycled Materials Usage (RMU2), Reuse and Recycle Water (RRW)	Smith and Ball (2012); Mouzon, Yildirim, and Twomey (2007); Field and Sroufe (2007); Gungor and Gupta (1999); Ilgin and Gupta (2010); Schlosser, Klocke, and Lung (2011); Nasr, Hilton, and German (2011); Herrmann, Thiede, and Heinemann (2011)
Manufacturing Strategy (MS)	
Eco-friendly Processes (EFP), Product Design (PD), Manufacturing Practices (MP), Production Facility and Location (PFL)	Seuring (2004); Sarkis (1995); Labuschagne and Brent (2005); Labuschagne, Brent, and Claasen (2005); Matos and Hall (2007); Liyanage (2007); Rădulescu, Rădulescu, & Rădulescu (2009)
Production Staff (PS)	
Shift management (SM), Work-Life Balance (WLB), Child or Forced Labour (CFL), Occupational Health and Safety (OHS), Workplace Discrimination (WD), Employee Wages (EW), Employee Working Hours (EWH), Freedom of Association (FA)	Caproni (1997); Dawson and McCulloch (2005); Gregory and Milner (2009); Crompton et al. (2006); Buller and Morris (2004); Yura (1994); O'Brien (1999); Quinn et al. (1998); Fernandes and Rocha (2011); Lu et al. (2011); Mohammed and Sadique (2011); Reich-Weiser et al. (2008)
Cleaning and Sanitation (CS)	
Cleaning, Sanitation, Temperature and Pest Control (CSTPC), Environment and Human Friendly Detergents and Disinfectants (EHFDD)	Smith and Ball (2012); Mouzon, Yildirim, and Twomey (2007); Field and Sroufe (2007); Liu, Leat, and Smith (2011); Zanoni and Zavanella (2011); Davim (2010)

Table 23: Key Literature Used for the SM Dimensions and Measures (continued)

Sustainable Manufacturing (SM) Dimensions and Measures	Key Literature
Production Regulatory Compliance (PRC)	
Australian Standards for Food Grading (ASFG), Australian Regulations for Food Labelling (ARFL), Australian Packaging Covenant (APC), Workplace Management Policies (WMP)	Zanoni and Zavanella (2011); OECD (2011); Aberdeen Group (2009b); MSA (2008); CSIRO (2011, 2012); GMC (2006); USDoC (2010)

Table 24: Summary of the SSCM Material Used for SM

Category	No. of Sources	Description
Peer Reviewed Journal Articles		
Sustainable Manufacturing (SM) Articles	40	Papers that discussed environmental or social issues in the context of manufacturing processes, workers' safety, production strategy, lean and cleaner production, manufacturing waste and industrial ecology.
General sustainable supply chain management (GSSCM) Articles	78	Papers that did not specifically focus on any supply chain process but generically discussed environmental and social issues in the context of sustainability at firm, industry or country level.
Miscellaneous		
Peer-Reviewed Conference Papers	8	All these papers were published in the Proceedings of the 8th Global Conference on Sustainable Manufacturing and touched on energy and resource consumption; product and process metrics; and lean manufacturing.
Books	1	The book on 'sustainable manufacturing' presented state-of-the-art developments in sustainable manufacturing.
Industry and Public Sector Publications	10	These publications focused on lean manufacturing, methodologies for enabling sustainable production processes and readiness of the Australian market.
Sustainability Frameworks	7	Frameworks used for the development of basic sustainability themes: Natural Capitalism, Cradle to Cradle, Biomimicry, Life Cycle Analysis, The Natural Step, Social Return on Investment and Triple Bottom Line
Corporate Sustainability Reports and Sustainability Guidelines	11	Material used for face validity – Annual sustainability reports of Unilever, Danone, Nestle, Campbell Soups, ConAgra, GrupoNutresa, Kraft Foods, General Mills, Heinz and Hershey and GRI guidelines

3.3.3.2 Sustainable Manufacturing Research Hypotheses

The systematic and detailed literature review and analysis led to seven hypotheses for the sustainable manufacturing (HSM) sub-construct. The conceptual model along with the hypotheses is presented below:

HSM1: Sustainable manufacturing is driven by written policy based on an environmental management system, food safety and preservation of biodiversity.

HSM2: Sustainable manufacturing must focus on pollution control and prevention through pollutants elimination, emissions reduction, waste management, process redesign and production management system.

HSM3: Sustainable manufacturing is positively associated with resource conservation encompassing energy savings and water recycling and reuse.

HSM4: Sustainable manufacturing should implement cleaning and sanitation procedures that ensure food safety and utilise environment and human friendly detergents and disinfectants.

HSM5: Sustainable manufacturing is positively related to the wellbeing and safety of production staff.

HSM6: Sustainable manufacturing must ensure compliance with the Australian standards related to food grading, labelling and packaging.

HSM7: Sustainable manufacturing is positively associated with manufacturing strategy based on eco-friendly processes, product design, manufacturing practices and production facility location.

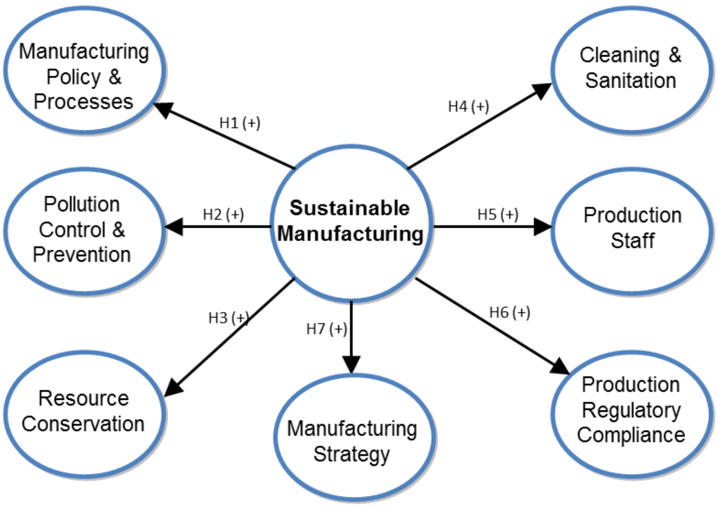

Figure 31: Conceptual Model of Sustainable Manufacturing

3.3.4 Sustainable Transportation (ST)

Transportation has always been a key ingredient of businesses and society. It played a pivotal role in the prosperity of human civilisation by fulfilling the traveling requirements and by enabling the movement of goods from one part of the globe to another. The economic, social and political role of transportation is widely acknowledged. Availability of high-quality products, at an affordable price, has only become possible due to faster and more efficient modes of transportation (Black, 1996, 2010; Waters, 2010). Some of the activities in today's world that cannot be imagined without reliable, safe and technologically-advanced transportation include family and academic reunions, global tourism, participation in international sporting events, overseas education, protection of national sovereignty, exploration of space, and the globalisation of trade, industry and research (Tom & Rao, 2009).

In the last few decades, the impact of transportation on the environment has attracted the attention of both policy makers and researchers due to an alarming increase in global warming. Scientists have reported that freight transport alone is responsible for 8 percent of CO_2 emissions worldwide (Kahn Ribeiro & Kobayashi, 2007). Also, according to the UK Committee on Climate Change [CCC] (2008), shipping will account for 15 – 30 percent of CO_2 emissions by 2050. Consequently, governments in developed countries have established carbon-reduction regulations for the logistics sector. Academic research in this area has been conducted since the 1970s and 'green logistics' is now established as an active field of research (Aronsson & Brodin, 2006).

However, the abatement of carbon-emissions alone has not improved the widespread effect of transportation on society. The atmospheric and marine pollution resulting from freight, air and sea transport has resulted in oil spills, acid rains, smog and high concentrations of chemicals and particulates in the air (e.g. NOx, HCs, CO and SO_2).

This has negatively affected biodiversity, marine-life and crops, and has led to diseases such as emphysema, nausea, asthma, various cancers, premature deaths and irritation to eyes, nose and throat (Cullinane & Edwards, 2010). In addition, the congestion, vibrations, visual intrusion and noise pollution generated from road traffic not only results in annoyance, but also leads to sleep disorders, reduced cerebral functioning, less productivity, and impaired physiological and psychological health (den Boer & Schrothen, 2007). According to the World Health Organization (Evans, 2003), motor vehicle accidents cause nearly a million fatalities and about 70 million wounds and injuries every year. These have given rise to the increased research focus on the societal impacts of transportation.

The research in the area of sustainable transportation can be broadly classified into green supply chain management, reverse logistics and environmental assessment (Abukhader & Jönson, 2004). Literature review has shown that the main drivers of research in the field of transportation are government policy agendas, corporate commitment to green logistics, and local and global environmental impacts of pollution. However, the focus seems to be gradually shifting from green to 'sustainable transportation' that could address not only the issues of climate change and air quality but also vehicle accidents, traffic congestion and rapidly-depleting petroleum reservoirs (McKinnon, Browne, & Whiteing, 2010).

The Brundtland Report (Brundtland, 1987) defined sustainability as 'the development that meets the needs of the present without compromising the ability of future generations to meet their needs.' It would therefore be imperative to apply this concept of sustainability in transportation. Sustainable transport beneficiaries pay the full social cost not only for themselves, but also for future generations (Schipper, 1996). Gordon (1995, p. 2) argued that sustainable transport is based on three visions – 'the first of these visions centres on changing people and the way they live, the second on changing technology, and the third on changing prices". More recently, the Mobility 2001 Report defined sustainable transport as *'the ability to meet the needs of society to move freely, gain access, communicate, trade and establish relationships without sacrificing other essential human or ecological values today or in the future'* (MIT & CRA, 2001). Transport Canada also focused on all three dimensions of sustainability (social, economic and environmental) and stated that *'a more sustainable transportation system is one which provides affordable access to freight and passenger service and does so in an environmentally sound and equitable manner'* (2003, p. 10). Even though the research focus in ST has shifted to practical issues, it is difficult to find concrete operational guidelines for the logistics industry leading to the following research questions (RQ):

RQ1: How can transportation play a role in achieving sustainability objectives?

RQ2: What are the major dimensions and measures of the ST sub-construct?

These research questions are answered by developing a theoretical and conceptual model for sustainable transportation (ST) through a rigorous and systematic methodology discussed in the previous section. Literature review revealed six key dimensions of ST: transportation policy, transportation mode and loads, transportation routing and scheduling, transportation shipping materials, transportation staff, and transportation regulatory compliance. These dimensions of ST, along with their measures, are discussed below and the hypothesised conceptual model is shown in **Figure 32.**

Transportation Policy and Processes (TPP) – Recent research has led to a general consensus that chances of technical breakthroughs for further energy-efficient vehicles are quite bleak. Improvements would mainly come through a transportation policy focusing on better fleet management (Cullinane & Julia, 2010). Literature review revealed six basic elements for fleet management that would ensure social, environmental and economic sustainability. These are vehicle design **(VD)**, inspection and maintenance **(IM)**, vehicle idling **(VI)**, vehicle tare weight **(VTW),** fuel efficiency **(FE)** and transportation management system **(TMS)**. Numerous case studies and good practices manuals have reported that aerodynamic design of vehicles could save about 6 – 20 percent of fuel (Department for Transport [DfT], 2006a). Also, the International Energy Agency [IEA] (2007) found that for heavy goods vehicles (HGVs), the aerodynamic profiling could represent 10 – 20 percent of all fuel savings. Thus, this element must be ingrained in the procurement policy for new vehicles (Smart Steps, 2009) by the transportation department. However, the benefits of new designs are eroded by poor maintenance and servicing of vehicles. Technical issues and problems that go unnoticed for weeks or months prevent vehicles from working at optimum efficiency. Daily checks, weekly maintenance and monthly servicing schedules should be followed in order to avoid any fuel or battery leaks, under-inflated tyres, wheel misalignments, loose screws, and unnecessary friction. According to a British government report, an under-inflation of 20 percent in tyres reduces fuel efficiency by 2 percent and increases rolling resistance by 10 percent (DfT, 2006a). In addition, research studies have estimated that only 2^{o} axle misalignment increases fuel consumption by 8 percent (Buckley, 2006). Regular inspection and maintenance can also help to reduce the noise pollution caused by the transportation fleet as road traffic is the main cause of environmental noise and disturbance, and it also has adverse effects on human health such as loss of sleep, annoyance, difficulty in communication, decrease in work productivity, long-term psychological and physiological issues (den Boer & Schroten, 2007). In addition, devices should also be used to prevent vehicle idling. The anti-idling equipment automatically turns off the engine when the vehicle is not in use (McKinnon, 2010). This will also result in fuel savings, and thus it is a vital element of the TPP dimension. Furthermore, efforts should be made to procure fuel efficient vehicles. According to Duleep (2007), one-third of improvements in fuel-efficiency come from aerodynamic design and tyres, and two-thirds come from technical enhancements in engine performance. Fuel efficiency can also be increased by decreasing the tare weight of vehicles, which is technically called 'light-weighting'. Modifications can be made to the current fleet by using lighter materials such as carbon-fibre and aluminium. A recent study by Greszler (2009) showed that reduction in weight is directly translated into better freight movement efficiency.

Furthermore, researchers have reported that 'the use of computerised procedures for the distribution process planning produces substantial savings (generally from 5 percent to 20 percent) in the global transportation costs' (Toth & Vigo, 2001). The transportation policy should guide all the features and functionalities of the transportation management system **(TMS)**. Literature shows that TMS helps in controlling and executing inbound and outbound operations; supports auditing of freight; manages payments processes; calculates all the key performance indicators (KPIs); performs trend analysis; reports carbon and GHG emissions and noise levels; provides communication options through web and EDI (electronic data interchange); plans optimal loads, schedules and routes; and helps in crafting future transportation strategies (Fredendall & Hill, 2000; Hugos, 2003). Therefore, some of the important advantages of TMS are improved service levels, reduced inventory, optimal vehicle fill, maximum vehicle utilisation, reduced receiving and delivery times and reduced carbon emissions (Palevich, 2011). The academic literature does not focus on the role of TMS in social sustainability. However, content analysis of industry publications and company reports (during face validity) clearly showed that TMS can also be used for tracking KPIs pertinent to transportation staff productivity, work planning, work-life balance, employee absenteeism, and training (CST, 2005; VTPI, 2010).

Transportation Mode and Loads (TML) – Literature review showed that there is a correlation between distance travelled and emissions generated, as shorter journeys result in lesser emissions and vice versa (Garnett, 2003). The TML dimension deals with elements such as transport modality **(TM)**, transport energy source **(TES)**, vehicle capacity utilisation **(VCU),** packaging design **(PD)** and load planning software **(LPS)**. Even though these elements are tightly integrated with each other, they are presented separately in this thesis to accentuate their importance.

Most of the research literature recommends the use of sea or marine transportation as they have the smallest carbon footprint and least greenhouse gas (GHG) emissions. The most GHG-intensive mode is air, followed by road, rail and sea (Garnett, 2010). However, rigorous content analysis of academic literature, company reports and industry publications has shown that the selection of transportation mode is not a straight-forward decision for transport and logistics managers. They have to take into consideration the lead times, optimal utilisation of current vehicle fleet, responsiveness to customer orders, product wastage and also targets for cost savings and emission reductions (Mathew & Rao, 2006; McKinnon, Browne, & Whiteing, 2010). For example, mixed transportation modes, consisting of road and rail, might be greener and faster but it would surely increase product handling (loading and unloading) leading to more wastage and thus increased costs. Marine modes might be greener than others but usually they are only suitable for orders with longer lead-times. Air transport is carbon intensive, but sometimes it is cheaper for delivering small order quantities, and is surely more responsive. Thus, the efficiency of transport modality is no longer just a function of cost, but one must take into account all the variables related to business, environment and social dimensions of sustainability (CTC, 2010; TTI, 2002). In addition, the selection of transport modality should also take into consideration the energy source of the mode. This deliberation is important not only during the procurement process of new transport vehicles but also while making decision for outsourcing operations to third party logistics (3PLs) providers. The main energy source used to fuel goods vehicles is diesel. However, some of the alternative technologies and energy sources are biodiesels, bioethanol, hydrogen fuel cells, liquefied natural gas, hybrid electric vehicles (HEVs) and battery electric vehicles (Cullinane & Julia, 2010).

Sustainability efforts incorporating fleet management and optimal transportation modes are diluted by poor load management. Several studies were done in the past to consolidate vehicle load in order to reduce emissions, road traffic and cost (Rushton, 1979). However, even up until today, and just in the European Union (EU), 25 percent of the total kilometres travelled by goods vehicles are run empty (Greszler, 2009). The load factor, which is the percentage of capacity of a mode (truck, rail, marine container, etc.) that is used, is also very low in most parts of the world. According to the Centre for Sustainable Transportation [CST] (2005), about 50 percent of the goods vehicles on Canadian roads are half full. Therefore, improved load factors would result in better asset utilisation, less traffic congestion, lower noise levels, reduced fuel consumption and lower per unit cost for shipped products (Smart Steps, 2009). This can be achieved through elements such as vehicle capacity utilisation **(VCU),** packaging design **(PD)** and load planning software **(LPS).** To optimally utilise the vehicle space, the transport or logistics manager must consider the demand fluctuations, health and safety regulations, vehicle weight and size restrictions, capacity of facilities, and compatibility of vehicle and products (McKinnon, 2007).

Logistics departments should also coordinate with product development departments so that shape, dimensions and stackability of product packaging can be optimised for maximum vehicle capacity utilisation. Innovative packaging designs have been used by many firms that resulted in 20 – 40 percent improvements in vehicle fill (Institute for Grocery Distribution [IGD], 2008; Sonneveld, 2000). Finally, these decisions are very complex as they involve numerous variables. Thus, use of load planning software which can take into account the legal restrictions for both origin and destination, weight and dimensions of products, safety regulations and capacity of the mode (truck, rail, container, etc.) is highly recommended (Palevich, 2011). As every firm has different requirements based on its customers, distribution network and suppliers, thus customised load planning and capacity management software should be developed with the input from actual users (Voss, 1985).

Transportation Routing and Scheduling (TRS) – Vehicle routing and scheduling has received considerable attention from researchers. A good overview can be found in the recent book by Golden, Reghavan, and Wasil (2008) which would be extremely beneficial for logistics managers. Routing and scheduling is a complex problem in which the main objectives are to reduce the travel distances, ensure in-time deliveries to customers, reduce fleet size, avoid traffic congestions and plan equal routes (in kilometres) for each vehicle (Toth & Vigo, 2001). Literature review revealed elements such as optimal travel distance **(OTD)**, optimal delivery scheduling **(ODS)**, reduction in empty running **(RER)**, vehicle routing and scheduling software **(VRSS)** and inbound/outbound vehicle inspection **(IOVI)** (Eglese & Dan, 2010).

All these practices hold tremendous potential for positively impacting social, environmental and economic sustainability in the supply chain. However, two aspects that clearly stand out through systematic literature analysis are RER and VRSS (Black, 2010; Waters, 2010). The logistics managers should also hunt for opportunities for reducing ‘empty running’ by maximising bi-directional load factors through backhauls, internet-based load matching services, and co-shipping. Researchers have suggested several approaches to determine optimal routing and scheduling solutions (Berbeglia, Cordeau, Gribkovskaia, & Laporte, 2007; Brandao, 2004; Lau, Sim, & Teo, 2003) but the implementation of vehicle routing and scheduling software for both inbound (procurement) and outbound (shipping) orders would be extremely helpful in making rational decisions to meet sustainability objectives (Baumgaertner, Leonardi, & Krusch, 2008).

Transportation Shipping Materials (TSM) – Reusable shipping materials can also help to improve sustainability performance of the transport or logistics department. This could be done through reusable shipping materials **(RSM1)**, recyclable shipping materials **(RSM2)**, recycled shipping materials **(RSM3)**. Most of the corrugated packaging is used only once in the transportation industry. However, containers made from plastic and durable fibreboard can be reused up to 50 and 250 times, respectively (NZBCSD, 2003). Even though they are expensive as compared to corrugated shipping materials, their continuous usage reduces their overall cost per trip and minimises wastage (Smart Steps, 2009). In addition, usage of collapsible, nestable and stackable containers will provide the additional benefit of better space utilisation. Also, these reusable materials result in better asset utilisation, improved handling safety and efficiency, and reduced cost (Lieb & Lieb, 2010; Pollard, 2001; Saphire, 1995). Recyclable cardboard, paper and pallets can also be used in conjunction with reusable materials. Furthermore, as a future objective, logistics and transportation companies should try to procure only those shipping materials that are made from recycled substances (APC, 2010, 2011; EPA, 2011).

Transportation Staff (TS) – The transportation staff dimension focuses on work-life balance **(WLB)**, shift management **(SM)**, occupational health and safety **(OHS)**, child or forced labour **(CFL)**, workplace discrimination **(WD)**, employee working hours **(EWH)**, employee wages **(EW)** and freedom of association **(FA)**. The optimal routing, scheduling, fleet management and transportation modes are only effective if employees are satisfied and happy (Carter & Jennings, 2002; Polk, 2003). The elements of this dimension highlight the importance of the social dimension of sustainability. The work-life balance is simply a balance between an individual's personal life and work. Hudson (2005) defined it as *'a 'fit'* *or satisfactory level of involvement between multiples roles in an individual's life'*. Traditional supply chain and transportation literature does not extensively focus on work-life balance (WLB). However, comparison with prevalent market standards and corporate sustainability reports confirmed that policies for ensuring WLB of transportation staff need to be a priority for management and not a superfluous agenda item (Caproni, 1997; Crompton et al., 2006; Gregory & Milner, 2009; GRI, 2011).

Shift work is a major contributor to fatigue which leads to mental and physical impairment. Human vigilance varies with the time of the day as individuals are programmed to sleep at night and to be awake during the daytime. Shift work is defined as 'any work pattern that causes a change in normal sleep patterns' by New Zealand Department of Labour [NZDoL] (2007). Shift work during the early hours of the day and at night time results in limited sleep and creates a 'sleep debt'. This impacts the immune system, mental health, cardiovascular health, safety and productivity of an individual (Dawson & McCulloch, 2005). Supply chain and transportation literature again seems to be silent about management of shift work and its impact on productivity and safety. However, analysis of the academic literature and corporate sustainability reports clearly highlighted that some logistics companies have achieved higher worker productivity and reduced accident rates by adopting employee/driver friendly shifts management practices (Smith et al., 2000).

In addition, OHS is a well-researched area and firms seem to be very concerned about it due to legal requirements. Generally, occupational health and safety is concerned with workplace illness and injuries and covers all forms of unpaid or paid work in all environments (Safe Work Australia, 2011; Work Safe Victoria, 2008). Literature does provide evidence that good OHS management improves productivity (Massey, Lamm, & Perry, 2006). Literature review showed that according to the research conducted by

National Occupational Health and Safety Advisory Committee [NOHSAC] (2006), there are significant economic and social costs attached to occupational health and safety.

Furthermore, the International Labour Organization (ILO) Declarations do not allow any form of workplace discrimination and child/forced labour. Thus, transportation and logistics operators must comply with the ILO Declarations. Also, employee wages and working hours should also be as per the market standards, and freedom of association must be respected by all transportation companies (GRI, 2011; NZBCSD, 2003).

Literature review showed that nearly all the literature, pertinent to transportation, explicitly emphasises the periodical training of ‘drivers’ **(DT)**. The focal areas should be fuel-efficient driving, daily checks of vehicles, and driver behaviour for safe and rage-free goods transportation on public roads/motorways. Computer simulations can be used for this purpose (Ward, Tyler, Wilson, & Eichinger, 2004). All drivers should also be well trained in safe and efficient use of loading and unloading equipment, manual handling, neutralising of hazardous substances, personal hygiene, stress and fatigue management, emergency escape, freight audits, vehicle maintenance, dealing with spillages and breakages on-site and during transportation, and use of fire-fighting equipment.

Finally, literature review emphasises that welfare of transportation staff is not possible without proper onsite facilities related to washing, drinking water, showers, change rooms, toilets for males and females, dining room, canteen and personal storage. These are the minimum requirements as per the national and state laws in most of the developed countries (Safe Work Australia, 2011). In addition, special facilities for drivers staying overnight and staff working on night shifts should be provided. These might include a workout area or a gym, a rest room, common area with television, sports area catering to indoor games such as table tennis, foosball, chess, and arcade video games (Safe Work South Australia, 2010, 2012). Good personal hygiene standards must be reinforced at all times, such as disinfection of toilets, cleanliness of shower and change rooms, proper seating in dining room, and pest disinfestation. Parking space should also be provided for all the employees. First-aid facilities should be available at all times. It is preferred to have an emergency/medical room staffed with a trained doctor and a nurse during the day. Proper signage and instructions must be provided to all staff members and some wardens should be trained in various first-aid and cardiopulmonary resuscitation (CPR) techniques. The emergency room should be large enough to accommodate at least two beds; few cupboards for storing dressings; linen and medicaments; proper disposal system; a stretcher; workbench or dressing trolley; and wash basin with hot and cold water (Safe Work Victoria, 2008).

Transportation Regulatory Compliance (TRC) – Analysis of industry literature showed that all the equipment and materials used in the transportation should be food graded as per the Australian standards **(ASFG)** (AFGC, 2010; FSANZ, 2011). In addition, appropriate temperature should be maintained for ambient, dry, chilled and frozen food products as per the Australian Regulations **(ARTM)**. Finally, cross-contamination should be avoided **(ACC)** during the transportation of the food products, as this can impact the food safety, nutritional value and hygienic integrity of the products, leading to health issues for the final consumers (ACF, 2003; AFGC, 2011a; ARIES, 2009b; DAFF, 2012; DEFRA, 2006).

3.3.4.1 SSCM Material Used for ST

Key literature used for ST is presented in **Table 25** while summary of all the SSCM material used to determine the ST dimensions and measures is presented in **Table 26.**

Table 25: Key Literature Used for the ST Dimensions and Measures

Sustainable Transportation (ST) Dimensions and Measures	Key Literature
Transportation Policy and Processes (TPP)	
Vehicle Design (VD), Inspection and Maintenance (IM), Vehicle Idling (VI), Vehicle Tare Weight (VTW), Fuel Efficiency (FE), Transportation Management System (TMS)	McKinnon (2007); Department for Transport [DfT] (2006); International Energy Agency [IEA] (2007); Smart Steps (2009); Buckley (2006); den Boer and Schroten (2007); Duleep (2007); Greszler (2009); Toth and Vigo (2001); Palevich (2011)
Transportation Mode and Loads (TML)	
Transport Modality (TM), Transport Energy Source (TES), Vehicle Capacity Utilisation (VCU), Packaging Design (PD), load planning software (LPS)	Garnett (2003); Garnett (2010); Cullinane and Julia (2010); Greszler (2009); The Centre for Sustainable Transportation [CST](2005); Smart Steps (2009); McKinnon (2007); IGD (2008); Sonneveld (2000); Palevich (2011).
Transportation Routing and Scheduling (TRS)	
Optimal Travel Distance (OTD), Optimal Delivery Scheduling (ODS), Reduce Empty Running (RER), Vehicle Routing and Scheduling Software (VRSS), Inbound/Outbound Vehicle Inspection (IOVI)	Golden, Reghavan, and Wasil (2008); Toth and Vigo (2001); Eglese and Dan (2010); Lau, Sim, and Teo (2003); Brandão (2004); Berbeglia, Cordeau, Gribkovskaia, and Laporte (2007); Baumgaertner, Léonardi, and Krusch (2008)
Transportation Shipping Materials (TSM)	
Reusable Shipping Materials (RSM1), Recyclable Shipping Materials (RSM2), Recycled Shipping Materials (RSM3)	Smart Steps (2009); Saphire (1995); Litman (2006); Richardson (2005); Pollard (2001); Lieb and Lieb (2010); EPA (2011); VTPI (2013); Straube and Doch (2011)
Transportation Staff (TS)	
Shift management (SM), Work-Life Balance (WLB), Child or Forced Labour (CFL), Occupational Health and Safety (OHS), Workplace Discrimination (WD), Employee Wages (EW), Employee Working Hours (EWH), Freedom of Association (FA), Driver Training (DT)	Carter and Jennings (2002); Polk (2003); Hudson (2005); New Zealand Department of Labour [NZDoL] (2007); Dawson and McCulloch (2005); Smith, Di Milia, Smith, Gee, and Mackay (2000); Massey, Lamm, and Perry (2006); National Occupational Health and Safety Advisory Committee [NOHSAC] (2006); Work Safe Victoria (2008); Safe Work Australia (2011).
Transportation Regulatory Compliance (TRC)	
Australian Standards for Food Grading (ASFG), Australian Regulations for Temperature Maintenance (ARTM), Avoidance of Cross-Contamination (ACC)	NZBCSD (2003); Smart Steps (2009); VTPI (2010); OECD (1996); AFGC (2010, 2011); DAFF (2008, 2011); CSIRO (2004, 2011); FSANZ (2011); APC (2011).

Table 26: Summary of the SSCM Material Used for ST

Category	No. of Sources	Description
Peer Reviewed Journal Articles		
Sustainable Transportation (ST) Articles	24	Papers related to network structures, capacity management, pricing, transportation modes, fuel efficiencies, inter-continental and urban transportation.
General sustainable supply chain management (GSSCM) Articles	78	Papers that did not specifically focus on any supply chain process but generically discussed environmental and social issues in the context of sustainability at firm, industry or country level.
Miscellaneous		
Peer Reviewed Conference Papers	1	This paper focused on the conceptual design to evaluate ecological and economical cause-effect relations in logistics planning processes.
Books	3	Books covered multitude of transportation issues, emerging trends, customers' needs, mobility requirements for urban areas with respect to environmental and social sustainability.
Industry and Public Sector Publications	8	Publications discussed performance measures, strategies, environmental quality and economic prosperity in the context of sustainable transportation.
Sustainability Frameworks	7	Frameworks used for the development of basic sustainability themes: Natural Capitalism, Cradle to Cradle, Biomimicry, Life Cycle Analysis, The Natural Step, Social Return on Investment and Triple Bottom Line
Corporate Sustainability Reports and Sustainability Guidelines	11	Material used for face validity – Annual sustainability reports of Unilever, Danone, Nestle, Campbell Soups, ConAgra, GrupoNutresa, Kraft Foods, General Mills, Heinz and Hershey and GRI guidelines

3.3.4.2 Sustainable Transportation Research Hypotheses

The systematic and detailed literature review and analysis led to six hypotheses for the sustainable Transportation (HST) sub-construct. The conceptual model along with the hypotheses is presented below:

HST1: Sustainable transportation depends on a written policy that could impart sustainability in all transportation functions and ensure efficient utilisation of vehicles and their regular inspection and maintenance.

HST2: Sustainable transportation is driven by transportation mode and loads focusing on fuel-efficiency, emissions reduction, optimised packaging configurations and maximum vehicle capacity utilisation.

HST3: Sustainable transportation is driven by transportation routing and scheduling targeted towards optimal vehicle routing and freight delivery schedules.

HST4: Sustainable transportation is positively related to the wellbeing and safety of transportation staff.

HST5: Sustainable transportation is positively associated with the transference of food products in reusable, recyclable or recycled shipping materials.

HST6: Sustainable transportation must ensure compliance with the Australian standards related to the transportation of food products encompassing food graded handling equipment, temperature maintenance and avoidance of cross-contamination.

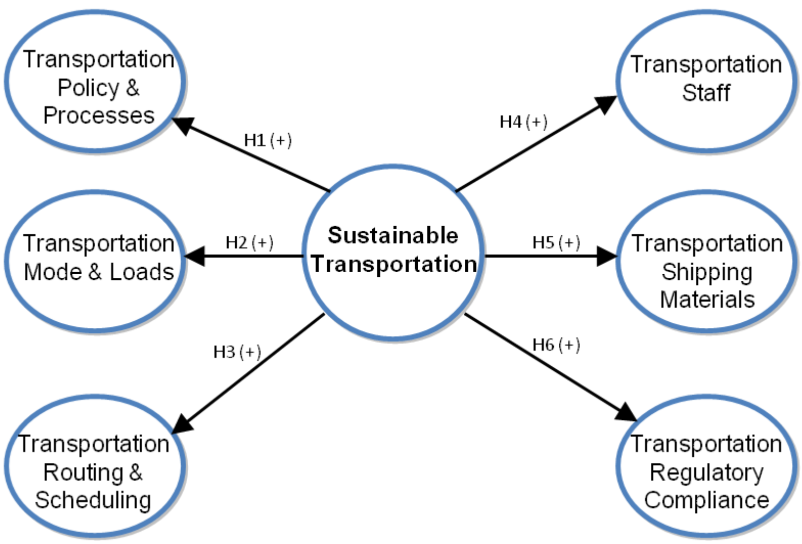

Figure 32: Conceptual Model of Sustainable Transportation

3.3.5 Sustainable Warehousing (SW) Dimensions and Measures

This section will focus on 'warehousing' which has received comparatively less attention from researchers but holds tremendous potential to achieve the goals of sustainable development. The Logistics Training Council Australia [LTC] (2011) in a recent survey reported that '...companies are still coming to terms with the question of sustainability. Warehousing facilities have the largest potential in terms of reducing environmental impacts…' Thus the following research questions (RQ) were considered while reviewing the academic literature and industry publications for SW.

RQ1: How can warehousing play a role in achieving sustainability objectives?

RQ2: What are the major dimensions and measures of the SW sub-construct?

These research questions are answered by developing a theoretical and conceptual model for sustainable warehousing (SW) through a rigorous and systematic methodology discussed in the previous section. Literature review revealed eight key dimensions of SW: warehouse design, warehouse layout, inventory management, warehouse staff, mechanical handling equipment, warehouse processes, onsite facilities and warehouse management system. These dimensions of SW, along with their measures, are discussed below and the hypothesised conceptual model is shown in **Figure 33.** *Since sustainable warehousing is the most neglected area in the academic literature, thus this section will discuss not only the dimensions, but every measure of SW in detail.*

3.3.5.1 Warehousing – Huge Potential for Sustainability

When it comes to understanding and alleviating sustainability issues (such as carbon footprints or energy intensity) in logistics, most attention is usually given to transportation. Warehousing (or storage) has received comparatively less consideration from researchers and practitioners. Also, it has been a victim of 'greenwash' and decorated with titles of green-warehousing or eco-warehousing, and the practices that are required to achieve such aspirations are hard to find. This thesis will make an effort to fill this gap. It will delineate various best practices (actions or guidelines) for each warehouse dimension that could be adopted by logistics firms and managers in order to improve their warehouse sustainability performance.

Warehousing is one of the most critical functions in a supply chain as it accounts for 24 percent of logistical costs (ELA, 2004). Chopra and Meindl (2007) defined warehousing as *'the storage of materials (packaging, finished goods and raw materials) at different stages of the supply chain.'* A warehouse, also referred to as distribution centre, storage facility and logistics service centre, is used for a variety of functions ranging from product distribution, cross-docking to composite storage. Thus, it has a wider intensive role based on the provision of many value-adding operations, customisation services and rapid fulfilment of customer orders (Baker & Canessa, 2009).

Warehouses are usually merged with buildings, offices and factories for the purpose of reporting and statistical analysis. The World Resources Institute [WRI] (2006) estimated that on a global scale, commercial buildings emit 5.25 percent of all greenhouse gases (GHG) and 65 percent of this come from energy consumption (such as electricity). Gazeley (2008) suggested through life cycle analysis (LCA) that 65 – 90 percent of energy consumption in a warehouse is due to heating, ventilation and air conditioning (HVAC).

Recently, the area occupied by warehouses has increased tremendously, and more significantly, the duration of operations, size and level of throughput are also rising steeply. This has resulted from changes in corporate strategies to centralise inventories and to serve more geographic area for business expansion (McKinnon, 1998). Consequently, the average floor area of warehouses has increased from 19,000m^2 in 1996 to 34,000m^2 by 2008 (Sturge, 2008). Also, to reduce response time to customer orders, the distribution centres and cross-docking facilities are now usually located near to delivery points, around residential areas and city centres, as compared to supply sites (Hesse, 2004). The increase in capital investment has pushed management for faster payback, which is usually achieved by working more shifts and days per week (Baker & Perotti, 2008). As a result, the unit fixed cost is reduced but consumption of energy has increased. It is quite evident that that the strategy to decrease total number of warehouses and concentrate on just a few, by expanding their capacity, size and operational timings, would lead to more vehicles visiting the sites for inbound supplies and outbound deliveries. As many of these sites are near urban centres, more congestion and noise pollution become unavoidable. Also, as more employees are required to perform the job, parking areas and onsite facilities need to be properly planned (Bartholdi & Hackman, 2008).

In addition, postponement used in agile and adaptive supply chain strategies transfers many value adding activities including labelling, final assembly, and packing of promotional items, from manufacturing to warehouses. This results in greater product differentiation and reduced order lead times, thereby further embellishing the role of the warehouse in a supply chain (Manzini, 2011).

The above discussion shows the diversity of areas affected by warehouse operations. On the one hand, there are firm-level inputs related to energy, land, water, fuel and building, and on the other hand, the outputs of operations not only impact the firm but also the local environment and society in the form of atmospheric emissions, waste, congestion, noise pollution, accidents, water contamination, and burden on public transport. This discussion clearly highlights that warehousing holds tremendous potential for achieving goals of sustainable development. Various dimension and measures of SW, based on rigorous review and analysis of academic literature, industry publication and company reports, are discussed below:

Warehouse Facility Design (WD) – Warehouse facility design is an extensive domain of research in itself. Discussion in this thesis is limited to critical sustainability practices related to the design and structure of 'warehouse building and site'. These can be considered during development of a new facility or while renovating an existing structure. Consultants can also be hired in order to obtain expert opinion. Saunders (2008) reported a number of organisations that provide consultancy and assessment services such as BREEAM (Building Research Establishment Environmental Assessment Method) in the UK, GREENSTAR in Australia, and LEED (Leadership in Energy and Environment Design) in the US. Sustainability elements for facility design are discussed below:

- ***Renewable energy sources (RES):*** This element dictates that efficient energy consumption must be ingrained in the entire warehouse facility. Energy costs are usually 5 – 10 percent (ambient warehouses) and 15 –20 percent (temperature-controlled warehouses) of operational expenses. It is one of the major inputs, other than materials and water, and has a direct impact on both environment and operating costs. Currently, major energy inputs are oil, gas, coal and electricity and they all produce greenhouse gas (GHG) emissions such as CO_2, CH_4, and N_2O (GBCA, 2012; Sabnis, 2012). Every effort should be made to use renewable energy sources such as solar thermal, solar photovoltaic, wind, biofuels, biomass (wood chips or other waste), geothermal resources and energy recovered from process waste (such as heat from air compressors). Also, biodiesel and natural gas, which are low carbon alternatives, can also be used (Fredendall & Hill, 2000; Hugos, 2003). The choice and mix of renewable energy sources should be made prudently, taking into consideration market factors, operational cost and regulatory compliance (Marchant, 2010).
- ***Daylight usage (DU):*** The warehouse facility must allow maximum use of daylight. It depends on numerous elements such as building height and orientation, aisle width, and daylight hours. Entry points for daylight are usually windows, entrances and spaces in

roofs. Their number and placement need to be determined carefully, keeping in view the weather conditions and landscape of the locality (Armstrong, 2007). In addition, walls and ceilings with light colour also help to distribute sunlight. The combination of natural and artificial sunlight is also critical. The artificial light should be dimmed appropriately according to the intensity of sunlight which may be different for different sections of the warehouse (Carbon Trust, 2007). Thus, proper mechanisms and daylight management techniques need to be adopted. An optimal use of daylight would not only reduce utility bills but would also decrease GHG emissions.

- ***Artificial lighting scheme (ALS):*** It is one of the most important determinants of sustainability although not much discussed for its impacts, but comes out very strongly from the analysis of industry publications. Recent research has shown that it not only helps to reduce emissions and bills but also has a strong impact on the productivity of the staff. Poor lighting schemes result in impaired visibility that leads to low productivity, as about 80 percent of the sensory input comes through eyes. Good quality of light has also been proved to positively impact the mood and alertness of staff and this can considerably reduce accidents in a warehouse. It helps to maintain an ideal level of hormones (cortisol, melatonin and serotonin) which trigger alertness, reduce sleep and increase happiness (Carbon Trust, 2007). The impact of lighting schemes on the work environment can be imagined from recent figures by Powerboss Eluma (Marchant, 2010) that a 400-watt sodium bulb operated continuously for a year produces 1.69 tonnes of CO_2. Therefore, choice of luminaries, lamp type and control gear for office space, main halls and car-parks should be made wisely. In addition, proper control mechanisms can also help to reduce utility bills. Manual switches can be combined with automatic controls such as motion and light sensors. In short, thorough analysis should be done to determine lighting requirements of different areas in a warehouse facility (internally and externally) by considering peak and off-peak hours, amount of daylight available, nature of job done and even the age of the staff working in a particular area.

- ***Temperature control (TC):*** Warehouse temperature needs to be controlled mainly to keep the products in a satisfactory condition. It is a priority in every warehouse guideline and appears frequently in the text. Statistical figures related to its impact on environment are quite hard to find, but surely reduction in temperature would help to conserve both energy and environment. According to Carbon Trust (2002), every 1 ^{0}C decrease in internal warehouse temperature results in 10 percent energy consumption savings which would automatically lead to a decrease in emissions. Marchant (2010) pointed out that the internal warehouse temperature depends on the type of the product stocked, humidity, weather conditions, orientation of the warehouse facility, type of insulation used in walls, volume and thermal mass of the facility and heat produced by operating mechanical handling equipment such as forklift trucks (Aberdeen Group, 2006, 2009a). Thus, if any of these factors could be controlled then significant economic and environmental savings can be attained.
- ***Water consumption (WC):*** The global figures of water consumption by warehousing facilities are not available. However, digging into text and data available through Elsevier and Emerald revealed few studies done by Greater Vancouver Regional District (GVRD) on water consumption in that area by wholesaling and warehousing facilities. According to the report, the sector used almost 10 percent of the commercial water in that region (Smart Steps, n.d.b). The breakdown of this usage is washroom (26 percent), landscaping (38 percent), kitchen (3 percent), cooling (23 percent) and others (10 percent). Water can be conserved through state-of-the-art roof design which can help to collect rainwater for later use in the warehouse and other areas of the facility (McKinnon, Browne, & Whiteing, 2010; Sabnis, 2012). Brown and green roofs, roof drainage techniques, water irrigation technology and modern sanitation fixtures can also

be used to conserve water. Water use for cooling compressors, chillers and steam boilers can be avoided by considering air-cooled equipment and chemical treatments at the design time (Smart Steps, n.d.b). Gazeley (2004) reported that some of the key ecological benefits of water conservation include lesser burden on municipal water supplies, reduction in distribution piping and decrease in release of chlorine into the environment. In addition, Gazeley's (2004) eco-template mentions that collection of rainwater fulfils about 89 percent of the water requirements in toilets, saves water required for nearly 89,000 flushes and, if purified, about 25,000,000 cups of tea per year.

- ***Noise pollution (NP):*** It is usually related to transportation and fleet management by most of the conventional supply chain and sustainability literature. However, content analysis of industry publications related to warehousing revealed that there are many steps that could be taken while designing and planning a warehouse facility to minimise the impacts of noise pollution on nearby communities. Some of the important points are: selection of the site and situation of the building (Smart Steps, n.d.b), use of green roofs that absorb noise transmission, and use of photovoltaics (PVs) that silently convert sunlight into electricity (Gazeley, 2004).
- ***Biodiversity (BD):*** It is also known as 'biological diversity' and refers to various life forms that exist in a particular locality consisting of natural vegetation, forests, animals, micro-organisms, waterways and eco-systems. Biodiversity is necessary for sustaining life on the planet Earth. Biodiversity is important for individuals, communities and businesses. Research shows that the property value of buildings near green spaces and parks is on average 8 percent more than those far away (CABE, 2005). Also, businesses with greener setting have more motivated employees which leads to increased productivity and reduced sick leave (NEN, 2008). However, the warehousing and supply chain literature seems to be alien to the concept of biodiversity, but content

analysis exposed a lot of emphasis from the latest sustainability standards (GRI, 2011) and annual sustainability reports by firms. Thus, biodiversity preservation is added as a practice in the sustainable warehouse facility dimension and it must be considered at the time of designing and renovating the facility.

Warehouse Layout (WL) – The layout dimension has a strong impact on warehousing costs. Layout decisions are mainly divided into two broad categories – first is related to the placement of departments (receiving, storage, picking, shipping, and quarantine), and the second concerns the design of layout, paths, and storage. (De Koster, Le-Duc, & Roodbergen, 2007). Thus, the layout configuration, type of storage system, design of aisles, and division of space into departments, partitions and zones determine the efficiency and flexibility of warehouse operations. The main objective is to reduce travelling distances and increase space utilisation. An optimal layout improves product flow, reduces cost, enhances responsiveness to customer orders, ensures safety of staff and ameliorates working conditions. Layout elements are discussed below:

- ***Layout configuration (LC):*** Warehouse layout configuration is a tactical decision made at design time (Rouwenhorst et al., 2000). Most of the warehouses have conventional layout which is rectangular with parallel straight aisles, both for storage and order-picking areas. Sometimes, modifications are done with additional cross-aisles creating multiple-block layouts. The layout of unit-load conventional warehouses, unit-load automatic storage and retrieval systems (AS/RS), selective pallet-rack system, shelving system, carousels, flow-rack system, mobile racks, and drive in/through racks are extensively discussed in literature (Bartholdi & Hackman, 2008). It must be noted that the layout decision is not made in isolation but it is inter-related with several other decisions such as equipment selection, operational strategy, and aisles width. The goal is to arrive at a design that results in minimal travelling distance for warehouse operations. Researchers have concluded that the order-picking process alone accounts for 55 percent of warehouse operating costs (Tomkins et al., 1996). Content analysis of the literature for the keyword ‘travelling distance’ highlighted some innovative layouts such as flying-V, fish-bone and chevron-aisles which are expected to decrease the travelling distance, to retrieve a single pallet, by 10 – 20 percent as compared with the traditional layouts (Meller & Gue, 2009).

- ***Storage system (SS):*** The storage system is a critical part of internal warehouse layout and is used to hold (or store) goods or materials of different types, forms and sizes. It has structural attributes that are concerned with the physical design of the system, and performance attributes that are related to the storage capacity, ease of access, space utilisation and storage policies (Bartholdi & Hackman, 2008; Manzini, 2011). Storage can be broadly classified as unit-load or small-load storage, and the selection of a storage system is a strategic decision made at design time (Rouwenhorst et al., 2000) where one has to decide from long list of choices such as block stacking, selective racks (single-deep), drive in/through racks, double-deep racks, mobile racks, flow through racks, and push back racks. Also, automated storage that mainly consists of carousels, A-frames and AS/RS should only be considered when labour cost is very high or there are special considerations pertinent to staff protection and uniformity of handling (Bartholdi & Hackman, 2011). Factors that should be considered for the most appropriate storage system are order profile, required throughput, number of stock keeping units (SKUs), cost of capital, product packaging stack-ability, and cost of labour. A thorough discussion can be found in work done by Cormier and Gunn (1992) and Gu, Goetschalckx, and McGinnis (2007; 2010). Different storage strategies can be employed to achieve optimum structural and performance results such as class-based (ABC classification), random, and dedicated storage. Also, the items that could cause contamination, odour mixing, explosion and bio-hazards should not be stored in adjacent locations, while those that are frequently ordered together or belong to the same bill of materials (BOM) should be placed in adjacent locations to reduce search and pick time (Hassan, 2002). The storage location assignment problem (SLAP) is discussed in detail by Gu et al. (2010). Therefore, the type of storage equipment, its structural and performance attributes, storage strategies, and location assignment clearly impact all the three dimensions of sustainability.

- ***Aisle design (AD):*** Design of aisles is an important part of material handling strategy. It directly impacts the economic and social dimension of sustainability. Poor design will result in wasted travelling and congestion that might lead to accidents. Decisions are related to the orientation of aisles, their length, width, location and number (Hassan, 2002) and must achieve the optimal blend of flexibility, space utilisation, equipment cost, safety and productivity. Aisles are usually categorised as wide aisles (WA) that use counterbalanced trucks; narrow aisles (NA) that use stand-up or double-deep reach trucks; and very narrow aisles (VNA) in which turret trucks are used (Bartholdi & Hackman, 2008).
- ***Departmentalisation (DPT):*** The placement of different functional areas (receiving, storage, picking, shipping and quarantine) in a warehouse layout is called departmentalisation. In addition to traditional functions, many warehouses provide value added services, rework damaged stock and keep customer returns. Also, sometimes blocked-stock is kept, awaiting approval from the quality department. All these functions need separate areas or departments that must be sized according to expected stock quantities. The storage department can be further divided into forward (or picking) and reserve areas to reduce material handling and movement. The reserve area may be further partitioned into sub-areas based on unit load size and customer demand, and the forward area may be partitioned into sub-areas corresponding to slow, medium and fast-moving products (Hassan, 2002). Zones can be identified in a picking

area with an order-picker assigned to each zone (De Koster, Le-Duc, & Roodbergen, 2007). Once departments, partitions and zones are decided, their arrangement is done in such a manner that could ensure the most efficient workflow pattern (circular, U shape, serpentine or straight-line). It must be noted that regardless of the most appropriate layout, efficient storage system and optimal aisle width; flawed departmentalisation could have a disastrous impact on the economic sustainability of warehouse (Bartholdi & Hackman, 2008).

Inventory Management (IM) – Inventory management helps to keep an optimum level of inventory (or stock) that could meet the fluctuating customer demand. This results in improved revenues, reduced degradation and obsolescence, improved warehouse utilisation, and lower utility, labour and capital costs. Thus, it is both directly and indirectly tied to potentially large financial gains.

- ***Inventory optimisation (IO):*** Inventory optimisation is crucial to the achievement of sustainability objectives. Excess inventory results in obsolescence and wastage, while lower inventory levels might lead to lost sales and stock-outs. Inventory optimisation is an arduous task as it is linked to replenishment lead times, forecasting, visibility, future inventory prices, available warehouse space, customer returns, obsolete inventory, carrying costs, and quality of supply (SCC, 2012). All these competing factors need to be balanced to achieve optimal inventory. However, a start can be made by implementing a warehouse management system, improving communication in the supply chain, eliminating obsolete inventory, improving supplier lead times and quality, forecasting accurately, standardising parts/components/ingredients, implementing vendor managed inventory (VMI) or just-in-time (JIT) inventory programs (SETLabs, 2007). A firm can adopt any inventory management approach which suits its overall strategy such as inventory speculation, inventory postponement, inventory consignment and reverse inventory consignment (Wallin, Rungtusanatham, & Rabinovich, 2006).

- ***Inventory accuracy (IA):*** Inventory is an asset of the firm and thus inventory records must be accurate. It is money in the form of goods or materials, and needs to be counted at regular intervals for tracking and valuation, managing stock levels, and controlling theft, shrinkage and loss. Inventory counts are also required for providing stock details to insurance companies in case of a natural disaster, and ensuring supply of seasonal products and placement of most valuable or frequently accessed items in the warehouse (SETLabs, 2007; SCC, 2012). Inventory counting is one of the most fundamental operations and its importance increases tremendously if viewed with the sustainability glasses. Natural disasters such as floods, earthquakes and tsunami have become a regular event in a calendar year. Thus, companies need to know their stock value to safeguard their assets against such catastrophes. Also, inaccurate inventory records will lead to high safety stocks and increase the inventory carrying costs. They will also result in lower productivity of pickers, increase in searching time and travelling distances, and thus will compromise the effort of optimising the warehouse layout. Incorrect records might also result in unavailability of promised stock to customers, resulting in lost sales and customer dissatisfaction (REM Associates, 1999). Technology should be employed, such as radio frequency (RF) readers and barcode scanning to improve speed and results of these operations (Palevich, 2012).

Warehouse Staff (WS) –The warehouse staff dimension focuses on work-life balance, shift management, staff training and occupational health and safety. The optimal storage equipment, operational strategy, and picking mechanism are only effective if employees are satisfied and happy. The following elements and practices highlight the importance of this dimension of SW.

- ***Work-life balance (WLB):*** Work-life balance is simply a balance between an individual's personal life and work. Traditional supply chain books do not extensively focus on one of the most important actors in the supply chain – people. The keyword search of 'work life balance' in many different forms resulted in zero occurrences of the word in about 10 academic supply books. The word 'balance', when searched separately, showed up in the context of 'balance sheet', 'balanced scorecard', 'balance between supply and demand', 'balance between competing objectives' and so forth. Academically, work-life balance is defined as *'the relationship between the institutional and cultural times and spaces of work and non-work in societies where income is predominantly generated and distributed through labour markets'* (Felstead, Jewson, Phizacklea, & Walters, 2002, p. 56). Literature review and keyword searches on mainstream research databases and Google Scholar showed that there is almost no research related to the impact of 'warehouse staff happiness' on throughput, inventory accuracy, worker productivity, and error minimisation. However, the sustainability themes identified earlier in this research study (phase I) and it should be a priority for the management, and not a superfluous agenda item (Caproni, 1997; Crompton et al., 2006; Gregory & Milner, 2009; GRI, 2011).
- ***Management of shifts (MS):*** Latest research has shown that shift work, especially night work, is a major contributor to fatigue which leads to mental and physical impairment. The human vigilance varies with the time of the day as individuals are programmed to sleep at night and to be awake during the daytime. Shift work is defined as *'any work pattern that causes a change in normal sleep patterns'* (NZDoL, 2007). Shift work during early hours of the day and at night time results in limited sleep and creates a 'sleep debt'. This impacts the immune system, mental health, cardiovascular health, safety and productivity of an individual (Dawson & McCulloch, 2005). Supply chain literature again seems to be silent about management of shift work and its impacts on

productivity and safety. However, analysis of corporate sustainability reports clearly highlighted that some companies have achieved higher worker productivity and reduced accident rates by adopting employee-friendly shifts management practices. These include assessment of risks posed by work done when fatigue level is high, implementation of systems to identify fatigue impairment, planning tasks to avoid fatigue accumulation, providing ample opportunities for fatigue recovery, planning shifts so that interruption to natural rhythms of alertness is minimised, and designing a roster that allows employees to periodically reset their body clocks to natural rhythms. Since warehouses usually operate for 2–3 shifts/day, proper management of shifts, especially roster rotation, is crucial for achieving productivity and safety objectives (Smith, Milia, Smith, Gee, & Mackay, 2000).

- ***Staff training (ST):*** Training is important for all warehouse staff in order to ensure their safety and efficient warehousing operations. Nearly all warehouse and supply chain literature emphasises various kinds of staff training. Thus, this element has been separately mentioned under the 'warehouse staff' dimension. Content analysis revealed that staff training should cover areas such as safe and efficient use of MHEs, manual handling, neutralising of hazardous substances, personal hygiene, stress and fatigue management, emergency escape, warehouse operations, storage equipment audits, MHE maintenance, stock counts, dealing with spillages and breakages, and use of fire-fighting equipment (NZBCSD, 2003; Smart Steps, n.d.b).
- ***Occupational health and safety (OHS):*** It is a well-researched area and firms seem to be very concerned about it due to legal requirements of national and state governments. Generally, occupational health and safety (OHS) is concerned with workplace illness and injuries and covers all forms of unpaid or paid work in all environments (Safe Work Australia, 2011; Work Safe Victoria, 2008). Literature does provide evidence that good OHS management improves productivity (Massey, Lamm, & Perry, 2006). Literature

review shows that there are significant economic and social costs attached to OHS. In 2006, the cost of workplace illness and injuries in New Zealand was about 4 percent of GDP (NZ$4.2 billion) (NOHSAC, 2006). The main safety hazards in a warehouse are related to vehicular movement, storage and racking, loading and unloading, hazardous substances, noise, fire risks, manual handling, electricity, and uneven slippery floors. Accidents or injuries can be avoided by having good housekeeping standards, regular staff training, avoiding any need for climbing, providing personal protection equipment (PPE) to all workers, servicing MHEs on a regular basis, restricting access to only authorised people, implementing specific rules for warehouse traffic (such as forklift trucks), dedicating a separate department to hazardous substances, issuing proper instruction to visiting personnel, clearly marking the emergency escape route, and regularly inspecting electricity and refrigeration systems (Kuorinka, 1994; Larsson & Rechnitzer, 1994).

Mechanical Handling Equipment (MHE) – Warehouses use different types of mechanical (or materials) handling equipment (MHE) for rapid movement of goods in order to achieve required efficiency levels and throughput. MHE is typically used for unloading, loading, moving and lifting of products. A manual warehouse will use counterbalanced trucks to unload, and hand-pallet truck to move products to block stacks. Reach trucks are used in warehouses having selective racks (single or double-deep) while order-picker trucks are used for efficient picking. It must be noted that the MHE dimension will not cover electro mechanical equipment such as conveyors, A-frames, and robotics (Baker, 2006) and its focus will be limited to forklift trucks.

- ***MHE power sources (MPS):*** The choice of power unit in forklift trucks is quite straight-forward. It lies between those that use an internal combustion engine and those that use lead-acid electric or nickel-metal hydride batteries. For combustion engines, the fuel could be diesel, liquefied petroleum gas (LPG) or compressed natural gas (CNG). Since counterbalanced trucks are used externally for receiving and shipping operations, the choice is between diesel, LPG or CNG; while reach trucks and order pickers are used for internal operations and therefore one has to choose between LPG, CNG or electric battery-operated trucks. The choice of fuel might seem simple, but an interesting comparison between energy consumed and emissions produced by Johnson (2008, p. 1572) showed that 'fuel carbon footprints of electric and LPG forklifts are, in principle about equal, while in actual practice, LPG's footprint is smaller than that of electricity'. Actually, the problem lies with the definition of 'system boundaries' meaning that whether the comparison of emission for two energy sources (LPG and batteries) should be done based on defined operational boundary, or one should also consider the emissions produced during production, generation, operation and disposal of these energy sources. There is no industry standard in this regard, and thus, as per Johnson (2008), overall LPG is more environment friendly as compared to electric batteries. The new generation of forklift trucks has also made a debut in the market with alternative power sources such as bio-diesel and hydrogen fuel cells (MacLeod, 2008). In addition, trucks with hybrid fuel combinations are also launched that operate on lithium-ion battery and diesel. Their fuel consumption is evaluated through JIS D6202 test that showed a 39 percent reduction in fuel intake, and 14.6 tonnes decrease in CO_2 emissions per year as compared to regular models (Mitsubishi Heavy Industries [MHI], 2010, p. 49). The decision regarding the choice of MHE, which is traditionally based on its usage rather than energy source, needs to also take into consideration its impact on the environment in order this achieve sustainability objectives.

- ***MHE maintenance and servicing (MMS):*** The benefits of new designs and hybrid energy sources are eroded by poor maintenance and servicing of forklift trucks. Technical issues and problems that go unnoticed for weeks or months prevent forklift trucks from working at optimum efficiency. Daily checks, weekly maintenance and monthly servicing schedule should be followed to avoid any fuel or battery leaks, under-inflated tyres, wheel misalignments, loose screws, and unnecessary friction. According to a British government report, an under-inflation of 20 percent in tyres reduces fuel efficiency by 2 percent, and increase rolling resistance by 10 percent (Department of Transport [DfT], 2006b). In addition, research studies have estimated that only 2^o axle misalignment increases fuel consumption by 8 percent (Buckley, 2006). In addition, a typical defect in forklift trucks is poor combustion that results in increased emissions and wasted energy. Literature review could not find any specific statistics for warehouse MHEs in this regard; however, this brief discussion clearly shows that regular MHE maintenance and servicing positively impacts the economic and environmental dimensions of sustainability.

- ***Driver/Operator training (DT):*** Even though training is considered in the 'warehouse staff' dimension, literature review showed that nearly all the literature pertinent to MHEs explicitly emphasises the periodical training of MHE drivers. Training should cover fuel-efficient driving and daily checks of forklift trucks to identify visible signs of defects, but most importantly, training needs to focus on driver behaviour related to safe movement of goods in a warehouse. Computer simulations can also be used to train staff for fuel-efficient and safe driving (Ward, Tyler, Wilson, & Eichinger, 2004). Thus, driver training impacts all dimensions of sustainability.

Warehouse Processes (WP) – Warehouse processes correspond to an extensive range of physical activities carried out in the warehouse on a daily basis. These include unloading, receiving, put-away, storage, pallet relocation, pallet handling, rework, picking area replenishment, case picking, retrieval, loading, handling returns, and inventory counting (Manzini, 2011; McKinnon, Browne, & Whiteing, 2010). All these operations need to be carefully coordinated in order to achieve optimal space, time, labour and equipment utilisation. For clarity purposes, we have broadly divided these operations into four main categories – inbound, storage, picking and outbound, in order to analyse their impact on sustainability. Literature review showed that these processes directly impact the economic dimension of sustainability (Aberdeen Group, 2006).

- ***Inbound processes (IP):*** The inbound processes mainly consist of operations such as unload, receive, rework and put-away. When goods are brought to a warehouse at the inbound (or receiving) dock, they are unloaded using counterbalanced forklift trucks to a staging area (a partition in the receiving department). The purpose is to inspect them for conformance with quality standards and to update the warehouse management system (WMS) so that they become available for put-away. Once material is unloaded, inspected and received in the system, it is put away to assigned locations determined by WMS as per the storage strategy (dedicated, random or class based). The incoming goods that are rejected after quality inspection are moved to the rework department (Bartholdi & Hackman, 2008). Usually, materials with minor issues such as missing labels, torn packaging, damaged cases and non-standard pallet build are moved to the rework department until quality requirements are satisfied, and then these are received in the system for put-away. Clearly, the cost of quality associated with rework, flawed storage strategy and inefficient staff could severely impact the economic dimension of sustainability during inbound processes (Aberdeen Group, 2006, 2009a).
- ***Storage processes (SP):*** Storage processes deal with the management of stored goods and storage slots, which is a fixed cost even if there are no products stored in the warehouse. Thus, storage processes consist of activities that start when a pallet is placed in a storage location, and end when it is retrieved for picking (Aberdeen Group, 2006, 2009a). These processes will include housekeeping activities, efficient utilisation of storage slots, pallet relocation and inventory counting. Once pallets (or products) are

placed by the put-away process in the storage locations, the housekeeping activities related to pallet orientation, safety, physical condition of cases and pallet stacking must be done (LTC, 2010; NZDoL, 1999). In addition, pallet relocation and inventory counting is required in order to improve utilisation of storage slots and efficiency of consequent handling activity related to retrieval and put-away processes. Inefficient storage processes negatively impact the economic dimension of sustainability (Fredendall & Hill, 2000; Hugos, 2003).

- ***Picking processes (PP):*** Picking is considered to be the most costly process in a warehouse as it accounts for 55 percent of the operating costs (Tomkins et al., 1996). It mostly includes activities related to replenishment of picking area (or forward area) and case picking when full-pallet-load is not ordered by the customer. Picking is classified into two main categories namely, picker-to-stock (in-the-aisle) system, and stock-to-picker (end-of-aisle) system. In the former system the picker needs to travel or ride to the storage location. According to Palevich (2011), an order picker may travel over 8 kilometres a day through various aisles in a warehouse, and 75 percent of his time is spent in non-value added activities (searching: 10 percent, writing: 5 percent, and walking/riding: 50 percent) while the actual picking is only 25 percent of the entire process. Thus, effort should be made to reduce travelling time so that dead-heading (travelling with empty forks) can be minimised. In later system (stock-to-picker) the pallet or container is mechanically brought to the picker. Examples include AS/RS, carousels, A-frames and mini load systems; however, in this method the container's travel time simply replaces the picker's travel time. Literature review clearly shows that picking processes have a huge impact on the economic dimension of sustainability. In addition, if non-value added activities of an order picker could be reduced somehow, then it will also help in reducing emissions of various GHG into the environment (Fredendall & Hill, 2000; Hugos, 2003; Renko, 2011).

- ***Outbound processes (OP):*** Outbound processes are related to stock movements aimed at fulfilling customer orders. These activities include transfer of stock from pick (or forward) area to outbound staging area, loading and finally despatching the vehicles to customers. Outbound operations may also include pallet customisation or repacking of products into new format (or standard) in order to address specific customer, business and market requirements (Aberdeen Group, 2006, 2009a).

On-site Facilities (OF) –A number of facilities emerge from the literature review that must be present on the warehouse site to support employee welfare and handle any medical emergencies. In addition, cross-docking is also added under this dimension. It is not a compulsory part of a warehouse but can help to save costs under special arrangements and is effectively used in food supply chains (Smart Steps, n.d.b). Finally, literature review showed that onsite recycling is considered by the sustainability literature as a mandatory constituent of a warehouse facility.

- ***Welfare facilities (WF):*** These include free access to drinking water, washing facilities, change rooms, showers, toilets for males and females, canteen, dining room and personal storage. These are the minimum requirements as per the national and state laws in most of the developed countries (Safe Work Australia, 2011). In addition, in the case of a warehouse, special facilities for drivers staying overnight and staff working on night shifts should be provided. These might include a workout area or a gym, a rest room, common area with television, sports area catering to indoor games such as table tennis and chess. Good personal hygiene standards must be reinforced at all times, such as disinfection of toilets, cleanliness of shower and change rooms, and pest disinfestation. Parking space should also be provided for all the employees.
- ***Emergency room (ER):*** First-aid facilities should be available in a warehouse at all times. It is preferred to have an emergency or medical room staffed with a trained

doctor and a nurse during the day. Proper signage and instructions must be provided to all staff members, and some wardens should be trained in various first-aid and cardiopulmonary resuscitation (CPR) techniques. The emergency room should be large enough to accommodate at least two beds; few cupboards for storing dressings; linen and medicaments; proper disposal system; and a stretcher (Safe Work Victoria, 2008).

- ***Cross-docking facility (CDF):*** A cross-docking facility in the real sense is a warehouse process in which products are directly transferred from inbound to outbound area and reconfigured according to customers' orders. It might include bulk breaking, sorting, merging and then consolidation, but by-passes costly put-away, storage and picking processes (Park, 2012). Even though it sounds easy and efficient, very few retailers have been able to implement true cross-docking due to extremely intricate coordination, transport management, and order planning. However, Wal-Mart is famous for pulling a large percentage of its products to their stores through their cross-docking sites. Also, Maytag maintains 41 cross-docking facilities in the US with zero inventory, and covers 70 percent of the US population (Blanchard, 2003).
- ***Recycling facility (RF):*** Reverse logistics is a vast domain in itself, and it is not possible to even touch upon its various aspects in this thesis. However, content analysis showed very high frequency of words similar to recycling, take-back programs, reprocessing, and reuse. These words were highlighted in relation to store sites, building, retail outlets and also warehouses. Thus, it is considered important to accentuate the importance of a recycling facility within a warehouse premises for reprocessing cardboards, shrink wraps, and packaging. In addition, food products that are expired, rejected by quality, and returned by customers also needs to be properly discarded or recycled (NZBCSD, 2003).

Warehouse Management System (WMS) – A warehouse management system (WMS) is crucial for managing a best-in-class sustainable warehouse. It controls the movement and storage of goods in a warehouse and performs all associated transactions for receiving, shipping, stocking and picking. The extent of work done in a warehouse can be easily imagined from former discussions in this thesis. WMS not only controls the internal processes but also manages the entire warehouse facility (Palevich, 2011). Thus, it plays an important role in improving the sustainability performance of a warehouse.

- ***Performance measurement (PM):*** One of the core functions of WMS is to keep track of all the key performance indicators (KPIs) for performance measurement. These may be clubbed into various reports for convenience, such as order fulfilment, inventory management, staff productivity, shelf-life monitoring, and work planning. In addition, KPIs related to work-life balance, employee absentees, training, emissions generated, housekeeping targets, and MHEs fuel consumption should also be programmed into the WMS. This will help to measure the sustainability performance and to identify avenues for further improvement.
- ***Warehouse strategy and roadmap (WSR):*** Continuous improvement can only be achieved by effectively using a WMS. It helps to resolve bottlenecks, monitor current performance, perform comparative analysis, set future targets, benchmark against industry standards, and perform simulations. Thus, the warehouse future roadmap and strategic planning for achieving highest levels of economic, social and environmental performance is not possible without a functioning WMS.

3.3.5.2 SSCM Material Used for SW

Key literature used for SW is presented in **Table 27** while summary of all the SSCM material used to determine the SW dimensions and measures is presented in **Table 28.**

Table 27: Key Literature Used for the SW Dimensions and Measures

Sustainable Warehousing (SW) Dimensions and Measures	Key Literature
Warehouse Design (WD)	
Renewable Energy Sources (RES), Daylight Usage (DU), Artificial Lighting Scheme (ALS), Temperature Control (TC), Water Consumption (WC), Noise Pollution (NP), Biodiversity (BD)	Saunders, (2008); Marchant, (2010); Smart Steps (n.d.b); Carbon Trust (2002, 2007); Gazeley (2004); Commission for Architecture and the Built Environment [CABE] (2005); Natural Economy Northwest [NEN] (2008); Global Reporting Initiative [GRI] (2011)
Warehouse Layout (WL)	
Layout Configuration (LC), Aisles Design (AD), Storage System (SS), Departmentalisation (DPT)	De Koster, Le-Duc, & Roodbergen, (2007); Meller and Gue (2009); Rouwenhorst et al. (2000); Tomkins et al. (1996); Hassan (2002); Gu, Goetschalckx, and McGinnis (2010)
Inventory Management (IM)	
Inventory Optimisation (IO), Inventory Accuracy (IA)	REM Associates (1999); Palevich (2011)
Warehouse Staff (WS)	
Work Life Balance (WLB), Shifts Roster (SR), General Training (GT), Occupational Health and Safety (OHS)	New Zealand Department of Labour (NZDoL) (2007); Ritchie and Spencer (2002); Hudson (2005); Smith, Di Milia, Smith, Gee, and Mackay (2000); National Occupational Health and Safety Advisory Committee [NOHSAC] (2006); Massey, Lamm, and Perry (2006);
Mechanical Handling Equipment (MHE)	
MHE Power Sources (MPS), MHE Maintenance and Servicing (MMS), Driver/Operator Training (DT)	Baker (2006); Johnson (2008); MacLeod (2008); Mitsubishi Heavy Industries [MHI] (2010); Department for Transport (DfT) (2006); Buckley (2006); Ward, Tyler, Wilson, and Eichinger (2004)
Warehouse Processes (WP)	
Inbound Processes (IP), Storage Processes (SP), Picking Processes (PP), Outbound Processes (OP)	Tomkins et al. (1996); Palevich (2011)
Onsite Facilities (OF)	
Welfare Facilities (WF), Emergency Room (ER), Cross-Docking Facility (CDF), Recycling Facility (RF)	Victoria, (2008); Park (2012); Australia (2011); Blanchard (2003); NZBCSD (2003)
Warehouse Management System (WMS)	
Performance Measurement (PM), Warehousing Strategy and Roadmap (WSR)	Palevich (2011)

Table 28: Summary of the SSCM Material Used for SW

Category	No. of Sources	Description
Peer Reviewed Journal Articles		
Sustainable Warehousing (SW) Articles	12	The keyword 'sustainable warehousing' did not produce any articles in the research databases. Consequently, combined keyword strings such as 'warehouse layout', 'warehouse design' AND 'energy conservation', 'worker safety' were used to find pertinent articles that were not typically focused on sustainable warehousing, but indirectly addressed environmental and social matters in a warehouse.
General sustainable supply chain management (GSSCM) Articles	78	All the papers that did not specifically focus on any supply chain process but generically discussed environmental and social issues in the context of sustainability at firm, industry or country level.
General Warehousing Articles	12	These were related to warehouse design, layout, literature review, and warehouse planning and control.
Miscellaneous		
Peer-Reviewed Conference Papers	3	These three papers focused on sustainable warehouse management and modelling.
Books	5	Most of these books generally discussed the warehouse and distribution science – types of storage systems, mathematical modelling for warehouse layout and design, picking algorithms, environmental impacts, refrigeration systems, building design and materials handling.
Industry and Public Sector Publications	23	Industry publications discussed the optimisation of warehouse operations, productivity benchmarking, workplace amenities, inventory accuracy and counting, health and safety issues, forklift operations, stacking and storage, lighting and illumination and tips for work-life balance and fatigue management.
Sustainability Frameworks	7	Frameworks used for the development of basic sustainability themes: Natural Capitalism, Cradle to Cradle, Biomimicry, Life Cycle Analysis, The Natural Step, Social Return on Investment and Triple Bottom Line
Corporate Sustainability Reports and Sustainability Guidelines	11	Material used for face validity – Annual sustainability reports of Unilever, Danone, Nestle, Campbell Soups, ConAgra, GrupoNutresa, Kraft Foods, General Mills, Heinz and Hershey and GRI guidelines

3.3.5.3 Sustainable Warehousing Research Hypotheses

From the above discussion it is clear that "Sustainable warehousing ensures economic, environmental and social well-being by mainly optimising warehouse design, processes, layout and inventory and focusing on staff welfare and safety." The systematic and detailed literature review and analysis led to eight hypotheses for the Sustainable Warehousing (HSW) sub-construct. The conceptual model along with the hypotheses is presented below:

HSW1: Sustainable warehousing depends on warehouse design that focuses on renewable energy sources, effective use of light, reduction in noise pollution and water conservation.

HSW2: Sustainable warehousing is driven by warehouse layout based on optimal configuration, aisle design, departmentalisation and an appropriate storage system.

HSW3: Sustainable warehousing is positively related to inventory management encompassing inventory accuracy and periodical inventory counting.

HSW4: Sustainable warehousing is positively related to the wellbeing and safety of the warehouse staff.

HSW5: Sustainable warehousing should ensure proper maintenance and utilisation of mechanical handling equipment.

HSW6: Sustainable warehousing is positively associated with the optimisation of inbound, outbound, storage and picking processes.

HSW7: Sustainable warehousing should ensure onsite facilities including emergency room, cross-docking facility and recycling facility.

HSW8: Sustainable warehousing is highly dependent on a warehouse management system that could keep track of all the operations and assist in future planning.

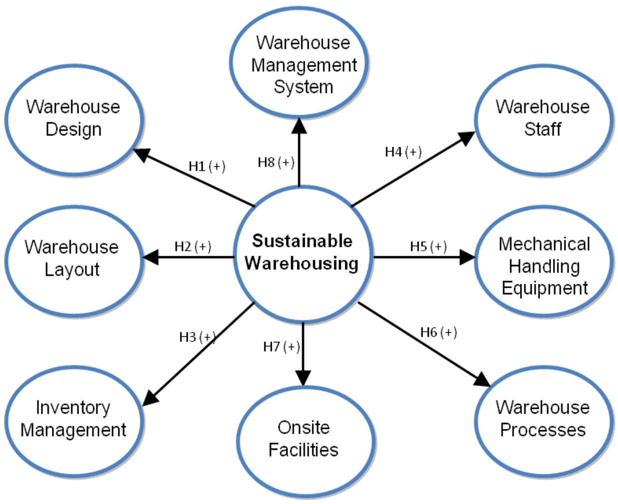

Figure 33: Conceptual Model of Sustainable Warehousing

3.3.6 Reverse Logistics (RL) Dimensions and Measures

Reverse logistics is a full-fledged domain in itself. Literature review revealed that it is a well-established field of knowledge and has received considerable attention from researchers. This area has huge potential for recovering value from used products and materials. The main focus in reverse logistics is on waste management, parts recovery (through remanufacturing) and materials recovery (through recycling) (Simpson, 2010). Research output related to reverse logistics has grown tremendously after the 1960s, but efforts to integrate it with the concept of sustainable supply chain are limited (Pokharel & Mutha, 2008). This PhD study has clearly shown that reverse logistics should be a part of every process (planning, procurement, manufacturing, transportation and warehousing). Manufacturing and warehousing should have an onsite recycling facility and the procurement department should ensure that suppliers have a proper waste management system, as firms' investment in waste reduction resources results in significant cost reduction (Simpson, 2012).

This research study will not delve into the details of reverse logistics and supply chain models, platforms, drivers and processes which will further assist in the synthesis of the field into SSCM: however, the study has managed to identify key practices through literature review that should be adopted by the supply chain department of a focal firm. These practices include the product take-back program **(TBP)** (NZBCSD, 2003; Smart Steps, 2009), a centralised product return centre **(CRC)** and a thorough standard operating procedure to estimate the value of returned goods **(VERP)** (Diener, Peltz, Lackey, Blake, & Vaidyanathan, 2004). Every manufacturing firm, distributor, wholesaler and retailer in the food industry should either develop standard operating procedures for customer returns, unsold stock and damaged SKUs (stock keeping units), or outsource the process to a third party logistics (3PL) provider **(ORL)**. Returned food products in good condition can also be donated to charities **(DC)** (McKinnon, Browne, & Whiteing, 2010; Waters, 2010).

Since reverse logistics is also covered under other SSCM sub-constructs in this thesis, thus it is not covered separately in this study due to time constraints, and is identified as an area of further research in the conclusion of this thesis.

3.3.6.1 Reverse Logistics Research Hypothesis

The literature review done for reverse logistics led to a single hypothesis (HRL) which is as follows:

HRL: Reverse logistics is positively associated with the product take-back program and a centralised product return centre (CRC) along with a thorough procedure to estimate the value of the returned goods.

CHAPTER 4: STEP 3 – CONTENT VALIDITY ASSESSMENT

Dunn, Seaker and Waller (1994) highlighted the importance of this step and stated that

> *'content validity exists when the scope of the construct is adequately represented by the items as a group…if content validity doesn't exist then there is no reason to proceed with the analysis because the desired construct is not being properly represented by the group of items. This means that researchers will not be able to use the scale to test hypothesis.'*

4.1 Content Validity Assessment (CVA) Technique

Content validity can be determined by different qualitative and quantitative methods. It was decided to use the technique suggested by Lawshe (1975). The finalised measures were circulated among 14 industry experts who had prior experience in procurement, logistics, customer services and supply chain planning at both operational and strategic levels in the food industry. They also had extensive experience of working in cross-functional teams, both locally and internationally, with members from product development, brand, sales and human resources department. First, they were asked to review each dimension of SPlng, SP, SM, ST, SW and RL. Second, they were requested to rate each measure (or item) as 'essential' (E), 'useful but not essential' (NE) or 'not necessary' (NN) to a dimension on the scale. The responses were used to calculate the content validity ratio (CVR) according to the formula CVR = (n – N/2) / (N/2) where 'N' is the total number of industry experts and 'n' is the frequency of 'essential' responses. Based on the above formula, the following characteristics for CVR can be identified:

1. If less than half of the experts say ‘essential’, then CVR is negative
2. If half of the experts say ‘essential’, then CVR is zero
3. If all the experts view a measure as ‘essential’, then CVR is 1.0
4. If more than half of the experts consider a measure as ‘essential’, but not all agree with it, then CVR is between 0 and 1.0

4.2 Assumptions and Rules for CVR and CVI Calculation

The panellists were provided with the dimensions and measures of each SSCM sub-construct and were requested to provide their judgement against each item by using the above mentioned codes: ‘E’, ‘NE’ and ‘NN’. The judgements of the respected panellists were entered in an Excel spreadsheet for each SSCM sub-construct. The content validity ratio (CVR) was calculated according to the formula given above, and the following assumptions (Lawshe, 1975) were considered for the interpretation of CVR results:

1. If all panellists disagree on a measure, then that item is not essential.
2. If all panellists agree on a measure, then either they are all right or all wrong. Since they are considered as experts, all of them cannot be wrong.
3. If a measure is perceived as ‘essential’ by more than half of the panellists, then it has some degree of content validity.

Since 14 panellists were used for the assessment of content validity, a CVR cut-off value of 0.57 was decided at $p = 0.05$, as per the statistical table provided by Lawshe (1975). The CVR value of 0.57 represents an ‘essential’ (E) response from 11 experts. In addition to CVR, the content validity index (CVI) was also calculated, which is the mean of all retained CVR values for a specific SSCM sub-construct. It represents the overall consensus of the experts regarding the relevance of the sub-construct and its measures. The content validity results are considered more reliable if CVI is close to 0.8, and vice versa. The following criteria were applied for retaining the measures of a construct:

1. Retain the measure if CVR is equal to or greater than 0.57 (unconditionally).
2. Retain a measure if its CVR is between 0 and 0.57 and the overall CVI of the SSCM sub-construct is greater than 0.6. This would mean that retaining an item would not impact the overall validity of the sub-construct.
3. Retain a measure if its CVR is less than or equal to 0 and the overall CVI of the sub-construct is higher than or equal to 0.8.
4. Include/Exclude/Merge measures based on overall consensus or discussion of the panellists.

4.3 CVA Results of the SSCM Sub-constructs

The dimensions and measures identified in Chapter 3 for each SSCM sub-construct were used for content validity assessment (CVA).

4.3.1 CVA Results – Sustainable Planning (SPlng)

All the measures for Sustainable Supply Chain Planning showed good CVR results with the exception of R&D and PD-CN that received 0.29 and -0.43 CVR, respectively. Since the overall CVI is nearly equal to 0.8, these two measures were not excluded. Initially, panellists were of the view that R&D is not the job of the supply chain department and is usually localised with a focus on the product development. Also, identification of the consumer needs is a typical marketing and brand function that has nothing to do with the supply chain department. However, after thorough discussion, it was concluded that these two items should be retained as the supply chain department can research into areas where waste can be reduced and optimise the processes. This will reduce the costs for the firm and consequently for the final consumer. Supply chain can address the consumer needs of fresh and wholesome food by making on-time deliveries and ensuring uncontaminated containers. CVA results for SPlng are presented in **Table 29**.

Table 29: CVA Results for SPlng

SPlng Dimensions	SPlng Elements/Measures/Practices	CVR	No. of 'essential' Responses
Institutional Policies (IP)	Corruption Free Operations (CFO)	1.00	14
	Transparent Market Practices (TMP)	0.86	13
	Communal Welfare Projects (CWP)	0.86	13
	Customer Satisfaction Survey (CSS)	1.00	14
	Employee Training & Development (ETD)	1.00	14
	Workforce Diversity (WDI)	1.00	14
	Equal Opportunity Employer (EOE)	1.00	14
	Workplace Discrimination (WDS)	1.00	14
	Employee Backup Planning (EBP)	0.86	13
	Continuous Improvement (CI)	0.57	11
	Research and Development (R&D)	***0.29***	***9***
	Fair Remuneration & Working Conditions (FRWC)	1.00	14
	Australian Food Industry Knowledge (AFIK)	0.71	12
Risk Mitigation (RM)	Business Continuity Plan (BCP)	0.71	12
	Natural Disaster Survival Plan (NDSP)	1.00	14
	Backup Suppliers (BS)	0.86	13
	Emergency Plan (EP)	1.00	14
Demand & Supply Planning (DSP)	Demand Forecast Accuracy (DFA)	0.86	13
	Collaborative Planning (CP)	0.71	12
	Accurate Production Scheduling (APS)	1.00	14
New Product Development (NPD)	Collaboration with Brand & Suppliers (CBS)	0.71	12
	NPD – Minimum Resource Requirements (PD-MRR)	0.57	11
	NPD – Non-Toxic Materials (PD-NTM)	0.71	12
	NPD – Optimised for Logistics (PD-OL)	0.57	11
	NPD – Local Sourcing (PD-LS)	0.71	12
	NPD – Take Back Strategy (PD-TBS)	0.86	13
	NPD – Recyclable Products (PD-RP)	1.00	14
	NPD – Competitive Pricing (PD-CP)	0.86	13
	NPD – Long Expiry (PD-LE)	0.71	12
	NPD – Functional Benefits (PD-FB)	0.86	13
	NPD – Address Consumer Needs (PD-CN)	***-0.43***	***9***
	Australian Food Safety Regulations (AFSR)	1.00	14
Content Validity Index (Mean CVR)		**0.79**	

4.3.2 CVA Results – Sustainable Procurement (SP)

The overall CVR results were very encouraging and reflected the rigour of the literature review. However, the CVRs for procurement processes such as needs analysis (NA), procurement plan (PP), purchasing (PUR) and procurement evaluation (PE) were very low, and panellists were of the view that these practices should not be assessed separately and may be merged into a single question. All these practices are actually steps of the process which is usually referred to as 'source-to-settle'. Clearly, if a firm has developed this process then it must have set up all the steps to ensure that needs are analysed, procurement plan is laid out, sourcing or purchasing of actual goods is carried out as per the plan and finally, post-evaluation is done at the end of the process. Hence, all these practices were eliminated from the questionnaire and a single statement requiring a response from the respondent was added. The statement is as follows: 'Our purchasing process from source-to-settle is governed by our procurement policy.'

Similarly, it was recommended that waste reduction (WR) and recyclable packaging (RP) should be combined in a single question. The advice was followed and they were combined as follows: 'Our suppliers reduce waste through reuse and recycling.' The modified arrangement in the form of questions, as per the input of the content validity exercise, can be seen in the next chapter. CVA results for SP are presented in **Table 30**. It can be seen that the overall CVI (mean CVRs of the retained items) is 0.76 which is acceptable at this stage of the scale development process.

All the measures that were removed from the questionnaire, based on the CVA results, are shown in **bold** and **strikethrough** in the following Table.

Table 30: CVA Results for SP

SP Dimensions	SP Elements/Measures/Practices	CVR	No. of 'essential' Responses
Procurement Policy and Processes (PPP)	Strategic Procurement (SP)	0.71	12
	Written Procurement Policy (WPP)	0.86	13
	~~Need Analysis (NA)~~	***-0.29***	***5***
	~~Procurement Plan (PP)~~	***-0.29***	***5***
	~~Purchasing (PUR)~~	***-0.14***	***6***
	~~Procurement Evaluation (PE)~~	***0.14***	***8***
	Contract Management Practice (CMP)	0.43	10
Operational Efficiency (OE)	Personnel Training (PT)	0.57	11
	Supply Base Development (SBD)	0.86	13
	Procurement Management System (PMS)	0.57	11
Supplier Selection and Assessment (SSA)	Supplier Selection (SS)	0.86	13
	Supplier Assessment / Audits (SA)	0.86	13
	Supplier Financial Strength (SFS)	1.00	14
	Supplier Involvement (SI)	1.00	14
Supplier Workplace Standards (SWS)	Occupational Health and Safety (OHS)	1.00	14
	Child or Forced Labour (CFL)	0.86	13
	Workplace Discrimination (WD)	0.86	13
	Employee Working Hours (EWH)	0.86	13
	Employee Wages (EW)	0.71	12
	Freedom of Association (FA)	1.00	14
Supplier Operations (SO)	Energy Conservation (EC)	0.86	13
	Water Conservation (WC)	0.86	13
	Reduction in Emissions (RE)	0.86	13
	Preservation of Biodiversity (PB)	0.29	9
	~~Waste Reduction (WR)~~	***0.29***	***9***
	~~Recyclable Packaging (RP)~~	***0.14***	***8***
	Traceability (TR)	0.57	11
	Specific Industry Requirements (SIR)	0.57	11
Supplier Regulatory Compliance (SRC)	Local and International Compliance (LIC)	0.71	12
	Food Products Labelling (FPL)	0.71	12
	Australian Packaging Covenant (APC)	0.71	9
Content Validity Index – CVI (Mean CVR)		**0.76**	

4.3.3 CVA Results – Sustainable Manufacturing (SM)

The overall CVR results were acceptable for majority of the measures; however, product adaptation (PTA), raw materials usage (RMU1) and recycled material usage (RMU2) were eliminated, as their CVR value was less than zero and the overall CVI is also less than 0.8. Experts were of the opinion that raw materials usage is a very general element and does not make much sense. Also, recycled materials usage is not very relevant to the food industry. It is usually related to IT industry, semi-conductor industry, and automobile industry where a number of components can be recycled and reused. The food industry has to be very cautious in terms of using recycled ingredients as they might have a negative impact on the nutritional value of the finished products.

In addition, there was a general consensus that the dimension of 'Manufacturing Strategy (MS)' is a repetition and all its measures are already covered, thus it should be eliminated. There was an agreement that the element – eco-friendly processes (EFP) is covered by the process adaptation (PRA), and product design (PD) is the responsibility of the brand team. Also, manufacturing practices (MP) and production facility and location (PFL) are already covered in the manufacturing policy (WMP) and other elements. The modified arrangement in the form of questions, as per the input of the content validity exercise, can be seen in the next chapter. CVA results for SM are presented in **Table 31**. All the measures have received a high CVR value. The overall CVI (mean CVRs of the retained items) is 0.73 which is acceptable at this stage of the scale development process.

All the measures that were removed from the questionnaire, based on the CVA results, are shown in **bold** and **strikethrough** in the following Table.

Table 31: CVA Results for SM

SM Dimensions	SM Elements/Measures/Practices	CVR	No. of 'essential' Responses
Manufacturing Policy and Processes (MPP)	Written Manufacturing Policy (WMP)	0.86	13
	Biodiversity Preservation Policy (BP)	0.57	11
	Environmental Management System (EMS)	0.71	12
	Food Safety Mechanisms (FS)	0.71	12
Pollution Control and Prevention (PCP)	Remedial Action Plan (RAP)	1.00	14
	End of Pipe Control (EPC)	1.00	14
	~~***Product Adaptation (PTA)***~~	***-0.29***	***2***
	Process Adaptation (PRA)	0.57	11
	Emission Monitoring and Control (EMC)	0.71	12
	Waste Management (WM)	0.71	12
	Production Management System (PMS)	0.86	13
Resource Conservation (RC)	Energy Conservation (EC)	1.00	14
	Water Conservation (WC)	1.00	14
	~~***Raw Materials Usage (RMU1)***~~	***-0.29***	***5***
	~~***Recycled Materials Usage (RMU2)***~~	***-0.43***	***4***
	Reuse and Recycle Water (RRW)	0.71	12
Manufacturing Strategy (MS)	~~***Eco-friendly Processes (EFP)***~~	***-0.86***	***1***
	~~***Product Design (PD)***~~	***-0.57***	***3***
	~~***Manufacturing Practices (MP)***~~	***-0.57***	***3***
	~~***Production Facility & Location (PFL)***~~	***-0.71***	***2***
Production Staff (PS)	Work-Life Balance (WLB)	0.57	11
	Shifts Management (SM)	0.86	13
	Occupational Health and Safety (OHS)	0.71	12
	Child or Forced Labour (CFL)	0.71	12
	Workplace Discrimination (WD)	0.86	13
	Employee Working Hours (EWH)	0.71	12
	Employee Wages (EW)	0.86	13
	Freedom of Association (FA)	0.71	12
Cleaning and Sanitation (CS)	Cleaning, Sanitation, Temperature and Pest Control (CSTPC)	0.57	11
	Environment and Human Friendly Detergents and Disinfectants (EHFDD)	0.71	12
Production Regulatory Compliance (PRC)	Australian Standards for Food Grading (ASFG)	0.43	10
	Australian Regulations for Food Labelling (ARFL)	0.57	11
	Australian Packaging Covenant (APC)	0.57	11
	Workplace Management Policies (WMP)	0.57	11
Content Validity Index (Mean CVR)		**0.73**	

4.3.4 CVA Results – Sustainable Transportation (ST)

The overall CVR results were acceptable for majority of the measures; however, almost all the panellists were of the view that vehicle tare weight (VTW) is automatically covered under regular inspection and maintenance (IM). In addition, there was a general consensus that optimal travel distance and delivery schedule (OTD and ODS) should not be presented as separate questions as the measure related to vehicle routing and scheduling software (VRSS) is adequately covering both OTD and ODS. Panellists were clear about the fact that if a firm is not using a routing and scheduling optimisation software then it can never achieve OTD and ODS due to the complex nature of distribution networks these days.

Also, it was recommended to shift the question related to load planning software (LPS) and inspection of inbound and outbound vehicles (IOVI) to TML and TRC dimensions respectively, as these questions are more suitable to these dimensions. In addition, it was suggested to merge employee working hours (EWH) and shifts management (SM) as both measures focus on the avoidance of anti-social hours. Furthermore, it was proposed that a question related to 'tie bands' should be added to the transportation shipping materials (TSM) dimension, as it a standard industry practice. The modified arrangement in the form of questions, as per the input of the content validity exercise, can be seen in the next chapter. CVA results for ST are presented in **Table 32.** All the measures have received a high CVR value. The overall CVI (mean CVRs of the retained items) is 0.84 which is very encouraging at this stage of the scale development process.

All the measures that were removed from the questionnaire, based on the CVA results, are shown in **bold** and **strikethrough** while those that were shifted to other dimensions or merged together are only shown in **bold** in the following Table.

Table 32: CVA Results for ST

ST Dimensions	ST Elements/Measures/Practices	CVR	No. of 'essential' Responses
Transportation Policy and Processes (TPP)	Vehicle Design (VD)	0.71	12
	Inspection and Maintenance (IM)	0.86	13
	~~Vehicle Tare Weight (VTW)~~	***-0.86***	***1***
	Vehicle Idling (VI)	0.86	13
	Fuel-Efficiency (FE)	0.86	13
	Transportation Management System (TMS)	1.00	14
Transportation Mode and Loads (TML)	Transport Modality (TM)	1.00	14
	Transport Energy Source (TES)	0.57	11
	Vehicle Capacity Utilisation (VCU)	0.71	12
	Packaging Design (PD)	0.57	11
	Load Planning Software (LPS)	**0.86**	**13**
Transportation Routing & Scheduling (TRS)	***~~Optimal Travel Distance (OTD)~~***	***-0.57***	***3***
	Reduce Empty Running (RER)	0.86	13
	Vehicle Routing & Scheduling Software (VRSS)	1.00	14
	~~Optimal Delivery Scheduling (ODS)~~	***-0.71***	***2***
	Inbound/Outbound Vehicle Inspection (IOVI)	**0.57**	**11**
Transportation Shipping Materials (TSM)	Reusable Shipping Materials (RSM1)	0.57	11
	Recyclable Shipping Materials (RSM2)	0.57	11
	Recycled Shipping Materials (RSM3)	0.71	12
Transportation Staff (TS)	Work-Life Balance (WLB)	0.71	12
	Shifts Management (SM)	**0.71**	**12**
	Occupational Health and Safety (OHS)	0.86	13
	Child or Forced Labour (CFL)	1.00	14
	Workplace Discrimination (WD)	1.00	14
	Employee Working Hours (EWH)	**1.00**	**14**
	Employee Wages (EW)	1.00	14
	Freedom of Association (FA)	1.00	14
	Driver Training (DT)	1.00	14
Transportation Regulatory Compliance (TRC)	Australian Standards for Food Grading (ASFG)	1.00	14
	Australian Regulations for Temperature Maintenance (ARTM)	1.00	14
	Avoidance of Cross-Contamination (ACC)	0.86	13
Content Validity Index (Mean CVR)		**0.84**	

4.3.5 CVA Results – Sustainable Warehousing (SW)

The overall CVR results were acceptable for most of the measures. However, there was a general consensus among the panellists that all questions under the dimension of warehouse processes (WP), such as inbound, outbound, picking and storage, should be combined in a single question. The advice was followed and a single question was designed to cater for all the processes. The statement requiring response is as follows: ‘The warehouse processes (inbound, storage, picking and outbound) are optimised for efficient and safe operations that ensure food safety and quality.’ Experts were also of the view that other important processes pertinent to the food products storage, such as control of hazardous materials, combined warehousing, First-expiry First-out (FEFO), housekeeping practices and use of technology should be added to the dimension of warehouse processes (WP) to enhance its purview.

It was suggested that the dimension of warehouse management system (WMS) should be deleted and it should be covered through a single question related to the ‘use of technology’ under the WP dimension. Finally, it was recommended to add at least two questions related to the warehouse regulatory compliance to the Australian standards, as done for other sub-constructs. The modified arrangement in the form of questions, as per the input of the content validity exercise, can be seen in the next chapter. CVA results for SW are presented in **Table 33**. All the measures have received a high CVR value. The overall CVI (mean CVRs of the retained items) is 0.69 which is acceptable at this stage of the scale development process.

All the measures that were removed from the questionnaire, based on the CVA results, are shown in **bold** and **strikethrough** while those that were shifted to other dimensions or merged together are only shown in **bold** in the following Table.

Table 33: CVA Results for SW

SW Dimensions	SW Elements/Measures/Practices	CVR	No. of 'essential' Responses
Warehouse Design (WD)	Renewable Energy Sources (RES)	0.29	9
	Daylight Usage (DU)	0.57	11
	Artificial Lighting Scheme (ALS)	0.57	11
	Temperature Control (TC)	0.86	13
	Water Consumption (WC)	0.71	12
	Noise Pollution (NP)	0.71	12
	Biodiversity (BD)	0.29	9
Warehouse Layout (WL)	Layout Configuration (LC)	1.00	14
	Aisles Design (AD)	1.00	14
	Storage System (SS)	1.00	14
	Departmentalisation(DPT)	1.00	14
Inventory Management (IM)	Inventory Optimisation (IO)	1.00	14
	Inventory Accuracy (IA)	1.00	14
Warehouse Staff (WS)	Work-Life Balance (WLB)	1.00	14
	Shifts Roster (SR)	1.00	14
	General Training (GT)	0.71	12
	Occupational Health and Safety (OHS)	0.86	13
Mechanical Handling Equipment (MHE)	MHE Power Sources (MPS)	0.57	11
	MHE Maintenance and Servicing (MMS)	0.57	11
	Driver/Operator Training (DT)	1.00	14
Warehouse Processes (WP)	***Inbound Processes (IP)***	***0.14***	***8***
	Storage Processes (SP)	***0.43***	***10***
	Picking Processes (PP)	***0.57***	***11***
	Outbound Processes (OP)	***0.14***	***8***
On-site Facilities (OF)	Welfare Facilities (WF)	0.86	13
	Emergency Room (ER)	0.71	12
	Cross-Docking Facility (CDF)	0.29	9
	Recycling Facility (RF)	0.57	11
~~Warehouse Management System (WMS)~~	***~~Performance Measurement (PM)~~***	***-0.57***	***3***
	~~Warehouse Strategy and Roadmap (WSR)~~	***-0.29***	***2***
Content Validity Index (Mean CVR)		**0.69**	

4.3.6 CVA Results – Reverse Logistics (RL)

Even though reverse logistics is not covered in detail due to time constraints; however, the basic set of RL practices, identified earlier, were presented to the 14 panellists and all of them agreed to retain them in the questionnaire. All the panellists were of the view that these are very important practices and every supply chain should ensure a reverse path for the returned, expired or unsold products. The CVR for all the RL measures is quite high leading to an overall CVI of 0.92. CVA results for RL are presented in **Table 34**.

Table 34: CVA Results for RL

Reverse Logistics	RL Elements/Measures/Practices	CVR	No. of 'essential' Responses
Reverse Logistics (RL)	Product Take-back Program (TBP)	0.86	13
	Centralised Product Return Centre (CRC)	1	14
	Outsourcing RL Operations (ORL)	0.86	13
	Value Estimation of Returned Products (VERP)	0.86	13
	Donation to Charities (DC)	1	14
Content Validity Index (Mean CVR)		**0.92**	

SUSTAINABLE SUPPLY CHAIN MANAGEMENT (SSCM) SCALE DEVELOPMENT

STAGE II – SSCM Scale Refinement and Validation

Overview of STAGE II

The scale refinement and validation was completed through exploratory factor analysis (EFA) and confirmatory factor analysis (CFA). It is important to mention the difference between EFA and CFA. EFA, as the name suggests, helps to explore the structure of the factors and CFA confirms that the outlined structure fits with the data. In other words, EFA paints a picture and CFA confirms whether or not it fits with reality. Ideally, different datasets should be used for EFA and CFA, and timing of data collection should also be different. This is an ideal approach which is usually not possible, as both time and financial resources are constrained (Koufteros, Vonderembse, & Doll, 1998). Many researchers are of the view that if theory is rigorously analysed through meticulous literature review, conceptual models are carefully developed to delineate the theoretical constructs, and content validity is achieved by involving experts of the domain, then EFA would only endorse the factorial structure, and going straight to CFA is probably a better option (Nunnally, 1978). This research study meticulously followed all the steps in Stage I (literature review, conceptual modelling and content validity); however, still it was decided to explore the factorial structure through a pilot study to further strengthen the rigour of the scales for sustainable supply chain planning (SPlng), sustainable procurement (SP), sustainable manufacturing (SM), sustainable transportation (ST), and sustainable warehousing (SW). Consequently, the EFA helped to mature the conceptual models leading to a more relevant and practical questionnaire for large scale data collection (Arrindell & Van der Ende, 1985).

The details of EFA and CFA are presented in the chapters 5, 6 and 7. **Chapter 5** discusses Step 4 of the scale development process and mainly presents pilot testing and the results of exploratory factor analysis (EFA). The data gathered through the pilot survey was used for exploratory factor analysis which helped to purify the items of the scale. This chapter presents the methodology that was used for pilot testing and also reviews the literature to justify the sample size used for the pilot testing. It also delineates the strategy that was employed to either reject or retain items based on correlation and reliability testing, and factor loadings of each sub-construct of SSCM.

Chapter 6 provides the details of Step 5 of the scale development process and discusses the sampling and data collection methodology. It elaborates various challenges faced during the data collection process and discusses techniques that were adopted to avoid non-response bias (NRB), common method bias (CMB) and social desirability bias (SDB).

Chapter 7 presents the sixth (and final) step of the scale development process which is related to the validation of SSCM sub-constructs. The data collected in Step 5 is subjected to structural equation modelling (SEM) through confirmatory factor analysis (CFA) in the AMOS tool. The results of first-order and second-order CFA models, reliability, convergent validity, discriminant validity and common method bias are discussed in this chapter for each SSCM sub-construct – sustainable planning, sustainable procurement, sustainable manufacturing, sustainable transportation, sustainable warehousing and reverse logistics. The final validated models, along with SEM fit statistics (such as GFI, NFI, IFI, CFI, RMSEA, SRMR and AVE), are presented in this chapter.

CHAPTER 5: STEP 4 – PILOT TESTING AND EXPLORATORY FACTOR ANALYSIS

5.1 Objectives of the Pilot Testing

Recently 'remarkable progress has been demonstrated…..by the quality and the sophistication of the research endeavours….' based on survey research (Rungtusanatham, 1998). Pilot testing has played an important role in this regard as it helps to identify any possible problems in the data collection instrument before large scale sampling. It also provides important information pertaining to the reliability of the scale and the correlations among the generated items (Dillman, Smyth, & Christian, 2009). In fact, pilot testing is the last chance to purify the items of the scale before large scale data collection. Therefore, clear objectives were set for this phase of the scale development – purification, unidimensionality and reliability.

In order to conduct the exploratory factor analysis, it is important to first purify the items of the scale. Churchill (1979) argues that 'when factor analysis is done before purification, there seems to be a tendency for factor analysis to produce many more dimensions than can be conceptually identified, confounding the interpretation of the factor analysis' (Koufteros, Vonderembse, & Doll, 1998). It was decided to purify items through item-total statistics, such as corrected-item-total-correlation (CITC) or squared-multiple-correlation (SMC). CITC is the correlation of an item with the overall scale if that item is not a part of the scale. If values are lower than 0.5 for an item, it means that the item is not measuring the same thing as the rest of the scale is trying to measure, and thus it should be considered for deletion. However, items with lower CITC values can be acceptable if they are important to the construct and backed by the literature.

The next step after item purification is to identify the latent dimensions or structure of the construct through exploratory factor analysis (EFA). In construct development, EFA helps to evaluate the unidimensionality of each sub-construct by cautiously eliminating the items that load on more than one factor (cross-loading items). EFA is considered as dimension-level analysis, as it provides an opportunity to modify (split or merge) various dimensions of the construct previously determined from literature. Item loadings are carefully examined and it was decided to delete those items that have cross-loadings of 0.4 or higher, on more than one factor.

Another important aspect that should be assessed in pilot testing is the precision of the items and dimensions of the construct. This is usually determined through reliability coefficients such as Cronbach's (1951) alpha. It is the most widely-used index for estimating the reliability of scale, questionnaires, multiple item tests and inventories (Raykov, 1997). Cronbach (2004) reported that his article on 'reliability coefficient alpha' is cited more than 5,000 times and has become a standard for estimating reliability of items in quantitative studies. Therefore, for EFA, the reliability of the items was established through Cronbach's alpha and only values equal or greater than 0.7 were considered acceptable (Nunnally, 1978).

5.2 Pilot Testing: Sample Size Literature Review

It is considered important at this juncture to briefly discuss the sample size for pilot testing, as it forms the basis for large scale data collection and subsequent confirmatory factor analysis. The minimum sample size for pilot studies which have used EFA and reliability tests is vigorously debated by researchers. There are various suggestions for robust estimation of these statistics. For reliability coefficient Cronbach's alpha, Peterson (1994) suggested a sample size of $n < 200$ in his meta-analysis study. However, Yurdugul (2009) argued that alpha not only depends on sample size but also on the eigenvalue of the sample data. He conducted simulations of various datasets using the Monte-Carlo method and bootstrap technique, and proved that for eigenvalue greater than 6.0, a sample with n = 30 is adequate for an unbiased estimation of coefficient alpha. Similarly, if the eigenvalue of the sample dataset of the population is between 3.0 and 6.0, then alpha, even with n = 100, is a robust reliability estimator of the items.

Similarly, for EFA and CFA, researchers have suggested various sample sizes. Early recommendations included minimum sample sizes of 200 (Guilford, 1954), 500 (Cattell, 1978), 50 – 1000 (Comrey, 1973) and 50 – 200 (Gorsuch, 1974). However, later studies showed that these recommendations were inconsistent (Arrindell & Van der Ende, 1985) and there is no absolute threshold. Since sample size is critical for large scale data collection and impacts the quality of results and findings, a thorough review of sample size recommendations was conducted for this research study and it was found that there are two main categories of researchers – one group favours an absolute number of participants (N), while the second category of researchers is in the favour of subject to variable (STV) ratio.

Kline (1979, p. 40) and Gorsuch (1983) recommended a sample size of 100 even if the number of variables is less than 20. Hatcher (1994) also proposed the same sample size, or 5 times more than the number of variables. Hutcheson and Sofroniou (1999) recommended that N should be at least 150 if variables are highly correlated, while Guilford (1954, p. 533) suggested that the number of cases should be at least 200. Cattell (1978) emphasised a minimum significant N of 250, while Lawley and Maxwell (1971) stressed that there should be 51 more cases than the number of variables. Recently, de Winter et al. (2009) conducted simulations and showed that EFA can yield satisfactory results even for N well below 50.

On the other hand, a large number of scholars favour the subject to variable (STV) ratio as the deciding strategy for the adequate sample size. Some of the recommended ratios are 10 cases for each item or 10:1 (Everitt, 1975; Nunnally, 1978), 5:1 (Bryant & Yarnold, 1995; Gorsuch, 1983) and 2:1 (Kline, 1979, p. 40).

In addition, few review papers are also published in which researchers have analysed the minimum sample size used across various studies. Henson and Roberts (2006) reviewed 60 factor analysis studies in four journals and found that the minimum sample size and STV reported is 42 and ~3:1, respectively. Fabrigar, Wegener, MacCallum and Strahan (1999) reviewed articles that used EFA in the Journal of Personality and Social Psychology (JPSP) and Journal of Applied Psychology (JAP) and found that the minimum sample size is 100 or less, and STV is 4:1 or less. Costello and Osborne (2005) investigated the PsychINFO articles and reported that many studies conducted the principal component analysis (PCA) with sample size based on STV of 2:1.

MacCallum, Widaman, Zhang, and Hong (1999) tried to resolve this mystery and studied the effects of sample size through a Monte Carlo study. They obtained excellent results for a sample of 60 cases and 20 variables, along with high level of communality (0.7 on average) and over-determination (three loaded factors). Their study clearly proved that general rules of thumb related to absolute sample size and STV are not valid. Garson (2008) also supports their findings, and states that there is no scientific evidence for the minimum number of cases required for factor analysis. A review of these studies revealed that there are many factors that play a pivotal role in generating statistically accurate results. These include **(1) communality** – high communality results in good estimation of population factors from the sample data irrespective of the sample size, STV and model error (MacCallum, Widaman, Preacher, & Hong, 2001, p. 636); **(2) degree of over-determination** (variable-to-factor ratio) – high number of variables per factor results in more stable model and experts have recommended at least 3 variables per factor (Velicer, & Fava, 1998, p. 243); **(3) size of loading** – it is suggested to have about 5 or more items with high loading (more than 0.5) on a factor (Costello & Osborne, 2005, p. 5); and **(4) model fit (*f*) or population root mean squared residual (RMSR)** – Preacher and MacCallum (2002) suggested that RMSR values of 0.00, 0.03 and 0.06 correspond to perfect, good and fair model fit, respectively.

Finally, the crux of this entire discussion can be presented in the words of Preacher & MacCallum (2002, p. 160): 'As long as communalities are high, the number of expected factors is relatively small, and model error is low (a condition which often goes hand-in-hand with high communalities), researchers and reviewers should not be overly concerned about small sample sizes.' Keeping in view this expert opinion, the following strategy was adopted for each SSCM sub-construct:

1. Ensure that the KMO (Kaiser-Mayer-Olkin) measure of *sample adequacy* is above 0.6
2. Ensure that the communality of each variable is more than 0.6
3. Confirm that the mean value of communality for all variables is greater than 0.07
4. Drop all components with eigenvalue less than 1.0 (Kaiser strategy – use scree plots)
5. Drop items with loadings less than 0.5
6. Drop or merge factors with less than three variables

5.3 Pilot Testing: Methodology

In this research study, pilot testing was administered through the online survey tool QuestionPro (https://www.QuestionPro.com). QuestionPro is an extremely effective survey tool and has been used extensively both by academics and practitioners. It provides various options for the development of online questionnaires, such as standard and advanced question types, validation and skip logic, questionnaire themes, settings for individual questions and sections, security features, distribution via email or mobile device, respondent tracking and statistics, real time reporting, social media integration, descriptive analysis, export features to Excel and SPSS, and 24-hour customer support services.

QuestionPro is a subscription service and has respondent panels related to various academic fields. The subscriber has the option to purchase as many respondents as required, depending upon the design of research and testing technique, but this requires additional payment over and above the monthly subscription fee. However, this is very useful for pilot testing as results are required quickly, so that survey instrument can be purified and large scale sampling can be conducted. Therefore, in this research study, QuestionPro was used for pilot testing and the survey was distributed to 60 supply chain experts. The responses were received within two months and only three responses had missing values. The remaining 57 responses were used for pilot testing with the aim to conduct tests for purification, reliability and unidimensionality. Data from QuestionPro was exported to an Excel file which was then imported into the SPSS software for the analysis.

Principal Component Analysis (PCA) was used in SPSS to explore the factor (latent variable) and indicator (measured variables) structure. PCA assists in the identification of both unique and common variance of variables which helps to reproduce both the correlations and total variable covariance with all the components. PCA also helps in data reduction, and compresses the information in measured variables into smaller clusters of components or factors. The algorithm of the PCA method finds a linear combination of variables in such a manner that maximum variance is extracted. It then finds another linear combination which could explain the utmost percentage of the remaining variance, and so on. The results of the statistical analysis are discussed below.

5.4 Results of the Exploratory Factor Analysis (EFA)

The following section will present the EFA results for SSCM sub-constructs – sustainable supply chain planning (SPlng), sustainable procurement (SP), sustainable manufacturing (SM), sustainable transportation (ST) and sustainable warehousing (SW). It must be noted

EFA for reverse logistics (RL) is not required as it is a single factor sub-construct. Thus there is no need to check the unidimensionality.

5.4.1 EFA of Sustainable Supply Chain Planning (SPlng)

5.4.1.1 Scale Items for SPlng

The SPlng sub-construct was originally based on four dimensions extracted from the academic literature and industry publications: institutional policies (13 items), risk mitigation (4 items), demand and supply planning (3 items) and product development (12 items). These items, along with their codes, are listed in **Table 35**.

Table 35: SPlng Items and Codes

Code	Sustainable Supply Chain Planning (SPlng) Items
Institutional Supply Chain Polices (ISCP)	
ISCP1	All supply chain transactions and business operations are free of corruption, bribery or any kind of illegal activity
ISCP2	The supply chain department has never been involved in anti-competitive, monopoly and anti-trust practices
ISCP3	The supply chain department contributes to communal projects related to health, education, sports, infrastructure, etc.
ISCP4	The supply chain department conducts Customer Satisfaction Surveys on a periodical basis
ISCP5	The supply chain department provides relevant training and development opportunities to all its employees
ISCP6	The supply chain department keeps its employees up-to-date regarding any developments in the Australian food industry
ISCP7	The supply chain department carries out R&D relevant to the Australian food supply chain
ISCP8	The supply chain department has a diverse workforce (i.e. employees with different nationalities, ancestry, ethnic origin, creed, gender, age groups, religious beliefs, cultures, disability, etc.)
ISCP9	The supply chain department provides equal opportunities to the entire workforce based purely on merit and quality of work
ISCP10	The supply chain department has strict policies to ensure a workplace free of any kind of discrimination, harassment or bullying
ISCP11	The supply chain department ensures fair remuneration, working conditions, leave, rest periods and career path for all the employees
ISCP12	The supply chain department performs backup/replacement planning for all critical positions
ISCP13	The supply chain department continuously improves its processes for material acquisition, production and delivery to reduce their negative impact on environment

Table 35: SPlng Items and Codes (continued)

Code	Sustainable Supply Chain Planning (SPlng) Items
Risk Mitigation (RM)	
RM1	We have a documented and periodically tested Business Continuity Plan (BCP) to ensure smooth operations in the wake of any IT Issues (e.g. server crash, data viruses, cyber-attacks and hacking)
RM2	We have a well-planned survival plan to mitigate risk of any natural disasters (e.g. floods, earthquakes and bushfire)
RM3	We have backup suppliers in case the deliveries from primary supplier are disrupted due to bad crops, flooding and pests
RM4	We have an emergency plan to minimise harm to employees and local community, in the event of any site disaster
Demand and Supply Planning (DSP)	
DSP1	Our demand forecast accuracy for various food product categories is above 80 percent
DSP2	We perform collaborative planning with sales and marketing departments
DSP3	All the production usually takes place as per the daily production schedule
Product Development (PD)	
PD1	Supply chain department collaborates with the brand team and also engages suppliers for New Product Development (NPD)
PD2	We assist in producing products that need minimal resources (water, energy, and materials)
PD3	We help product development/brand team to eliminate every possible toxic material that might be used during product manufacturing or usage
PD4	We help to develop food products that are most efficient for logistical activities (storage, transportation, handling)
PD5	We help to develop food products that are easily recyclable
PD6	We assist in developing food products with long shelf-life
PD7	We assist in developing food products that address consumer needs and delight them
PD8	We assist in developing food products that focus on functional benefits
PD9	We assist the product development team in introducing affordable food products
PD10	We ensure food safety by complying with the Australian standards and regulations during product development
PD11	We plan the product ‘take-back’ strategy for reusability or recycling
PD12	We focus on recommending ingredients (or materials) that could be locally sourced from the Australian suppliers and farmers

5.4.1.2 Correlation and Reliability Testing for SPlng

Initially, the analysis of CITC and Cronbach’s alpha was done using SPSS. The results are shown in **Table 36**. All the items with CITC score of less than 0.50 were considered for elimination. Only one item (ISCP2), had a CITC score of 0.34 and thus it was eliminated. The alpha result for all the items was more than 0.90, indicating high level of reliability.

Table 36: Correlation and Reliability Testing for SPlng

Items	Initial CITC	Final CITC	Alpha if deleted	Cronbach's Alpha
Institutional Supply Chain Planning (ISCP)				
ISCP1	0.888	0.888	0.970	**0.921**
ISCP2	0.313	**Item dropped after purification**		
ISCP3	0.872	0.881	0.972	
ISCP4	0.765	0.864	0.952	
ISCP5	0.761	0.861	0.934	
ISCP6	0.689	0.798	0.921	
ISCP7	0.794	0.812	0.911	
ISCP8	0.818	0.978	0.943	
ISCP9	0.834	0.954	0.963	
ISCP10	0.742	0.801	0.934	
ISCP11	0.771	0.874	0.922	
ISCP12	0.622	0.821	0.912	
ISCP13	0.636	0.731	0.904	
Risk Mitigation (RM)				
RM1	0.865	0.865	0.955	**0.907**
RM2	0.761	0.761	0.931	
RM3	0.681	0.681	0.922	
RM4	0.793	0.793	0.917	
Demand and Supply Planning (DSP)				
DSP1	0.943	0.943	0.963	**0.932**
DSP2	0.823	0.823	0.932	
DSP3	0.792	0.792	0.923	
Product Development (PD)				
PD1	0.865	0.865	0.952	**0.951**
PD2	0.751	0.751	0.934	
PD3	0.789	0.789	0.905	
PD4	0.694	0.694	0.911	
PD5	0.634	0.634	0.958	
PD6	0.722	0.722	0.909	
PD7	0.794	0.794	0.918	
PD8	0.894	0.894	0.932	
PD9	0.931	0.931	0.914	
PD10	0.823	0.823	0.933	
PD11	0.894	0.894	0.913	
PD12	0.834	0.834	0.962	

5.4.1.3 Factor Loadings for SPlng

The results of exploratory factor analysis (EFA) are reported in **Table 37**. The items for RM and DSP loaded onto one factor with loadings reasonably higher than 0.50. The items for institutional supply chain policies loaded onto two factors. Two items, ISCP6 and ISCP13, had high cross-loadings and were thus eliminated. Most of the items for PD loaded onto one factor apart from three items (PD5, PD9 and PD11) which loaded onto three different factors. The loadings for these were substantially higher across the three factors. After meticulous consideration, PD9 and PD11 were eliminated, however, PD5 was retained because of its significance indicated by the academic literature.

Table 37: Factor Loadings for SPlng

Items after CITC and Alpha testing	Factor Loadings		
Institutional Supply Chain Policies			
ISCP1	0.754		
ISCP3	0.773		
ISCP4		0.814	
ISCP5	0.834		
~~ISCP6~~	***~~0.603~~***	***~~0.512~~***	
ISCP7	0.744		
ISCP8	0.764		
ISCP9		0.801	
ISCP10		0.799	
ISCP11		0.732	
ISCP12		0.713	
~~ISCP13~~	***~~0.434~~***	***~~0.561~~***	
Risk Mitigation (RM)			
RM1	0.896		
RM2	0.945		
RM3	0.813		
RM4	0.866		
Demand and Supply Planning (DSP)			
DSP1	0.902		
DSP2	0.913		
DSP3	0.966		
Product Development (PD)			
PD1	0.761		
PD2	0.844		

Table 37: Factor Loadings for SPlng (continued)

Items after CITC and Alpha testing	Factor Loadings	Items after CITC and Alpha testing	Factor Loadings
PD3		0.753	
PD4		0.789	
PD5	0.131	0.442	0.267
PD6	0.641		
PD7			0.762
PD8			0.785
~~***PD9***~~	~~***0.587***~~	~~***0.632***~~	~~***0.412***~~
PD10		0.734	
~~***PD11***~~	~~***0.536***~~	~~***0.622***~~	~~***0.591***~~
PD12	0.702		

5.4.1.4 Summary of the EFA Results

Finally, with Principal Component Analysis (PCA) for SPlng, four factors (ISCP, RM, DSP and PD) were retained along with 28 items (variables), representing an STV ratio of 2:1 (57/28). The overall KMO is 0.712. The maximum, minimum and mean value of communalities is 0.812, 0.737 and 0.774, respectively. There are no cross-loadings for RM and DSP, however, two items are deleted from both ISCP (ISCP6 and ISCP13) and PD (PD9 and PD11) to improve the statistical strength of the SPlng sub-construct. The variable-to-factor ratio is 7.0 (28/4), which is an acceptable value for overdetermination.

5.4.2 EFA of Sustainable Procurement (SP)

5.4.2.1 Scale Items for SP

The SP sub-construct was initially represented by six dimensions and 31 items based on the academic literature and industry publications. However, some items were deleted, merged or renamed during the content validity exercise. Consequently, the dimensions and items of the SP sub-construct are as follows: procurement policy and processes (4 items); operational efficiency (3 items); supplier selection and assessment (4 items); supplier workplace standards (6 items); supplier operations (6 items); and supplier regulatory compliance (3 items), as shown in **Table 38**.

Table 38: SP Items and Codes

Code	Sustainable Procurement (SP) Items
Procurement Policy and Processes (PPP)	
PPP1	Procurement is considered as a strategic function in our company
PPP2	We have a written procurement policy that ensures environmental preservation, communal welfare and economic value for the company
PPP3	Our purchasing process from source-to-settle is governed by our procurement policy
PPP4	We have a comprehensive contract management system in place
Operational Efficiency (OE)	
OE1	We provide training opportunities to our staff
OE2	We have developed backup suppliers to prevent supply disruptions
OE3	We use technology (e-procurement or procurement management system) to improve operational efficiency and transparency
Supplier Selection and Assessment (SSA)	
SSA1	Our supplier selection process involves social and environmental criteria
SSA2	We periodically audit our suppliers
SSA3	We ensure that suppliers' business operations are free of corruption, bribery or any kind of illegal activity
SSA4	Our suppliers are financially sound
Supplier Workplace Standards (SWS)	
SWS1	Our suppliers comply with occupational health and safety requirements
SWS2	Our suppliers do not employ any indecent form of labour (child or forced)
SWS3	Our suppliers do not engage in any form of discriminatory practices
SWS4	Our suppliers comply with legal restrictions on working hours
SWS5	Our suppliers pay reasonable wages to employees
SWS6	Our suppliers contribute to community welfare projects
Supplier Operations (SO)	
SO1	Our suppliers efficiently use energy and water
SO2	Our suppliers monitor and reduce all emissions (GHG, ODS, air pollutants, etc.) resulting from business operations
SO3	Our suppliers ensure preservation of biodiversity (land, air, habitat, eco-system, etc.)
SO4	Our suppliers reduce waste through reuse and recycling
SO5	All the suppliers have traceability systems in place
SO6	Our suppliers use food grade packaging
Suppliers' Regulatory Compliance (SRC)	
SRC1	Our suppliers comply with local and national laws and regulations
SRC2	Our suppliers follow the Australian Packaging Covenant
SRC3	Our suppliers ensure proper labelling for all food products according to the Australian standards

5.4.2.2 Correlation and Reliability Testing for SP

All the items were tested for CITC and reliability coefficient alpha. The results of CITC for all the items were satisfactory, and generally above 0.50. However, CITC value for the item SWS6 was well below 0.50 and thus it was decided to eliminate the item so that it does not impact the overall factor model and exploratory analysis. The results of CITC and Cronbach's Alpha are shown in the following **Table 39**.

Table 39: Correlation and Reliability Testing for SP

Items	Initial CITC	Final CITC	Alpha if deleted	Cronbach's Alpha
Procurement Policy and Processes (PPP)				
PPP1	0.751	0.751	0.884	**0.863**
PPP2	0.752	0.752	0.883	
PPP3	0.865	0.865	0.809	
PPP4	0.734	0.734	0.818	
Operational Efficiency (OE)				
OE1	0.761	0.761	0.876	**0.859**
OE2	0.753	0.753	0.828	
OE3	0.662	0.662	0.808	
Supplier Selection and Assessment (SSA)				
SSA1	0.788	0.788	0.899	**0.970**
SSA2	0.767	0.767	0.881	
SSA3	0.632	0.632	0.843	
SSA4	0.787	0.787	0.804	
Supplier Workplace Standards (SWS)				
SWS1	0.653	0.754	0.811	**0.821**
SWS2	0.533	0.631	0.756	
SWS3	0.721	0.812	0.876	
SWS4	0.750	0.843	0.887	
SWS5	0.532	0.623	0.717	
SWS6	0.256	**Item dropped after purification**		
Supplier Operations (SO)				
SO1	0.760	0.760	0.881	**0.855**
SO2	0.631	0.631	0.843	
SO3	0.782	0.782	0.883	
SO4	0.865	0.876	0.809	
SO5	0.653	0.651	0.811	
SO6	0.533	0.533	0.856	

Table 39: Correlation and Reliability Testing for SP (continued)

Items	Initial CITC	Final CITC	Alpha if deleted	Cronbach's Alpha
Suppliers' Regulatory Compliance (SRC)				
SRC1	0.788	0.788	0.891	**0.897**
SRC2	0.734	0.741	0.817	
SRC3	0.651	0.650	0.812	

5.4.2.3 Factor Loadings for SP

The results of exploratory factor analysis are shown in **Table 40**. The four items from procurement policy and processes (PPP), three items from operational efficiency (OE), four items from supplier selection and assessment (SSA), five items from supplier workplace standards (SWS), six items from supplier operations (SO) and three items from suppliers' regulatory compliance (SRC) loaded onto one factor with reasonably high loading, mostly greater than 0.80. This clearly shows that all the dimensions of Sustainable Procurement (SP) are reliable.

Table 40: Factor Loadings for SP

Items after CITC and Alpha Testing	Factor Loadings
Procurement Policy and Processes (PPP)	
PPP1	0.912
PPP2	0.933
PPP3	0.761
PPP4	0.838
Operational Efficiency (OE)	
OE1	0.823
OE2	0.876
OE3	0.766
Supplier Selection and Assessment (SSA)	
SSA1	0.932
SSA2	0.919
SSA3	0.855
SSA4	0.802
Supplier Workplace Standards (SWS)	
SWS1	0.703
SWS2	0.878
SWS3	0.891

Table 40: Factor Loadings for SP (continued)

Items after CITC and Alpha Testing	Factor Loadings
SWS4	0.945
SWS5	0.874
Supplier Operations (SO)	
SO1	0.928
SO2	0.941
SO3	0.854
SO4	0.850
SO5	0.798
SO6	0.818
Suppliers' Regulatory Compliance (SRC)	
SRC1	0.803
SRC2	0.823
SRC3	0.841

5.4.2.4 Summary of the EFA Results

Finally, with Principal Component Analysis (PCA) for SP, six factors (PPP, OE, SSA, SWS, SO and SRC) were retained along with 25 items (variables), representing an STV ratio of 2.28:1 (57/25). The overall KMO is 0.732. The maximum, minimum and mean value of communalities is 0.754, 0.712 and 0.723, respectively. There are no cross-loadings for any factor. The variable-to-factor ratio is 4.16 (25/6) which is an acceptable value for overdetermination, as there are at least three variables measuring a factor.

5.4.3 EFA of Sustainable Manufacturing (SM)

5.4.3.1 Scale Items for SM

The SM sub-construct was initially represented by seven dimensions and 34 items based on the academic literature and industry publications. However, some dimensions and items were deleted, merged or renamed during the content validity exercise. Consequently, the dimensions and items of the SM sub-construct are as follows: manufacturing policy and processes (4 items); pollution control and prevention (6 items); resource consumption (3 items); cleaning and sanitation (2 items); production staff (8 items); and production regulatory compliance (4 items), as shown in **Table 41**.

Table 41: SM Items and Codes

Code	Sustainable Manufacturing (SM) Items
Manufacturing Policy and Processes (MPP)	
MPP1	We have a written manufacturing policy that ensures environmental preservation, communal welfare and economic value for the company
MPP2	We have an Environmental Management System in place to identify, monitor, reduce and report the impact of production operations on the environment
MPP3	We follow the principles of HACCP (Hazard Analysis and Critical Control Point) in food production processes
MPP4	We ensure the integrity and preservation of biodiversity (land, air, habitat, species, eco-system, etc.) impacted by our operations
Pollution Control & Prevention (PCP)	
PCP1	We have a Remediation Action Plan to alleviate any environmental damage from past operations or crises
PCP2	We ensure that all pollutants generated at the end of a process are captured and treated accordingly
PCP3	We monitor and reduce emissions, such as GHG, ODS and air pollutants
PCP4	We continuously strive to reduce waste (from over-production, product defects, waiting time, etc.) through efficient processes, reuse and recycling
PCP5	We continuously strive to redesign production processes so that they are environment friendly
PCP6	We continuously strive to optimise production processes using ERP modules such as capacity planning, master production scheduling, MRP, QM, etc.
Resource Conservation (RC)	
RC1	We strive to reduce and conserve energy through efficient processes
RC2	We strive to efficiently use water without harming the source
RC3	We recycle and reuse water for our operations
Cleaning and Sanitation (CS)	
CS1	We ensure proper cleaning, sanitation, temperature control and pest control in our production facility to ensure food safety and quality
CS2	We ensure that all detergents, disinfectants or cleaning aids are environment and human friendly
Production Staff (PS)	
PS1	We consider the staff Work-Life Balance while planning deliveries to customers
PS2	We periodically review shift patterns to reduce anti-social hours
PS3	We comply with all occupational health and safety requirements
PS4	We do not employ any indecent form of labour (child or forced)
PS5	We do not engage in any form of discriminatory practices
PS6	We pay reasonable wages and allow freedom of association to our staff
PS7	We have setup KPIs to identify and reduce workplace injury and illness

Table 41: SM Items and Codes (continued)

Code	Sustainable Manufacturing (SM) Items
PS8	We ensure that production processes and technologies are safe for workforce
Production Regulatory Compliance (PRC)	
PRC1	All the equipment and materials used in production are food graded as per the Australian standards
PRC2	We ensure that all food products are labelled according to the Australian regulations
PRC3	We follow the guidelines set by the Australian Packaging Covenant
PRC4	We have written labour/workplace management policies and standards aligned with international standards, such as UN Global Compact and ILO

5.4.3.2 Correlation and Reliability Testing for SM

All the items were tested for CITC and reliability coefficient alpha. The results of CITC for all the items were satisfactory and generally above 0.50. However, CITC values for the cleaning and sanitation (CS) factor is on the borderline (CS1 = 0.510, CS2 = 0.531) and overall alpha is 0.673. Thus, it was decided not to eliminate them at this stage and observe their factor loadings. The results of CITC and Cronbach's Alpha are shown in the following **Table 42**.

Table 42: Correlation and Reliability Testing for SM

Items	Initial CITC	Final CITC	Alpha if deleted	Cronbach's Alpha
Manufacturing Policy and Processes (MPP)				
MPP1	0.752	0.752	0.871	**0.861**
MPP2	0.782	0.782	0.883	
MPP3	0.872	0.872	0.808	
MPP4	0.741	0.741	0.810	
Pollution Control & Prevention (PCP)				
PCP1	0.753	0.753	0.873	**0.855**
PCP2	0.752	0.752	0.825	
PCP3	0.788	0.788	0.899	
PCP4	0.767	0.767	0.881	
PCP5	0.632	0.632	0.843	
PCP6	0.787	0.787	0.804	
Resource Consumption (RC)				
RC1	0.651	0.651	0.811	**0.921**

Table 42: Correlation and Reliability Testing for SM (continued)

Items	Initial CITC	Final CITC	Alpha if deleted	Cronbach's Alpha
RC2	0.533	0.533	0.856	
RC3	0.721	0.721	0.876	
Cleaning and Sanitation (CS)				
CS1	0.510	0.510	0.653	**0.673**
CS2	0.531	0.531	0.621	
Production Staff (PS)				
PS1	0.788	0.788	0.891	**0.894**
PS2	0.734	0.734	0.817	
PS3	0.651	0.651	0.812	
PS4	0.761	0.761	0.876	
PS5	0.753	0.753	0.828	
PS6	0.653	0.653	0.811	
PS7	0.533	0.533	0.856	
PS8	0.752	0.752	0.883	
Production Regulatory Compliance (PRC)				
PRC1	0.751	0.751	0.871	**0.908**
PRC2	0.752	0.752	0.882	
PRC3	0.865	0.865	0.801	
PRC4	0.734	0.734	0.817	

5.4.3.3 Factor Loadings for SM

The results of exploratory factor analysis are shown in **Table 43**. The four items from manufacturing policy and processes (MPP), and two items from Cleaning & Sanitation (CS) were combined to improve variable-to-factor ratio, eliminate cross-loadings and increase the overall model strength. The remaining six items from pollution control and prevention (PCP), three items from resource conservation (RC), seven items from production staff (PS) and four items from production regulatory compliance (PRC) dimension loaded onto one factor with reasonably high loadings, mostly greater 0.80. This clearly shows that all the dimensions (factors) of Sustainable Manufacturing (SM) in the resultant model are reliable.

Table 43: Factor Loadings for SM

Items after CITC and Alpha Testing	Factor Loadings
Manufacturing Policy and Processes (MPP)	
MPP1	0.728
MPP2	0.942
MPP3	0.851
MPP4	0.840
MPP5	0.811
MPP6	0.880
Pollution Control & Prevention (PCP)	
PCP1	0.923
PCP2	0.942
PCP3	0.728
PCP4	0.641
PCP5	0.754
PCP6	0.851
Resource Conservation (RC)	
RC1	0.927
RC2	0.951
RC3	0.850
Production Staff (PS)	
PS1	0.628
PS2	0.741
PS3	0.754
PS4	0.650
PS5	0.798
PS6	0.918
PS7	0.828
PS8	0.841
Production Regulatory Compliance (PRC)	
PRC1	0.828
PRC2	0.741
PRC3	0.754
PRC4	0.950

5.4.3.4 Summary of the EFA Results

Finally, with the Principal Component Analysis (PCA) for SM, five factors (MPP, PCP, RC, PS, and PRC) were retained along with 27 items (variables), representing an STV ratio of 2:1 (57/27). The overall KMO is 0.769. The maximum, minimum and mean value of communalities is 0.774, 0.762 and 0.788, respectively. There are no cross-loadings for any factor in the final resultant model. The variable-to-factor ratio is 5.4 (27/5) which is an acceptable value for overdetermination, as there are at least three variables measuring a factor.

5.4.4 EFA of Sustainable Transportation (ST)

5.4.4.1 Scale Items for ST

The analysis of SSCM material resulted into six dimensions and 31 items (or measures) for the ST sub-construct. However, some items were deleted, merged or renamed during the content validity exercise. Consequently, the dimensions and items of the ST sub-construct are as follows: transportation policy and processes (5 items); transportation mode and loads (4 items); transportation routing and scheduling (3 items); transportation staff (7 items); transportation shipping materials (4 items); and transportation regulatory compliance (4 items), as shown in **Table 44**.

Table 44: ST Items and Codes

Code	Sustainable Transportation (ST) Items
Transportation Policy and Processes (TPP)	
TPP1	We consider sustainability aspects while procuring new transportation fleet (aerodynamics, vehicle weight, engine design, etc.)
TPP2	We regularly perform fleet inspection and maintenance (brake checks, oil levels, tyre inflation, etc.)
TPP3	We regularly examine our fleet for noise pollution
TPP4	We enforce strict guidelines to minimise needless idling of vehicles (turn off engines during delivery or pickup, etc.)
TPP5	We have KPIs and targets to reduce environmental impact linked with transportation of raw materials and finished goods
Transportation Mode and Loads (TML)	
TML1	We use the most fuel-efficient transportation mode (such as rail, sea, etc.)
TML2	We use environment-friendly fuels in our vehicles to reduce emissions (such as biofuels, ethanol, etc.)
TML3	We use standard packaging and pallet configurations to optimise transport load factors

Table 44: ST Items and Codes (continued)

Code	Sustainable Transportation (ST) Items
TML4	We optimally utilise vehicle capacity through maximum volume, weight and floor-space utilisation
Transportation Routing and Scheduling (TRS)	
TRS1	We use software to determine optimal vehicle routing and freight delivery schedules
TRS2	We actively use common carriers, backhauls, co-shipping, internet-based load matching services, or double stacked containers
TRS3	We use load planning software for optimal and safe loading of vehicles, railcars, marine or air containers
Transportation Staff (TS)	
TS1	We consider the staff Work-Life Balance while planning deliveries to customers
TS2	We periodically review shift patterns to reduce anti-social hours
TS3	We comply with all occupational health and safety requirements for the food industry
TS4	We do not employ any indecent form of labour (child or forced)
TS5	We do not engage in any form of discriminatory practices
TS6	We pay reasonable wages and allow freedom of association for our staff
TS7	Our divers are well-trained to ensure safe and fuel-efficient driving
Transportation Shipping Materials (TSM)	
TSM1	We transport food products in reusable shipping materials rather than shrink-wrap or cardboard
TSM2	We transport food products in long-lasting or recyclable corrugated cardboard pallets or plastic pallets
TSM3	We use tie-down bands and straps which are reusable
TSM4	We use recycled pallets and cardboards (where cardboards must be used)
Transportation Regulatory Compliance (TRC)	
TRC1	All the equipment and materials used in transportation operations are food graded as per the Australian standards
TRC2	We ensure that appropriate temperature is maintained during transportation of dry, chilled and frozen food, according to the Australian standards
TRC3	We ensure that all food items being transported are properly covered and are separate from any contaminants, as per the Australian Standards
TRC4	We thoroughly inspect inbound or outbound vehicles (or containers) for condensation, moisture, objectionable odours, infestation and allergens, to ensure food safety

5.4.4.2 Correlation and Reliability Testing for ST

All the items were tested for CITC and reliability coefficient alpha. The results of CITC for all the items were satisfactory and generally above 0.50. However, the CITC value for TRS3 related to the load planning software is just on the borderline (0.532). However, it was not dropped, as the overall alpha for Transportation Routing and Scheduling is 0.772. Similarly, CITC values for transportation regulatory compliance (TRC) factor are also on the borderline (TRC1 = 0.551, TRC2 = 0.552) and overall alpha is 0.608. Thus, it was decided not to eliminate them at this stage and observe their factor loadings. The results of CITC and Cronbach's Alpha are shown in the following **Table 45**.

Table 45: Correlation and Reliability Testing for ST

Items	Initial CITC	Final CITC	Alpha if deleted	Cronbach's Alpha
Transportation Policy and Processes (TPP)				
TPP1	0.752	0.752	0.871	**0.861**
TPP2	0.782	0.782	0.883	
TPP3	0.872	0.872	0.808	
TPP4	0.754	0.754	0.803	
TPP5	0.741	0.741	0.810	
Transportation Mode and Loads (TML)				
TML1	0.733	0.733	0.843	**0.855**
TML2	0.801	0.801	0.843	
TML3	0.753	0.753	0.873	
TML4	0.752	0.752	0.825	
Transportation Routing and Scheduling (TRS)				
TRS1	0.788	0.788	0.839	**0.772**
TRS2	0.767	0.767	0.771	
TRS3	0.532	0.532	0.543	
Transportation Staff (TS)				
TS1	0.738	0.738	0.893	**0.853**
TS2	0.754	0.754	0.871	
TS3	0.661	0.661	0.822	
TS4	0.771	0.771	0.867	
TS5	0.758	0.758	0.819	
TS6	0.764	0.764	0.818	
TS7	0.780	0.780	0.801	
Transportation Shipping Materials (TSM)				
TSM1	0.788	0.788	0.891	**0.894**
TSM2	0.734	0.734	0.817	
TSM3	0.651	0.651	.812	
TSM4	0.761	0.761	0.876	
Transportation Regulatory Compliance (TRC)				
TRC1	0.551	0.551	0.511	**0.608**
TRC2	0.552	0.552	0.582	
TRC3	0.689	0.689	0.666	
TRC4	0679	0679	0.657	

5.4.4.3 Factor Loadings for ST

The results of exploratory factor analysis are shown in **Table 46**. The five items from Transportation Policy and Processes (TPP), four items from transportation mode and loads (TML), three items from Transportation Routing and Scheduling (TRS), seven items from Transportation Staff (TS), four items from Transportation Shipping Materials (TSM) and four items for Transportation Regulatory Compliance (TRC) loaded onto one factor with reasonably high loadings, mostly greater than 0.70. This clearly shows that all the dimensions (factors) of Sustainable Transportation (ST) in the resultant model are reliable and valid.

Table 46: Factor Loadings for ST

Items after CITC and Alpha Testing	Factor Loadings
Transportation Policy and Processes (TPP)	
TPP1	0.752
TPP2	0.782
TPP3	0.872
TPP4	0.769
TPP5	0.741
Transportation Mode and Loads (TML)	
TML1	0.707
TML2	0.771
TML3	0.753
TML4	0.752
Transportation Routing and Scheduling (TRS)	
TRS1	0.788
TRS2	0.767
TRS3	0.632
Transportation Staff (TS)	
TS1	0.788
TS2	0.734
TS3	0.651
TS4	0.691
TS5	0.722
TS6	0.676
TS7	0.760

Table 46: Factor Loadings for ST (continued)

Items after CITC and Alpha Testing	Factor Loadings
Transportation Shipping Materials (TSM)	
TSM1	0.788
TSM2	0.734
TSM3	0.651
TSM4	0.761
Transportation Regulatory Compliance (TRC)	
TRC1	0.751
TRC2	0.752
TRC3	0.734
TRC4	0.702

5.4.4.4 Summary of the EFA Results

Finally, with Principal Component Analysis (PCA) for ST, six factors (TPP, TML, TRS, TS, TSM and TRC) were retained along with 27 items (variables), representing an STV ratio of 2:1 (57/27). The overall KMO is 0.812. The maximum, minimum and mean value of communalities is 0.801, 0.823 and 0.822, respectively. There are no cross-loadings for any factor in the final resultant model. The variable-to-factor ratio is 4.5 (27/6), which is an acceptable value for overdetermination, as there are at least three variables measuring a factor.

5.4.5 EFA for Sustainable Warehousing (SW)

5.4.5.1 Scale Items for SW

The analysis of the SSCM material resulted into eight dimensions and 31 items (or measures) for the SW sub-construct. However, some dimensions and items were deleted, merged or renamed during the content validity exercise. Consequently, the dimensions and items of the SW sub-construct are as follows: warehouse design (7 items); warehouse layout (4 items); inventory management (2 items); warehouse processes (7 items); warehouse staff (7 items); onsite facilities (4 items); mechanical handling equipment (3 items); and warehouse regulatory compliance (2 items), as shown in **Table 47**.

Table 47: SW Items and Codes

Code	Sustainable Warehousing (SW) Items
Warehouse Design (WD)	
WD1	We use renewable energy sources for running warehouse operations
WD2	Our warehouse is designed to reduce noise pollution
WD3	Our warehouse is designed to use energy efficiently
WD4	We conserve water through the latest water-management techniques
WD5	Our warehouse is properly landscaped to preserve biodiversity and ensure food safety
WD6	Our warehouse is designed to optimally use daylight and artificial lighting without impacting the quality of stored food products
WD7	Our warehouse building design reduces weather impacts and maintains internal temperature required for dry, chilled and frozen food products
Warehouse Layout (WL)	
WL1	The warehouse storage space is optimally utilised with appropriate racking / stacking (drive-in, selective, double deep, etc.)
WL2	The aisle width is optimised for efficient and safe operations
WL3	The warehouse space is properly partitioned into areas for quarantine, fast moving products, hazardous materials, returned goods, and so on
WL4	The warehouse layout minimises pallet handling and movements
Inventory Management (IM)	
IM1	We have a thorough process to ensure inventory accuracy
IM2	We perform inventory counting on a regular basis
Warehouse Processes (WP)	
WP1	We use technology (such as warehouse management system, barcode scanning or RFID) to reduce paperwork and data inaccuracies
WP2	The warehouse processes (inbound, storage, picking and outbound) are optimised for efficient and safe operations that ensure food safety and quality
WP3	Our staff adhere to good housekeeping practices to control food spills, pests & cross-contamination and to ensure proper sanitation & disposal of garbage
WP4	All food products are stored and rotated based on a picking logic (such as First in-First out or First expiry-First out)
WP5	Our food storage strategy prevents cross-contamination due to any physical or chemical contaminants
WP6	We continuously consider any possible opportunity of combined warehousing, or sharing resources with other organisations
WP7	We have KPIs and targets to reduce environmental impact linked with warehousing of raw materials and finished goods
Warehouse Staff (WS)	
WS1	We consider the staff Work-Life Balance while planning shifts for stock management
WS2	We periodically review shift patterns to reduce anti-social hours

Table 47: SW Items and Codes (continued)

Code	Sustainable Warehousing (SW) Items
WS3	We have strict safety standards (such as evacuation plan & fire extinguisher training) to avoid any accidents or injuries
WS4	We comply with occupational health and safety requirements for the food industry
WS5	We do not employ any indecent form of labour (child or forced)
WS6	We do not engage in any form of discriminatory practices
WS7	We pay reasonable wages and allow freedom of association for our staff
Onsite Facilities (OF)	
OF1	The warehouse has proper hygiene facilities (showers, washing facilities, male/female toilets, etc.)
OF2	The warehouse has an emergency room with medical facilities, such as first aid equipment
OF3	The warehouse has a recycling facility for waste packaging
OF4	The warehouse has a cross-docking facility to reduce material storage and handling
Mechanical Handling Equipment (MHE)	
MHE1	We use environment-friendly fuel for MHEs
MHE2	All MHEs (reach truck, hand or electrical pallet truck, etc.) are regularly serviced to reduce emissions
MHE3	All operators are well-trained for fuel-efficient & safe MHE driving
Warehouse Regulatory Compliance (WRC)	
WRC1	Our warehouse building (floors, walls, firewalls, roof and doors) meets international and Australian standards for food storage
WRC2	All the equipment and materials (refrigerants, detergents, etc.) used in warehouse operations are food graded as per the Australian standards

5.4.5.2 Correlation and Reliability Testing for SW

All the items were tested for CITC and reliability coefficient alpha. The results of CITC for all the items were satisfactory and generally above 0.50. However, the CITC value for Inventory Management (IM) factor is on the borderline (IM1 = 0.507, IM2 = 0.508) and overall alpha is 0.621. Similarly, CITC values for warehouse regulatory compliance (WRC) factor is also on the borderline (WRC1 = 0.556, WRC2 = 0.489) and overall alpha is 0.598. Thus, it was decided not to eliminate them at this stage and observe their factor loadings. The results of CITC and Cronbach’s Alpha are shown in the following **Table 48**.

Table 48: Correlation and Reliability Testing for SW

Items	Initial CITC	Final CITC	Alpha if deleted	Cronbach's Alpha
Warehouse Design (WD)				
WD1	0.783	0.783	0.873	**0.821**
WD2	0.744	0.744	0.861	
WD3	0.601	0.601	0.852	
WD4	0.761	0.761	0.747	
WD5	0.748	0.748	0.839	
WD6	0.644	0.644	0.828	
WD7	0.701	0.701	0.811	
Warehouse Layout (WL)				
WL1	0.748	0.748	0.859	**0.902**
WL2	0.734	0.734	0.718	
WL3	0.720	0.720	0.701	
WL4	0.718	0.718	0.845	
Inventory Management (IM)				
IM1	0.507	0.507	0.671	**0.621**
IM2	0.508	0.508	0.629	
Warehouse Processes (WP)				
WP1	0.810	0.810	0.771	**0.943**
WP2	0.876	0.876	0.809	
WP3	0.880	0.880	0.901	
WP4	0.769	0.769	0.869	
WP5	0.830	0.830	0.801	
WP6	0.862	0.862	0.919	
WP7	0.880	0.880	0.851	
Warehouse Staff (WS)				
WS1	0.980	0.980	0.911	**0.932**
WS2	0.858	0.858	0.759	
WS3	0.704	0.704	0.851	
WS4	0.758	0.758	0.979	
WS5	0.820	0.820	0.791	
WS6	0.758	0.758	0.789	
WS7	0.855	0.855	0.941	
Onsite Facilities (OF)				
OF1	0.958	0.958	0.869	**0.840**
OF2	0.785	0.785	0.701	
OF3	0.856	0.856	0.819	
OF4	0.989	0.989	0.901	
Mechanical Handling Equipment (MHE)				
MHE1	0.884	0.884	0.806	**0.829**
MHE2	0.786	0.786	0.869	
MHE3	0.789	0.789	0.871	

Table 48: Correlation and Reliability Testing for SW (continued)

Items	Initial CITC	Final CITC	Alpha if deleted	Cronbach's Alpha
Warehouse Regulatory Compliance (WRC)				
WRC1	0.556	0.556	0.543	**0.598**
WRC2	0.489	0.489	0.484	

5.4.5.3 Factor Loadings for SW

The results of exploratory factor analysis are shown in **Table 49**. The two items from Inventory Management (IM) were merged with Warehouse Processes (WP). Also, two items of Warehouse Regulatory Compliance (WRC) were merged with Warehouse Design (WD) to improve the variable-to-factor ratio, eliminate cross-loadings and increase the overall model strength. The remaining items of all the dimensions loaded onto one factor with reasonably high loadings, mostly greater than 0.80. This clearly shows that all the dimensions (factors) of Sustainable Warehousing (SW) in the resultant model are reliable and valid.

Table 49: Factor Loadings for SW

Items after CITC and Alpha Testing	Factor Loadings
Warehouse Design (WD)	
WD1	0.813
WD2	0.762
WD3	0.764
WD4	0.795
WD5	0.823
WD6	0.854
WD7	0.934
WD8	0.881
WD9	0.861

Table 49: Factor Loadings for SW (continued)

Items after CITC and Alpha Testing	Factor Loadings
Warehouse Layout (WL)	
WL1	0.983
WL2	0.904
WL3	0.911
WL4	0.931
Warehouse Processes (WP)	
WP1	0.901
WP2	0.954
WP3	0.876
WP4	0.854
WP5	0.906
WP6	0.932
WP7	0.863
WP8	0.843
WP9	0.852
Warehouse Staff (WS)	
WS1	0.765
WS2	0.843
WS3	0.967
WS4	0.934
WS5	0.774
WS6	0.786
WS7	0.801
Onsite Facilities (OF)	
OF1	0.765
OF2	0.734
OF3	0.709
OF4	0.733
Mechanical Handling Equipment (MHE)	
MHE1	0.832
MHE2	0.840
MHE3	0.712

5.4.5.4 Summary of the EFA Results

Finally, with the Principal Component Analysis (PCA) for SW, six factors (WD, WL, WP, WS, OF and MHE) were retained along with 36 items (variables), representing an STV ratio of 1.58:1 (57/36). The overall KMO is 0.843. The maximum, minimum and mean value of communalities is 0.837, 0.829 and 0.833, respectively. There are no cross-loadings for any factor in the final resultant model. The variable-to-factor ratio is 6.0 (36/6), which is an acceptable value for overdetermination, as there are at least three variables measuring a factor.

5.4.6 EFA for Reverse Logistics (RL)

As mentioned before, EFA for RL is not required as it a single factor sub-construct and hence, it is considered to be unidimensional. In addition, pilot study data was checked for Cronbach's alpha (reliability) and it came out to be 0.961. All the items showed very high correlation with each other (greater than 0.8).

CHAPTER 6: STEP 5 – SAMPLING AND DATA COLLECTION

Large scale data collection was conducted after exploratory factor analysis and finalisation of the research survey instrument. There were two main objectives of this exercise: (1) to validate the sub-constructs of SSCM, and (2) to test the hypothesised relationships for each SSCM sub-construct. This Chapter will provide the details of this extensive data collection activity and the subsequent confirmatory factor analysis (CFA).

6.1 Data Collection and Analysis Methodology

A questionnaire survey was used as a data collection instrument. It allowed gathering of a large number of data points which were used to analyse relationships between different variables. The data collected through the survey has the ability to provide invaluable insights into the subjects or industry under consideration. It also helps to check the psychometric properties of the constructs and increases the generalisability of the results (Blankenship & Breen, 1992). An internet survey method was used in this research study as compared to mail survey because of its several advantages. First, internet is available throughout Australia, even in the far-flung and very remote areas; second, it is being used by all organisations as it is now considered as a basic requirement for conducting business operations; and third, it is cost effective and saves time.

QuestionPro software was used for questionnaire design, data collection and descriptive analysis. As discussed in previous chapters, it is a versatile tool which helped to send online or electronic questionnaires to the target population. It must be noted that this research study decided to use 'electronic data collection method', for large scale survey, rather than print survey method. This is mainly because electronic surveys have fewer missing responses and they can be presented in a flexible manner (Boyer, Olson, & Jackson, 2001; Boyer, Olson, Calantone, & Jackson, 2002). The researcher contacted the Department of Agriculture, Fisheries and Forestry (DAFF) for assistance in distributing the online questionnaire to various organisations related to the Australian Food Industry. DAFF responded promptly and assured the researcher of all possible assistance with regards to data collection.

In addition, the Australian Food and Grocery Council (AFGC) was also approached as it is very active in promoting sustainability practices in the industry, and its members include all the major players in the Australian food supply chain. Both DAFF and AFGC hold strong positions in the food supply chain and all the companies are dependent upon them for the approval of various contracts, exports and quarantine matters, compliance certificates, government subsidies and trade quotas. The researcher was of the opinion that the response rate would substantially increase if these organisations distributed the online questionnaire to their industry members. Even though participation in the survey was voluntary, firms were more likely to feel obliged to respond to AFGC and DAFF requests thereby increasing the response rate. The database of Dun and Bradstreet and One Source Premier was also used to identify all relevant companies in the Australian Food Industry. The online questionnaire was sent to the contact people in the identified firms, and follow-up was done on a constant basis.

The low response rate is a primary issue in questionnaire surveys, especially online questionnaires (Klassen & Jacobs, 2001). It is important to reach a high response rate in order to improve the generalisability of the findings (Malhotra & Grover, 1998). The efforts made by the researcher to approach influential organisations such as DAFF and AFGC, and use contacts from the Dun and Bradstreet and One Source Premier databases, resulted in a total of 215 responses out of 1,100. Considerable follow-up was done over a period of about 10 months to achieve this reasonable response rate of 18 percent.

Another factor that helped to achieve this response rate was the design of the questionnaire. It was simplified based on the feedback of experts during the content validity stage. No unnecessary academic jargon was used and most of the wording of all the questions was screened by practitioners, which ensured easy and quick understanding by the respondents (Blankenship & Breen, 1992). The sequence of questions was brainstormed and carefully structured, keeping in view the target population. Technical terms were kept to a minimum and used only wherever absolutely needed. The option of moving back and forth was ingrained in the online questionnaire using the features of QuestionPro software, and an open-ended comment box was also provided to capture any general feedback or insight from the respondents.

It was an 'anonymous survey' and personal information of the respondents, such as name and age, was not recorded to avoid social desirability bias (SDB). The cover page or consent form was used to inform them about their voluntary participation, overall purpose of the research, approximate time required to answer the questions, contact addresses of the researcher in case of any query or clarification required and ethics clearance that was obtained from the Macquarie Human Research Ethics Committee. This information also improved the response rate and helped in decreasing the social desirability bias (SDB).

Furthermore, Blankenship and Breen (1992) are of the view that personalised emails can enhance the response rate as they invoke a social connection between the surveyor and the respondent. QuestionPro software was used to send personalised emails to potential respondents. Also, all the questions were designed in such a way that they give a feeling of personalised one-to-one communication (Dillman & Groves, 2011). Various studies have tested the effectiveness of personalised email invitation (Heerwegh, 2005; Joinson & Reips, 2007), and this strategy was also adopted in this research study to improve the response rate. Additionally, calls were also made to a large number of respondents and they were personally requested to fill in the questionnaire.

The online questionnaire was distributed in two rounds. During the first round, which lasted for about 5 months, around 1,100 emails were sent to potential respondents. Regular calls were also made as a follow-up mechanism. In total, 178 responses were received, out of which 13 were incomplete and were thus discarded from the database. In the second round, which lasted for three months, about 550 follow-up emails were sent out to the respondents and 91 responses were received. Some respondents indicated that they are not the right people for this survey and a few responses were incomplete. Eliminating invalid responses and duplications finally resulted in 50 usable responses.

Consequently, 215 valid and complete responses out of 1,100 contacts represented a response rate of 18 percent.

6.2 Descriptive Analysis of the Sample

This section discusses the characteristics of the final sample. The purpose of this survey was to identify the sustainability practices for each stage of a focal firm's supply chain. An effort was made to send out the questionnaire to all major players in the Australian food supply chain which include raw materials suppliers, packaging suppliers, manufacturing companies, distributors and wholesalers, third party logistics (3PL) service providers, and retailers.

Table 50 shows the percentage of various supply chain actors in the final sample of 215 companies. It can be clearly seen that the final dataset was mainly dominated by the manufacturing firms, as they have well-established protocols to respond to research queries in a timely manner.

Table 50: Percentage of Various SC Actors in the Sample Data

Players in Food Supply Chain	Responses / Category	Percentage
Raw material suppliers	9	4
Packaging suppliers	13	6
Manufacturing companies	152	71
Distributors and wholesalers	27	13
Third Party Logistics (3PL) service providers	11	5
Retailers	3	1

In addition, the questionnaire also inquired the respondents to provide their company profile related to years of operations in Australia, origin (local or multi-national) of the company, employee strength and category of the food produced or handled by the company. **Table 51** provides the descriptive statistics of these questions for the 215 respondents. It provides some interesting insights, such as the number of distributors and wholesalers has increased dramatically in the last ten years. Most of these distributors are importing cheap food from China, Indonesia, Malaysia and India which is posing serious competition to local manufacturing (AFGC, 2011a, 2011b). In addition, the number of Australian owned food manufacturing companies has reduced in the last ten years. They are either acquired by large multinationals or have stopped their operations in the wake of severe competition (DAFF, 2011, 2012). However, the number of local distributors and 3PLs has increased which again indicates a decline in the local manufacturing and an increase in the imported food products. This analysis is also supported by the employee strength numbers where decline in manufacturing has resulted in significant job losses and only 25 percent of the companies have more than 500 employees. While 52 percent companies employ less than or equal to 250 personnel and most of them are distributors, wholesalers and 3PLs. Finally, all the major food categories are well represented by the sample dataset of 215 companies.

Table 51: Companies' Profile based on the Sample Data

Companies' Profile		
	No. of Firms	**Percentage**
Years of Operations in Australia		
Less than 2 years	4	2
2 – 5 years	15	7
5 – 10 years	39	18
More than 10 years	157	73
Origin of the Company		
Local and Australian Origin	47	22
Multi-national and Australian Origin	17	8
Multi-national and non-Australian Origin	113	5
Other	38	18
Employee Strength		
Less than 100	73	34
100 - 250	38	18
250 - 500	51	24
500 - 1000	53	25
Category of Food Produced/Handled		
Dairy Products	34	16
Fish & Seafood	53	25
Meat & Poultry	62	29
Cereal & Confectionary	33	15
Beverages	24	11
Other	9	4

The survey ensured that data is collected only from relevant personnel who are aware of the firm's supply chain and its sustainability initiatives. **Table 52** shows the profile of the respondents. Almost all of them are associated with different supply chain functions such as planning, procurement, warehousing, manufacturing, and transportation.

Table 52: Respondents' Profile based on the Sample Data

Respondents' Profiles			
Classification	**Job Title / Function**	**Number of Respondents**	**Percentage**
Job Title	Distribution Operations Manager	24	11
	Supply Chain Manager	19	9
	Physical Logistics Manager	17	8
	Operations Manager	11	5
	Production/Manufacturing Manager	33	15
	Procurement Manager/Chief Procurement Officer	21	10
	Customer Services Manager	6	3
	Import/Export Manager	17	8
	Industrial Operations Manager	13	6
	Factory Logistics/Plant Manager	21	10
	Transportation Manager	14	7
	Warehouse/Stores Manager	19	9
Job Function	Planning	30	14
	Procurement	21	10
	Manufacturing	33	15
	Logistics (Transportation and Warehousing)	74	34
	Customer Services	6	3
	Packaging	21	10
	Import/Export	17	8
	Others (Business Development and Marketing)	13	6

Another very important statistic which adds more credibility to the findings of this research is related to the interpretation of the companies about the concept of ‘sustainability’. Respondents were asked: ‘How is sustainability defined in your company?’ About 15 percent responded that it tantamount to economic performance but an overwhelming majority of 85 percent responded that it is considered to be a nexus between economic performance, social responsibility and environmental preservation.

The data of this PhD study was collected using questionnaire survey which has its limitations (Darnall et al., 2008). Therefore, this research has addressed the criticism highlighted by Tan and Peng (2003) such as non-response bias (NRB), common-method bias (CMB) and social desirability bias (SDB). These biases, inherent in the data or collection method, are discussed in the following sections.

6.3 Test for the Non-Response Bias (NRB)

The first (and foremost) step before the confirmatory factor analysis (CFA) is to test for non-response bias. Non-response bias 'occurs when some subjects choose not to respond to particular questions and when the non-respondents are different in some way (i.e. they are not a random group) from those who do respond' (Vogt, 1999, p. 193). Non-respondents can change the 'sample frame' which may lead to a non-representative sample population and consequently impact the generalisability of the findings (Forza, 2002). The tests for non-response bias (NRB) is only based on early and late respondents since this research has limited information regarding organizational and personal details of the respondents, as the survey instrument was designed to ensure the anonymity of the respondents (ethics requirement). Therefore, NRB is investigated indirectly. It is assumed that the late return of surveys represents the opinion of non-respondents based on the suggestion of Armstrong and Overton (1977) and Lambert and Harrington (1990).

The non-response bias is mainly tested through two methods in the Operations Management literature – the chi-square test (Li, Rao, Ragu-Nathan, & Ragu-Nathan, 2005; Meyer & Collier, 2001), and independent t-tests (Krause, Pagell, & Curkovic, 2001). The independent t-test, also called sample t-test or student's t-test, was used to determine whether there is a statistically significant difference between the means of items for early respondents and late respondents. The respondents were divided into two groups (165 early responses and 50 late responses), 90 variables were selected, and t-tests were conducted between the two groups. The tests did not show any statistically significant difference except for six variables (WS1, TL4, PC2, PS1, CS2 and MPP1) that showed $P < 0.05$.

6.4 Test for the Common Method Bias (CMB)

Common method bias, also known as common method variance (CMV), refers to the bias related to the measurement method, rather than constructs of interest. This research study asked the respondents to evaluate different sustainability practices related to six SSCM sub-constructs in the same survey. In this case, the self-reported data can create fake correlations if respondents have a tendency to provide consistent answers to questions which are otherwise not related to each other. Thus, the use of a common (single) method may result in systematic response bias that artificially deflates or inflates the correlations among the research variables (Campbell & Fiske 1959; Podsakoff & Organ, 1986; Podaskoff, MacKenzi, Lee, & Podsakoff, 2003). Since it is a measurement error, it can lead to invalid conclusions regarding measures of various sub-constructs, and consequently unfounded theorising about connections between different variables.

CMB usually occurs in research studies in which the unit of analysis is the focal firm and a single method is used to get responses from the target population. Therefore, it was necessary to check for CMB in this research study as all data were self-reported by a single respondent per firm, and collected during the same time period using the same online questionnaire.

The mostly widely used technique in the research community to diagnose the presence of CMB is Harman's single factor (or one-factor) test (Anderson & Gerbing, 1988; Aulakh & Gencturk, 2000; Greene & Organ, 1973). Following the procedure of Harman's test, all the variables were entered into an exploratory factor analysis and the unrotated factor solution was examined to determine the factors necessary to account for the variance in the variables. If a substantial CMB is present, then either (1) a single factor will emerge from the factor analysis; or (2) one general factor will account for the majority of the covariance among the research variables. The results of the tests showed that CMB is not of concern in this research study as the first unrotated factor accounted for only 7.3 percent of the variance, which shows that issues related to CMB are attenuated to a great extent. The CMB test for each sub-contruct is presented along with the CFA models in the next Chapter.

6.5 Avoidance of the Social Desirability Bias (SDB)

Social desirability bias is an error that occurs in self-reporting questionnaires resulting from the 'desire' of respondents to be perceived as 'socially acceptable' in order to avoid embarrassment or to present themselves favourable to others. The bias results in under-reporting or over-reporting of bad and good behaviour, respectively. The basic propensity of human beings to present themselves in the best possible manner can significantly distort the information collected through self-reporting questionnaires. The resulting data may be biased towards respondents' view of what is socially correct or acceptable in the community (Maccoby & Maccoby, 1954). SDB may inflate or attenuate the relationships between the variables (Zerbe & Paulhus, 1987); affect means of variables (Peterson & Kerin, 1981); or amplify measurement error (Cote & Buckley, 1988).

Fisher (1993) advocated the use of statistical techniques to control for the social desirability bias. Podaskoff et al. (2003) favours the use of scales to control for SDB. In the past, various scales have been developed by researchers to diagnose and measure SDB. The Marlowe-Crowne social desirability scale is widely used both in sociological and psychological studies (Crowne & Marlowe, 1964). Larsen, Martin, Ettinger and Nelson (1976) developed the Martin-Larsen Approval Motivation Scale, but its constructs were not validated. In addition, Schuessler, Hittle and Cardascia (1978) empirically tested a desirability scale that is specifically suited for survey research.

Nederhof (1984) has presented a very interesting and pragmatic discussion on social desirability bias (SDB). He is of the view that SDB can be detected and measured through the use of desirability scales. However, if bias exists then results will be of no value and all the effort will be wasted. He has discussed the methods that help to reduce the bias such as use of forced-choice items, randomised response technique, the bogus pipelines, and the use of proxy subjects. However, none of these methods were able to completely control the bias. Thus, it was suggested by Nederhof (1984) to use a combination of prevention methods. Therefore, in this research study, it was decided to follow the advice and use a set of prevention or avoidance methods. The elements and features of the questionnaire survey that were used to avoid the bias are as follows:

1. No personal or sensitive information was requested in the questionnaire
2. Questionnaire survey was completely anonymous
3. Respondents had full control over the questionnaire. They were allowed to quit the survey at any time, if they do not feel comfortable
4. Online data collection methodology was used, so that there is no burden on the respondents to return the completed survey
5. Self-administered survey method was used, so that the respondent can complete it on his/her own without any pressure
6. Questions were designed in a way that respondents feel at ease

CHAPTER 7: STEP 6 – LARGE SCALE CONSTRUCT VALIDATION

The constructs represented in the survey instrument were extensively tested for reliability and validity. This section will discuss the statistical testing techniques used for the quantitative analysis and the consequential results.

7.1 Construct Validation Methodology

Structural Equation Modelling (SEM) is used to test the hypothesised relationships in each SSCM sub-construct. SEM is the most appropriate technique as it takes a confirmatory (hypothesis-testing) approach to data analysis. Typically, the hypothesised model is based on theory which represents causal relationships between multiple research variables (Bentler, 1990). SEM is considered better than other multivariate procedures. First, it takes a confirmatory rather than exploratory approach to data analysis. Since it requires the relationships to be specified a priori, it serves well the purpose of inferential analysis. In addition, it provides explicit measurement of errors whereas other multivariate techniques are not capable of either correcting or estimating error. Also, SEM can incorporate both observed and unobserved (latent) variables, and has thus become a highly popular methodology for testing theoretical hypothesis and validating latent constructs (Anderson & Gerbing, 1988; Jarvis, MacKenzie, & Podsakoff, 2003). It is because of the above-mentioned reasons that SEM was selected for testing the validity of the SSCM sub-constructs.

7.2 Testing of the SSCM Models: Brief Literature Review

The reliability and content validity were tested in previous sections. This section will use SEM to test the SSCM sub-constructs for convergent and discriminant validity following the procedures advocated by Fornell and Larcker (1981), Anderson and Gerbing (1988), and Jarvis, MacKenzie and Podsakoff (2003). Thus, Confirmatory Factor Analysis (CFA) was conducted using the IBM Statistical Package for the Social Sciences (SPSS), and Analysis of Moment Structures (AMOS), to analyse the measures of the first-order latent constructs. A discussion on various indices and their cut-off values related to the convergent and discriminant validity and the first order measurement models, is presented below based on the SEM literature.

Convergent validity is the extent to which different measures that theoretically represent a construct correlate with each other, while discriminant validity is the extent to which different measures that theoretically represent different constructs do not correlate with each other. Both are subcategories of the construct validity, and work together. Thus, it needs to be demonstrated that both convergent and discriminant validity exist to establish the construct validity. CFA methods using AMOS are used in this research study to evaluate the validity of the SSCM sub-constructs. In addition, the SEM literature shows that there are various fit indices that can be used to evaluate the model fit (Byrne, 2010). However, usually two types of fit indices are reported in the research studies – incremental fit and absolute fit measures. Incremental fit indices (incremental fit index [IFI], normed fit index [NFI] and comparative fit index [CFI]) compare the hypothesised model to two alternative models – an ideal model which completely matches the hypothesised model, and a null model which assumes that there are no correlations among the constructs. Absolute fit indices ($\chi 2$, root mean square error of approximation [RMSEA], standardised root mean square residual [SRMR] and goodness-of-fit-index [GFI]) measure how well the hypothesised model fits the data (Hu & Bentler, 1998; Shah & Goldstein, 2006).The acceptable cut-off values for the model fit indices are also identified in the literature. Usually, values of GFI > 0.8 are considered as an acceptable evidence of the model fit. SRMR is an error indicator, and thus values lower than 0.05 indicate good model fit.

Similarly, RMSEA values of less than 0.09 are acceptable errors of approximation. NFI, IFI and CFI, which are incremental model fit indices, are also used in this study and generally values of at least 0.9 are considered as an evidence of model fit (Browne & Cudeck, 1993; Hair, Tatham, Anderson, & Black, 2006; Jöreskog & Sörbom, 1986). Also, in SEM the average variance extracted (AVE) is used to assess convergent validity. It is considered as a summarised measure of convergence for a set of measures representing a construct. It is the average percent of variation explained among the items. In this research study, AVE is calculated for each first-order measurement model and values of 0.5 or higher will be considered as an adequate measure and target threshold. AVE can also be used to assess discriminant validity which exists if the AVE of each construct is greater than the square of the correlations (Braunscheidel & Suresh, 2009). In other words, the square root of a construct's AVE should be greater than the correlations between constructs (Koufteros, Vonderembse, & Doll, 1998). Finally, reliability will be assessed through Cronbach's alpha and values > 0.60 will be considered acceptable in this research study. Even though values of 0.70 or greater are usually preferable, in the case of new scales 0.60 is also acceptable for CFA (Cronbach, 1951; Nunnally, 1978). Various statistical cut-offs and threshold values used in this study for different measures and indices are shown in Table 53.

Table 53: Cut-off Values for Various Statistical Measures

Statistical Measures	Cut-off Value
GFI	> 0.85
NFI	> 0.90
IFI	> 0.90
CFI	> 0.90
RMSEA	< 0.09
SRMR	< 0.08
AVE	> 0.50
Cronbach's Alpha	> 0.60

7.3 CFA Measurement Models: Analysis and Results

The validation results of CFA measurement models for SSCM sub-constructs are discussed in this section. In CFA, the regression coefficients generated by the regression of observed variables on unobserved variables are termed as factor loadings. In this research study, the factor loadings in the first-order models represent the validity estimates of observed variables, while in second-order models they represent the validity results of the factors. Larger values of factor loadings show that the measured variables or factors are more representative of the underlying constructs (Bollen, 1989; Mueller, 1996).

7.3.1 CFA Model for Sustainable Supply Chain Planning (SPlng)

SPlng is represented by 28 items and four dimensions (Institutional Supply Chain Polices [ISCP], Risk Mitigation [RM], Demand and Supply Planning [DSP], Product Development [PD]). The factor loadings for both first-order and second-order CFA measurement models are shown in **Table 54** and graphically presented in **Figure 34** and **Figure 35**. Items with low factor loadings were sequentially deleted in AMOS, to improve the convergent validity while preserving the content validity of the SPlng sub-construct.

7.3.1.1 Reliability and Convergent Validity

The convergent validity for institutional supply chain planning is just above the threshold (AVE = 0.53). The items ISCP3 and ISCP7 pertinent to communal projects and R&D are deleted due to low factor loadings (ISCP3 = 0.410; ISCP7 = 0.414). Even though community services are considered as a critical corporate responsibility in the sustainability literature, it seems from the large scale survey that the supply chain (SC) departments still consider it as a responsibility of the central company management and not the department itself.

Similarly, R&D is not consistent with the remaining items in the ISCP factor. Probably, it is considered the duty of a separate department within the organisation that is supposed to conduct the research and development related to all organisational functions. Nevertheless, SC functions are content in monitoring customer satisfaction, providing training to their workforce; ensuring non-discriminatory attitude, fair remuneration and backup planning; and conducting operations which are free of corruption and bribery. All items for RM and DSP were retained because of their high factor loadings.

However, PD7 which is related to consumer needs was deleted due to low factor loading (0.342). It seems from some of the comments in the survey that firms consider it as the sole responsibility of the marketing department and not the supply chain team. They still consider that supply chain has nothing to do with it, and it is the job of the brand managers to understand the needs of the consumers and develop products accordingly. The value of AVE shows acceptable convergent validity for each factor or dimension of the sustainable supply chain planning sub-construct (SPlng). Reliability, represented by alpha in the table, is also good. The value of alpha is greater than 0.7 for most of the factors (ISCP = 0.71, RM = 0.81, DSP = 0.73 and PD = 0.66) which shows that all the dimensions of SPlng are very relevant and consistent. All the deleted items are shown in **Bold** and **Strikethrough** in the following Table.

Table 54: Summary of the CFA Model for SPlng

Item Labels	Item Descriptions	Factor Loadings (1st Order)	Factor Loadings (2nd Order)
Institutional Supply Chain Planning: ISCP (final AVE = 0.53 & alpha = 0.71)			**0.612**
ISCP1	All supply chain transactions and business operations are free of corruption, bribery or any kind of illegal activity	0.664	0.607
~~ISCP3~~	***~~The supply chain department contributes to communal projects related to health, education, sports, infrastructure, etc.~~***	***~~0.410~~***	***~~0.410~~***
ISCP4	The supply chain department conducts Customer Satisfaction Surveys on periodical basis	0.564	0.603
ISCP5	The supply chain department provides relevant training and development opportunities to all its employees	0.709	0.724

Table 54: Summary of the CFA Model for SPlng (continued)

Item Labels	Item Descriptions	Factor Loadings (1st Order)	Factor Loadings (2nd Order)
~~*ISCP7*~~	~~***The supply chain department carries out R&D relevant to Australian food supply chain***~~	~~***0.414***~~	~~***0.414***~~
ISCP8	The supply chain department has a diverse workforce (employees with different nationalities, ancestry, ethnic origin, creed, gender, age groups, religious beliefs, cultures, disability, etc.)	0.710	0.774
ISCP9	The supply chain department provides equal opportunities to the entire workforce purely based on merit and quality of work	0.665	0.674
ISCP10	The supply chain department has strict policies to ensure a workplace free of any kind of discrimination, harassment and bullying	0.742	0.779
ISCP11	The supply chain department ensures fair remuneration, working conditions, leave, rest periods and career path for all the employees	0.654	0.622
ISCP12	The supply chain department performs backup/replacement planning for all critical positions	0.510	0.574
Risk Mitigation: RM (final AVE = 0.732 & alpha = 0.814)			**0.857**
RM1	We have a documented and periodically tested Business Continuity Plan (BCP) to ensure smooth operations in the wake of any IT Issues (e.g. server crash, data viruses, cyber-attacks and hacking)	0.810	0.874
RM2	We have a well-planned survival plan to mitigate risk of any natural disasters (e.g. floods, earthquakes and bushfire)	0.765	0.774
RM3	We have backup suppliers in case the deliveries from primary supplier are disrupted due to bad crops, flooding and pests	0.842	0.879
RM4	We have an emergency plan, to minimise harm to employees and local community, in the event of any site disaster	0.854	0.822
Demand and Supply Planning: DSP (final AVE = 0.556 & alpha = 0.732)			**0.739**
DSP1	Our demand forecast accuracy for various food product categories is above 80 percent	0.715	0.734
DSP2	We perform collaborative planning with sales and marketing departments	0.624	0.697
DSP3	All the production usually takes place as per the daily production schedule	0.742	0.712
Product Development: PD (final AVE = 0.669 & alpha = 0.663)			**0.783**
PD1	Supply chain department collaborates with brand team and also engages suppliers for New Product Development (NPD)	0.842	0.879

Table 54: Summary of the CFA Model for SPlng (continued)

Item Labels	Item Descriptions	Factor Loadings (1st Order)	Factor Loadings (2nd Order)
PD2	We assist in producing products that need minimal resources (water, energy, and materials)	0.854	0.822
PD3	We help the product development/brand team to eliminate every possible toxic material that might be used during product manufacturing or usage	0.624	0.639
PD4	We help to develop food products that are most efficient for logistical activities (storage, transportation, handling)	0.615	0.634
PD5	We help to develop food products that are easily recyclable	0.724	0.797
PD6	We assist in developing food products with long shelf-life	0.542	0.512
~~***PD7***~~	~~***We assist in developing food products that address consumer needs and delight them***~~	~~***0.342***~~	~~***0.342***~~
PD8	We assist in developing food products that focus on functional benefits	0.654	0.622
PD10	We ensure food safety by complying with the Australian standards and regulations during product development	0.509	0.533
PD12	We focus on recommending ingredients (or materials) that could be locally sourced from the Australian suppliers and farmers	0.515	0.534
Initial Model Fit (1st Order)	χ^2/df = 3.190, RMSEA = 0.0901, SRMR = 0.0775, GFI = 0.735, CFI = 0.802, NFI = 0.737, IFI = 0.806		
Final Model (1st Order)	χ^2/df = 2.639, RMSEA = 0.0702, SRMR = 0.0631, GFI = 0.935, CFI = 0.902, NFI = 0.937, IFI = 0.906		
Initial Model Fit (2nd Order)	χ^2/df = 2.393, RMSEA = 0.0734, SRMR = 0.0753, GFI = 0.853, CFI = 0.912, NFI = 0.913, IFI = 0.921		
Final Model (2nd Order)	χ^2/df = 1.393, RMSEA = 0.0643, SRMR = 0.0635, GFI = 0.953, CFI = 0.924, NFI = 0.973, IFI = 0.941		

7.3.1.2 First-Order CFA Model for the SPlng Sub-Construct

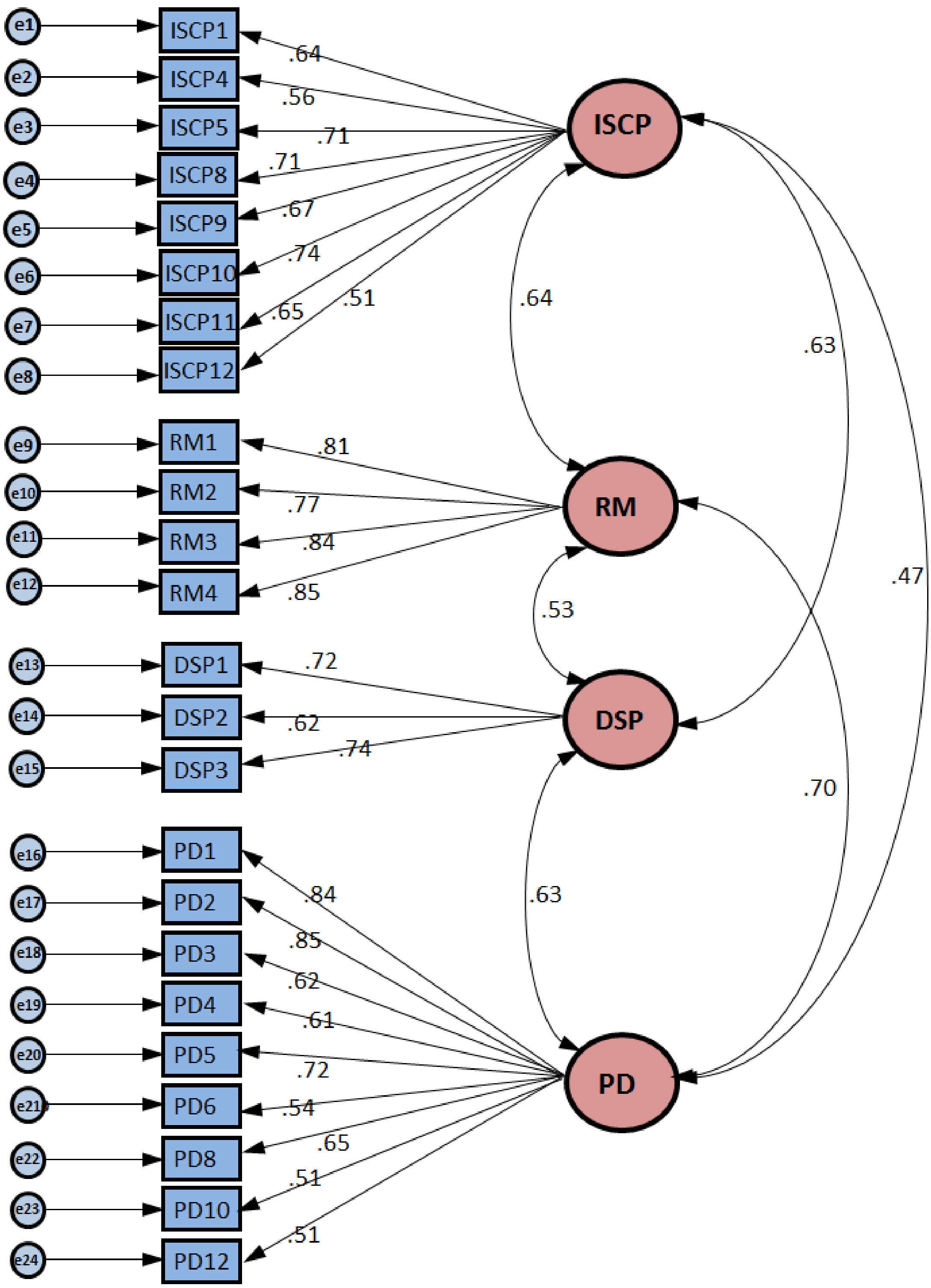

Figure 34: First-Order CFA Model for the SPlng Sub-Construct

7.3.1.3 Second-Order CFA Model for the SPlng Sub-Construct

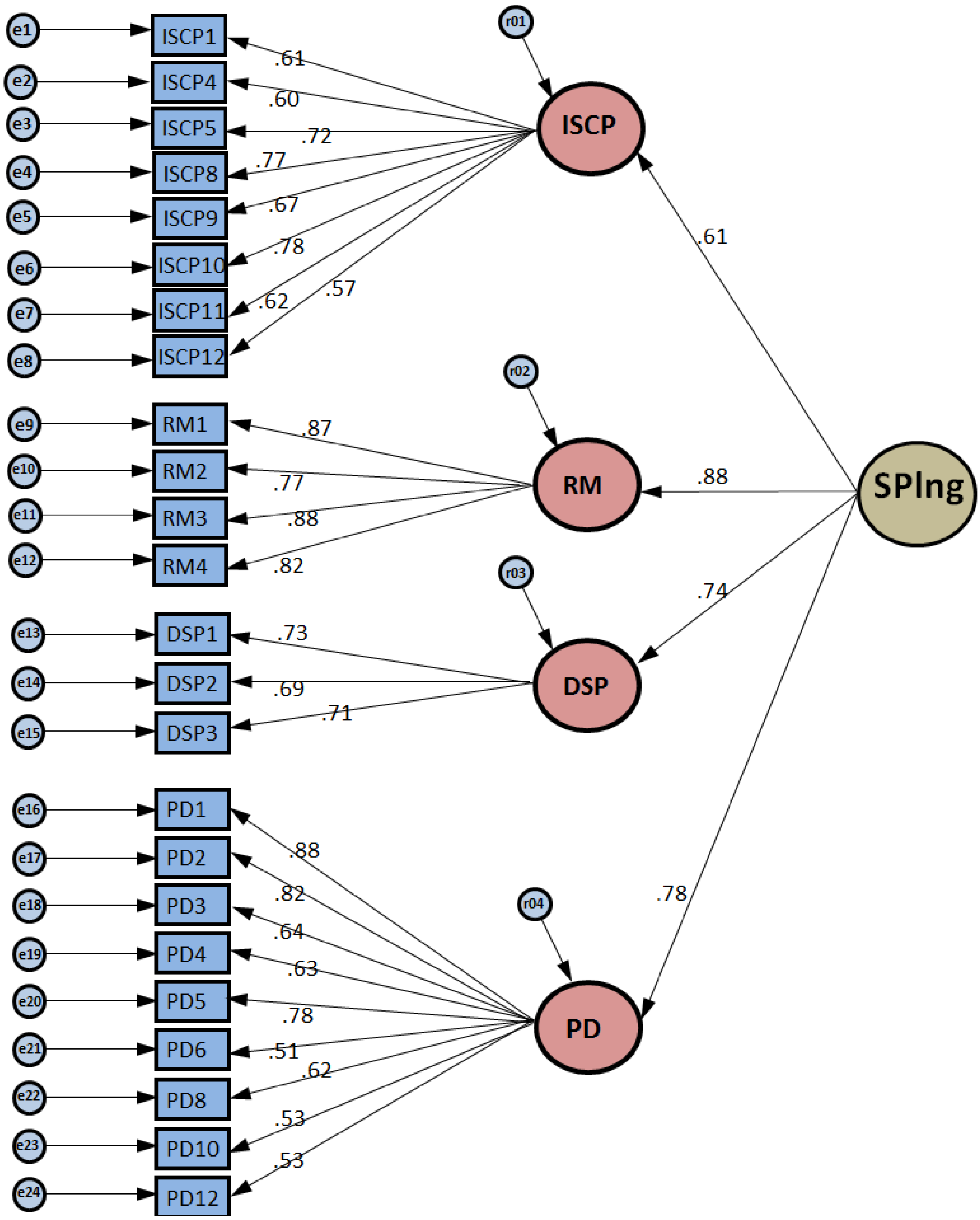

Figure 35: Second-Order CFA Model for the SPlng Sub-Construct

7.3.1.4 Discriminant Validity and Test of CMB

The inter-construct correlations are shown in **Table 55**. It can be seen that diagonal values, which are the square roots of AVEs of different factors, are much higher than their correlations with other factors. This simply means these factors are more related to themselves than to any other factor, and thus discriminant validity is established. In addition, pairwise chi-square difference test was also done to further establish discriminant validity. The results supported the analysis and are provided in Appendix 5.

Table 55: Discriminant Validity through Inter-construct Correlations for SPlng

	ISCP	RM	DSP	PD
ISCP	**0.728**			
RM	0.643	**0.855**		
DSP	0.632	0.534	**0.746**	
PD	0.466	0.703	0.632	**0.818**

The diagonal represents the square roots of AVEs

In addition, CMB is checked through Harman's one-factor method that tests the hypothesis that a single factor can explain the majority of the variance in the data. All the factors for SPlng were extracted through SPSS by constraining the model to have only one factor. Usually, Promax and Varimax rotations are used, but in this case none of the rotations was selected. The results showed that a single factor could only account for 23.1 percent of the variance in the model. The common latent factor (CLF) method was also used to further check for CMB. It helps to determine the common shared variance in all the factors. A latent factor was added to the AMOS SPlng model, and it was connected to all the measured variables. Then all the paths from CLF to observed items were constrained to be equal through a regression weight 'b' and the variance in the CLF was constrained to '1'. The model was run successfully and it was found that the common variance shared by all the factors is only 3 percent, which confirms that CMB does not exist.

7.3.2 CFA Model for Sustainable Procurement (SP)

SP is represented by 25 items and six dimensions (Procurement Policy and Processes [PPP], Operational Efficiency [OE], Supplier Selection and Assessment [SSA], Supplier Workplace Standards [SWS], Supplier Operations [SO] and Supplier Regulatory Compliance [SRC]). The factor loadings both for first-order and second-order CFA measurement models are shown in **Table 56** and graphically presented in **Figure 36** and **Figure 37**. Items with low factor loadings were sequentially deleted to improve the convergent validity while preserving the content validity of the SP sub-construct.

7.3.2.1 Reliability and Convergent Validity

The convergent validity is in the acceptable range (greater than 0.6) for all the dimensions of sustainable procurement (SP). The factor loading of the item related to biodiversity (SO3) is very low (0.405) and thus it was deleted. The survey showed that companies do not have an understanding that biodiversity is part of sustainability, and negative impacts on the local ecosystem have both short and long-term consequences for the local communities and their surrounding geography. Also, the factor loading of the item (SRC2) related to suppliers complying with the Australian Packaging Covenant was also very low (0.355) and it was deleted in the AMOS model. It is hard to understand that why this item is not consistent with the SP model. There are no direct comments in the survey that could help to elucidate the reasons for this inconsistency, but it could be clearly seen that many respondents considered it as a ‘N/A – Not Applicable’ item. Probably, the reason is that the Australian Packaging Covenant is voluntary and firms do not consider that it should be an obligatory requirement for the suppliers in the context of sustainability performance. The reliability (alpha values) is quite high for almost all the dimensions of the SP sub-construct. All the deleted items are shown in **Bold** and **Strikethrough** in the following Table.

Table 56: Summary of the CFA Model for SP

Item Labels	Item Descriptions	Factor Loadings (1st Order)	Factor Loadings (2nd Order)
Procurement Policy & Processes: PPP (final AVE = 0.612 & alpha = 0.703)			**0.832**
PPP1	Procurement is considered as a strategic function in our firm	0.634	0.617
PPP2	We have a written procurement policy that ensures environmental preservation, communal welfare and economic value for the firm	0.750	0.764
PPP3	Our purchasing process from source-to-settle is governed by our procurement policy	0.574	0.613
PPP4	We have a comprehensive contract management system in place	0.789	0.724
Operational Efficiency: OE (final AVE = 0.632 & alpha = 0.814)			**0.817**
OE1	We provide training opportunities to our staff	0.780	0.874
OE2	We have developed backup suppliers to prevent supply disruptions	0.775	0.774
OE3	We use technology (e-procurement or procurement management system) to improve operational efficiency and transparency	0.852	0.979
Supplier Selection & Assessment: SSA (final AVE = 0.656 & alpha = 0.771)			**.739**
SSA1	Our supplier selection process involves social and environmental criteria		
SSA2	We periodically audit our suppliers	0.745	0.774
SSA3	We ensure that suppliers' business operations are free of corruption, bribery or any kind of illegal activity	0.694	0.747
SSA4	Our suppliers are financially sound	0.732	0.702
Supplier Workplace Standards: SWS (final AVE = 0.669 & alpha = 0.763)			**0.813**
SWS1	Our suppliers comply with occupational health and safety requirements	0.802	0.879
SWS2	Our suppliers do not employ any indecent form of labour (child or forced)	0.884	0.822
SWS3	Our suppliers do not engage in any form of discriminatory practices	0.694	0.739
SWS4	Our suppliers comply with legal restrictions on working hours	0.664	0.801
SWS5	Our suppliers pay reasonable wages to employees	0.712	0.739

Table 56: Summary of the CFA Model for SP (continued)

Item Labels	Item Descriptions	Factor Loadings (1st Order)	Factor Loadings (2nd Order)
Supplier Operations: SO (final AVE = 0.614 & alpha = 0.811)			**0.944**
SO1	Our suppliers efficiently use energy and water	0.834	0.854
SO2	Our suppliers monitor and reduce all emissions (e.g., GHG, ODS, air pollutants, etc.) resulting from business operations	0.876	0.877
~~***SO3***~~	~~***Our suppliers ensure preservation of biodiversity (e.g., land, air, habitat, eco-system, etc.)***~~	~~***0.405***~~	~~***0.405***~~
SO4	Our supplier reduce waste through reuse and recycling	0.843	0.859
SO5	All the suppliers have traceability systems in place	0.789	0.831
SO6	Our suppliers use food grade packaging	0.801	0.911
Suppliers' Regulatory Compliance: SRC (final AVE = 0.751 & alpha = 0.802)			**0.747**
SRC1	Our suppliers comply with local and national laws and regulations	0.731	0.774
~~***SRC2***~~	~~***Our suppliers follow the Australian Packaging Covenant***~~	~~***0.355***~~	~~***0.355***~~
SRC3	Our suppliers ensure proper labelling for all food products according to the Australian standards	0.912	0.922
Initial Model Fit (1st Order)	χ^2/df = 3.210, RMSEA = 0.090, SRMR = 0.078, GFI = 0.754, CFI = 0.812, NFI = 0.787, IFI = 0.894		
Final Model (1st Order)	χ^2/df = 2.639, RMSEA = 0.061, SRMR = 0.058, GFI = 0.955, CFI = 0.922, NFI = 0.903, IFI = 0.946		
Initial Model Fit (2ndOrder)	χ^2/df = 2.402, RMSEA = 0.074, SRMR = 0.0832, GFI = 0.853, CFI = 0.812, NFI = 0.913, IFI = 0.901		
Final Model (2nd Order)	χ^2/df = 2.101, RMSEA = 0.053, SRMR = 0.0615, GFI = 0.983, CFI = 0.984, NFI = 0.973, IFI = 0.971		

7.3.2.2 First-Order CFA Model for the SP Sub-Construct

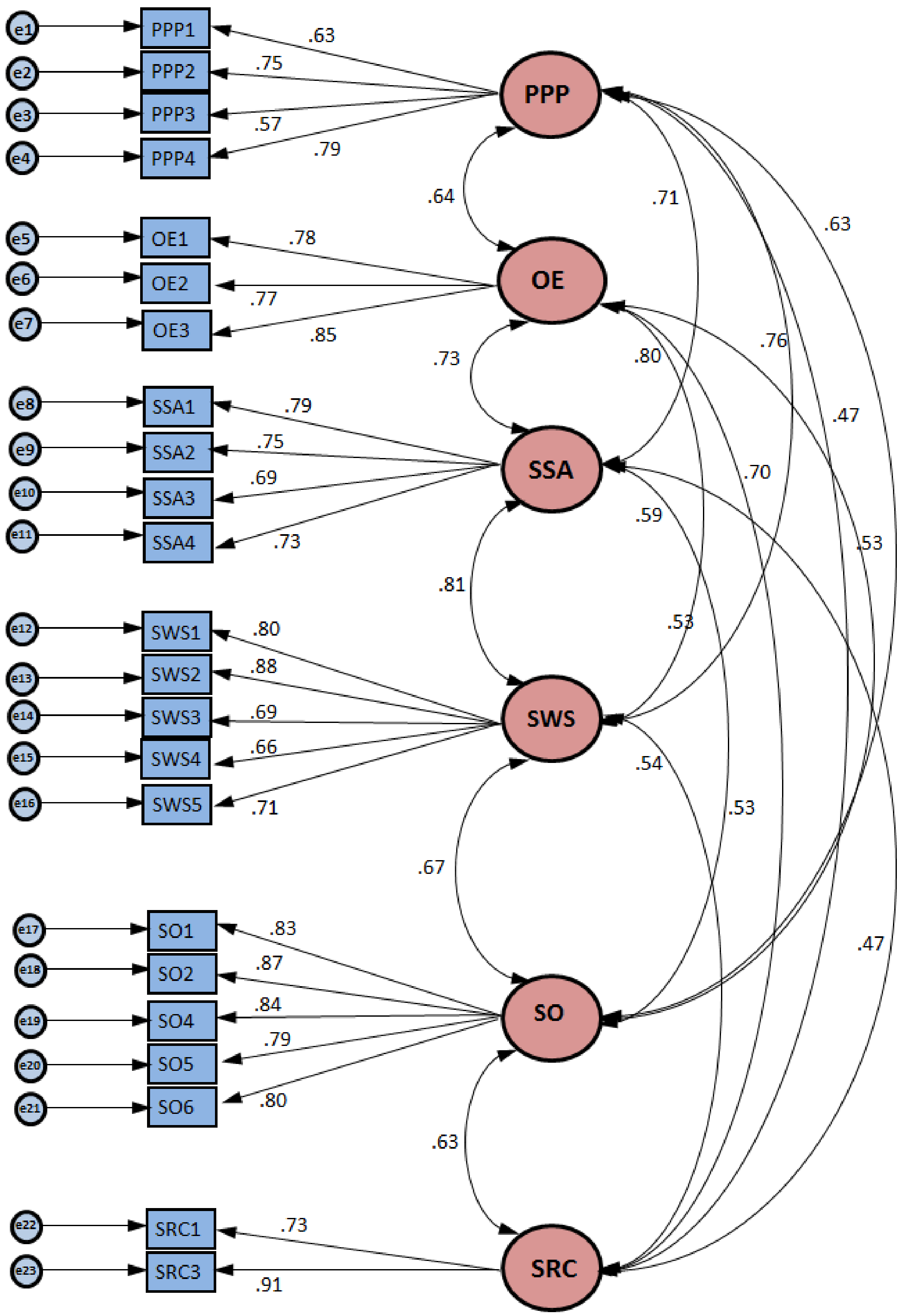

Figure 36: First-Order CFA Model for the SP Sub-Construct

7.3.2.3 Second-Order CFA Model for the SP Sub-Construct

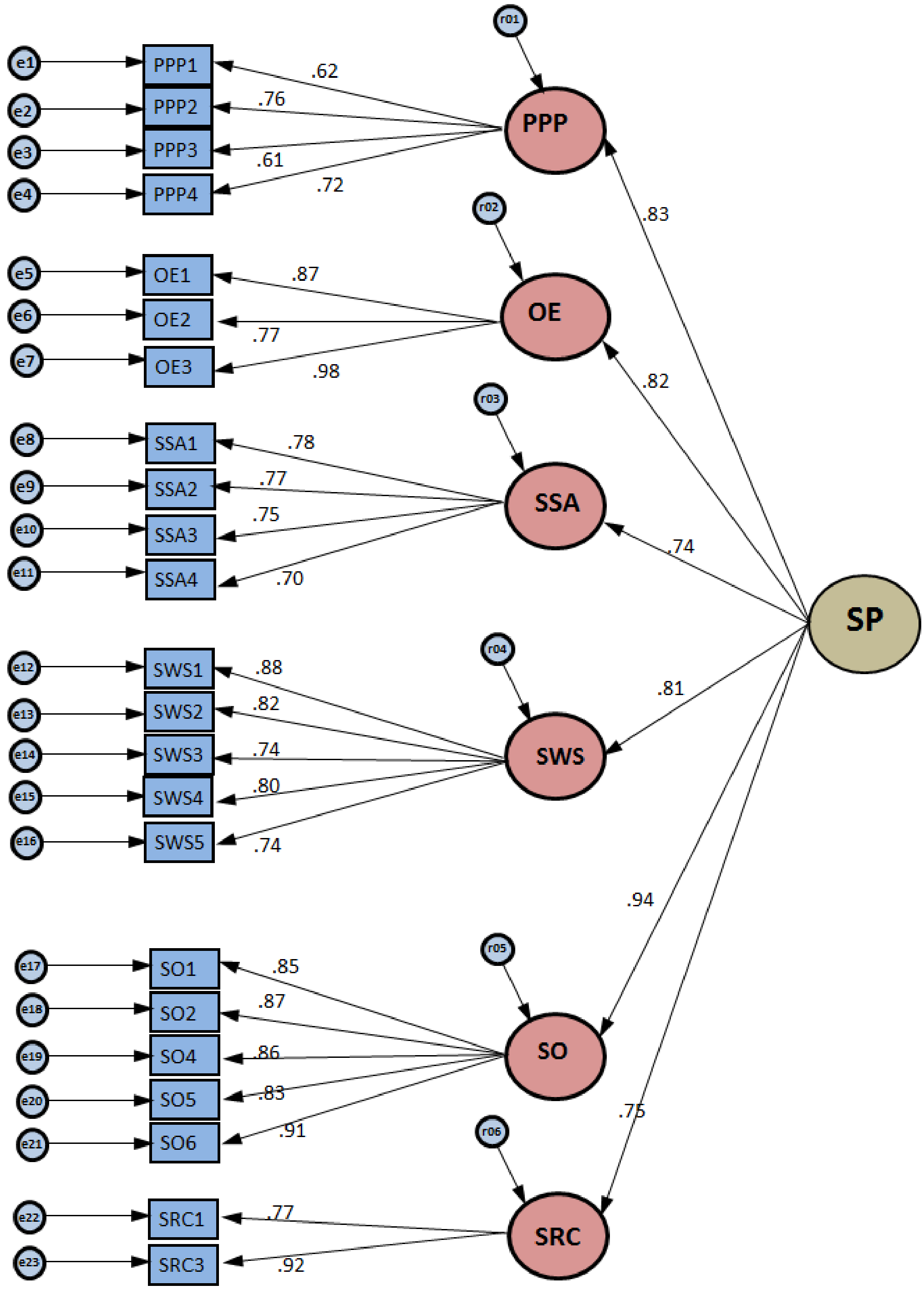

Figure 37: Second-Order CFA Model for the SP Sub-Construct

7.3.2.4 Discriminant Validity and Test of CMB

The inter-construct correlations are shown in **Table 57**. It can be seen that diagonal values, which are the square roots of AVEs of different factors, are much higher than their correlations with other factors. This simply means these factors are more related to themselves than to any other factor and thus discriminant validity is established. In addition, pairwise chi-square difference test was also done to further establish discriminant validity. The results supported the analysis and are provided in Appendix 5.

Table 57: Discriminant Validity through Inter-Construct Correlations for SP

	PPP	OE	SSA	SWS	SO	SRC
PPP	**0.782**					
OE	0.643	**0.795**				
SSA	0.712	0.733	**0.809**			
SWS	0.756	0.801	0.812	**0.816**		
SO	0.632	0.534	0.589	0.656	**0.784**	
SRC	0.466	0.703	0.473	0.544	0.632	**0.866**

The diagonal represents the square roots of AVEs

In addition, common method bias was tested through Harman's one-factor test and the common latent factor (CLF) method, as explained for the sustainable supply chain planning (SPlng) sub-construct. The results showed that a single factor could only account for 29.3 percent of the variance in the model and the common variance shared by all the factors is only 2 percent, which confirms that CMB does not exist.

7.3.3 CFA Model for Sustainable Manufacturing (SM)

SM is represented by 27 items and five dimensions (Manufacturing Policy and Processes [MPP], Pollution Control and Prevention [PCP], Resource Conservation [RC], Production Staff [PS] and Production Regulatory Compliance [PRC]). The factor loadings both for first-order and second-order CFA measurement models are shown in Table 58 and graphically presented in **Figure 38** and **Figure 39**. Items with low factor loadings were sequentially deleted to improve the convergent validity while preserving the content validity of the SM sub-construct.

7.3.3.1 Reliability and Convergent Validity

The convergent validity (AVE) is good for all the factors of the sustainable manufacturing sub-construct. The convergent validity for PCP, RC and PRC is 0.632, 0.609 and 0.663 respectively, which shows the strength of the model. Again, it can be seen in the model that the loadings of items related to biodiversity and the Australian Packaging Covenant are very low, and thus both items MPP4 and PRC3 were deleted. This shows that the respondents do not consider biodiversity as an important part of their social and environmental responsibility.

Also, a large number of firms are signatory to the Australian Packaging Covenant, but they consider it the responsibility of the marketing department to determine the packaging requirements of the food products. It appears as if the respondents consider that the SC department is responsible only for operations and it has nothing to do with the product design and layout. This is against the sustainability mindset in which every department and function should consider itself responsible for the sustainability performance of the firm. In this case, the manufacturing function should take the lead and convince brand managers about the benefits of complying with the Australian Packaging Covenant. The reliability values are above the acceptable threshold set for this research study. Alpha is above 0.7 for PCP, PS and PRC, while it is just below 0.7 for MPP and RC. All the deleted items are shown in **Bold** and **Strikethrough** in the following Table.

Table 58: Summary of the CFA Model for SM

Item Labels	Item Descriptions	Factor Loadings (1st Order)	Factor Loadings (2nd Order)
Manufacturing Policy & Processes: MPP (final AVE = 0.512 & alpha = 0.691)			**0.712**
MPP1	We have a written manufacturing policy that ensures environmental preservation, communal welfare and economic value for the company	0.764	0.807
MPP2	We have an Environmental Management System in place to identify, monitor, reduce and report the impact of production operations on the environment	0.610	0.674
MPP3	We follow the principles of HACCP (Hazard Analysis and Critical Control Point) in food production processes	0.554	0.613
~~***MPP4***~~	~~***We ensure the integrity and preservation of biodiversity (e.g., land, air, habitat, species, eco-system etc.) impacted by our operations***~~	~~***0.309***~~	~~***0.309***~~
MPP5	We ensure proper cleaning, sanitation, temperature control and pest control in our production facility to ensure food safety and quality	0.756	0.784
MPP6	We ensure that all detergents, disinfectants or cleaning aids are environment and human friendly	0.676	0.681
Pollution Control & Prevention: PCP (final AVE = 0.632 & alpha = 0.714)			**0.887**
PCP1	We have a Remediation Action Plan to alleviate any environmental damage from past operations or crises	0.910	0.974
PCP2	We ensure that all pollutants generated at the end of a process are captured and treated accordingly	0.865	0.874
PCP3	We monitor and reduce emissions, such as GHG, ODS and air pollutants	0.844	0.875
PCP4	We continuously strive to reduce waste (from over-production, product defects, waiting time, etc.) through efficient processes, reuse and recycling	0.775	0.834
PCP5	We continuously strive to redesign production processes so that they are environment friendly	0.624	0.697
PCP6	We continuously strive to optimise production processes using ERP modules such as capacity planning, master production scheduling, MRP, QM, etc.	0.742	0.812
Resource Consumption: RC (final AVE = 0.609 & alpha = 0.693)			**0.883**
RC1	We strive to reduce and conserve energy through efficient processes	0.812	0.879
RC2	We strive to efficiently use water without harming the source	0.804	0.822
RC3	We recycle and reuse water for our operations	0.724	0.739

Table 58: Summary of the CFA Model for SM (continued)

Item Labels	Item Descriptions	Factor Loadings (1st Order)	Factor Loadings (2nd Order)
Production Staff: PS (final AVE = 0.554 & alpha = 0.742)			**0.936**
PS1	We consider the staff Work-Life Balance while planning deliveries to customers	0.909	0.921
PS2	We periodically review shift patterns to reduce anti-social hours	0.876	0.887
PS3	We comply with all occupational health and safety requirements	0.855	0.873
PS4	We do not employ any indecent form of labour (child or forced)	0.842	0.886
PS5	We do not engage in any form of discriminatory practices	0.786	0.907
PS6	We pay reasonable wages and allow freedom of association to our staff	0.775	0.785
PS7	We have set up KPIs to identify and reduce workplace injury and illness	0.938	0.965
PS8	We ensure that production processes and technologies are safe for the workforce	0.933	0.947
Production Regulatory Compliance: PRC (final AVE = 0.663 & alpha = 0.753)			**0.943**
PRC1	All the equipment and materials used in production are food graded as per the Australian standards	0.921	0.963
PRC2	We ensure that all food products are labelled according to the Australian regulations	0.897	0.907
~~***PRC3***~~	~~***We follow the guidelines set by the Australian Packaging Covenant***~~	~~***0.754***~~	~~***0.754***~~
PRC4	We have written labour/workplace management policies and standards aligned with international standards such as the UN Global Compact and ILO	0.876	0.894
Initial Model Fit (1st Order)	χ^2/df = 2.254, RMSEA = 0.0911, SRMR = 0.0754, GFI = 0.735, CFI = 0.802, NFI = 0.637, IFI = 0.816		
Final Model (1st Order)	χ^2/df = 1.529, RMSEA = 0.0662, SRMR = 0.0611, GFI = 0.835, CFI = 0.952, NFI = 0.917, IFI = 0.926		
Initial Model Fit (2nd Order)	χ^2/df = 1.793, RMSEA = 0.0734, SRMR = 0.0673, GFI = 0.863, CFI = 0.912, NFI = 0.953, IFI = 0.911		
Final Model (2nd Order)	χ^2/df = 1.655, RMSEA = 0.0543, SRMR = 0.0645, GFI = 0.894, CFI = 0.964, NFI = 0.976, IFI = 0.948		

7.3.3.2 First-Order CFA Model for the SM Sub-Construct

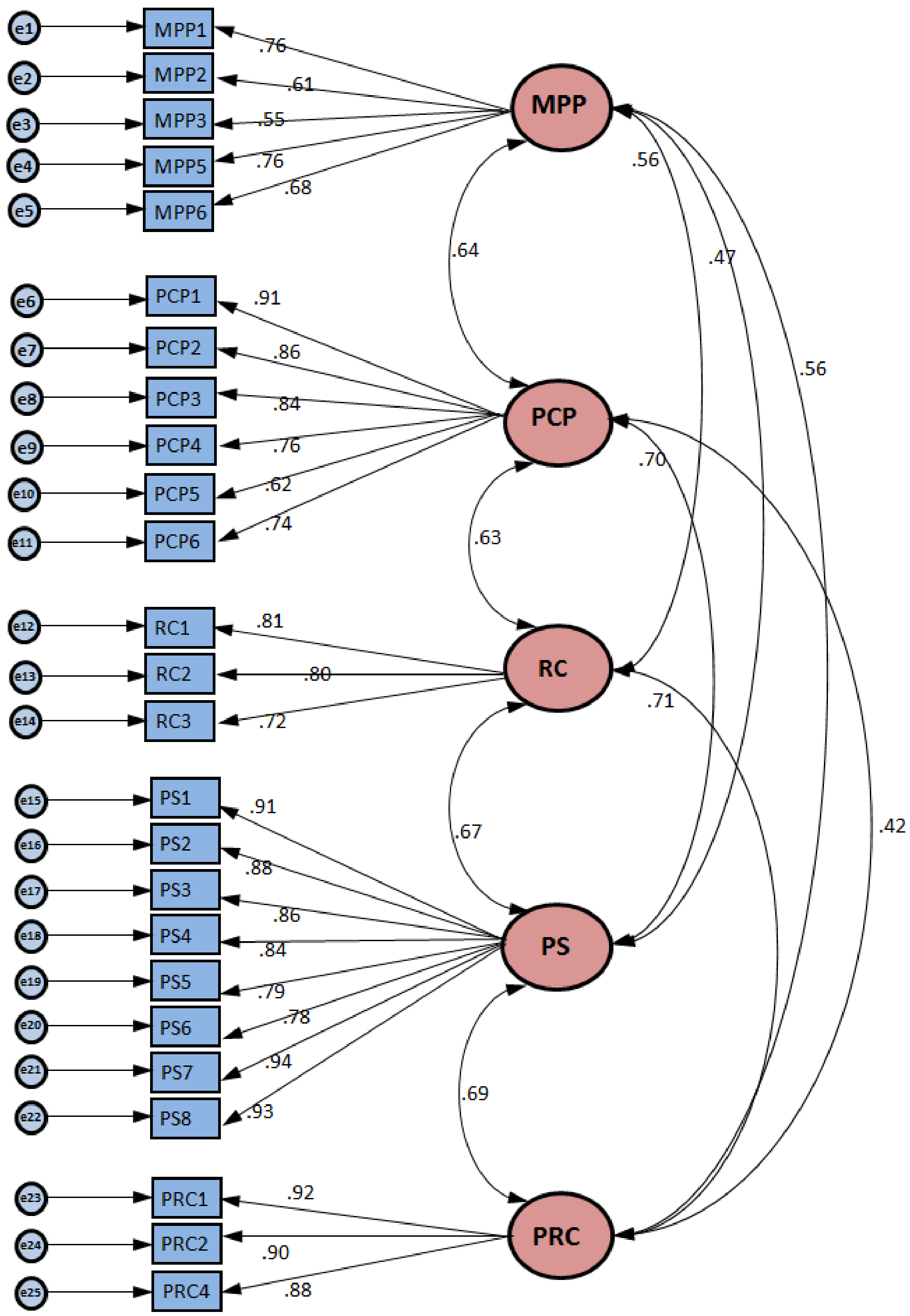

Figure 38: First-Order CFA Model for the SM Sub-Construct

7.3.3.3 Second-Order CFA Model for the SM Sub-Construct

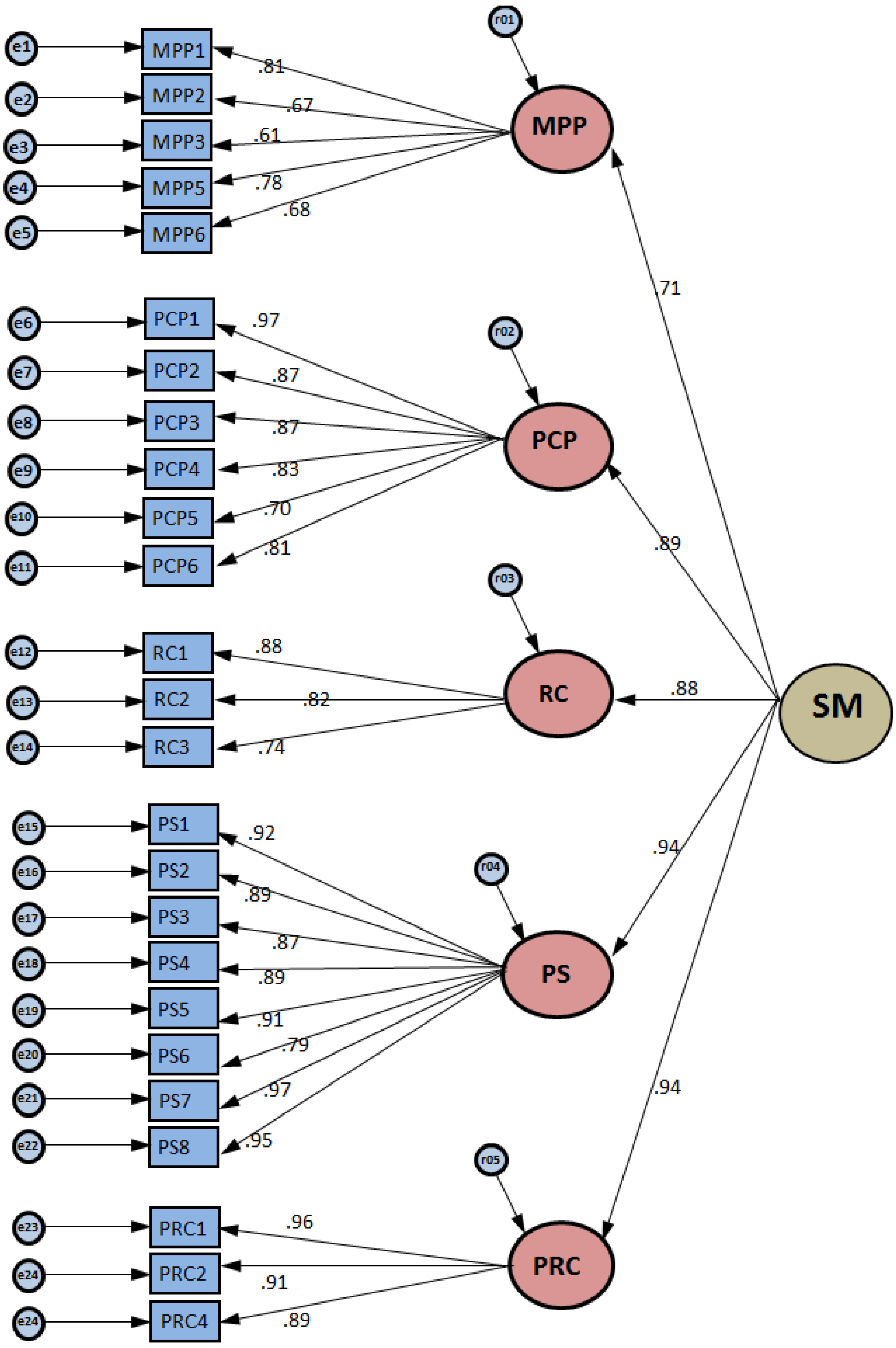

Figure 39: Second-Order CFA Model for the SM Sub-Construct

7.3.3.4 Discriminant Validity and Test of CMB

The inter-construct correlations are shown in **Table 59**. It can be seen that diagonal values, which are the square roots of AVEs of different factors, are much higher than their correlations with other factors. This simply means that these factors are more related to themselves than to any other factor, and thus discriminant validity is established. In addition, pairwise chi-square difference test was also done to further establish discriminant validity. The results supported the analysis and are provided in Appendix 5.

Table 59: Discriminant Validity through Inter-Construct Correlations for SM

	MPP	**PCP**	**RC**	**PS**	**PRC**
MPP	**0.715**				
PC	0.643	**0.795**			
RC	0.561	0.633	**0.780**		
PS	0.466	0.703	0.673	**0.744**	
PRC	0.595	0.416	0.712	0.693	**0.814**

The diagonal represents the square roots of AVEs

In addition, common method bias was tested through Harman's one-factor test and the common latent factor (CLF) method, as explained for the sustainable supply chain planning (SPlng) construct. The results showed that a single factor could only account for 31 percent of the variance in the model and the common variance shared by all the factors is only 4.6 percent, which confirms that CMB does not exist.

7.3.4 CFA Model for Sustainable Transportation (ST)

ST is represented by 27 items and six dimensions (Transportation Policy and Processes [TPP], Transportation Mode and Loads [TML], Transportation Routing and Scheduling [TRS], Transportation Staff [TS], Transportation Shipping Materials [TSM] and Transportation Regulatory Compliance [TRC]). The factor loadings for both first-order and second-order CFA measurement models are shown in **Table 60** and graphically presented in **Figure 40** and **Figure 41**. Items with low factor loadings were sequentially deleted to improve the convergent validity while preserving the content validity of the ST sub-construct.

7.3.4.1 Reliability and Convergent Validity

The convergent validity (AVE) for all the dimensions of sustainable transportation is well above 0.5. In most of the cases it is above 0.65, which shows that measures of various dimensions of ST are highly related to each other. The factor loading of the item related to tie-bands and straps is very low (0.279), and thus it was decided to delete this item as it was inconsistent with the remaining items of the ST sub-construct. Many respondents considered it as ‘N/A – Not Applicable’. Even though it is regarded as a standard technique, but probably there are other mechanisms that could be used to ensure that food items are properly transported. This practice was added during the content validity phase, and it was considered very important by the researchers as it implies less transportation damage, which subsequently translates into less food wastage and lower transportation costs. The reliability of all the factors is also very good, and in most of the cases it is above 0.7. All the deleted items are shown in **Bold** and **Strikethrough** in the following Table.

Table 60: Summary of the CFA Model for ST

Item Labels	Item Descriptions	Factor Loadings (1st Order)	Factor Loadings (2nd Order)
Transportation Policy & Processes: TPP (final AVE = 0.712 & alpha = 0.841)			**0.712**
TPP1	We consider sustainability aspects while procuring new transportation fleet (aerodynamics, vehicle weight, engine design, etc.)	0.614	0.657
TPP2	We regularly perform fleet inspection and maintenance (brake checks, oil levels, tyre inflation, etc.)	0.710	0.784
TPP3	We regularly examine our fleet for noise pollution	0.544	0.613
TPP4	We enforce strict guidelines to minimise needless idling of vehicle (turn off engines during delivery or pickup, etc.)	0.769	0.794

Table 60: Summary of the CFA Model for ST (continued)

Item Labels	Item Descriptions	Factor Loadings (1st Order)	Factor Loadings (2nd Order)
TPP5	We have KPIs and targets to reduce environmental impact linked with transportation of raw materials and finished goods	0.643	0.682
Transportation Mode & Loads: TML (final AVE = 0.652 & alpha = 0.894)			**0.875**
TML1	We use the most fuel-efficient transportation mode (such as rail, sea, etc.)	0.774	0.767
TML2	We use the environment-friendly fuels in our vehicles to reduce emissions (such as biofuels, ethanol, etc.)	0.812	0.876
TML3	We use standard packaging and pallets configurations to optimise transport load factors	0.830	0.877
TML4	We optimally utilise vehicle capacity through maximum volume, weight and floor-space utilisation	0.745	0.747
Transportation Routing & Scheduling: TRS (final AVE = 0.586 & alpha = 0.652)			**0.793**
TRS1	We use load planning software for optimal and safe loading of vehicles, railcars, marine or air containers	0.693	0.701
TRS2	We actively use common carriers, backhauls, co-shipping, internet based load matching services or double stacked containers	0.715	0.734
TRS3	We use software to determine optimal vehicle routing and freight delivery schedules	0.614	0.657
Transportation Staff: TS (final AVE = 0.554 & alpha = 0.783)			**0.742**
TS1	We consider the staff Work-Life Balance while planning deliveries to customers	0.664	0.671
TS2	We periodically review shift patterns to reduce anti-social hours	0.712	0.744
TS3	We comply with all occupational health and safety requirements for food industry	0.745	0.783
TS4	We do not employ any indecent form of labour (child or forced)	0.609	0.655
TS5	We do not engage in any form of discriminatory practices	0.532	0.603
TS6	We pay reasonable wages and allow freedom of association for our staff	0.686	0.713
TS7	Our divers are well-trained to ensure safe and fuel-efficient driving	0.599	0.652
Transportation Shipping Materials: TSM (final AVE = 0.754 & alpha = 0.811)			**0.654**
TSM1	We transport food products in reusable shipping materials rather than shrink-wrap or cardboard	0.549	0.563
TSM2	We transport food products in long-lasting or recyclable corrugated cardboard pallets or plastic pallets	0.543	0.555

Table 60: Summary of the CFA Model for ST (continued)

Item Labels	Item Descriptions	Factor Loadings (1st Order)	Factor Loadings (2nd Order)
~~*TSM3*~~	~~*We use tie-down bands and straps which are reusable*~~	~~*0.279*~~	~~*0.279*~~
TSM4	We use recycled pallets and cardboards (where cardboards must be used)	0.594	0.607
Transportation Regulatory Compliance: TRC (final AVE = 0.663 & alpha = 0.962)			**0.883**
TRC1	All the equipment and materials used in transportation operations are food graded as per the Australian standards	0.911	0.932
TRC2	We ensure that appropriate temperature is maintained during transportation of dry, chilled and frozen food according to Australian standards	0.956	0.973
TRC3	We thoroughly inspect inbound or outbound vehicles (or containers) for condensation, moisture, objectionable odours, infestation and allergens to ensure food safety	0.822	0.853
TRC4	We ensure that all food items being transported are properly covered and are separate from any contaminants	0.707	0.754
Initial Model Fit (1st Order)	$\chi^2/\,df$ = 2.563, RMSEA = 0.091, SRMR = 0.082, GFI = 0.735, CFI = 0.802, NFI = 0.743, IFI = 0.816		
Final Model (1st Order)	$\chi^2/\,df$ = 2.209, RMSEA = 0.062, SRMR = 0.076, GFI = 0.935, CFI = 0.912, NFI = 0.917, IFI = 0.922		
Initial Model Fit (2ndOrder)	$\chi^2/\,df$ = 2.154, RMSEA = 0.074, SRMR = 0.0746, GFI= 0.853, CFI0= 0.766, NFI = 0.629, IFI = 0.763		
Final Model (2nd Order)	$\chi^2/\,df$ = 1.939, RMSEA = 0.067, SRMR = 0.060, GFI = 0.953, CFI = 0.954, NFI = 0.972, IFI = 0.914		

7.3.4.2 First-Order CFA Model for the ST Sub-Construct

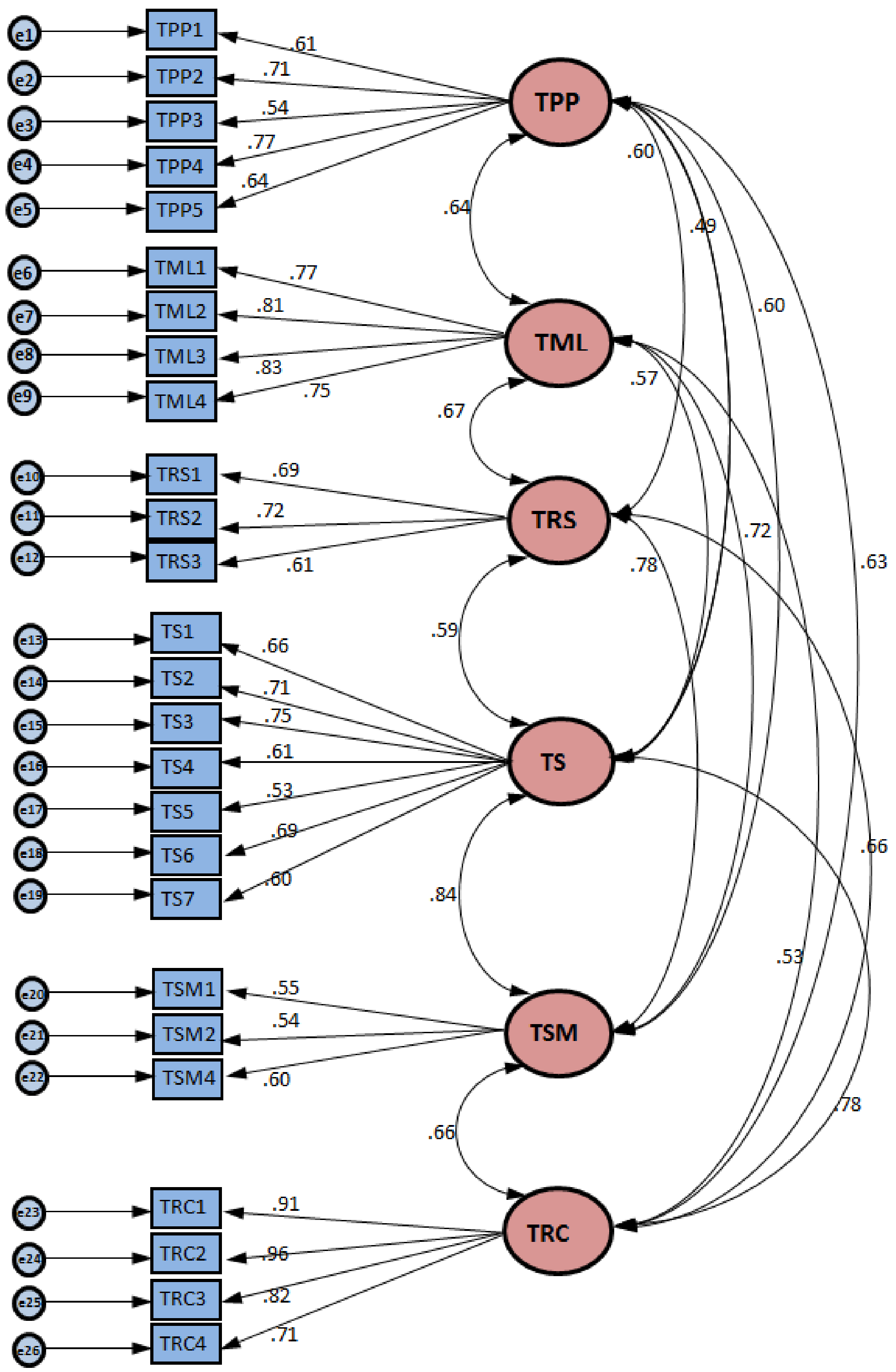

Figure 40: First-Order CFA Model for the ST Sub-Construct

7.3.4.3 Second-Order CFA Model for the ST Sub-Construct

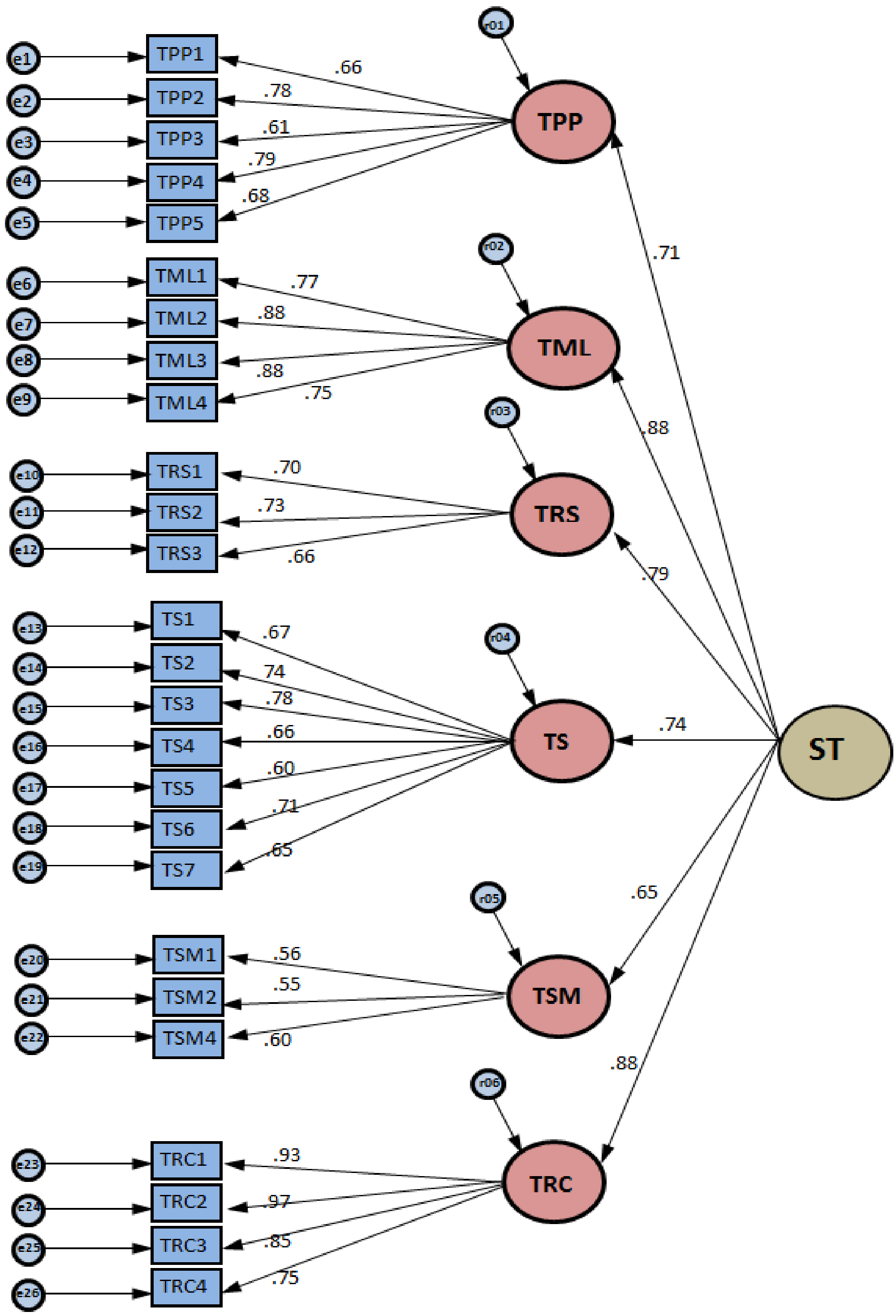

Figure 41: Second-Order CFA Model for the ST Sub-Construct

7.3.4.4 Discriminant Validity and Test of CMB

The inter-construct correlations are shown in **Table 61**. It can be seen that diagonal values, which are the square roots of AVEs of different factors, are much higher than their correlations with other factors. This simply means these factors are more related to themselves than to any other factor, and thus discriminant validity is established. In addition, pairwise chi-square difference test was also done to further establish discriminant validity. The results supported the analysis and are provided in Appendix 5.

Table 61: Discriminant Validity through Inter-Construct Correlations for ST

	TPP	TML	TRS	TS	TSM	TRC
TPP	**0.843**					
TML	0.643	**0.795**				
TRS	0.594	0.669	**0.766**			
TS	0.486	0.574	0.593	**0.744**		
TSM	0.601	0.721	0.776	0.839	**0.868**	
TRC	0.632	0.534	0.656	0.784	0.659	**0.814**

The diagonal represents the square roots of AVEs

In addition, common method bias was tested through Harman's one-factor test and the common latent factor (CLF) method, as explained for the sustainable supply chain planning (SPlng) construct. The results showed that a single factor could only account for 34 percent of the variance in the model and the common variance shared by all the factors is only 7 percent, which confirms that CMB does not exist.

7.3.5 CFA Model for Sustainable Warehousing (SW)

SW is represented by 36 items and six dimensions (Warehouse Design [WD], Warehouse Layout [WL], Warehouse Processes [WP], Warehouse Staff [WS], Onsite Facilities [OF], Mechanical Handling Equipment [MHE]). The factor loadings both for first-order and second-order CFA measurement models are shown in **Table 62** and graphically presented in **Figure 42** and **Figure 43**. Items with low factor loadings were sequentially deleted to improve the convergent validity while preserving the content validity of the SW sub-construct.

7.3.5.1 Reliability and Convergent Validity

The convergent validity (AVE) for all the dimensions of sustainable warehousing is well above 0.5. In most of the cases it is above 0.55, which shows that the measures of various dimensions of SW are highly related to each other. The factor loading of four items (WD1, WD5, WP1 and WP7) is below the threshold set for this research study, and therefore it was decided to delete these items. The item WD1, which is related to the use of renewable energy sources, is highly recommended in the academic literature and industry publications and all the practitioners also supported it during the content validity phase. However, the data collected through the questionnaire survey showed that it is not consistent with the rest of the items of the SW sub-construct. The reason seems to be that biofuels and solar energy are not prevalent in the warehousing industry. This might be due to the high initial investment; low efficiency as compared to conventional power sources; and low amounts of sunlights in many areas. In addition, item WD5, which is related to biodiversity seems to be inconsistent with the rest of the items. This seems to be a continuation of the same mindset in the supply chain departments where preservation of natural habitat and eco-systems is not considered as a part of the sustainability canvas. The item WP1 is pertinent to the use of RFID, and as per the literature, it is highly recommended in the logistics industry for cargo and container identification, as no contact is required between the reader and the tag, and RFID systems can identify and track unique items (Ray, 2008; Waters, 2010). However, it seems from the comments received in the survey that RFID is not widely used by the firms in the food supply chain because of high cost, greater size and weight as compared to barcodes, inability to track and identify damaged tags, and erroneous data transmission if tags come close to certain metals or liquids. The reliability values for all the dimensions are higher than 0.7. All the deleted items are shown in **Bold** and **Strikethrough** in the following Table.

Table 62: Summary of the CFA Model for SW

Item Labels	Item Descriptions	Factor Loadings (1st Order)	Factor Loadings (2nd Order)
Warehouse Design: WD (final AVE = 0.63 & alpha = 0.81)			**0.612**
~~WD1~~	***~~We use renewable energy sources for running warehouse operations~~***	***~~0.364~~***	***~~0.364~~***
WD2	Our warehouse is designed to reduce noise pollution	0.730	0.774
WD3	Our warehouse is designed to use energy efficiently	0.564	0.603
WD4	We conserve water through the latest water-management techniques	0.719	0.724
~~WD5~~	***~~Our warehouse is properly landscaped to preserve biodiversity and ensure food safety~~***	***~~0.412~~***	***~~.412~~***
WD6	Our warehouse is designed to optimally use daylight and artificial lighting without impacting the quality of stored food products	0.689	0.693
WD7	Our warehouse building design reduces weather impacts and maintains internal temperature required for dry, chilled and frozen food products	0.723	0.789
WD8	Our warehouse building (floors, walls, firewalls, roof and doors) meets international and Australian standards for food storage	0.624	0.645
WD9	All the equipment and materials (refrigerants, detergents, etc.) used in warehouse operations are food graded as per the Australian standards	0.593	0.633
Warehouse Layout: WL (final AVE = 0.602 & alpha = 0.839)			**0.857**
WL1	The warehouse storage space is optimally utilised with appropriate racking / stacking (drive-in, selective, double deep, etc.)	0.909	0.913
WL2	The aisle width is optimised for efficient and safe operations	0.863	0.887
WL3	The warehouse space is properly partitioned into areas for quarantine, fast moving products, hazardous materials, returned goods, and so on	0.810	0.874
WL4	The warehouse layout minimises pallet handling and movements	0.765	0.774
Warehouse Processes: WP (final AVE = 0.569 & alpha = 0.763)			**0.783**
~~WP1~~	***~~We use technology (such as warehouse management system, barcode scanning or RFID) to reduce paperwork and data inaccuracies~~***	***~~0.442~~***	***~~0.442~~***

Table 62: Summary of the CFA Model for SW (continued)

Item Labels	Item Descriptions	Factor Loadings (1st Order)	Factor Loadings (2nd Order)
WP2	The warehouse processes (inbound, storage, picking and outbound) are optimised for efficient and safe operations that ensure food safety and quality	0.864	0.822
WP3	Our staff adheres to good housekeeping practices to control food spills, pests & cross-contamination and to ensure proper sanitation & disposal of garbage	0.854	0.812
WP4	All food products are stored and rotated based on a picking logic (such as First in-First out or First expiry-First out)	0.658	0.643
WP5	Our food storage strategy prevents cross-contamination due to any physical or chemical contaminants	0.754	0.767
WP6	We continuously consider any possible opportunity for combined warehousing or sharing resources with other organisations	0.689	0.753
~~***WP7***~~	~~***We have KPIs and targets to reduce environmental impact linked with warehousing of raw materials and finished goods***~~	~~***0.396***~~	~~***0.396***~~
WP8	We have a thorough process to ensure inventory accuracy	0.779	0.748
WP9	We perform inventory counting on a regular basis	0.612	0.659
Warehouse Staff: WS (final AVE = 0.554 & alpha = 0.802)			**0.769**
WS1	We consider the staff Work-Life Balance while planning shifts for stock management	0.633	0.654
WS2	We periodically review shift patterns to reduce anti-social hours	0.731	0.765
WS3	We have strict safety standards (such as evacuation plan & fire extinguisher training) to avoid any accidents or injuries	0.653	0.604
WS4	We comply with occupational health and safety requirements for the food industry	0.721	0.775
WS5	We do not employ any indecent form of labour (child or forced)	0.673	0.654
WS6	We do not engage in any form of discriminatory practices	0.791	0.725
WS7	We pay reasonable wages and allow freedom of association for our staff	0.643	0.614
Onsite Facilities: OF (final AVE = 0.648 & alpha = 0.847)			**0.812**
OF1	The warehouse has proper hygiene facilities (showers, washing facilities, male/female toilets, etc.)	0.693	0.754

Table 62: Summary of the CFA Model for SW (continued)

Item Labels	Item Descriptions	Factor Loadings (1^{st} Order)	Factor Loadings (2^{nd} Order)
OF2	The warehouse has an emergency room with medical facilities, such as first aid equipment	0.761	0.775
OF3	The warehouse has a recycling facility for waste packaging	0.753	0.804
OF4	The warehouse has a cross-docking facility to reduce material storage and handling	0.821	0.875
Mechanical Handling Equipment: MHE (final AVE = 0.674 & alpha = 0.782)			**0.794**
MHE1	We use environment-friendly fuel for MHEs	0.613	0.654
MHE2	All MHEs (each truck, hand or electrical pallet truck, etc.) are regularly serviced to reduce emissions	0.831	0.865
MHE3	All operators are well-trained for fuel-efficient & safe MHE driving	0.853	0.904
Initial Model Fit (1^{st} Order)	χ^2/df = 1.990, RMSEA = 0.081, SRMR = 0.0775, GFI = 0.735, CFI = 0.712, NFI = 0.737, IFI = 0.806		
Final Model (1^{st} Order)	χ^2/df = 1.639, RMSEA = 0.060, SRMR = 0.063, GFI = 0.975, CFI = 0.922, NFI = 0.937, IFI = 0.906		
Initial Model Fit (2^{nd}Order)	χ^2/df = 2.393, RMSEA = 0.0734, SRMR = 0.083, GFI = 0.853, CFI = 0.712, NFI = 0.813, IFI = 0.921		
Final Model (2^{nd} Order)	χ^2/df = 1.347, RMSEA = 0.053, SRMR = 0.0635, GFI = 0.993, CFI = 0.904, NFI = 0.934, IFI = 0.941		

7.3.5.2 First-Order CFA Model for the SW Sub-Construct

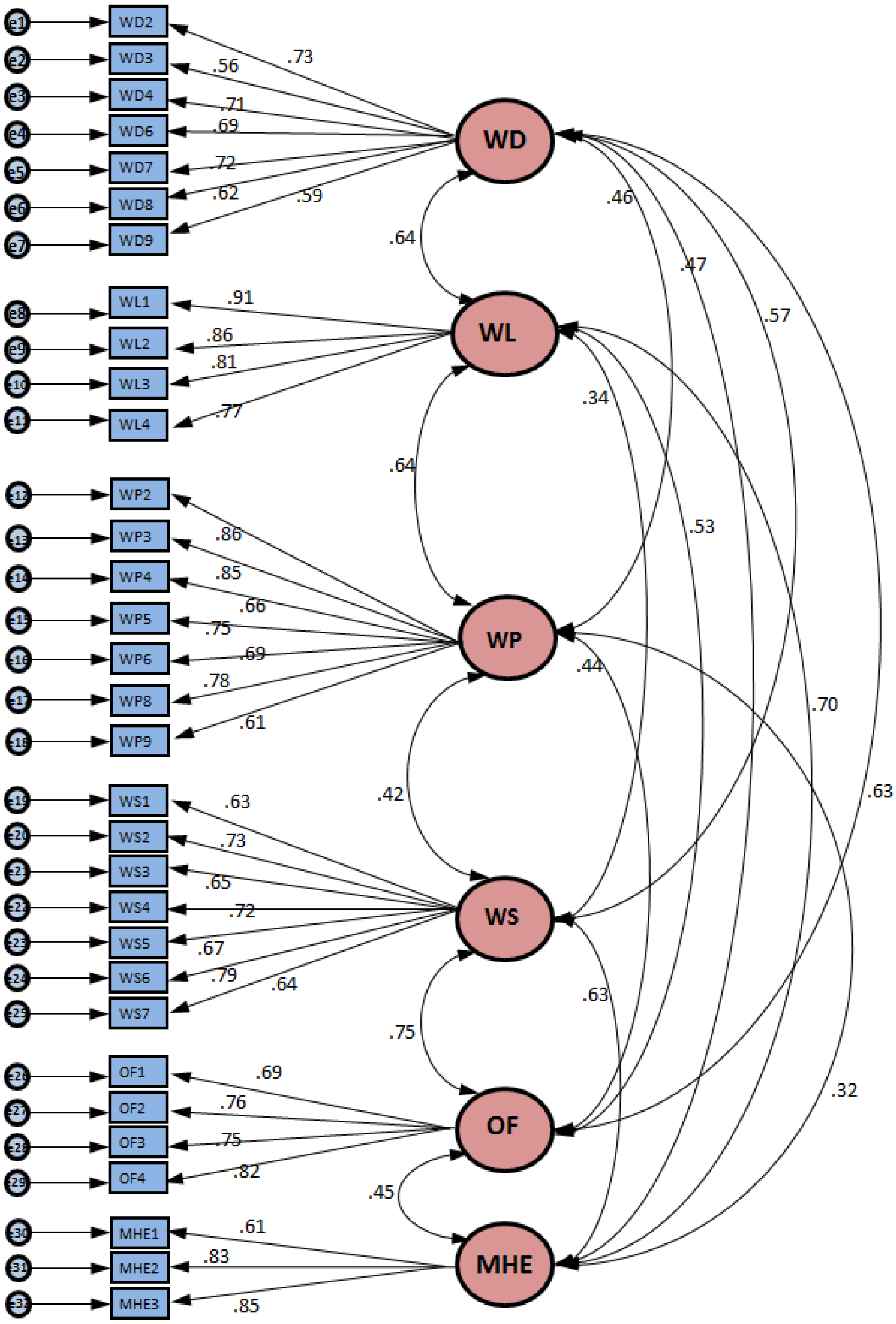

Figure 42: First-Order CFA Model for the SW Sub-Construct

7.3.5.3 Second-Order CFA Model for the SW Sub-Construct

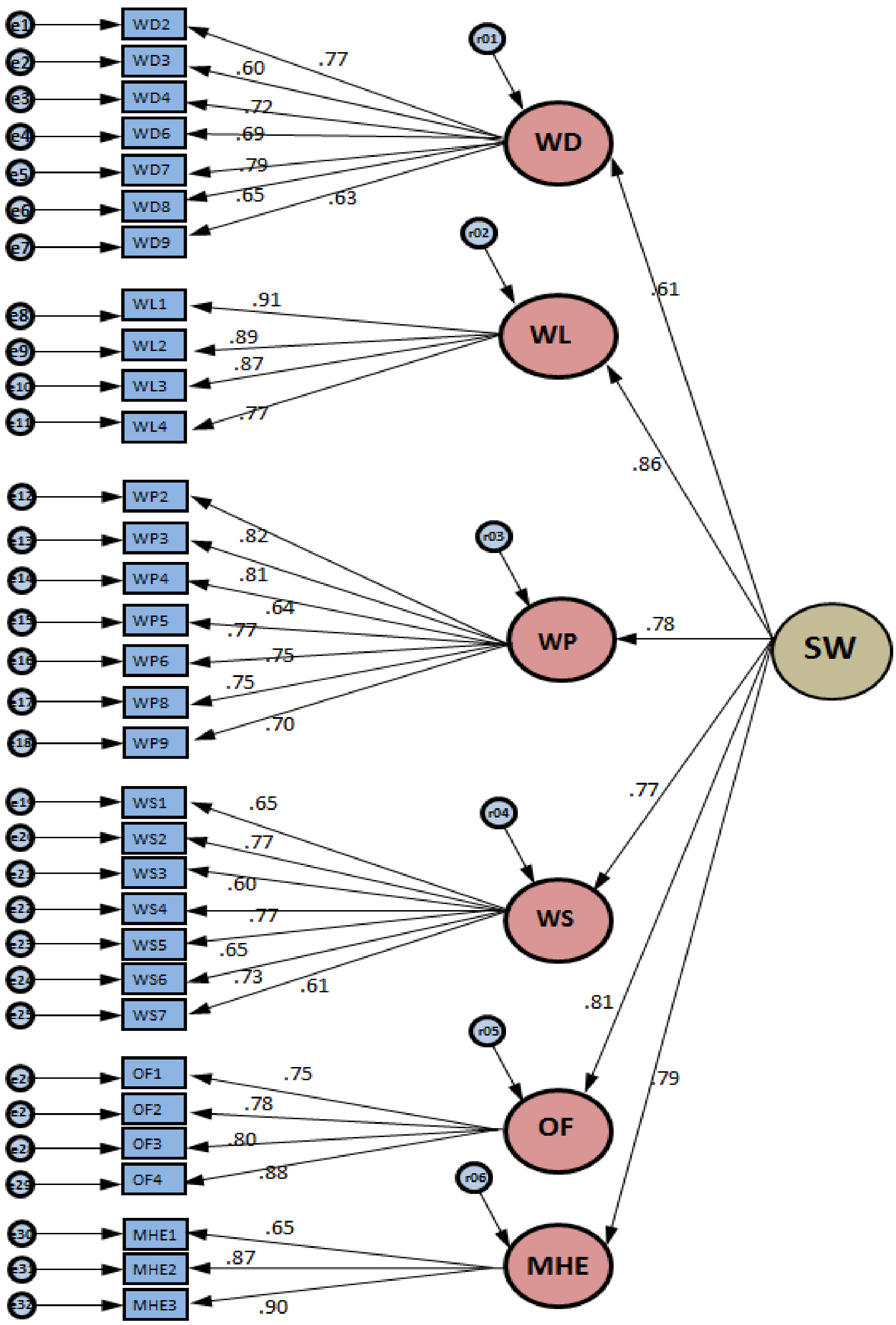

Figure 43: Second-Order CFA Model for the SW Sub-Construct

7.3.5.4 Discriminant Validity and Test of CMB

The inter-construct correlations are shown in **Table 63**. It can be seen that diagonal values, which are the square roots of AVEs of different factors, are much higher than their correlations with other factors. This simply means that these factors are more related to themselves than to any other factor, and thus discriminant validity is established. In addition, pairwise chi-square difference test was also done to further establish discriminant validity. The results supported the analysis and are provided in Appendix 5.

Table 63: Discriminant Validity through Inter-Construct Correlations for SW

	WD	WL	WP	WS	OF	MHE
WD	**0.797**					
WL	0.643	**0.775**				
WP	0.465	0.641	**0.754**			
WS	0.569	0.343	0.421	**0.744**		
OF	0.632	0.534	0.439	0.746	**0.805**	
MHE	0.466	0.703	0.321	0.632	0.449	**0.821**

The diagonal represents the square roots of AVEs

In addition, common method bias was tested through Harman's one-factor test and the common latent factor (CLF) method, as explained for the sustainable supply chain planning (SPlng) construct. The results showed that a single factor could only account for 25.6 percent of the variance in the model and the common variance shared by all the factors is only 6.6 percent, which confirms that CMB does not exist.

7.3.6 CFA Model for Reverse Logistics (RL)

Reverse Logistics is only represented by five items. The factor loadings for the first order CFA measurement model is shown in **Table 64** (and **Figure 44**) along with Cronbach's alpha and other SEM fit statistics.

Table 64: Summary of the CFA Model for RL

Item Labels	Item Descriptions	Factor Loadings (1st Order)
Reverse Logistics (RL): (alpha = 0.81)		
RL1	We have implemented a pro-active take-back program	0.903
RL2	We have implemented a centralised product return centre	0.824
RL3	We have outsourced reverse logistics operations	0.893
RL4	We determine recycling, reuse and resale potential of returned products	0.913
RL5	We give products in proper condition to charity organizations	0.864
Final Model (1st order)	χ^2/df = 1.699, RMSEA = 0.0602, SRMR = 0.0651, GFI = 0.956, CFI = 0.985, NFI = 0.981, IFI = 0.985	

7.3.6.1 First-Order CFA Model for the RL Sub-Construct

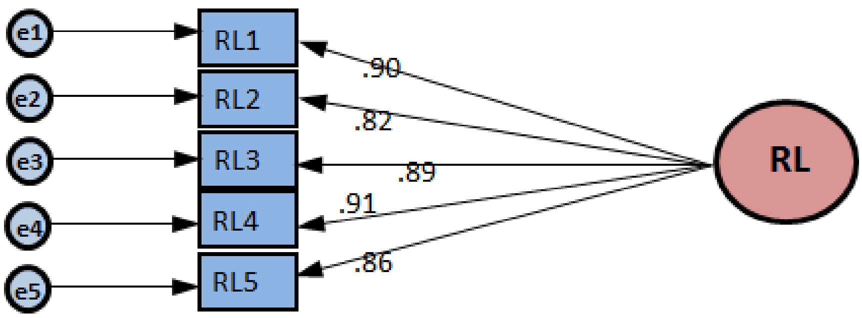

Figure 44: First-Order CFA Model for the RL Sub-Construct

7.4 Summary of the Confirmatory Factor Analysis

The summary of CFA analysis for all the SSCM sub-constructs: sustainable supply chain planning (SPlng), sustainable procurement (SP), sustainable manufacturing (SM), sustainable transportation (ST), sustainable warehousing (SW) and reverse logistics (RL) is provided in **Table 65**.

Table 65: Summary of the CFA Analysis

Sustainable Supply Chain Planning (SPlng) (second-order sub-construct)			
First-Order SPlng Sub-Constructs	**No. of Items**	**Alpha**	**AVE**
Institutional Supply Chain Planning: ISCP	8	0.53	0.71
Risk Mitigation: RM	4	0.732	0.814
Demand and Supply Planning: DSP	3	0.556	0.731
Product Development: PD	9	0.669	0.663
Final Model (1st order)	χ^2/df = 2.639, RMSEA = 0.0702, SRMR = 0.0631, GFI = 0.935, CFI = 0.902, NFI = 0.937, IFI = 0.906		
Final Model (2nd order)	χ^2/df = 1.393, RMSEA= 0.0643, SRMR = 0.0635, GFI = 0.953, CFI = 0.924, NFI = 0.973, IFI = 0.941		

Sustainable Procurement (SP) (second-order sub-construct)			
First-Order SP Sub-Constructs	**No. of Items**	**Alpha**	**AVE**
Procurement Policy & Processes: PPP	4	0.612	0.703
Operational Efficiency: OE	3	0.632	0.814
Supplier Selection & Assessment: SSA	4	0.656	0.771
Supplier Workplace Standards: SWS	5	0.669	0.763
Supplier Operations: SO	5	0.614	0.811
Suppliers' Regulatory Compliance: SRC	2	0.751	0.802
Final Model (1st order)	χ^2/df = 2.639, RMSEA = 0.061, SRMR = 0.058, GFI = 0.955, CFI = 0.922, NFI = 0.903, IFI =0.946		
Final Model (2nd order)	χ^2/df = 2.101, RMSEA = 0.053, SRMR = 0.0615, GFI = 0.983, CFI = 0.984, NFI = 0.973, IFI = 0.971		

Table 65: Summary of the CFA Analysis (continued)

Sustainable Manufacturing (SM) (second-order sub-construct)			
First-Order SM Sub-Constructs	**No. of Items**	**Alpha**	**AVE**
Manufacturing Policy & Processes: MPP	5	0.512	0.691
Pollution Control & Prevention: PCP	6	0.632	0.714
Resource Consumption: RC	3	0.609	0.693
Production Staff: PS	8	0.554	0.742
Production Regulatory Compliance: PRC	3	0.663	0.753
Final Model (1st order)	χ^2/df = 1.529, RMSEA = 0.0662, SRMR = 0.0611, GFI = 0.835, CFI = 0.952, NFI = 0.917, IFI = 0.926		
Final Model (2nd order)	χ^2/df = 1.655, RMSEA = 0.0543, SRMR = 0.0645, GFI = 0.894, CFI = 0.964, NFI = 0.976, IFI = 0.948		

Sustainable Transportation (ST) (second-order sub-construct)			
First-Order SM Sub-Constructs	**No. of Items**	**Alpha**	**AVE**
Transportation Policy & Processes: TPP	5	0.712	0.841
Transportation Mode & Loads: TML	7	0.652	0.894
Transportation Routing & Scheduling: TRS	3	0.586	0.652
Transportation Staff: TS	4	0.554	0.783
Transportation Shipping Materials: TSM	3	0.754	0.811
Transportation Regulatory Compliance: TRC	4	0.663	0.962
Final Model (1st order)	χ^2/df = 2.209, RMSEA = 0.062, SRMR = 0.076, GFI = 0.935, CFI = 0.912, NFI = 0.917, IFI = 0.922		
Final Model (2nd order)	χ^2/df = 1.939, RMSEA = 0.067, SRMR = 0.060, GFI = 0.953, CFI = 0.954, NFI = 0.972, IFI = 0.914		

Table 65: Summary of the CFA Analysis (continued)

Sustainable Warehousing (SW) (second-order sub-construct)			
First-Order SM Sub-Constructs	**No. of Items**	**Alpha**	**AVE**
Warehouse Design: WD	7	0.63	0.81
Warehouse Layout: WL	4	0.602	0.839
Warehouse Processes: WP	7	0.569	0.763
Warehouse Staff: WS	7	0.554	0.802
Onsite Facilities: OF	4	0.648	0.847
Mechanical Handling Equipment: MHE	3	0.674	0.782
Final Model (1st order)	$\chi^2/\ df$ = 1.639, RMSEA = 0.060, SRMR = 0.063, GFI = 0.975, CFI = 0.922, NFI = 0.937, IFI = 0.906		
Final Model (2nd order)	$\chi^2/\ df$ = 1.347, RMSEA = 0.053, SRMR = 0.0635, GFI = 0.993, CFI = 0.904, NFI = 0.934, IFI = 0.941		

Reverse Logistics (RL) (first order sub-construct)	
No. of Items	**Alpha**
5	0.81
Final Model (1^{st} order)	$\chi^2/\ df$ = 1.699, RMSEA = 0.0602, SRMR = 0.0651, GFI = 0.956, CFI = 0.985, NFI = 0.981, IFI = 0.985

7.5 Miscellaneous Robustness Tests

Miscellaneous tests were conducted to ensure the robustness of data for the SEM analysis. Some of these tests include: multivariate normality test, Mahalanobis Distance Test to detect outliers and the Full Information Maximum Likelihood (FIML) test to check for ‘missing data bias’.

7.5.1 Results of the Multivariate Normality Test

A critical assumption in the use of SEM analysis through AMOS is that the data are multivariate normal. This is rooted in large sample theory from which SEM has spawned. Thus, before any analysis of data was undertaken in this PhD study, it was assured that this criterion is met.

The prerequisite of multivariate normality assessment is univariate normality. Therefore, data of all the items in the proposed models for SSCM sub-constructs were first checked for univariate normality using AMOS. The values of standardised z-test critical ratio (C.R.) and kurtosis of all items were used for this purpose. The cut-off value of 7.0 was decided for kurtosis and it was found that no item in the SSCM models significantly violated normality.

Then the multivariate kurtosis values were used with the associated z-statistic and a cut-off value of 5.0 was set for this purpose. All the models satisfied the requirements except the SEM model for sustainable warehousing (SW) and non-normality was found with Kurtosis = 109.318 and C.R. = 11.605. Consequently, Satorra-Bentler robust method (Satorra & Bentler, 1994) was performed. The goodness-of-fit indices for two models as suggested by Byrne (2010) were compared to evaluate the bias caused by this multivariate non-normality. Adequate fit and insignificant difference between chi-squares showed multivariate non-normality will not be a risk to the analysis.

An additional step was also undertaken and bootstrap resampling approach was used in AMOS. The bootstrap p-value was calculated as 0.09 which is greater than 0.05 and hence the model was correct despite existence of multivariate non-normality. Therefore, it was concluded the even though the assumption of multivariate normality was not met in the data for SW but this error will not cause a problem to the analysis

7.5.2 Results of the Mahalanobis Distance Test – Detecting Outliers

The questionnaires are subject to inattentive responses in the survey research. This usually results in outliers in the data (Meade & Craig, 2012). In this research study, outliers were identified using the squared Mahalanobis distance (D^2) in AMOS (Byrne, 2010, p. 106). This technique was used as it is appropriate for multiple-item surveys. Typically, if there is an outlying case then its D^2 value stands distinctively apart from other D^2 values (Byrne, 2010, p. 106). Minimal evidence of multivariate outliers was found and thus multivariate outliers did not pose a threat to the analysis.

7.5.3 Results of the Full Information Maximum Likelihood Test – Checking for Missing Data Bias

Missing data is inherent in survey research but it should be minimal. Cohen and Cohen (1983) argued that missing data of up to 10 percent does not cause a problem during analysis. In this research study, the number of missing cases was less than five percent. However, it was decided to check for any possible 'missing bias'. The Full Information Maximum Likelihood (FIML) approach was employed in AMOS and expectation-maximization (EM) in SPSS was used to examine whether missing data is missing completely at random (MCAR) (Schafer & Graham, 2002) or missing at random (MAR). It was found that missing data bias is negligible and will not be a threat to the analysis.

CHAPTER 8: CONCLUSION

This chapter presents a summary of the quantitative analysis, general sustainability insights for the Australian food industry, implications for managers, implications for research, miscellaneous findings, limitations of this PhD research study and future research directions.

8.1 Summary of Results

This main aim of this PhD research study is to develop a valid and reliable Sustainable Supply Chain Management (SSCM) scale that could help to identify the best practices for a firm in the Australian food industry. In this regard, the following gaps were identified through broader review of the literature:

First, in supply chain and operations management literature there is no comprehensive scale that could highlight the measures for operationalising sustainability in a firm's supply chain. Consequently, theory development is limited and there is a dire need to develop a valid and reliable scale for sustainable supply chain management (SSCM).

Second, broad review of the literature showed that sustainability can only be realised if initiatives are taken along different stages (or processes) of a firm's supply chain (Green et al., 1996; Nathan, 2005). However, no SSCM literature review has analysed the current status of sustainability research separately for supply chain planning, procurement, manufacturing, transportation, warehousing and reverse logistics. Thus, a thorough literature review is required focusing on each stage of a firm's supply chain.

Third, investigation into scale development literature showed that scales are not 'developed' carefully, and are rather 'assembled'. This is due to the absence of a systematic framework that could explain all the primary and secondary steps related to the conceptualisation and identification of scale measures (DeVellis, 2003).

Fourth, both academic literature and industry publications are silent about specific practices that could help to instil sustainability in a firm's supply chain in the Australian food industry.

Based on these gaps, the following research questions were articulated:

1. What are the sustainability 'best practices' for supply chain planning, procurement, manufacturing, transportation, warehousing and reverse logistics for a firm in the Australian food industry?
2. How have sustainability challenges been addressed in the academic literature to date for each supply chain process?
3. Which steps should be followed for systematic construct conceptualisation and measures identification during the scale development process?

This research study made an effort to respond to these research questions in the most appropriate manner by ensuring that apposite techniques and methodologies are employed at each stage of the research study. Consequently, this study has developed a construct conceptualisation and measures identification framework, which is quite generic in nature and can be adapted to any industry. In addition, the study has conducted a thorough review of the SSCM literature with the lens of the supply chain operations reference (SCOR) process model. Finally, it has developed the 'best practices' for each stage of a firm's supply chain in the Australian food industry. Relevant details are provided below:

8.1.1 Construct Conceptualisation and Measures Identification Framework

The conceptualisation and measures identification framework is developed for Stage I of the scale development process. It is based on extensive academic literature related to sustainability, SCM, management theories and scale development. It defines a step-by-step procedure for construct conceptualisation and measures identification. It also incorporates expert feedback at different steps to develop measures with sound psychometric properties and high industry relevance. It includes a unique four-phased methodology for 'item generation' which is usually the weakest aspect of the scale development research studies. The four-phased methodology, which is a part of the complete framework, was presented in the form of a conference paper at the 8th Annual Symposium of the Institute of Sustainable Leadership (ISL) in Nice, France, and it received **the best paper award** after double-blind review by a panel of ISL experts.

Overall, the construct conceptualisation and measures identification framework presents the first stage of the scale development process in a cohesive and coherent manner. Also, the framework can be adapted to disciplines other than SCM to generate relevant sustainability dimensions and measures. Some of the steps might change accordingly, but a major portion of the framework (coding methodology; techniques; and strategies) will remain the same. In addition, the framework clearly shows that content and thematic analyses are powerful techniques that could be effectively applied to embryonic fields such as sustainable supply chain management. The complete framework was recently presented in the form of a conference paper at the 9th Annual Symposium of Institute of Sustainable Leadership (ISL) in Salzburg, Austria, and it also received **the best paper award** after double-blind review by a panel of ISL experts. Please refer to **Figure 2** for the graphical presentation of the framework.

8.1.2 Review of the SSCM Literature with the Lens of the SCOR Model

Many literature reviews have recently been published that analysed various aspects of the research done in the field of sustainable supply chain management (SSCM). It was noted that most of the SSCM review papers broadly discussed the research methodologies, modelling techniques, performance metrics and supply chain drivers, which help to improve the sustainability performance of a supply chain. However, no review has been conducted via the lens of the Supply Chain Operations Reference (SCOR) process model that could separately analyse the status of sustainability research for each major stage of supply chain, so that specific gaps are identified and practices can be developed accordingly. This PhD research study attempted to fill this gap and carried out a full-fledged review of the SSCM literature and separately analysed the sustainable supply chain literature for planning, procurement, manufacturing, transportation, warehousing and reverse logistics.

It devised a unique four-phased methodology to review and analyse the SSCM academic material consisting of 349 peer-reviewed academic articles. This study found that the purview of sustainable supply chain is very broad, as there are 74 journals from various disciplines that contributed either one or two papers to the publication sample of 349 papers. In addition, the top contributing journals such as Greener Management International and Business Strategy and the Environment, which contributed 21 papers each, are not typical supply chain and operations management journals. This clearly showed that any sustainable supply chain management study focusing only on operations research (OR) and supply chain management (SCM) journals will be extremely deficient in terms of the credibility and validity of its findings.

Various other findings and thorough descriptive analysis of this comprehensive review activity, that formed the basis of further research in this PhD study, are discussed in

Chapter 3 (section 3.1). (The review of SSCM literature, via the lens of the SCOR process model, along with its findings, was presented at the 74th Annual Meeting of the Academy of Management (AoM), Philadelphia, PA, USA in 2014 with good reviews.)

8.1.3 SSCM Best Practices for the Australian Food Industry

It was stated in the Introduction that *'the overall aim of this PhD study is to develop a valid and reliable SSCM scale that could help to identify best practices for a firm in the Australian food industry.'* In this regard, hypotheses resulting from the literature analysis were tested through exploratory and confirmatory factor analysis for each SSCM sub-construct: sustainable supply chain planning, sustainable procurement, sustainable manufacturing, sustainable transportation, sustainable warehousing and reverse logistics. Consequently, this extensive process of scale validation resulted in a set of sustainable practices for each supply chain process, as outlined below:

8.1.3.1 Sustainable Supply Chain Planning (SPlng) Best Practices

Planning is one of the most important but challenging areas in a supply chain. In the last two decades, the focus of SC planning has shifted from the shop floor to a holistic view of various logistics, production and procurement activities within a focal firm. To answer the research questions, in section 3.3, of how sustainability can be ingrained into supply chain planning, and what are the elements or practices for sustainable planning, the literature analysis resulted in four hypotheses: HSPlng1, HSPlng2, HSPlng3 and HSPlng4. Please see section 3.3 for the details. These hypotheses were quantitatively examined through a survey containing a set of questions based on the dimensions and measures identified in the literature analysis. The quantitative analysis was done using structural equation modelling (SEM) through SPSS and AMOS, which resulted in a set of practices outlined in **Table 66**.

Table 66: Best Practices for SPlng

Sr. #	Item Labels	Sustainable Supply Chain Planning: Best Practices
1.	ISCP1	Ensure that all supply chain transactions and operations are transparent
2.	ISCP4	Conduct Customer Satisfaction Survey on periodical basis
3.	ISCP5	Provide training and development opportunities to all employees
4.	ISCP9	Provide equal opportunities and fair remuneration to all employees
5.	ISCP10	Ensure strict policies against discrimination, harassment and bullying
6.	ISCP11	Ensure good working conditions for all employees
7.	ISCP12	Perform backup planning for all critical positions
8.	RM1	Develop and periodically test Business Continuity Plan (BCP) for IT issues
9.	RM2	Develop a survival plan for natural disasters
10.	RM3	Develop backup suppliers to mitigate disruptions from primary suppliers
11.	RM4	Develop an emergency plan to ensure employee safety in the event of site disaster
12.	DSP1	Achieve demand forecast accuracy of at least 80 percent
13.	DSP2	Perform collaborative planning with Sales and Marketing
14.	DSP3	Ensure production schedule accuracy
15.	PD1	Collaborate with Marketing and involve suppliers for developing sustainable products
16.	PD2	Assist product development/brand team in producing products that need minimal resources (water, energy, and materials)
17.	PD3	Assist product development/brand team to eliminate every possible toxic material that might be used during product manufacturing or usage
18.	PD4	Assist product development/brand team to develop food products that are most efficient for logistical activities (storage, transportation, and handling)
19.	PD5	Assist product development/brand team to develop food products that are easily recyclable
20.	PD6	Assist product development/brand team to develop food products with long shelf-life
21.	PD8	Assist in developing food products that focus on functional benefits
22.	PD10	Ensure food safety by complying with the Australian standards and regulations during product development
23.	PD12	Focus on recommending ingredients (or materials) that could be locally sourced from the Australian suppliers and farmers

8.1.3.2 Sustainable Procurement (SP) Best Practices

The era of sustainability has accentuated the importance of the procurement function. Various stakeholders such as governments, customers, environmentalists and the general public are forcing the firms to work with their suppliers to reduce the negative environmental and societal impacts of poisonous ingredients, emissions of greenhouse gases (GHG), contamination of waterways and exploitation of low cost labour markets (Sharfman et al., 2009). Firms must ingrain the sustainability criteria in their supplier selection, assessment and development framework encompassing indicators related to environmental preservation, communal welfare and economic value. In addition, firms should perform regular audits of their suppliers to ensure compliance with the Australian standards.

According to practitioners, *'sustainable procurement means taking into account economic, environmental and social impacts in buying choices. This includes optimising price, quality, availability…but also environmental life-cycle impact and social aspects linked to product/services origin'* (PwC, EcoVadis, & INSEAD, 2010).

To answer the research questions, in section 3.3, about how sustainability can be ingrained in procurement, and what are the elements or practices for sustainable procurement, the literature analysis resulted in six hypotheses HSP1, HSP2, HSP3, HSP4, HSP5 and HSP6. Please see section 3.3 for the details. These hypotheses were quantitatively examined through a survey containing a set of questions based on the measures identified in the literature analysis. The quantitative analysis was done using structural equation modelling (SEM) through SPSS and AMOS, which resulted in a set of practices outlined in **Table 67.**

Table 67: Best Practices for SP

Sr. #	Item Labels	Sustainable Procurement: Best Practices
1.	PPP1	Procurement should be considered as a strategic function in the firm
2.	PPP2	Develop a written procurement policy that ensures environmental preservation, communal welfare and economic value for the firm
3.	PPP3	Set up purchasing process from source-to-settle that is governed by the sustainable procurement policy (SPP)
4.	PPP4	Implement a comprehensive contract management system governed by SPP
5.	OE1	Provide training opportunities to all procurement employees
6.	OE2	Develop backup suppliers to prevent supply disruptions
7.	OE3	Use technology (e-procurement or procurement management system) to improve operational efficiency and transparency
8.	SSA1	Develop supplier selection criteria that encompasses social and environmental indicators
9.	SSA2	Periodically audit all the suppliers for social and environmental performance
10.	SSA3	Ensure that suppliers' business operations are free of corruption, bribery or any kind of illegal activity
11.	SSA4	Ensure that suppliers are financially sound
12.	SWS1	Ensure that suppliers comply with occupational health and safety requirements as per the Australian standards
13.	SWS2	Ensure that suppliers do not employ any indecent form of labour (child or forced)
14.	SWS3	Ensure that suppliers do not engage in any form of discriminatory practices
15.	SWS4	Ensure that suppliers comply with legal restrictions on working hours
16.	SWS5	Ensure that suppliers pay reasonable wages to employees
17.	SO1	Ensure that suppliers efficiently use energy and water
18.	SO2	Ensure that suppliers monitor and reduce all emissions (e.g., GHG, ODS, air pollutants, etc.) resulting from business operations
19.	SO4	Ensure that suppliers reduce waste through reuse and recycling
20.	SO5	Ensure that suppliers have traceability systems in place
21.	SO6	Ensure that suppliers use food grade packaging as per the Australian standards
22.	SRC1	Ensure that suppliers comply with the Australian and international laws and regulations
23.	SRC3	Ensure that suppliers use proper labelling for all food products according to the Australian standards

8.1.3.3 Sustainable Manufacturing (SM) Best Practices

Manufacturing processes require high inputs of energy and materials for value creation. Electric power generation and fuel combustion for facility heating, during production processes, are estimated to contribute 9 percent and 25 percent of GHG emissions, respectively (Nasr, Hilton, & German, 2011; Smart Steps, n.d.c). The waste generated from production centres and plants highly contaminate the local and the global environment. It usually contains various heavy metals discharged in waste-water such as Cu, Pb, hexavalent chromium, cadmium, Zn, Ni and Hg; organic pollutants and pesticides; oil and grease; pathogens; suspended solids; and nitrogen and phosphorous (Nasr, Hilton, & German, 2011). Therefore, socially and environmentally responsible manufacturing is not an option any more, but is a business imperative. More recently, the US Department of Commerce [USDoc] (2010) defined sustainable manufacturing as *'the creation of manufactured products that use processes that minimize negative environmental impacts, conserve energy and natural resources, are safe for employees, communities, and consumers and are economically sound.'*

To answer the research questions, in section 3.3, of how sustainability can be ingrained in SM, and what are the elements or practices for sustainable manufacturing, the literature analysis resulted in seven hypotheses: HSM1, HSM2, HSM3, HSM4, HSM5, HSM6 and HSP7. Please see section 3.3 for the details. These hypotheses were quantitatively examined through a survey containing a set of questions based on the measures identified in the literature analysis. The quantitative analysis was done using structural equation modelling (SEM) through SPSS and AMOS, which resulted in a set of practices outlined in **Table 68**.

Table 68: Best Practices for SM

Sr. #	Item Labels	Sustainable Manufacturing: Best Practices
1.	MPP1	Develop a written manufacturing policy that ensures environmental preservation, communal welfare and economic value for the firm
2.	MPP2	Implement an Environmental Management System to identify, monitor, reduce and report the impact of production operations on the environment
3.	MPP3	Follow the principles of HACCP (Hazard Analysis and Critical Control Point) in food production processes
4.	MPP5	Ensure proper cleaning, sanitation, temperature control and pest control in the production facility to ascertain food safety and quality
5.	MPP6	Ensure that all detergents, disinfectants or cleaning aids are environment and human friendly
6.	PCP1	Implement a Remediation Action Plan to alleviate any environmental damage from past operations or crises
7.	PCP2	Ensure that all pollutants generated at the end of a process are captured and treated accordingly
8.	PCP3	Monitor and reduce emissions such as GHG, ODS and air pollutants
9.	PCP4	Reduce waste (from over-production, product defects, waiting time, etc.) through efficient processes, reuse and recycling
10.	PCP5	Continuously strive to redesign production processes so that they are environment friendly
11.	PCP6	Optimise production processes using ERP modules such as capacity planning, master production scheduling, MRP, QM, etc.
12.	RC1	Reduce and conserve energy through efficient processes
13.	RC2	Efficiently use water without harming the source
14.	RC3	Recycle and reuse water for the production operations
15.	PS1	Consider the staff work-life balance while planning deliveries to customers
16.	PS2	Periodically review shift patterns to reduce anti-social hours
17.	PS3	Comply with all occupational health and safety requirements as per the Australian standards
18.	PS4	Do not employ any indecent form of labour (child or forced)
19.	PS5	Do not engage in any form of discriminatory practices
20.	PS6	Pay reasonable wages and allow freedom of association to all staff
21.	PS7	Setup KPIs to identify and reduce workplace injury and illness
22.	PS8	Ensure that production processes and technologies are safe for workforce
23.	PRC1	All the equipment and materials used in production should be food graded as per the Australian standards
24.	PRC2	Ensure that all food products are labelled according to the Australian regulations
25.	PRC4	The firm must have a written labour/workplace management policies and standards aligned with international standards such as UN Global Compact and ILO

8.1.3.4 Sustainable Transportation (ST) Best Practices

Transportation has always been a key ingredient of businesses and society. It played a pivotal role in the prosperity of human civilisation by fulfilling the travelling requirements and by enabling the movement of goods from one part of the globe to another. The economic, social and political role of transportation is widely acknowledged. Recently, the Mobility 2001 Report defined sustainable transport as *'the ability to meet the needs of society to move freely, gain access, communicate, trade and establish relationships without sacrificing other essential human or ecological values today or in the future'* (MIT & CRA, 2001).

In the last few decades, the impact of transportation on the environment has attracted the attention of both policy makers and researchers due to an alarming increase in global warming. Scientists have reported that freight transport alone is responsible for 8 percent of CO_2 emissions worldwide (Kahn Ribeiro & Kobayashi, 2007). Also, according to the UK Committee on Climate Change [CCC] (2008), shipping will account for 15 – 30 percent of CO_2 emissions by 2050.

To answer the research questions, in section 3.3, of how sustainability can be ingrained in transportation, and what are the elements or practices for sustainable transportation, the literature analysis resulted in six hypotheses: HST1, HST2, HST3, HST4, HST5 and HST6. Please see section 3.3 for the details. These hypotheses were quantitatively examined through a survey containing a set of questions based on the measures identified in the literature analysis. The quantitative analysis was done using structural equation modelling (SEM) through SPSS and AMOS, which resulted in a set of practices outlined in **Table 69.**

Table 69: Best Practices for ST

Sr. #	Item Labels	Sustainable Transportation: Best Practices
1.	TPP1	Consider sustainability aspects while procuring new transportation fleet (e.g., aerodynamics, vehicle weight, engine design, etc.)
2.	TPP2	Regularly perform fleet inspection and maintenance (e.g., brake checks, oil levels, tyre inflation, etc.)
3.	TPP3	Regularly examine the transportation fleet for noise pollution
4.	TPP4	Enforce strict guidelines to minimise needless idling of vehicle (e.g. turn off engines during delivery or pickup, etc.)
5.	TPP5	Develop KPIs and targets to reduce environmental impact linked with transportation of raw materials and finished goods
6.	TML1	Use the most fuel-efficient transportation mode (such as rail, sea, etc.)
7.	TML2	Use environmentally-friendly fuels (such as biofuels, ethanol, etc.) in vehicles to reduce emissions
8.	TML3	Use standard packaging and pallet configurations to optimise transport load factors
9.	TML4	Optimally utilise vehicle capacity through maximum volume, weight and floor-space utilisation
10.	TRS1	Use load planning software for optimal and safe loading of vehicles, railcars, marine or air containers
11.	TRS2	Actively use common carriers, backhauls, co-shipping, internet based load matching services or double-stacked containers
12.	TRS3	Use software to determine optimal vehicle routing and freight delivery schedules
13.	TS1	Consider the staff work-life balance while planning deliveries to customers
14.	TS2	Periodically review shift patterns to reduce anti-social hours
15.	TS3	Comply with all occupational health and safety requirements as per the Australian standards
16.	TS4	Do not employ any indecent form of labour (child or forced)
17.	TS5	Do not engage in any form of discriminatory practices
18.	TS6	Pay reasonable wages and allow freedom of association for the staff
19.	TS7	Divers should be well trained to ensure safe and fuel-efficient driving
20.	TSM1	Transport food products in reusable shipping materials rather than shrink-wrap or cardboard
21.	TSM2	Transport food products in long-lasting or recyclable corrugated cardboard pallet or plastic pallet
22.	TSM4	Use recycled pallets and cardboards (where cardboards must be used)
23.	TRC1	All the equipment and materials used in transportation operations should be food graded as per the Australian standards
24.	TRC2	Ensure that appropriate temperature is maintained during transportation of dry, chilled and frozen food, according to the Australian standards
25.	TRC3	Thoroughly inspect inbound or outbound vehicles (or containers) for condensation, moisture, objectionable odours, infestation and allergens to ensure food safety
26.	TRC4	Ensure that all food items being transported are properly covered and are separate from any contaminants

8.1.3.5 Sustainable Warehousing (SW) Best Practices

Warehousing has received comparatively less attention from researchers but holds tremendous potential to achieve the goals of sustainable development. The Transport and Logistics Industry Skills Council Australia [LTC] (2011) in a recent survey reported that '...companies are still coming to terms with the question of sustainability. Warehousing facilities have the largest potential in terms of reducing environmental impacts…'.

Warehousing is one of the most critical functions in a supply chain as it accounts for 24 percent of logistical costs (ELA, 2004). Chopra and Meindl (2007) defined warehousing as *'the storage of materials (packaging, finished goods and raw materials) at different stages of the supply chain.'* A warehouse, also referred to as distribution centre, storage facility and logistics service centre, is used for a variety of functions ranging from product distribution, cross-docking to composite storage. Thus, it has a wider intensive role based on the provision of many value-adding operations, customisation services and rapid fulfilment of customer orders (Baker & Canessa, 2009).

However, it has been a victim of 'greenwashing' and decorated with other titles like eco-warehousing, and the practices that are required to achieve such aspirations are hard to find. To answer the research questions, in section 3.3, of how sustainability can be ingrained in warehousing, and what are the elements or practices for sustainable warehousing, the literature analysis resulted in eight hypotheses: HSW1, HSW2, HSW3, HSW4, HSW5, HSW6, HSW7 and HST8. Please see section 3.3 for the details. These hypotheses were quantitatively examined through a survey containing a set of questions based on the measures identified in the literature analysis. The quantitative analysis was done using structural equation modelling (SEM) through SPSS and AMOS, which resulted in a set of practices outlined in **Table 70**.

Table 70: Best Practices for SW

Sr. #	Item Labels	Sustainable Warehousing: Best Practices
1.	WD2	Warehouse should be designed to reduce noise pollution
2.	WD3	Warehouse should be designed to use energy efficiently
3.	WD4	Water should be conserved through latest water-management techniques
4.	WD6	Warehouse should be designed to optimally use daylight and artificial lighting without impacting the quality of stored food products
5.	WD7	Warehouse building design should reduce weather impacts and maintain internal temperature required for dry, chilled and frozen food products
6.	WD8	Warehouse building (floors, walls, firewalls, roof and doors) must meet international and the Australian standards for food storage
7.	WD9	All the equipment and materials (refrigerants, detergents, etc.) used in warehouse operations must be food graded as per the Australian standards
8.	WL1	Optimally utilise the warehouse storage space with appropriate racking / stacking (e.g. drive-in, selective, double deep, etc.)
9.	WL2	Optimise aisle width for efficient and safe operations
10.	WL3	Properly partition the warehouse space into areas for quarantine, fast moving products, hazardous materials, returned goods and so on
11.	WL4	The warehouse layout should minimise pallet handling and movements
12.	WP2	The warehouse processes (inbound, storage, picking and outbound) should be optimised for efficient and safe operations that ensure food safety and quality
13.	WP3	Warehouse staff must adhere to good housekeeping practices to control food spills, pests & cross-contamination, and to ensure proper sanitation and disposal of garbage
14.	WP4	All food products should be stored and rotated based on a picking logic (such as First in-First out, or First expiry-First out)
15.	WP5	The food storage strategy must prevent cross-contamination due to any physical or chemical contaminants
16.	WP6	The firm should continuously consider any possible opportunity of combined warehousing or sharing resources with other organizations
17.	WP8	Implement a thorough process to ensure inventory accuracy
18.	WP9	Perform inventory counting on regular basis
19.	WS1	Consider the staff work-life balance while planning shifts for stock management
20.	WS2	Periodically review shift patterns to reduce anti-social hours
21.	WS3	Implement strict safety standards (such as evacuation plan & fire extinguisher training) to avoid any accidents or injuries
22.	WS4	Comply with occupational health and safety requirements for the food industry as per the Australian standards
23.	WS5	Do not employ any indecent form of labour (child or forced)
24.	WS6	Do not engage in any form of discriminatory practices
25.	WS7	Pay reasonable wages and allow freedom of association for the staff
26.	OF1	The warehouse should have proper hygiene facilities (showers, washing facilities, male/female toilets, etc.)

Table 70: Best Practices for SW (continued)

Sr. #	Item Labels	Sustainable Warehousing: Best Practices
27.	OF2	The warehouse should have an emergency room with medical facilities such as first aid equipment
28.	OF3	It is recommended to have recycling facility on premises for waste packaging
29.	OF4	It is recommended to have a cross-docking facility to reduce material storage and handling
30.	MHE1	Use environmentally-friendly fuel for MHEs
31.	MHE2	Regularly service all MHEs (e.g. reach truck, hand or electrical pallet truck, etc.) to reduce emissions
32.	MHE3	All MHE operators should be well trained for fuel-efficient and safe MHE driving

8.1.3.6 Reverse Logistics (RL) Key Practices

Reverse logistics is complete domain in itself. Literature review revealed that it is a well-established field of knowledge and has received considerable attention from researchers. This area has huge potential for recovering value from used products and materials. The main focus in reverse logistics is on waste management, parts recovery (through remanufacturing) and materials recovery (through recycling) (Simpson, 2010).

This research study could not delve deeper into reverse logistics due to time constraints; however, a single hypothesis developed in section 3.3 was tested through CFA, and some of the key practices are presented in **Table 71**.

Table 71: Key Practices for RL

Sr. #	Item Labels	Reverse Logistics: Best Practices
1.	RL1	Implement a pro-active product take-back program
2.	RL2	Implement a centralised product return centre
3.	RL3	Outsource reverse logistics operations if in-house costs are high
4.	RL4	Determine recycling, reuse and resale potential of returned products
5.	RL5	Donate products in proper condition to charity organizations

8.2 General Sustainability Insights for the Australian Food Industry

The research study showed the response of the Australian Food Industry to sustainability practices based on the analysis of academic literature and industry publications. Some of the responses endorsed the theoretical findings; however, many surprising and contradictory results were identified for each supply chain process through a large-scale survey. Highlights for each process are discussed below:

Sustainable Supply Chain Planning – Even though community services are considered as a critical corporate responsibility in the sustainability literature, it seems from the large scale survey that the supply chain (SC) departments still consider it as a job of the central firm management and not the department itself. Similarly, R&D is not consistent with the remaining items in ISCP factor. It may be that it is considered the duty of a separate department within the organisation that is supposed to conduct the research and development related to all organisational functions and mainly, new products and services. Nevertheless, SC functions are involved in monitoring customer satisfaction; providing training to their workforce; ensuring non-discriminatory attitude, fair remuneration, backup planning; and conducting operations that are free of corruption and bribery.

The practice or measure related to identification of consumer needs was also deleted from the model due to low factor loadings. It seems from some of the comments in the survey that firms consider it the sole responsibility of the marketing department and not the supply chain. They still consider that it is the job of the brand managers to understand the needs of the consumers and to develop products that are affordable and fresh. However, this clearly shows that there is a lack of understanding that the supply chain can play an effective role in providing insights that could lead to products being optimised for logistics operations, or that by revamping their processes, fresh produce can reach the shelves of the retailers earlier. In the food industry, price and freshness are highly sought out by the customers, and supply chain and marketing departments should work together to assure it.

Sustainable Procurement – Confirmatory factor analysis of data collected through large scale survey provides some results that are quite surprising. The factor loading of the item related to biodiversity is statistically insignificant and thus it was deleted. The survey showed that firms do not have an understanding that biodiversity is part of sustainability, and that negative impacts on the local ecosystem have both short and long-term consequences for the local communities and their surrounding geography. Even though the face validity, content validity and pilot testing all indicated that biodiversity should be a key element for consideration when selecting, assessing and developing suppliers, the comments in the large scale survey showed that firms are least concerned about it, which might consequently mean that firms in the Australian food industry are only willing to comply with mandatory regulations and do not possess concrete, ethical and sustainable frameworks of their own. Also, the factor loading of the item (SRC2) related to suppliers complying with Australian Packaging Covenant was also very low and it was deleted in the AMOS model. It is hard to understand that why this item is not consistent with the remaining items in the Sustainable Procurement model. There are no direct comments in the survey which could help to elucidate the reasons for this inconsistency, but it could be clearly seen that many respondents considered it as an 'N/A – Not Applicable' item. The reason is probably that the Australian Packaging Covenant is voluntary and firms do not consider that it should be a mandatory requirement for the suppliers, as it will increase their cost of doing business in the era of the fluctuating Australian dollar and financial crisis.

Sustainable Manufacturing – The results of sustainable manufacturing are quite consistent with the findings related to sustainable procurement. Again, it can be seen in the sustainable manufacturing model that the loadings of items related to biodiversity and the Australian Packaging Covenant (APC) are very low, and thus both items MPP4 and PRC3 were deleted. It is evident that the respondents do not consider biodiversity as an important part of their social and environmental responsibility. Although, many of the firms are signatory to the APC, they consider it the responsibility of the marketing department to determine the packaging requirements of the food product. It appears as if the respondents consider that the SC department is responsible only for operations and has nothing to do with the product design and layout. This is simply against the sustainability mindset in which every department and function should consider itself responsible for the sustainability performance of the firm. In this case, the manufacturing function should take the lead and convince brand managers about the benefits of complying with the Australian Packaging Covenant.

Sustainable Transportation – The factor loading of the item related to tie-bands and straps was insignificant and thus it was decided to delete this item as it was inconsistent with the remaining items of the Sustainable Transportation sub-construct. Many respondents considered it as 'N/A – Not Applicable'. Even though it is a standard technique, respondents are of the view that it has nothing to do with sustainability. This point did not arise during the content validity phase, and this element was considered very important as it leads to less transportation damage which subsequently translates into less food wastage and lower transportation costs. It also came out quite clearly that most of the manufacturing firms have outsourced their outbound transportation of ambient, chilled and frozen food products to third party service providers (3PLs) that specialise in logistics services. These 3PLs are very conscious of the effective usage of their transportation fleet. They carry regular maintenance and servicing of their trucks, use load management software for optimal capacity utilisation of trucks, reduce delivery times through vehicle routing and scheduling software and reuse shipping materials. The Australian logistics and transportation sector seems to be very advanced. However, the use of hybrid vehicles is negligible and more than 90 percent of the logistics service providers use diesel as the main fuel.

Sustainable Warehousing – In the SW model, the item related to the use of renewable energy sources is highly recommended in the academic literature and industry publications, and all the practitioners also supported it during the content validity phase. However, the data collected through the questionnaire survey showed that it is not consistent with the rest of the items of the SW sub-construct. The reason seems to be that biofuels and solar energy are not prevalent in the warehousing industry. This might be due to the high initial investment, low efficiency as compared to conventional power sources, and low amounts of sunlights in many areas. Again, item WD5, which is related to biodiversity, seems to be inconsistent with the rest of the items. This seems to be a continuation of the same mindset in the supply chain departments where preservation of natural habitat and eco-systems is not considered as a part of the sustainability canvas. The item WP1 is pertinent to the use of RFID, and as per the literature, it is highly recommended in the logistics industry for cargo and container identification, as no contact is required between the reader and the tag and RFID systems can identify and track unique items. However, it seems from the comments received in the survey that RFID is not widely used by the firms in the Australian food supply chain because of high cost, greater size and weight as compared to barcodes, inability to track and identify damaged tags, and erroneous data transmission if tags come close to certain metals or liquids.

8.3 Current Status of the SSCM Research

This research study carried out an extensive analysis of already existing SSCM literature reviews to understand the current status of SSCM research. It examined 14 SSCM reviews to comprehend the focus areas of the SSCM research to date. This proved to be a time-consuming activity in itself; however, it provided noteworthy insights into the SSCM literature which were later used in this PhD study. Some of the highlights are presented in the Conclusion.

It was found that earlier reviews on SSCM mainly focused on greening of the supply chain, and identified green product and process development as the basis for incorporating environmental issues into the supply chain without any concern for social matters (Gungor & Gupta, 1999; Kleindorfer, Singhal, & Wassenhove, 2005). Most of the reviews in the last ten years are mainly general or focused on quantitative models or empirical research. Those by Srivastava (2007), and Min and Kim (2012) are limited only to green supply chain management (GSCM), but other researchers have targeted the entire gamut of SSCM. Overall, the reviewers are of the opinion that sustainability is usually driven by customers, governments or other stakeholders (Gold, Seuring, & Beske, 2010a, 2010b; Seuring & Müller, 2008) and most of the empirical research is mainly focused on a single firm and the manufacturing sector (Carter & Easton, 2011; Hassini, Surti, & Searcy, 2012). Seuring and Müller (2008) are also of the view that the primary focus of the SSCM research is still ‘environment’, while social issues are broadly overlooked.

It must also be noted that most of the reviews have restricted their literature search and scope only to logistics and SCM journals. However, Ashby, Leat, and Hudson-Smith (2012) and Teuteberg and Wittstruck (2010) have also included other relevant journals in their reviews. They are of the opinion that since sustainability is in an embryonic stage, therefore many other journals that may fall outside of the typical SCM research arena still reasonably inform SSCM, and thus should be included in the review to analyse the advancement in the field. For details, please refer to Chapter 3 (section 3.1).

8.4 Industry Insights Based on the Descriptive Analysis of the Sample Data

Descriptive analysis provided some interesting insights, such as the number of distributors and wholesalers has increased dramatically in the last ten years. Most of these distributors are importing cheap food from China, Indonesia, Malaysia and India which is posing serious competition to local manufacturing (AFGC, 2011). In addition, the number of Australian owned food manufacturing companies has reduced in the last ten years. They are either acquired by large multinationals or have stopped their operations in the wake of severe competition (DAFF, 2011, 2012). This analysis is also supported by the employee strength numbers where decline in manufacturing has resulted in significant job losses and only 25 percent of the companies in the sample data have more than 500 employees. While 52 percent companies (mostly distributors, wholesalers and 3PLs) employ less than or equal to 250 personnel. Another very important statistic which adds more credibility to the findings of this research is related to the interpretation of the companies about the concept of ‘sustainability’. Respondents were asked: ‘How is sustainability defined in your company?’ About 15 percent responded that it tantamount to economic performance but an overwhelming majority of 85 percent responded that it is considered to be a nexus between economic performance, social responsibility and environmental preservation. For details of the descriptive analysis, please refer to Chapter 6.

8.5 The Soul of Sustainability: Insights from General Sustainability Frameworks

High-level sustainability frameworks were studied during the first phase of the analysis process to comprehend the purview of sustainability. These frameworks included: Natural Capitalism, Biomimicry, Cradle to Cradle, Life Cycle Analysis, Social Return on Investment, The Natural Step, Sustainability Helix and Triple Bottom Line (Cook, 2004;

McDonough & Braungart, 2010; Shedroff, 2009). The crux of that extensive exercise is presented in the Conclusion.

The thematic analysis of the high-level sustainability frameworks made it clear that at its core, sustainability is about ‘efficiency’. It preaches elimination of any kind of waste and better utilisation of resources. It enforces ‘risk mitigation’ to help avoid vulnerabilities related to financial, political, operational, social and environmental hazards. It encourages taking the ‘systems perspective’, so that impacts of decisions and strategies can be evaluated on a broader scale. Also, sustainability promotes ‘resilient enterprises’ that are stable, flexible, accessible, adaptable and have a learning attitude. It endorses ‘diversity’ of workforce, ideas, solutions and approaches because a diverse enterprise is more capable of facing a challenging situation related to market trends, unprecedented catastrophes and financial crunch. It discourages ‘centralisation’ of power, control, resources and decision-making as this is unresponsive and devoid of local knowledge and expertise. It institutionalises a blend of ‘cooperation, collaboration and competition’ among the stakeholders, providing the opportunity for continuous innovation. For details, please refer to Chapter 3 (section 3.2).

8.6 Implications for Practitioners

One of the main targets of this study was to keep it relevant to the corporate world. Thus, practitioners and industry experts were involved in nearly all the stages, first, during the development of the high-level research framework, and then during content validation. Finally, in order to communicate the findings of this study to the practitioners, it was decided to present the best practices of sustainable supply chain management in the form of a holistic and graphical model, for each SSCM sub-construct, that could sum up all the practices for each sustainability dimension (environment, social and economic). These models are presented below:

8.6.1 Sustainable Supply Chain Planning Model

The best practices identified for sustainable supply chain planning in the earlier section of the Conclusion, based on the results of exploratory and confirmatory factor analysis, were provided to the industry experts and they were requested to identify the primary impact of each practice on various dimensions of sustainability (social, environmental and economic). The practices were grouped together and presented in the following model in **Figure 45**.

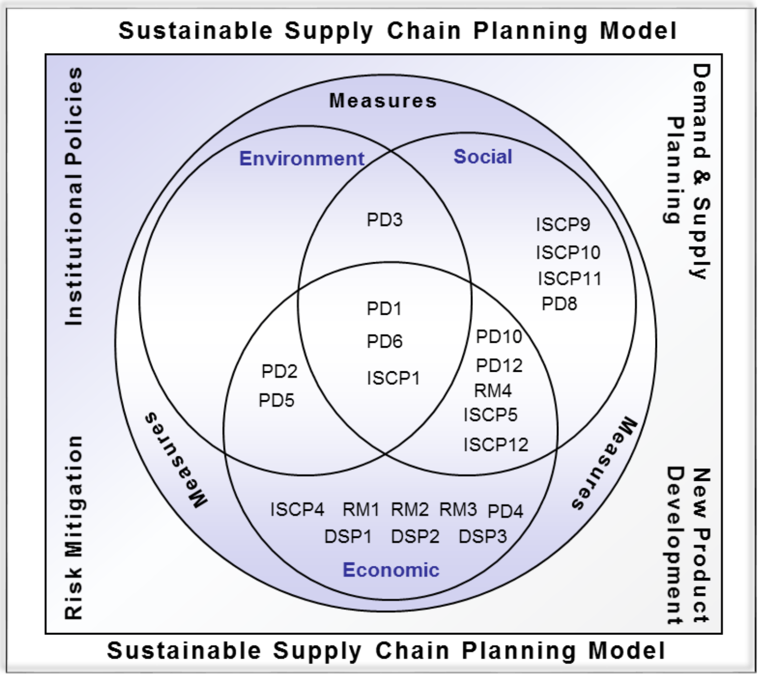

Figure 45: Sustainable Supply Chain Planning Model

The above model represents the four dimensions or pillars of sustainable supply chain planning. In addition, it shows the 23 practices or measures with single, double or triple impact. The model indicates that about 47 percent of the practices have either a double or triple impact, and about 78 percent of the practices will improve the economic situation of the firm. Thus, the model coming out of this extensive PhD research presents a strong business case for any firm to implement sustainable practices in its food supply chain. It must also be noted that even the practices related to human resource management (ISCP9, ISCP10 and ISCP11), which ensure non-discriminatory environment, fair compensation and a conducive working environment, will improve the economic performance of the firm. These practices will boost the employee morale and connect them strongly with the organisation. Consequently, this will improve their productivity and efficiency leading to an improvement in the financial performance of the firm. Thus, it can be shown that nearly all the practices presented in the model will, either directly or indirectly, improve the economic performance of the firm.

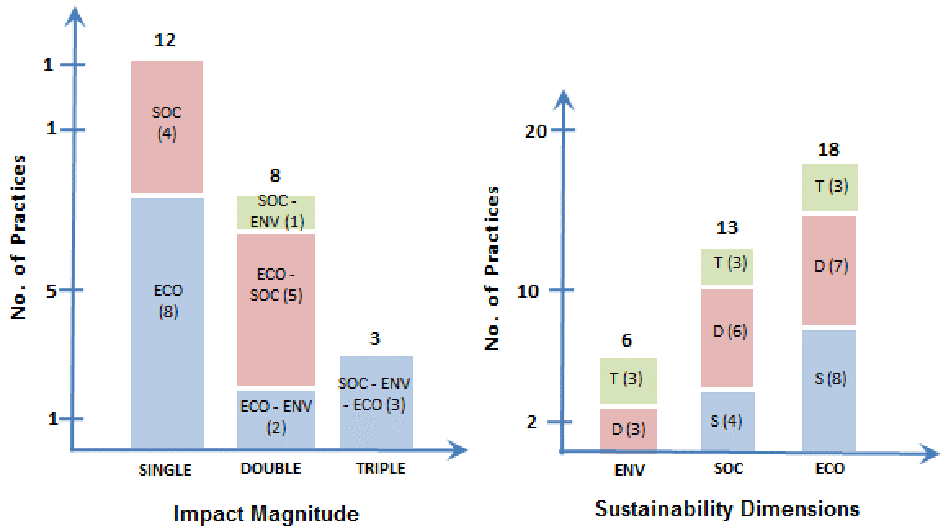

Figure 46: Analysis of the SPlng Model

The impact-wise analysis (Figure 46 – left graph) shows that three practices impact all the dimensions of sustainability (SOC-ENV-ECO = Social-Environmental-Economic), while eight practices have double impact. Also, 12 practices impact single dimension of sustainability in which 8 practices will improve the economic performance and 4 practices will positively impact the social dimension of sustainability. In addition, dimension-wise analysis (Figure 46 – right graph) shows that 18 practices (73 percent) improve the economic value of the firm (ECO), while six practices ameliorate the environmental performance (ENV) of the firm. Finally, 13 practices will positively impact the social dimension (SOC) of the firm out of which four have single impact (S), six impact any two dimensions of sustainability (D – double impact) and three practices positively impact all three dimensions of sustainability (T – triple impact).

8.6.2 Sustainable Procurement Model

The sustainable procurement model shows the six important pillars or focus areas (dimensions) for ingraining sustainability in the procurement or purchasing function. It also shows the 23 practices that have been identified as the key measures that will help to improve the sustainability performance of the procurement function. The model is presented in **Figure 47**.

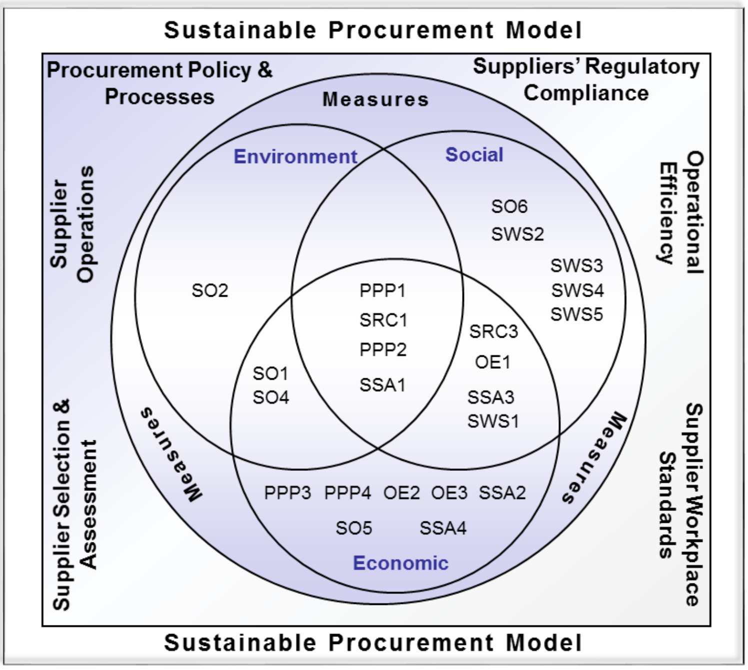

Figure 47: Sustainable Procurement Model

The model clearly shows that practices such as SRC3, OE1 and SSA3, which are related to employee training, corruption-free operations and food labelling according to the Australian regulations, directly improve the economic and social performance of the firm. Training will not only boost the employee morale but will also make them more efficient and productive. Compliance with the Australian food labelling standards will provide relevant information to all the consumers and will also ensure that no penalties are paid for not following the government regulations. Similarly, SO1 and SO4, which are related to efficient use of resources (energy and water) and recycling, will improve both the environmental and economic performance of the firm. Again, it can be seen that about 74 percent of the practices improve the financial condition of the firm and about 43 percent have double or triple impact.

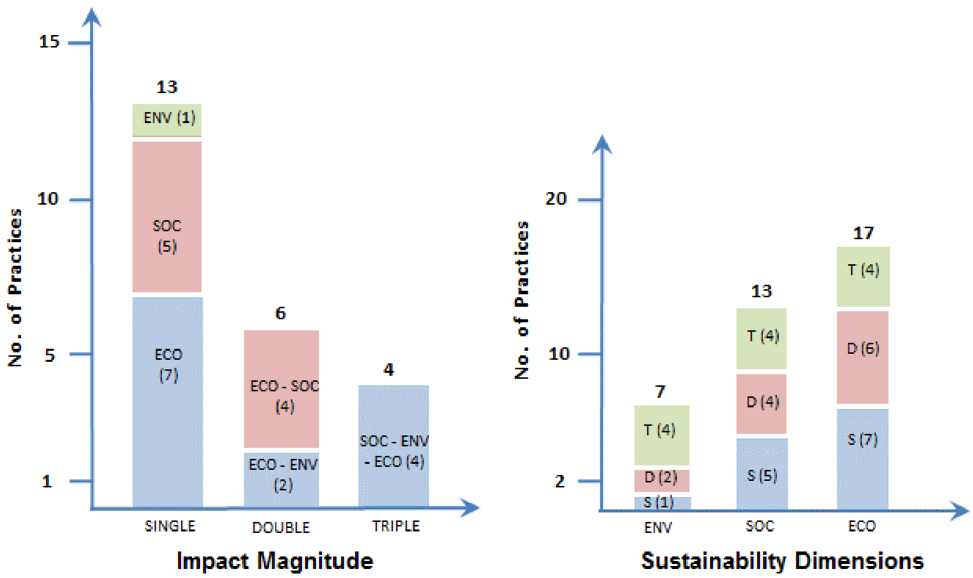

Figure 48: Analysis of the SP Model

The impact-wise analysis (Figure 48 – left graph) shows that four practices impact all the dimensions of sustainability (SOC-ENV-ECO = Social-Environmental-Economic) while six practices have double impact. In addition, dimension-wise analysis (Figure 48 – right graph) shows that 17 practices improve the economic value of the firm while 13 practices ameliorate the social performance of the firm. Seven practices will improve the environmental performance of the firm, out of which one practice impacts only a single (S) dimension of sustainability, two practices impact any two (D) dimensions of sustainability and four practices impact all three (T) dimensions of sustainability.

8.6.3 Sustainable Manufacturing Model

The sustainable manufacturing model shows five important dimensions that will help to ingrain sustainability in the manufacturing function. It also shows the 26 practices related to these dimensions that will ensure the operationalisation of sustainability in the function. The model is presented in **Figure 49**.

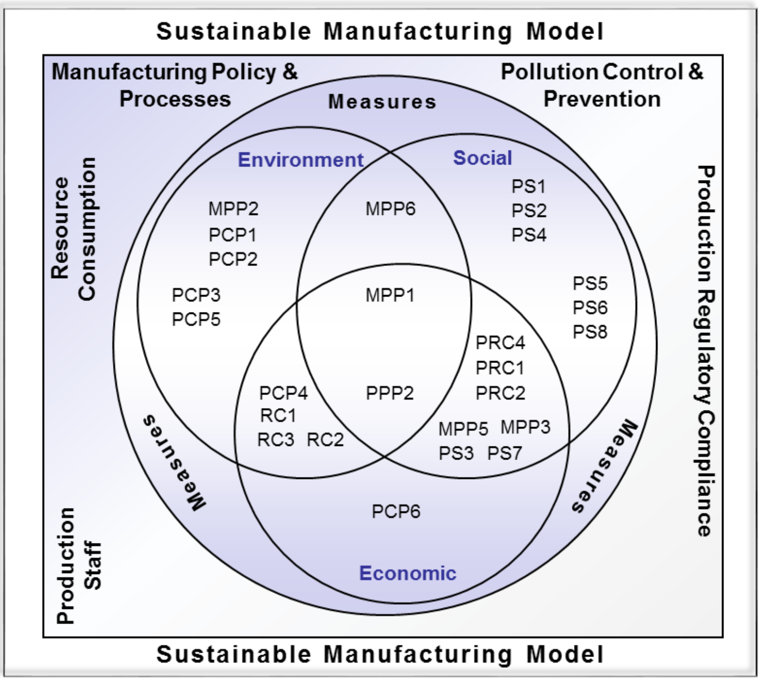

Figure 49: Sustainable Manufacturing Model

According to the response from industry experts, it can be seen that about 14 practices (53 percent) have either double or triple impact, and about the same number will improve the economic performance of the firm. Hence, the results provide strong evidence that investment in improving the social and environmental performance of the firm will also ameliorate the financial status of the firm.

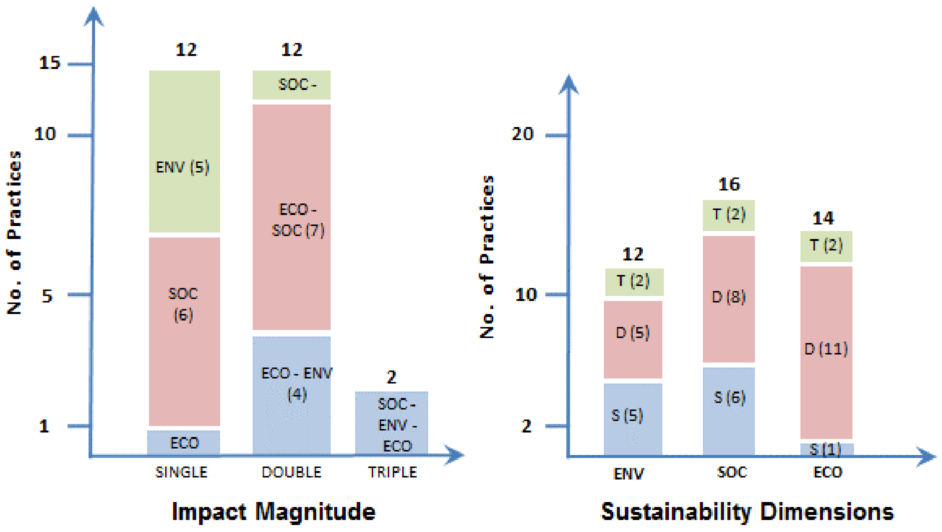

Figure 50: Analysis of the SM Model

The impact-wise analysis (Figure 50 – left graph) shows that two practices impact all the dimensions of sustainability (SOC-ENV-ECO = Social-Environmental-Economic), while twelve practices have double impact; and the same number of practices impact a single dimension of sustainability. In addition, dimension-wise analysis (Figure 50 – right graph) shows that 14 practices improve the economic value of the firm, while 16 practices ameliorate the social performance of the firm. Twelve practices improve the environmental performance of the firm, out of which five practices impact only one dimension of sustainability (S – single impact) and the same number impact any two dimensions (D – double impact) of sustainability while two practices have triple (T) impact – meaning they impact all three dimensions of sustainability.

8.6.4 Sustainable Transportation Model

The sustainable transportation model shows six important dimensions that will help to ingrain sustainability in the transportation function. It also shows the 28 practices related to these dimensions that will ensure the operationalisation of sustainability in the function. The model is presented in **Figure 51**.

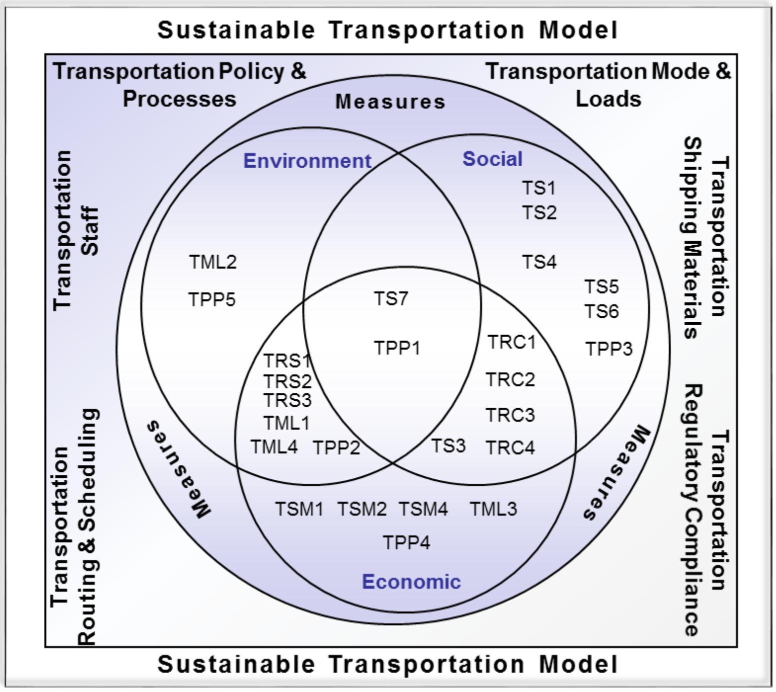

Figure 51: Sustainable Transportation Model

According to the response from industry experts, it can be seen that about 13 practices (46 percent) have either double or triple impact, and 18 practices will improve the economic performance of the firm. Hence, the results provide strong evidence that investment in improving the social and environmental performance of the firm will also ameliorate the financial status of the firm.

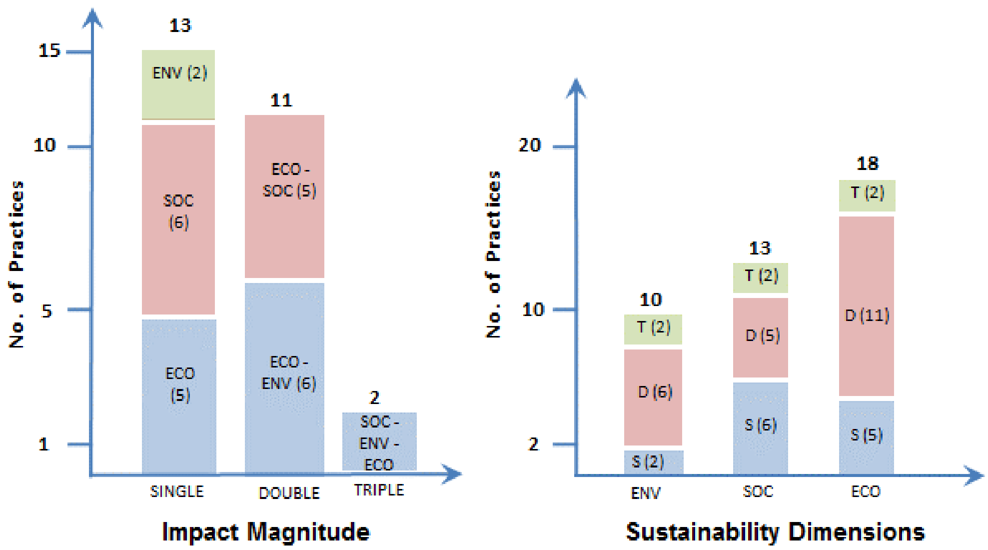

Figure 52: Analysis of the ST Model

The impact-wise analysis (Figure 52 – left graph) shows that two practices impact all the dimensions of sustainability (SOC-ENV-ECO = Social-Environmental-Economic) while 11 practices have double impact and 13 practices improve only one dimension of sustainability. In addition, dimension-wise analysis (Figure 52 – right graph) shows that 18 practices improve the economic value of the firm while 13 practices ameliorate the social performance of the firm. Finally, 10 practices improve the environmental performance of the firm, out of which two practices impact only a single (S) dimension of sustainability, six impact any two dimensions of sustainability (D – double impact) and two practices positively impact all three dimensions of sustainability (T – triple impact).

8.6.5 Sustainable Warehousing Model

The sustainable warehousing model shows six important dimensions that will help to ingrain sustainability in the warehousing function. It also shows the 32 practices related to these dimensions that will ensure the operationalisation of sustainability in the function. The model is presented in **Figure 53**.

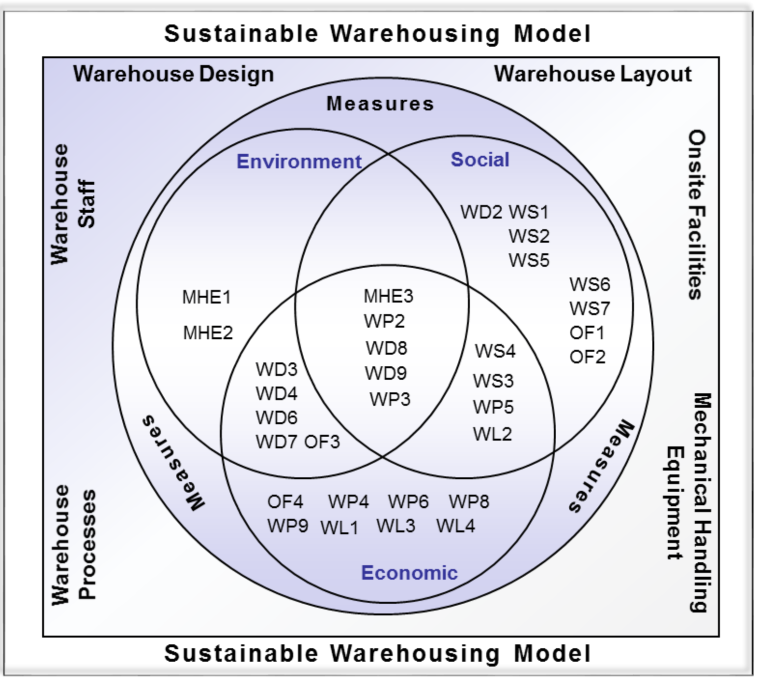

Figure 53: Sustainable Warehousing Model

According to the response from industry experts, it can be seen that about 14 (44 percent) practices have either double or triple impact, and 22 practices will improve the economic performance of the firm. Hence, the results provide strong evidence that investment in improving the social and environmental performance of the firm will also ameliorate the financial status of the firm.

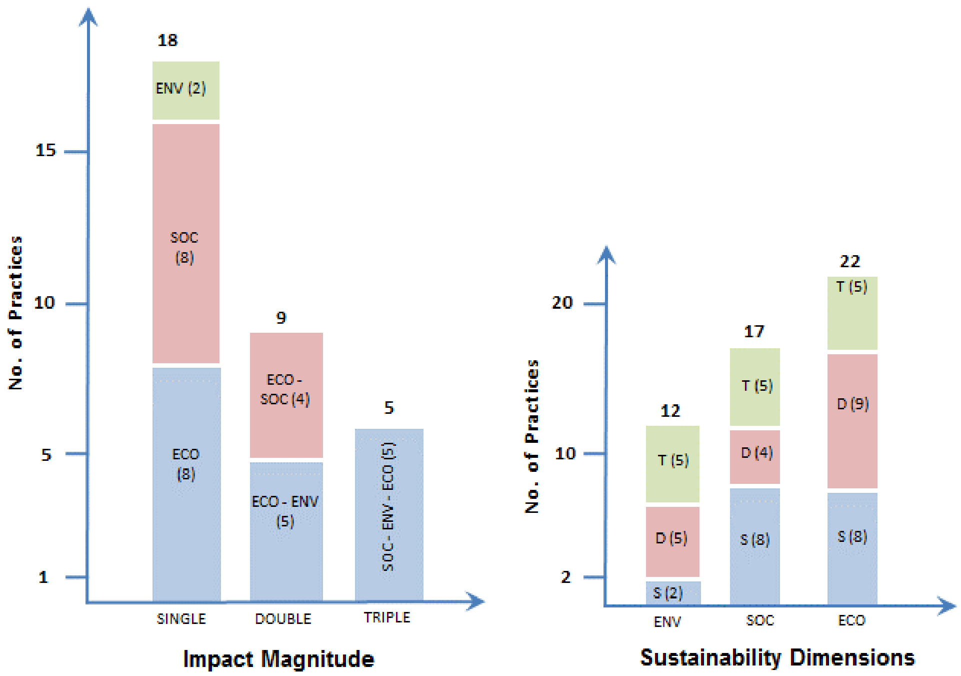

Figure 54: Analysis of the SW Model

The impact-wise analysis (Figure 54 – left graph) shows that five practices impact all the dimensions of sustainability (SOC-ENV-ECO = Social-Environmental-Economic), while nine practices have double impact and 18 have single impact. In addition, dimension-wise analysis (Figure 54 – right graph) shows that 22 practices improve the economic value of the firm while 17 practices ameliorate the social performance of the firm. Finally, 12 practices improve the environmental performance of the firm, out of which two practices impact only a single (S) dimension of sustainability, five impact any two dimensions of sustainability (D – double impact) and the same number positively impact all three dimensions of sustainability (T – triple impact).

8.6.6 Practical Significance of Sustainability Models

The models have significant practical utility. They were provided to practising managers and very strong positive feedback was received. The three most important benefits that were highlighted by all the respondents are as follows:

- Models clearly show that initiatives to address social and environmental dimensions of sustainability have financial benefits. Practices to achieve objectives of sustainable development are not alien to economic benefits. In fact, societal and ecological improvements result in both short-term and long-term profitability. Thus, these models can be used to convince higher management of the value of sustainability investments in various supply chain processes
- Models can be used by supply chain managers, operations mangers, production engineers, logistics mangers, warehouse managers, transportation managers and procurement officers to evaluate the sustainability standards or status of their function. They can easily compare their current practices with these models to understand the gaps, or potential areas for improvement.
- Models can be used as a roadmap to develop a sustainability strategy for the entire firm’s supply chain, or for each supply chain process. For example, it can be easily identified which practices will require least resources and will have maximum impact on all the stakeholders. Thus, models can be used for developing both short-term and long-term sustainability strategy for the firm’s food supply chain.

8.7 Implications for Research

The research study draws upon many theoretical lenses such as resource-based view (RBV), triple bottom line (TBL), stakeholder theory (ST) and institutional theory (IT). The empirical findings are consistent with these theories and therefore this PhD study further expands the purview of these theories within the field of sustainable supply chain management.

8.7.1 Triple Bottom Line (TBL)

First, this study tested various sustainability practices for each supply chain process and provided a set of reliable and valid measures through an extensive exploratory and confirmatory factor analysis. Later, these practices were categorised into sustainability dimensions (economic, environmental and social) based on their primary impact (shown in the previous section), and it clearly validated the triple bottom line concept for each supply chain process. These findings further endorse the legitimacy and usefulness of the TBL approach for operationalising sustainability in supply chains. Discussion of these supply chain models in the earlier part of the conclusion clearly extend the TBL literature to incorporate the field of sustainable supply chain management.

8.7.2 Resource Based View (RBV)

Second, the empirical findings of this research study further extends the knowledge base of the resource-based view (RBV) by establishing sustainability practices for each supply chain process that could prove to be a unique and inimitable resource for any firm, resulting in a competitive advantage in the market. RBV is well established in the field of operations management (Corbett and Claridge, 2002) and supply chain literature (Rai et al., 2006; Wu et al., 2006). Recently, research studies in SSCM have also used RBV as the primary theoretical base (Lee and Klassen, 2008; Pullman et al., 2009). This research study also enriches the RBV literature by providing evidence that inter- and intra-organisational SSCM practices can prove to be an inimitable resource for the firm.

8.7.3 Stakeholder Theory (ST)

Third, this research study further extends the purview of the stakeholder theory to the field of SSCM. It clearly shows that a firm must give due regard to its stakeholders such as customers, employees, suppliers, regulatory authorities and even the environment. The empirical testing shows that sustainability in supply chain is not possible without keeping in consideration the work-life balance, fair remuneration, good working conditions and equal opportunities for all the employees. Also, sustainability objectives can only be met by involving and engaging suppliers in product development, and by ensuring that apposite occupational health and safety (OHS) requirements are fulfilled at suppliers' sites. The firms must take care of the local communities in which they operate and minimise negative impacts of their operations on them by reducing noise pollution, emissions, wastage. Furthermore, sustainable food supply chain will not be possible without complying with the standards established by the Australian regulatory authorities.

8.7.4 Institutional Theory (IT)

Fourth, Scholars have used institutional theory as a lens for studying the adoption of innovative practices in the supply chain (Heugens & Lander, 2009; Rogers et al., 2007; Teo et al., 2003). They are of the view that institutional pressures originating from the external environment can strongly affect a firm's decision to adopt innovative supply chain practices. Rogers et al. (2007) have contended, 'Arguments from institutional theory can contribute to a better understanding of the social context of OM and SCM strategies' (p. 569). This research study also provides clear evidence that firms are adopting sustainable practices in their supply chains due to institutional pressures from governments, the general public, employees and, above all, consumers.

8.7.5 SCOR Process Model

Finally, this research study also provides evidence regarding the practical utility and application of the supply chain operations reference (SCOR) model. It shows that the firms aiming to gain competitive advantage through sustainable operations should evaluate the social and environmental impact of their supply chain with the lens of the SCOR process model. This strategy would require them to dissect their supply chain into its constituent processes and then assess the sustainability performance of their operations in each process. This bottom-up approach will ensure the implementation of specific measures in each process, rather than generic and broad practices, which would pragmatically operationalise sustainability along the entire supply chain.

8.8 Miscellaneous Findings

This research study is unique as it looks at the cross-section of a supply chain and makes an effort to extract sustainability concepts specific to each process. It is clear that if sustainability is not ingrained in each process of a supply chain, an organisation will not be able to realise the vision of sustainable development put forward by the Brundtland Report (Brundtland, 1987).

8.8.1 Sustainable Warehousing – An Overlooked Domain

In this context, it is surprising to see that sustainable warehousing is almost completely overlooked by the academic researchers. However, it holds tremendous potential to achieve the goals of overall sustainable development. The Transport and Logistics Industry Skills Council Australia (LTC, 2011) in a recent survey reported that *'...companies are still coming to terms with the question of sustainability. Warehousing facilities have the largest potential in terms of reducing environmental impacts…'*. This statement by an industry organisation is an eye-opener for academic researchers and they need to extend their work to develop knowledge related to sustainable warehousing. This PhD study also endorses the viewpoint of LTC. The review and analysis of academic literature and industry publications, face validity, content validity assessment, exploratory and confirmatory factor analysis – all accentuate the importance and potential of sustainable warehousing.

8.8.2 Environmental Dimension – Main Focus of the Academic Research

The environment is still the main focus of most of the academic research. It might be due to the fact that environmental models and strategies are at least five decades old, and it is easier to develop them further and quantify or measure them in the context of sustainability. Even though the social dimension has recently increased in importance, there are no quantitative and measurable instruments, that are holistic and all-encompassing in nature, to measure the social performance of a firm's supply chain.

8.8.3 SSCM – Not Equivalent to GSCM

This piece of research also helps to understand that SSCM is not equivalent to green supply chains, but in fact, green supply chains are a subset of sustainable supply chains. Also, sustainable supply chain management is a broader phenomenon that is a combination of six different constructs that are extensive knowledge domains in their own capacity.

8.8.4 Purview of the Sustainable Supply Chain Management Domain

It can also be seen that the purview of sustainable supply chain management is very broad, as this study found that there are 74 journals from various disciplines that contributed either one or two papers to the publication sample of 349 papers. In addition, the top contributing journals such as Greener Management International and Business Strategy and the Environment, which contributed 21 papers each, are not typical supply chain and operations management journals. This clearly shows that any study focusing only on OR and SCM journals will be extremely deficient in terms of the credibility and validity of its findings.

8.8.5 Critical Role of Supply Chain Planning

Critical analysis of the 'planning' process shows that supply chain department has a very important cross-functional role; that is, to assist the product development or brand department in developing more socially and environment-friendly products by engaging suppliers and configuring products that are optimised for logistics operations. However, further research is required in this arena to clarify the role and responsibilities of the supply chain function in this regard.

8.8.6 Critical Role of Procurement

Also, the ‘procurement’ function is mostly involved in selection, evaluation, assessment, development and negotiations with suppliers on daily basis. It can ensure that green raw materials are sourced and suppliers exercise high ecological and social standards in their operations. Thus, the procurement department has the power to positively impact the sustainability performance of other firms. However, further research is required to answer questions related to how contract management can help in achieving sustainability objectives. How can the mindset of buyers be changed so that they prioritise sustainability in addition to price and quality? How can e-procurement tools be used to instil sustainability in purchasing processes? How can procurement transactions be made more transparent and corruption free? There are many operational and strategic questions that still need to be answered, and researchers must focus their attention towards them so that sustainability can be genuinely operationalised in procurement.

8.8.7 Gaps in Sustainable Manufacturing and Transportation

Many gaps can be seen in sustainable manufacturing and transportation themes. Even though these fields are very mature and have evolved at a very fast pace during the last three decades, their social dimensions are still relatively weak. Researchers have extensively investigated their technological aspects such as manufacturing of end-of-pipe equipment, water treatment technology, pollution prevention equipment, aerodynamic vehicle designs, fuel-efficient engines and load management techniques, but the human resource that runs these production plants and inbound/outbound trucks is largely ignored. Issues related to shift management, roster management, road safety standards, negative noise impacts and family life of these workers and drivers need to be comprehensively examined.

8.8.8 Generic Nature of the Construct Conceptualisation and Measures Identification Framework

The framework presented in this research study is based on extensive academic literature related to sustainability, SCM, management theories and scale development. It chalks out a step-by-step procedure for construct conceptualisation and measures identification. The framework is generic in nature and can be adapted to disciplines other than SCM to generate relevant sustainability dimensions and measures. It can be used to develop specific sustainability measures for different types of supply chains such as services supply chains, retail supply chains, defence supply chains, government supply chains, and emergency response supply chains. It can also be adapted to different industries and domains of knowledge.

8.8.9 Advantages of the Qualitative Data Analysis (QDA) Software

This study shows that the use of qualitative data analysis (QDA) software makes it possible to organise and analyse voluminous data in a strategic manner. Even though it is the decision of the researcher to select the relevant tools and optimally exhaust the capabilities of the software to achieve the research objectives, it cannot be denied that software enhances the validity of the results through a rigorous and transparent coding mechanism. Brainstorming, deliberations, critical analysis, close examination of literature, and constant review and comparison performed by researchers are still at the core of the entire analysis process and their value should never be underestimated; but the use of the software relieves the researchers of time-consuming data organisation, storage and presentation, and enables them to focus more on the analytical part of the research. This is considered a leap forward in the research arena and clearly reflected in this PhD research study.

8.9 Limitations and Future Research

No research is perfect, and this PhD study is not an exception. It has several limitations and the findings of this study must be considered in the light of these limitations. Future research endeavours should account for them to further develop the field of sustainable supply chain management (SSCM).

First, the respondents for this research study come from all the stages of the food supply chain. They consist of manufacturers, third-party logistics providers (3PLs), packaging suppliers, basic ingredients suppliers, exporters and importers. Thus, this study represents a large proportion of small to medium sized firms (67 percent) for whom investment in sustainability practices is not affordable in the wake of the current economic crises and recession. These organisations usually do not have well-developed supplier management systems, enterprise resource planning (ERP) systems and environmental management systems (EMS). Future research studies should verify the research findings of this study in large multinational firms (MNFs).

Second, the data used for empirical testing or scale validation is cross-sectional in nature. Thus, it cannot confirm the validity of the sustainability practices in the long term. Therefore, a longitudinal study, conducted with a gap of three to four years, will help to confirm if the same practices are required to operationalise sustainability, in each supply chain process, regardless of the time factor.

Third, this research study adapted the SSCM items for the Australian food industry. Even though many items remained generic across all supply chain processes, some new measures were added and a few existing items were modified so that they can be related to the stakeholders in the Australian food industry. Future studies can conduct the same study in other industries, and compare the results, or they can carry out the empirical testing in other countries by using the scale developed in this research study and adapting it to other countries. Thus, cross-industry and cross-country comparison will further help to develop the field of SSCM.

Fourth, the data in this research study is based on 'single respondents' (such as supply chain managers, procurement officers, transport mangers, logistics managers, etc.) and single method. Therefore, there is a chance of method bias in this research study. Even though efforts are made to minimise the social desirability and common-method bias, it is usually difficult to collect data from different respondents through multiple methods. Future research studies that could replicate the results using multiple methods or respondents would be very beneficial for the field of SSCM.

Fifth, all the constructs are carefully developed through a rigorous methodology to ensure that all SSCM sub-constructs have at least three items. However, ideally a construct is statistically stronger if it has five or more items. Also, all models representing supply chain processes are second-order constructs. This may have created convergence issues because of an increased number of parameter estimates (Peng and Lai, 2012). This research study has conducted a number of statistical tests to ensure the overall reliability and validity of all the SSCM sub-constructs. In doing so, few items have been deleted that have high theoretical significance because of the limitations of the AMOS statistical analysis tool. Future studies can use PLS methodology to alleviate this issue pertinent to the complexity of research models.

Sixth, the thesis sample data of 215 companies mainly consisted of manufacturing firms (71 percent). Future research studies may use the questionnaire developed in this research study and collect data which is more representative of all the key players in the Australian food industry along the supply chain, such as raw materials suppliers, packaging suppliers, distributors and wholesalers, third party logistics (3PL) service providers, and retailers.

Seventh, this research study has effectively developed five scales (sustainable supply chain planning, sustainable procurement, sustainable manufacturing, sustainable transportation, and sustainable warehousing) to operationalise SSCM in a focal firm. However, reverse logistics (RL), which is identified as one of the SSCM sub-constructs, has not been covered separately in a comprehensive manner due to time constraints. Future research studies can develop a comprehensive framework for RL to see how it can be integrated into a firm's supply chain.

Finally, this study has mainly focused on a focal firm's supply chain without much consideration for joint ventures, collaborations, alliances and partnerships with other companies and government bodies in order to ensure sustainable operations (Youn et al., 2013). Future research studies may consider the impact of collaboration and partnerships with other organisations on firms' sustainability performance.

REFERENCES

Please note that if a reference is not found in the ***'List of References Used in the Thesis'****, then kindly refer to the* ***'List of 349 Journal Articles Used for the SSCM Literature Review'.*** *The latter list separately presents the publication sample used for the SSCM literature review and many of those references are not repeated in the former list.*

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APPENDICES

Appendix 1: Questionnaire Used for Data Collection

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Chief Investigator's / Supervisor's Name: Prof. Norma J. Harrison

Information and Consent Form

Name of Project: Operationalizing Sustainability in supply chain: The case of the Australian Food Industry

You are invited to participate in a study of sustainability in food supply chain. The purpose of the study is (1) to develop detailed sustainability criteria for all stages (planning, procurement, production, warehousing, transportation, reverse logistics) of the food supply chain; (2) to measure the impact of sustainable Halal food supply chain on customer satisfaction and firm performance.

The study is being conducted by Chief Investigator Professor Norma J. Harrison, Macquarie Graduate School of Management, contact +61 2 9850 9005, email norma.harrison@mgsm.edu.au and Co Investigator Mr. Tayyab Waqas Amjed, Macquarie Graduate School of Management, contact +61 410 176 048, email tayyab.amjed@students.mq.edu.au. This research is being conducted to meet the requirements of Ph.D. in Management under the supervision of Prof. Norma J. Harrison.

If you decide to participate, you will be asked to fill in the online survey which will take 15 – 20 minutes. The questions are related to the various aspects of the supply chain and sustainability. This research presents no risk to the participants. Also, the participation in this research is unpaid.

Any information or personal details gathered in the course of the study are confidential. No individual will be identified in any publication of the results. Access to data will be restricted to Chief Investigator and Co Investigator. A summary of the results of the data can be made available to you on request on an aggregated basis and no individual respondents or organizations will be identified.

Participation in this study is entirely voluntary: you are not obliged to participate and if you decide to participate, you are free to withdraw at any time without having to give a reason and without consequence.

The ethical aspects of this study have been approved by the Macquarie University Human Research Ethics Committee. If you have any complaints or reservations about any ethical aspect of your participation in this research, you may contact the Committee through the Director, Research Ethics (telephone (02) 9850 7854; email ethics@mq.edu.au). Any complaint you make will be treated in confidence and investigated, and you will be informed of the outcome.

If you require more information about the specifics of the study, please do not hesitate to contact the Chief Investigator **Prof. Norma J. Harrison** on **+61 2 9850 9005**.

☐ I have read and understand the information above and any questions I have asked have been answered to my satisfaction. By clicking the **"Agree"** button below, I consent to participate in this research.

Continue

Please enter the name of your company to confirm that no other personnel from your company has already responded to this survey (this will avoid the duplication of data)

What is your designation in the company?

How long is your company in the food business in Australia?

1. Less than 2 years
2. 2 – 5 years
3. 5 – 10 years
4. More than 10 years

Kindly identify the type of your company from the following list:

1. Local and Australian Origin
2. Multi-national and Australian Origin
3. Multi-national and non-Australian Origin
4. Other ____________________

What is the overall Employee strength of the company (permanent, temporary, contractual, etc.)?

1. Less than 100
2. 100 - 250
3. 250 - 500
4. 500 - 1000
5. More than 1000

Kindly select the categories of food produced/handled by your company:

1. Dairy Products
2. Fish & Seafood
3. Meat & Poultry
4. Cereal & Confectionary
5. Beverages
6. Other

Does your company offer Sustainable products or services?

1. Yes
2. No

How is Sustainability defined in your company?

1. Economic Performance
2. Social Responsibility
3. Environmental Preservation
4. All of the above

If your company has a procurement or purchasing department, then select Yes and answer the following questions. Otherwise select No and click the Continue button at the bottom of the page to go to the next section.

1. Yes
2. No

Kindly answer the following questions related to the procurement function:

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	N/A
Procurement is considered as a strategic function in our company	❑	❑	❑	❑	❑	❑
We have a written procurement policy that ensures environmental preservation, communal welfare and economic value for the company	❑	❑	❑	❑	❑	❑
Our purchasing process from source-to-settle is governed by our procurement policy	❑	❑	❑	❑	❑	❑
We provide training opportunities to our staff	❑	❑	❑	❑	❑	❑
We use technology (e-procurement or procurement management system) to improve operational efficiency and transparency	❑	❑	❑	❑	❑	❑
We have a comprehensive contract management system in place	❑	❑	❑	❑	❑	❑
Our suppliers comply with local and national laws and regulations	❑	❑	❑	❑	❑	❑
Our supplier selection process involves social and environmental criteria	❑	❑	❑	❑	❑	❑
We periodically audit our suppliers	❑	❑	❑	❑	❑	❑
We ensure that suppliers' business operations are free of corruption, bribery or any kind of illegal activity	❑	❑	❑	❑	❑	❑
Our suppliers are financially sound	❑	❑	❑	❑	❑	❑
Our suppliers comply with ocuupational health and safety requirements	❑	❑	❑	❑	❑	❑
Our suppliers do not employ any indecent form of labour (child or forced)	❑	❑	❑	❑	❑	❑
Our suppliers do not engage in any form of discriminatory practices	❑	❑	❑	❑	❑	❑
Our suppliers comply with legal restrictions on working hours	❑	❑	❑	❑	❑	❑
Our suppliers pay reasonable wages to employees	❑	❑	❑	❑	❑	❑
Our suppliers contribute to community welfare projects	❑	❑	❑	❑	❑	❑
Our suppliers efficiently use energy and water	❑	❑	❑	❑	❑	❑
Our suppliers monitor and reduce all emissions (e.g., GHG, ODS, air pollutants, etc.) resulting from business operations	❑	❑	❑	❑	❑	❑
Our suppliers ensure preservation of biodiversity (e.g., land, air, habitat, eco-system, etc.)	❑	❑	❑	❑	❑	❑
Our supplier reduce waste through reuse and recycling	❑	❑	❑	❑	❑	❑
All the suppliers have traceability systems in place	❑	❑	❑	❑	❑	❑
Our suppliers use food grade packaging	❑	❑	❑	❑	❑	❑
Our suppliers follow the Australian Packaging Covenant	❑	❑	❑	❑	❑	❑

Our suppliers ensure proper labelling for all food products according to Australian standards	❑	❑	❑	❑	❑	❑
We have developed backup suppliers to prevent supply disruptions	❑	❑	❑	❑	❑	❑

Comments:

If your company has a warehouse or stores raw materials, finished goods or equipment, then select Yes and answer the following questions. Otherwise select No and click the Continue button at the bottom of the page to go to the next section.

1. Yes
2. No

Kindly answer the following questions related to the warehousing function:

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	N/A
We use renewable energy sources for running warehouse operations	❑	❑	❑	❑	❑	❑
Our warehouse is designed to reduce noise pollution	❑	❑	❑	❑	❑	❑
Our warehouse is designed to use energy efficiently	❑	❑	❑	❑	❑	❑
Our warehouse is designed to optimally use daylight and artificial lighting without impacting the quality of stored food products	❑	❑	❑	❑	❑	❑
Our warehouse building design reduces weather impacts and maintains internal temperature required for dry, chilled and frozen food products	❑	❑	❑	❑	❑	❑
We conserve water through latest water-management techniques	❑	❑	❑	❑	❑	❑
Our warehouse building (floors, walls, firewalls, roof and doors) meets international and Australian standards for food storage	❑	❑	❑	❑	❑	❑
Our warehouse is properly landscaped to preserve biodiversity and ensure food safety	❑	❑	❑	❑	❑	❑
The warehouse storage space is optimally utilized with appropriate racking / stacking (e.g., drive-in, selective, double deep, etc.)	❑	❑	❑	❑	❑	❑
The Aisle width is optimised for efficient and safe operations	❑	❑	❑	❑	❑	❑
The warehouse space is properly partitioned into areas for quarantine, fast moving products, hazardous materials, returned goods and so on	❑	❑	❑	❑	❑	❑
The warehouse layout minimises pallet handling and movements	❑	❑	❑	❑	❑	❑
We have a thorough process to ensure inventory accuracy	❑	❑	❑	❑	❑	❑
We perform inventory counting on regular basis	❑	❑	❑	❑	❑	❑
All food products are stored and rotated based on a picking logic (such as First in-First out or	❑	❑	❑	❑	❑	❑

First expiry-First out)						
Our food storage strategy prevents cross-contamination due to any physical or chemical contaminants	❑	❑	❑	❑	❑	❑
We consider the staff Work-Life Balance while planning shifts for stock management	❑	❑	❑	❑	❑	❑
We periodically review shift patterns to reduce anti-social hours	❑	❑	❑	❑	❑	❑
We have strict safety standards (such as evacuation plan & fire extinguisher training) to avoid any accidents or injuries	❑	❑	❑	❑	❑	❑
We comply with occupational health and safety requirements for food industry	❑	❑	❑	❑	❑	❑
We dont employ any indecent form of labour (child or forced)	❑	❑	❑	❑	❑	❑
We dont engage in any form of discriminatory practices	❑	❑	❑	❑	❑	❑
We pay reasonable wages and allow freedom of association for our staff	❑	❑	❑	❑	❑	❑
We use environment-friendly fuel for MHEs	❑	❑	❑	❑	❑	❑
All MHEs (e.g., reach truck, hand or electrical pallet truck etc.) are regularly serviced to reduce emissions	❑	❑	❑	❑	❑	❑
All the equipment and materials (refrigerants, detergents, etc.) used in warehouse operations are food graded as per the Australian standards	❑	❑	❑	❑	❑	❑
All operators are well-trained for fuel-efficient & safe MHE driving	❑	❑	❑	❑	❑	❑
We use technology (such as warehouse management system, barcode scanning or RFID) to reduce paperwork and data inaccuracies	❑	❑	❑	❑	❑	❑
The warehouse processes (inbound, storage, picking and outbound) are optimised for efficient and safe operations that ensure food safety and quality	❑	❑	❑	❑	❑	❑
Our staff adheres to good housekeeping practices to control food spills, pests & cross-contamination and to ensure proper sanitation & disposal of garbage	❑	❑	❑	❑	❑	❑
The warehouse has proper hygiene facilities (showers, washing facilities, male/female toilets, etc.)	❑	❑	❑	❑	❑	❑
The warehouse has an emergency room with medical facilities such as first aid equipment	❑	❑	❑	❑	❑	❑
The warehouse has a recycling facility for waste packaging	❑	❑	❑	❑	❑	❑
The warehouse has a cross-docking facility to reduce material storage and handling	❑	❑	❑	❑	❑	❑
We continuously consider any possible opportunity of combined warehousing or sharing resources with other organizations	❑	❑	❑	❑	❑	❑
We have KPIs and targets to reduce environmental impact linked with warehousing of raw materials and finished goods	❑	❑	❑	❑	❑	❑

Comments:

If your company performs inbound or outbound transportation of raw materials or finished products, then select Yes and answer the following questions. Otherwise select No and click the Continue button at the bottom of the page to go to the next section.

1. Yes
2. No

Kindly answer the following questions related to Transportation:

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	N/A
We consider sustainability aspects while procuring new transportation fleet (e.g., aerodynamics, vehicle weight, engine design, etc.)	❑	❑	❑	❑	❑	❑
We regularly perform fleet inspection and maintenance (e.g., brake checks, oil levels, tire inflation, etc.)	❑	❑	❑	❑	❑	❑
We regularly examine our fleet for noise pollution	❑	❑	❑	❑	❑	❑
Our divers are well-trained to ensure safe and fuel-efficient driving	❑	❑	❑	❑	❑	❑
We enforce strict guidelines to minimise needless idling of vehicle (e.g., turn off engines during delivery or pickup etc.)	❑	❑	❑	❑	❑	❑
We thoroughly inspect inbound or outbound vehicles (or containers) for condensation, moisture, objectionable odours, infestation and allergens to ensure food safety	❑	❑	❑	❑	❑	❑
We ensure that appropriate temperature is maintained during transportation of dry, chilled and frozen food according to Australian standards	❑	❑	❑	❑	❑	❑
We ensure that all food items being transported are properly covered and are separate from any contaminants	❑	❑	❑	❑	❑	❑
We use the most fuel-efficient transportation mode (such as rail, sea, etc.)	❑	❑	❑	❑	❑	❑
We use the environment-friendly fuels in our vehicles to reduce emissions (such as biofuels, ethanol, etc.)	❑	❑	❑	❑	❑	❑
We optimally utilise vehicle capacity through maximum volume, weight and floor-space utilization	❑	❑	❑	❑	❑	❑
We use standard packaging and pallets configurations to optimise transport load factors	❑	❑	❑	❑	❑	❑
We use load planning software for optimal and safe loading of vehicles, railcars, marine or air containers	❑	❑	❑	❑	❑	❑
We actively use common carriers, backhauls, co-shipping, internet based load matching services or double stacked containers	❑	❑	❑	❑	❑	❑
We use software to determine optimal vehicle routing and freight delivery schedules	❑	❑	❑	❑	❑	❑

We consider the staff Work-Life Balance while planning deliveries to customers	☐	☐	☐	☐	☐	☐
We periodically review shift patterns to reduce anti-social hours	☐	☐	☐	☐	☐	☐
We comply with all occupational health and safety requirements for food industry	☐	☐	☐	☐	☐	☐
We do not employ any indecent form of labour (child or forced)	☐	☐	☐	☐	☐	☐
We do not engage in any form of discriminatory practices	☐	☐	☐	☐	☐	☐
We pay reasonable wages and allow freedom of association for our staff	☐	☐	☐	☐	☐	☐
We transport food products in reusable shipping materials rather than shrink wrap or cardboard	☐	☐	☐	☐	☐	☐
We transport food products in long-lasting or recyclable corrugated cardboard pallet or plastic pallet	☐	☐	☐	☐	☐	☐
All the equipment and materials used in transportation operations are food graded as per the Australian standards	☐	☐	☐	☐	☐	☐
We use tie-down bands and straps which are reusable	☐	☐	☐	☐	☐	☐
We use recycled pallets and cardboards (where cardboards must be used)	☐	☐	☐	☐	☐	☐
We have KPIs and targets to reduce environmental impact linked with transportation of raw materials and finished goods	☐	☐	☐	☐	☐	☐

Comments:

If your company has a food manufacturing plant (or factory), then select Yes and answer the following questions. Otherwise select No and click the Continue button at the bottom of the page to go to the next section.

1. Yes
2. No

Kindly answer the following questions related to food Production:

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	N/A
We have a written manufacturing policy that ensures environmental preservation, communal welfare and economic value for the company	☐	☐	☐	☐	☐	☐
We have Environmental Management System in place to identify, monitor, reduce and report the impact of production operations on the environment	☐	☐	☐	☐	☐	☐
We ensure compliance with local and national environmental laws and regulations	☐	☐	☐	☐	☐	☐
We have Remediation Action Plan to alleviate any environmental damage from past operations or crises	☐	☐	☐	☐	☐	☐
We follow the principles of HACCP (Hazard Analysis and Critical Control Point) in food	☐	☐	☐	☐	☐	☐

production processes						
We ensure that all pollutants generated at the end of a process are captured and treated accordingly	❑	❑	❑	❑	❑	❑
We ensure the integrity and preservation of biodiversity (e.g., land, air, habitat, species, eco-system etc.) impacted by our operations	❑	❑	❑	❑	❑	❑
We strive to reduce and conserve energy through efficient processes	❑	❑	❑	❑	❑	❑
We strive to efficiently use water without harming the source	❑	❑	❑	❑	❑	❑
We recycle and reuse water for our operations	❑	❑	❑	❑	❑	❑
We monitor and reduce emissions such as GHG, ODS and air pollutants)	❑	❑	❑	❑	❑	❑
We continuously strive to reduce waste (from over-production, product defects, waiting time, etc.) through efficient processes, reuse and recycling	❑	❑	❑	❑	❑	❑
We ensure proper cleaning, sanitation, temperature control and pest control in our production facility to ensure food safety and quality	❑	❑	❑	❑	❑	❑
We continuously strive to redesign production processes so that they are environment friendly	❑	❑	❑	❑	❑	❑
We continuously strive to optimise production processes using ERP modules such as capacity planning, master production scheduling, MRP, QM, etc.	❑	❑	❑	❑	❑	❑
We ensure that all detergents, disinfectants or cleaning aids are environment and human friendly	❑	❑	❑	❑	❑	❑
All the equipment and materials used in production are food graded as per the Australian standards	❑	❑	❑	❑	❑	❑
We ensure that all food products are labelled according to Australian regulations	❑	❑	❑	❑	❑	❑
We follow the guidelines set by Australian Packaging Covenant	❑	❑	❑	❑	❑	❑
We have written labour/workplace management policies and standards aligned with international standards such as UN Global Compact and ILO	❑	❑	❑	❑	❑	❑
We consider the staff Work-Life Balance while planning deliveries to customers	❑	❑	❑	❑	❑	❑
We periodically review shift patterns to reduce anti-social hours	❑	❑	❑	❑	❑	❑
We comply with all occupational health and safety requirements	❑	❑	❑	❑	❑	❑
We do not employ any indecent form of labour (child or forced)	❑	❑	❑	❑	❑	❑
We do not engage in any form of discriminatory practices	❑	❑	❑	❑	❑	❑
We pay reasonable wages and allow freedom of association to our staff	❑	❑	❑	❑	❑	❑
We have setup KPIs to identify and reduce workplace injury and illness	❑	❑	❑	❑	❑	❑
We ensure that production processes and technologies are safe for workforce	❑	❑	❑	❑	❑	❑
We do not employ any form of child or forced labour for our operations	❑	❑	❑	❑	❑	❑

Comments:

Kindly answer the following questions related to Reverse Logistics:

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	N/A
We have implemented a pro-active take-back program	❑	❑	❑	❑	❑	❑
We have implemented a centralised product return centre (CRC)	❑	❑	❑	❑	❑	❑
We have outsourced reverse logistics operations	❑	❑	❑	❑	❑	❑
We determine recycling, reuse and resale potential of returned products	❑	❑	❑	❑	❑	❑
We give products in proper condition to charity organizations	❑	❑	❑	❑	❑	❑

Comments:

Kindly answer the following questions related to Supply Chain Planning: Institutional Policies

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	N/A
All supply chain transactions and business operations are free of corruption, bribery or any kind of illegal activity	❑	❑	❑	❑	❑	❑
The supply chain department has never been involved in anti-competitive, monopoly and ant-trust practices	❑	❑	❑	❑	❑	❑
The supply chain department contributes to communal projects related to health, education, sports, infrastructure, etc.	❑	❑	❑	❑	❑	❑
The supply chain department conducts Customer Satisfaction Survey on periodical basis	❑	❑	❑	❑	❑	❑
The supply chain department provides relevant training and development opportunities to all its employees	❑	❑	❑	❑	❑	❑
The supply chain department keeps its employees up-to-date regarding any developments in Australian food industry	❑	❑	❑	❑	❑	❑
The supply chain department carries out R&D relevant to Australian food supply chain	❑	❑	❑	❑	❑	❑
The supply chain department has a diverse workforce (i.e., employees with different nationalities, ancestry, ethnic origin, creed, gender, age groups, religious beliefs, cultures,	❑	❑	❑	❑	❑	❑

disability, etc.)						
The supply chain department provides equal opportunities to the entire workforce purely based on merit and quality of work	❏	❏	❏	❏	❏	❏
The supply chain department has strict policies to ensure a workplace free of any kind of discrimination, harassment and bullying	❏	❏	❏	❏	❏	❏
The supply chain department ensures fair remuneration, working conditions, leaves, rest periods and career path for all the employees	❏	❏	❏	❏	❏	❏
The supply chain department performs backup/replacement planning for all critical positions	❏	❏	❏	❏	❏	❏
The supply chain department continuously improves its processes for material acquisition, production and delivery to reduce their negative impact on environment	❏	❏	❏	❏	❏	❏

Risk Mitigation

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	N/A
We have a documented and periodically tested Business Continuity Plan (BCP) to ensure smooth operations in the wake of any IT Issues (e.g., server crash, data viruses, cyber-attacks and hacking)	❏	❏	❏	❏	❏	❏
We have a well-planned survival plan to mitigate risk of any natural disasters (e.g., floods, earthquakes and bush fire)	❏	❏	❏	❏	❏	❏
We have backup suppliers in case the deliveries from primary supplier are disrupted due to bad crops, flooding and pests	❏	❏	❏	❏	❏	❏
We have emergency plan, to minimise harm to employees and local community, in the event of any site disaster	❏	❏	❏	❏	❏	❏

Demand and Supply Planning

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	N/A
Our demand forecast accuracy for various food product categories is above 80 percent	❏	❏	❏	❏	❏	❏
We perform collaborative planning with sales and marketing department	❏	❏	❏	❏	❏	❏
All the production usually takes place as per the daily production schedule	❏	❏	❏	❏	❏	❏

Product Development

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	N/A
Supply chain department collaborates with brand team and also engages suppliers for New Product Development (NPD)	❏	❏	❏	❏	❏	❏
We assist in producing products that need minimal resources (water, energy, and materials)	❏	❏	❏	❏	❏	❏

We help product development/brand team to eliminate every possible toxic material that might be used during product manufacturing or usage	❑	❑	❑	❑	❑	❑
We help to develop food products that are most efficient for logistical activities (storage, transportation, handling)	❑	❑	❑	❑	❑	❑
We help to develop food products that are easily recyclable	❑	❑	❑	❑	❑	❑
We assist in developing food products with long shelf-life	❑	❑	❑	❑	❑	❑
We assist in developing food products that address consumer needs and delight them	❑	❑	❑	❑	❑	❑
We assist in developing food products that focus on functional benefits	❑	❑	❑	❑	❑	❑
We assist product development team in introducing affordable food products	❑	❑	❑	❑	❑	❑
We ensure food safety by complying with Australian standards and regulations during product development	❑	❑	❑	❑	❑	❑
We plan the product ‘take-back’ strategy for reusability or recycling	❑	❑	❑	❑	❑	❑
We focus on recommending ingredients (or materials) that could be locally sourced from Australian suppliers and farmers	❑	❑	❑	❑	❑	❑

Comments:

Appendix 2: Screenshots of the Online Questionnaire

Welcome and Consent Page

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http://www.questionpro.com/a/TakeSurvey?id=3619552&ext_ref=test_response

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2%

Exit Survey

Macquarie Graduate School of Management
MACQUARIE UNIVERSITY NSW 2109

Chief Investigator Phone: +61 (02) 9850 9005
Chief Investigator Email: norma.harrison@mgsm.edu.au

Chief Investigator's / Supervisor's Name: Prof. Norma J. Harrison

Information and Consent Form

Name of Project: Operationalizing Sustainability in supply chain. The case of Australian Food Industry

You are invited to participate in a study of sustainability in food supply chain. The purpose of the study is (1) to develop detailed sustainability criteria for all stages (planning, procurement, production, warehousing, transportation, reverse logistics) of the food supply chain; (2) to measure the impact of sustainable food supply chain on customer satisfaction and firm performance.

The study is being conducted by Chief Investigator Professor Norma J. Harrison, Macquarie Graduate School of Management, contact +61 2 9850 9005, email norma.harrison@mgsm.edu.au and Co Investigator Mr. Tayyab Waqas Amjed, Macquarie Graduate School of Management, contact +61 410 176 048, email tayyab.amjed@students.mq.edu.au. This research is being conducted to meet the requirements of Ph.D. in Management under the supervision of Prof. Norma J. Harrison.

If you decide to participate, you will be asked to fill in the online survey which will take 15 – 20 minutes. The questions are related to the various aspects of the supply chain and sustainability. This research presents no risk to the participants. Also, the participation in this research is unpaid.

Any information or personal details gathered in the course of the study are confidential. No individual will be identified in any publication of the results. Access to data will be restricted to Chief Investigator and Co Investigator. A summary of the results of the data can be made available to you on request on an aggregated basis and no individual respondents or organizations will be identified.

Participation in this study is entirely voluntary: you are not obliged to participate and if you decide to participate, you are free to withdraw at any time without having to give a reason and without consequence.

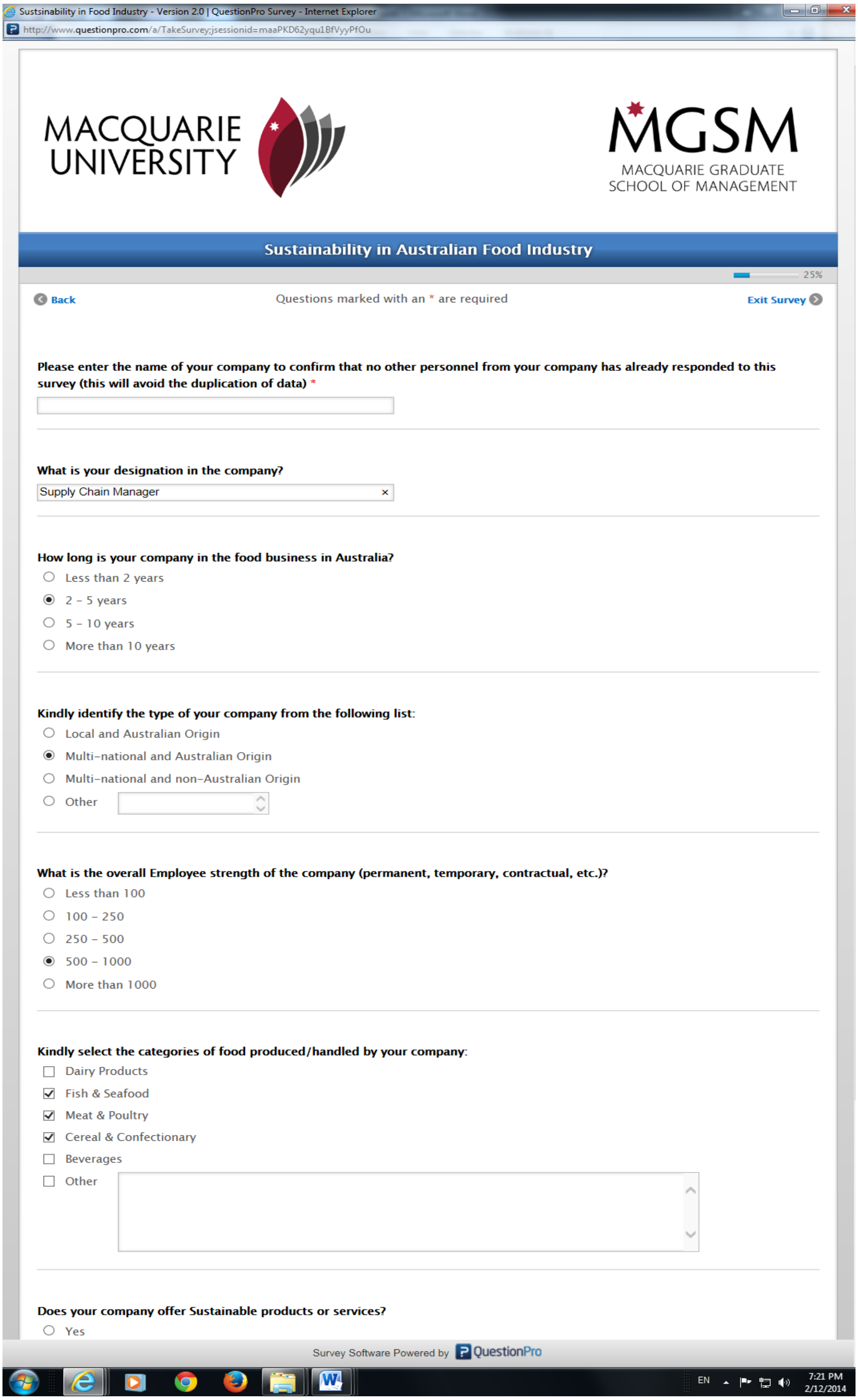
The ethical aspects of this study have been approved by the Macquarie University Human Research Ethics Committee. If you have any complaints or reservations about any ethical aspect of your participation in this research, you may contact the Committee through the Director, Research Ethics (telephone (02) 9850 7854; email ethics@mq.edu.au). Any complaint you make will be treated in confidence and investigated, and you will be informed of the outcome.

If you require more information about the specifics of the study, please do not hesitate to contact the Chief Investigator Prof. Norma J. Harrison on +61 2 9850 9005.

☐ I have read and understand the information above and any questions I have asked have been answered to my satisfaction. By clicking the "Continue" button below, I consent to participate in this research.

Continue

General Demographics



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http://www.questionpro.com/a/TakeSurvey;jsessionid=maaPKD62yqu1BfVyyPfOu

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25%

Back | Questions marked with an * are required | Exit Survey

Please enter the name of your company to confirm that no other personnel from your company has already responded to this survey (this will avoid the duplication of data) *

What is your designation in the company?

Supply Chain Manager

How long is your company in the food business in Australia?

- ( ) Less than 2 years
- (•) 2 – 5 years
- ( ) 5 – 10 years
- ( ) More than 10 years

Kindly identify the type of your company from the following list:

- ( ) Local and Australian Origin
- (•) Multi-national and Australian Origin
- ( ) Multi-national and non-Australian Origin
- ( ) Other

What is the overall Employee strength of the company (permanent, temporary, contractual, etc.)?

- ( ) Less than 100
- ( ) 100 – 250
- ( ) 250 – 500
- (•) 500 – 1000
- ( ) More than 1000

Kindly select the categories of food produced/handled by your company:

- [ ] Dairy Products
- [x] Fish & Seafood
- [x] Meat & Poultry
- [x] Cereal & Confectionary
- [ ] Beverages
- [ ] Other

Does your company offer Sustainable products or services?

- ( ) Yes

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Questions Related to Sustainable Supply Chain Planning

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80%

Back

Exit Survey

Kindly answer the following questions related to Supply Chain Planning:

Institutional Policies

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	N/A
All supply chain transactions and business operations are free of corruption, bribery or any kind of illegal activity	○	○	○	●	○	○
The supply chain department has never been involved in anti-competitive, monopoly and ant-trust practices	○	○	○	●	○	○
The supply chain department contributes to communal projects related to health, education, sports, infrastructure, etc.	○	○	●	○	○	○
The supply chain department conducts **Customer Satisfaction Survey** on periodical basis	○	○	○	●	○	○
The supply chain department provides relevant training and development opportunities to all its employees	○	○	○	○	○	●
The supply chain department keeps its employees up-to-date regarding any developments in Australian food industry	●	○	○	○	○	○
The supply chain department carries out **R&D** relevant to Australian food supply chain	○	○	○	●	○	○
The supply chain department has a diverse workforce (i.e., employees with different nationalities, ancestry, ethnic origin, creed, gender, age groups, religious beliefs, cultures, disability, etc.)	○	○	●	○	○	○
The supply chain department provides equal opportunities to the entire workforce purely based on merit and quality of work	○	○	○	●	○	○
The supply chain department has strict policies to ensure a workplace free of any kind of discrimination, harassment and bullying	○	○	●	○	○	○
The supply chain department ensures fair remuneration, working conditions, leaves, rest periods and career path for all the employees	○	●	○	○	○	○
The supply chain department performs **backup/replacement planning** for all critical positions	○	○	○	●	○	○
The supply chain department continuously improves its processes for material acquisition, production and delivery to reduce their negative impact on environment	○	○	○	●	○	○

Risk Mitigation

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	N/A
We have a documented and periodically tested **Business Continuity Plan** (BCP) to ensure smooth operations in the wake of any IT Issues (e.g., server crash, data viruses, cyber-attacks and hacking)	○	○	○	●	○	○
We have a well-planned survival plan to mitigate risk of any **natural disasters** (e.g., floods, earthquakes and bush fire)	○	○	○	●	○	○
We have backup suppliers in case the deliveries from primary supplier are disrupted due to bad crops, flooding and pests	○	●	○	○	○	○
We have emergency plan, to minimise harm to employees and local community, in the event of any site disaster	○	○	○	●	○	○

Demand and Supply Planning

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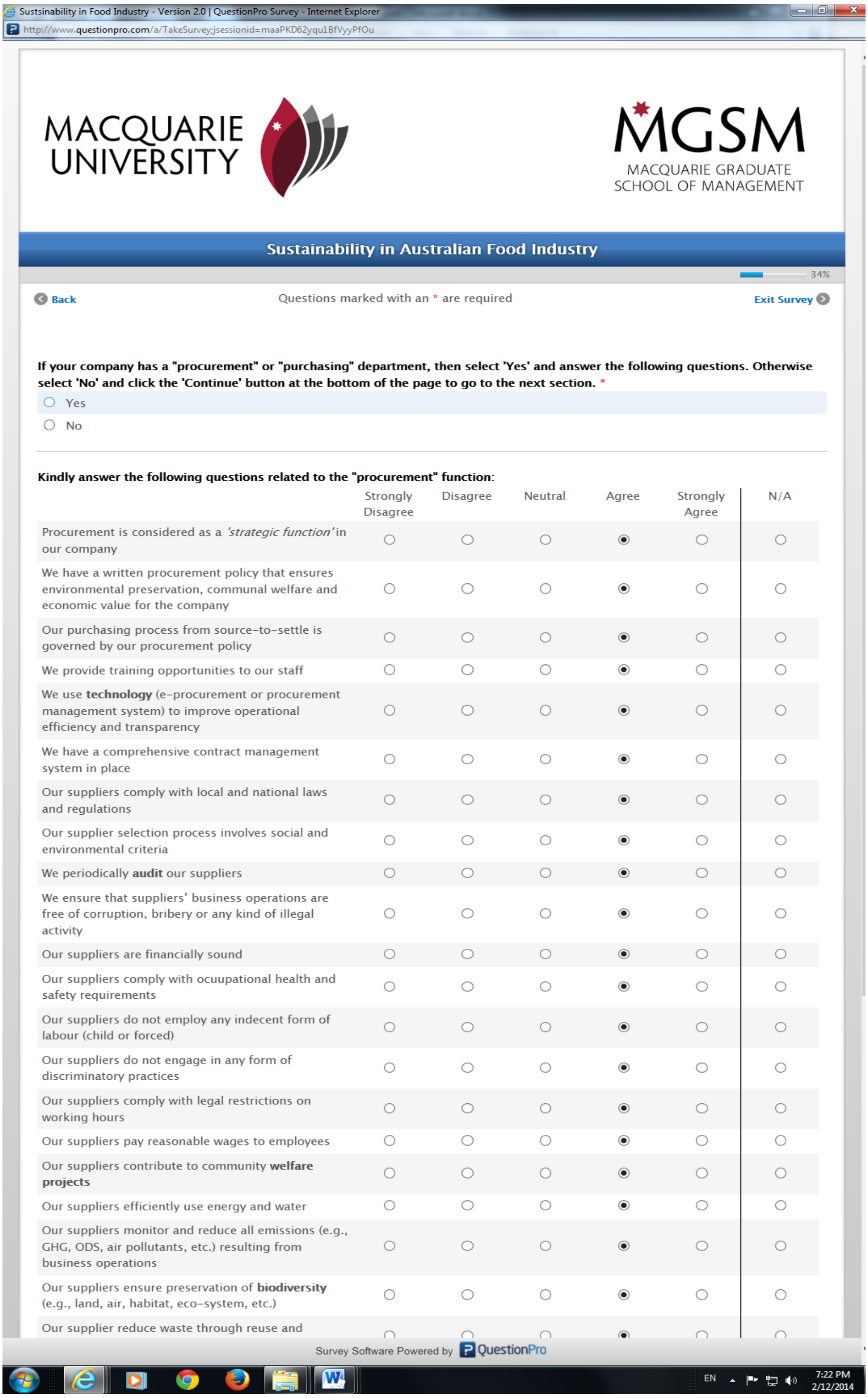
Questions Related to Sustainable Procurement



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34%

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If your company has a "procurement" or "purchasing" department, then select 'Yes' and answer the following questions. Otherwise select 'No' and click the 'Continue' button at the bottom of the page to go to the next section. *

○ Yes

○ No

Kindly answer the following questions related to the "procurement" function:

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	N/A
Procurement is considered as a *'strategic function'* in our company	○	○	○	◉	○	○
We have a written procurement policy that ensures environmental preservation, communal welfare and economic value for the company	○	○	○	◉	○	○
Our purchasing process from source-to-settle is governed by our procurement policy	○	○	○	◉	○	○
We provide training opportunities to our staff	○	○	○	◉	○	○
We use **technology** (e-procurement or procurement management system) to improve operational efficiency and transparency	○	○	○	◉	○	○
We have a comprehensive contract management system in place	○	○	○	◉	○	○
Our suppliers comply with local and national laws and regulations	○	○	○	◉	○	○
Our supplier selection process involves social and environmental criteria	○	○	○	◉	○	○
We periodically **audit** our suppliers	○	○	○	◉	○	○
We ensure that suppliers' business operations are free of corruption, bribery or any kind of illegal activity	○	○	○	◉	○	○
Our suppliers are financially sound	○	○	○	◉	○	○
Our suppliers comply with ocuupational health and safety requirements	○	○	○	◉	○	○
Our suppliers do not employ any indecent form of labour (child or forced)	○	○	○	◉	○	○
Our suppliers do not engage in any form of discriminatory practices	○	○	○	◉	○	○
Our suppliers comply with legal restrictions on working hours	○	○	○	◉	○	○
Our suppliers pay reasonable wages to employees	○	○	○	◉	○	○
Our suppliers contribute to community **welfare projects**	○	○	○	◉	○	○
Our suppliers efficiently use energy and water	○	○	○	◉	○	○
Our suppliers monitor and reduce all emissions (e.g., GHG, ODS, air pollutants, etc.) resulting from business operations	○	○	○	◉	○	○
Our suppliers ensure preservation of **biodiversity** (e.g., land, air, habitat, eco-system, etc.)	○	○	○	◉	○	○
Our supplier reduce waste through reuse and	○	○	○	◉	○	○

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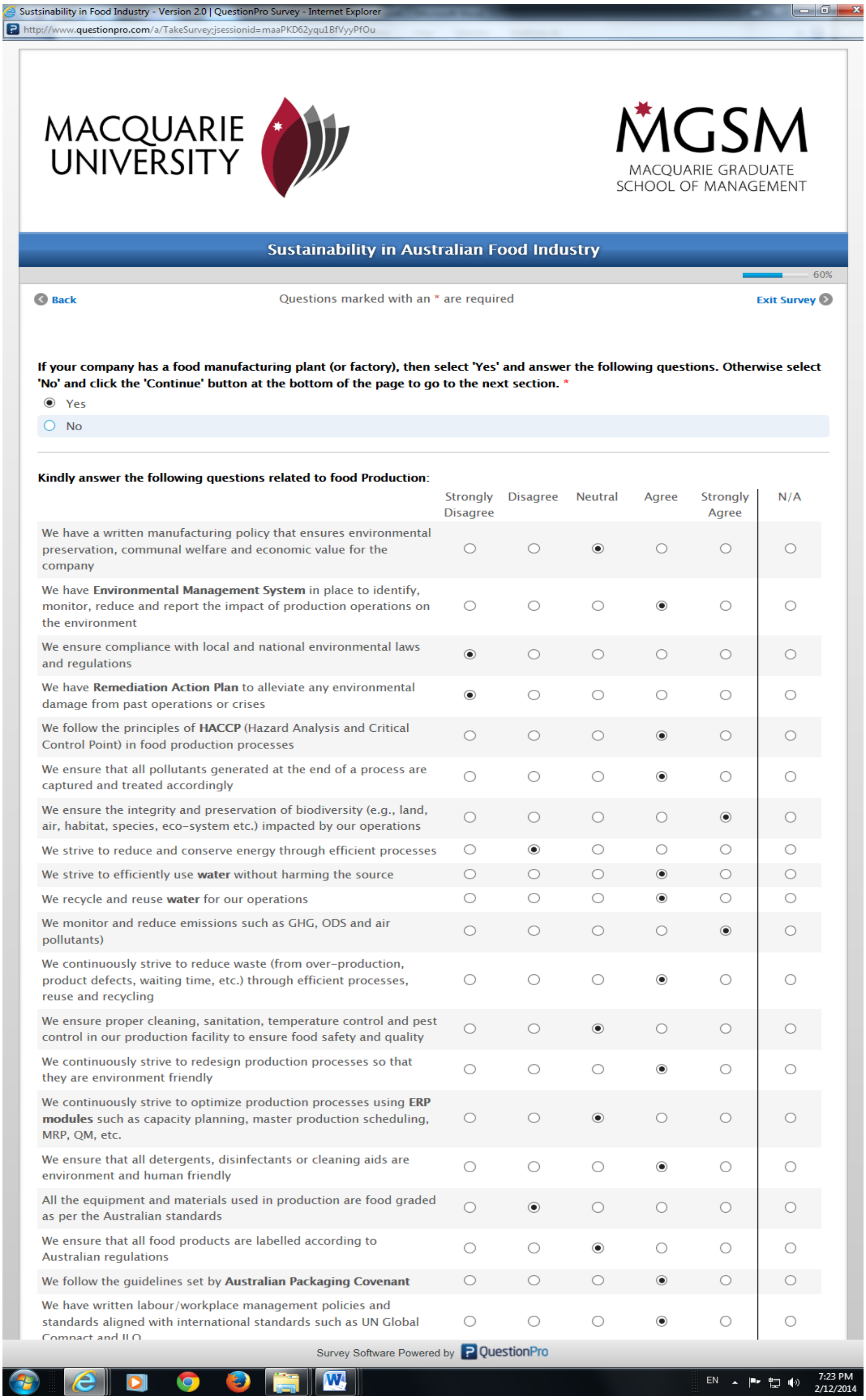
Questions Related to Sustainable Manufacturing



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60%

Back | Questions marked with an * are required | Exit Survey

If your company has a food manufacturing plant (or factory), then select 'Yes' and answer the following questions. Otherwise select 'No' and click the 'Continue' button at the bottom of the page to go to the next section. *

◉ Yes

○ No

Kindly answer the following questions related to food Production:

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	N/A
We have a written manufacturing policy that ensures environmental preservation, communal welfare and economic value for the company	○	○	◉	○	○	○
We have **Environmental Management System** in place to identify, monitor, reduce and report the impact of production operations on the environment	○	○	○	◉	○	○
We ensure compliance with local and national environmental laws and regulations	◉	○	○	○	○	○
We have **Remediation Action Plan** to alleviate any environmental damage from past operations or crises	◉	○	○	○	○	○
We follow the principles of **HACCP** (Hazard Analysis and Critical Control Point) in food production processes	○	○	○	◉	○	○
We ensure that all pollutants generated at the end of a process are captured and treated accordingly	○	○	○	◉	○	○
We ensure the integrity and preservation of biodiversity (e.g., land, air, habitat, species, eco-system etc.) impacted by our operations	○	○	○	○	◉	○
We strive to reduce and conserve energy through efficient processes	○	◉	○	○	○	○
We strive to efficiently use **water** without harming the source	○	○	○	◉	○	○
We recycle and reuse **water** for our operations	○	○	○	◉	○	○
We monitor and reduce emissions such as GHG, ODS and air pollutants)	○	○	○	○	◉	○
We continuously strive to reduce waste (from over-production, product defects, waiting time, etc.) through efficient processes, reuse and recycling	○	○	○	◉	○	○
We ensure proper cleaning, sanitation, temperature control and pest control in our production facility to ensure food safety and quality	○	○	◉	○	○	○
We continuously strive to redesign production processes so that they are environment friendly	○	○	○	◉	○	○
We continuously strive to optimize production processes using **ERP modules** such as capacity planning, master production scheduling, MRP, QM, etc.	○	○	◉	○	○	○
We ensure that all detergents, disinfectants or cleaning aids are environment and human friendly	○	○	○	◉	○	○
All the equipment and materials used in production are food graded as per the Australian standards	○	◉	○	○	○	○
We ensure that all food products are labelled according to Australian regulations	○	○	◉	○	○	○
We follow the guidelines set by **Australian Packaging Covenant**	○	○	○	◉	○	○
We have written labour/workplace management policies and standards aligned with international standards such as UN Global Compact and ILO	○	○	○	◉	○	○

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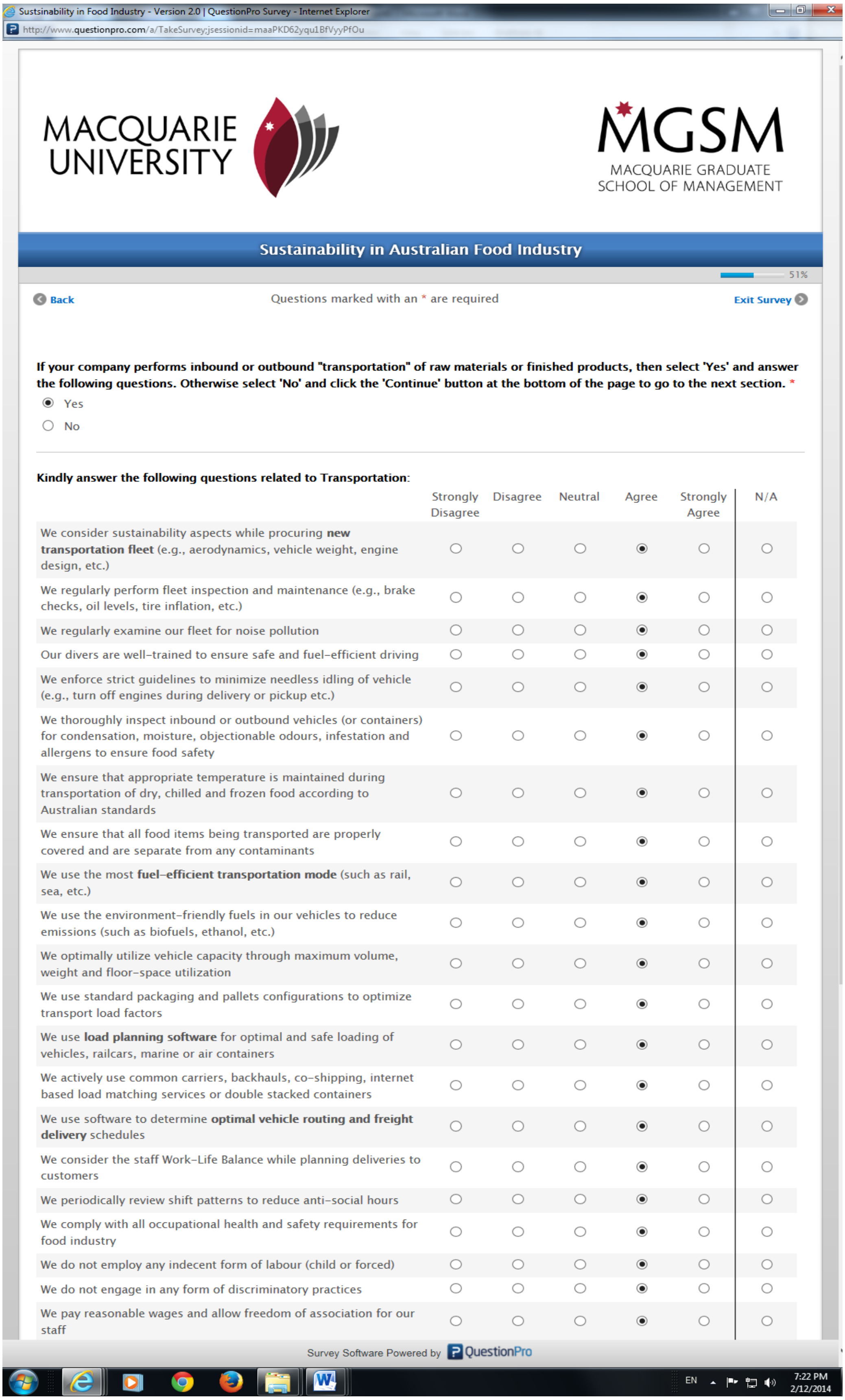
Questions Related to Sustainable Transportation



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51%

Back | Questions marked with an * are required | Exit Survey

If your company performs inbound or outbound "transportation" of raw materials or finished products, then select 'Yes' and answer the following questions. Otherwise select 'No' and click the 'Continue' button at the bottom of the page to go to the next section. *

◉ Yes

○ No

Kindly answer the following questions related to Transportation:

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	N/A
We consider sustainability aspects while procuring **new transportation fleet** (e.g., aerodynamics, vehicle weight, engine design, etc.)	○	○	○	◉	○	○
We regularly perform fleet inspection and maintenance (e.g., brake checks, oil levels, tire inflation, etc.)	○	○	○	◉	○	○
We regularly examine our fleet for noise pollution	○	○	○	◉	○	○
Our divers are well-trained to ensure safe and fuel-efficient driving	○	○	○	◉	○	○
We enforce strict guidelines to minimize needless idling of vehicle (e.g., turn off engines during delivery or pickup etc.)	○	○	○	◉	○	○
We thoroughly inspect inbound or outbound vehicles (or containers) for condensation, moisture, objectionable odours, infestation and allergens to ensure food safety	○	○	○	◉	○	○
We ensure that appropriate temperature is maintained during transportation of dry, chilled and frozen food according to Australian standards	○	○	○	◉	○	○
We ensure that all food items being transported are properly covered and are separate from any contaminants	○	○	○	◉	○	○
We use the most **fuel-efficient transportation mode** (such as rail, sea, etc.)	○	○	○	◉	○	○
We use the environment-friendly fuels in our vehicles to reduce emissions (such as biofuels, ethanol, etc.)	○	○	○	◉	○	○
We optimally utilize vehicle capacity through maximum volume, weight and floor-space utilization	○	○	○	◉	○	○
We use standard packaging and pallets configurations to optimize transport load factors	○	○	○	◉	○	○
We use **load planning software** for optimal and safe loading of vehicles, railcars, marine or air containers	○	○	○	◉	○	○
We actively use common carriers, backhauls, co-shipping, internet based load matching services or double stacked containers	○	○	○	◉	○	○
We use software to determine **optimal vehicle routing and freight delivery** schedules	○	○	○	◉	○	○
We consider the staff Work-Life Balance while planning deliveries to customers	○	○	○	◉	○	○
We periodically review shift patterns to reduce anti-social hours	○	○	○	◉	○	○
We comply with all occupational health and safety requirements for food industry	○	○	○	◉	○	○
We do not employ any indecent form of labour (child or forced)	○	○	○	◉	○	○
We do not engage in any form of discriminatory practices	○	○	○	◉	○	○
We pay reasonable wages and allow freedom of association for our staff	○	○	○	◉	○	○

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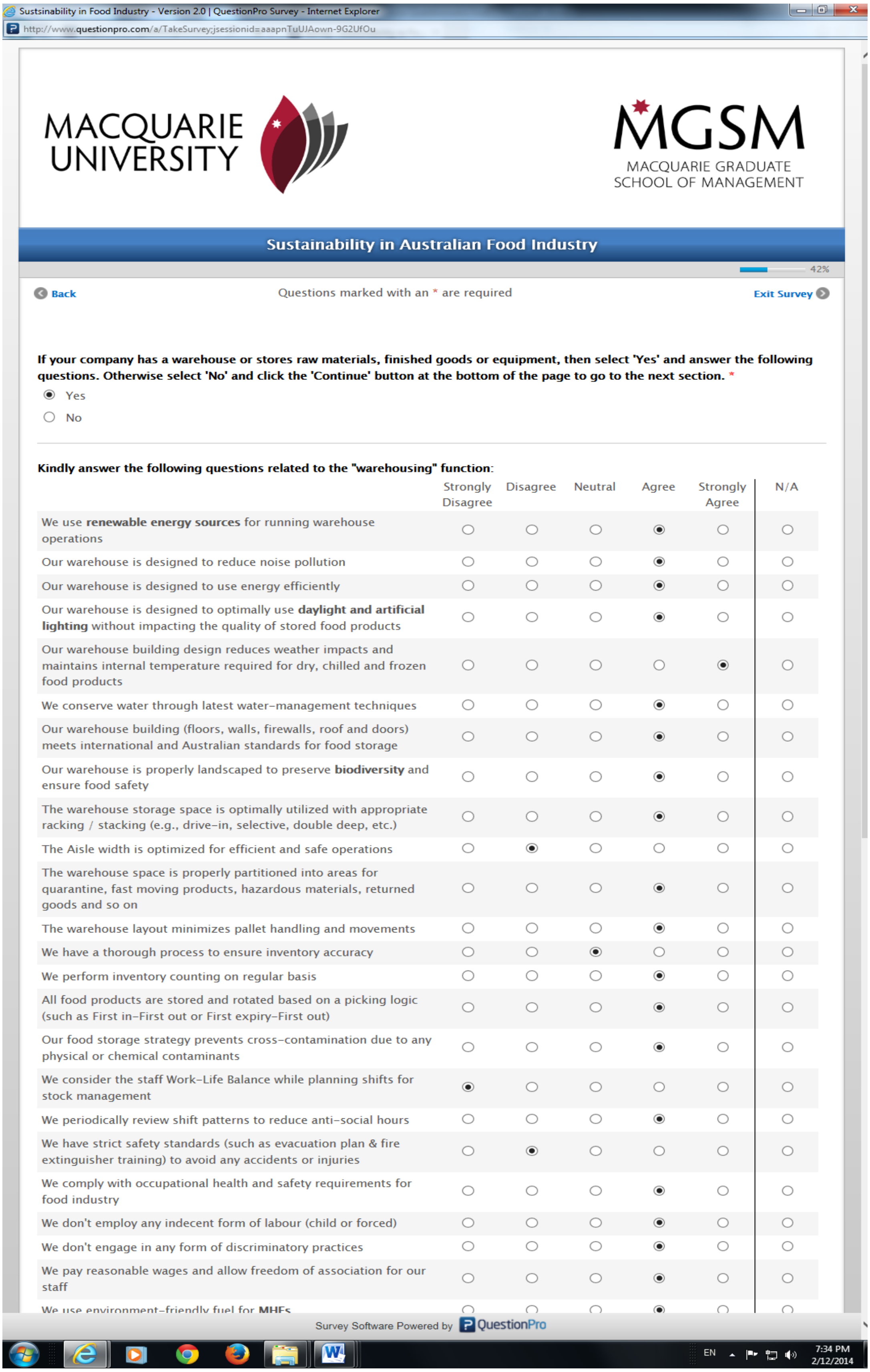
Questions Related to Sustainable Warehousing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http://www.questionpro.com/a/TakeSurvey;jsessionid=aaapnTuUJAown-9G2UfOu

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Back — Questions marked with an * are required — Exit Survey

If your company has a warehouse or stores raw materials, finished goods or equipment, then select 'Yes' and answer the following questions. Otherwise select 'No' and click the 'Continue' button at the bottom of the page to go to the next section. *

● Yes

○ No

Kindly answer the following questions related to the "warehousing" function:

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	N/A
We use **renewable energy sources** for running warehouse operations	○	○	○	●	○	○
Our warehouse is designed to reduce noise pollution	○	○	○	●	○	○
Our warehouse is designed to use energy efficiently	○	○	○	●	○	○
Our warehouse is designed to optimally use **daylight and artificial lighting** without impacting the quality of stored food products	○	○	○	●	○	○
Our warehouse building design reduces weather impacts and maintains internal temperature required for dry, chilled and frozen food products	○	○	○	○	●	○
We conserve water through latest water-management techniques	○	○	○	●	○	○
Our warehouse building (floors, walls, firewalls, roof and doors) meets international and Australian standards for food storage	○	○	○	●	○	○
Our warehouse is properly landscaped to preserve **biodiversity** and ensure food safety	○	○	○	●	○	○
The warehouse storage space is optimally utilized with appropriate racking / stacking (e.g., drive-in, selective, double deep, etc.)	○	○	○	●	○	○
The Aisle width is optimized for efficient and safe operations	○	●	○	○	○	○
The warehouse space is properly partitioned into areas for quarantine, fast moving products, hazardous materials, returned goods and so on	○	○	○	●	○	○
The warehouse layout minimizes pallet handling and movements	○	○	○	●	○	○
We have a thorough process to ensure inventory accuracy	○	○	●	○	○	○
We perform inventory counting on regular basis	○	○	○	●	○	○
All food products are stored and rotated based on a picking logic (such as First in-First out or First expiry-First out)	○	○	○	●	○	○
Our food storage strategy prevents cross-contamination due to any physical or chemical contaminants	○	○	○	●	○	○
We consider the staff Work-Life Balance while planning shifts for stock management	●	○	○	○	○	○
We periodically review shift patterns to reduce anti-social hours	○	○	○	●	○	○
We have strict safety standards (such as evacuation plan & fire extinguisher training) to avoid any accidents or injuries	○	●	○	○	○	○
We comply with occupational health and safety requirements for food industry	○	○	○	●	○	○
We don't employ any indecent form of labour (child or forced)	○	○	○	●	○	○
We don't engage in any form of discriminatory practices	○	○	○	●	○	○
We pay reasonable wages and allow freedom of association for our staff	○	○	○	●	○	○
We use environment-friendly fuel for **MHEs**	○	○	○	●	○	○

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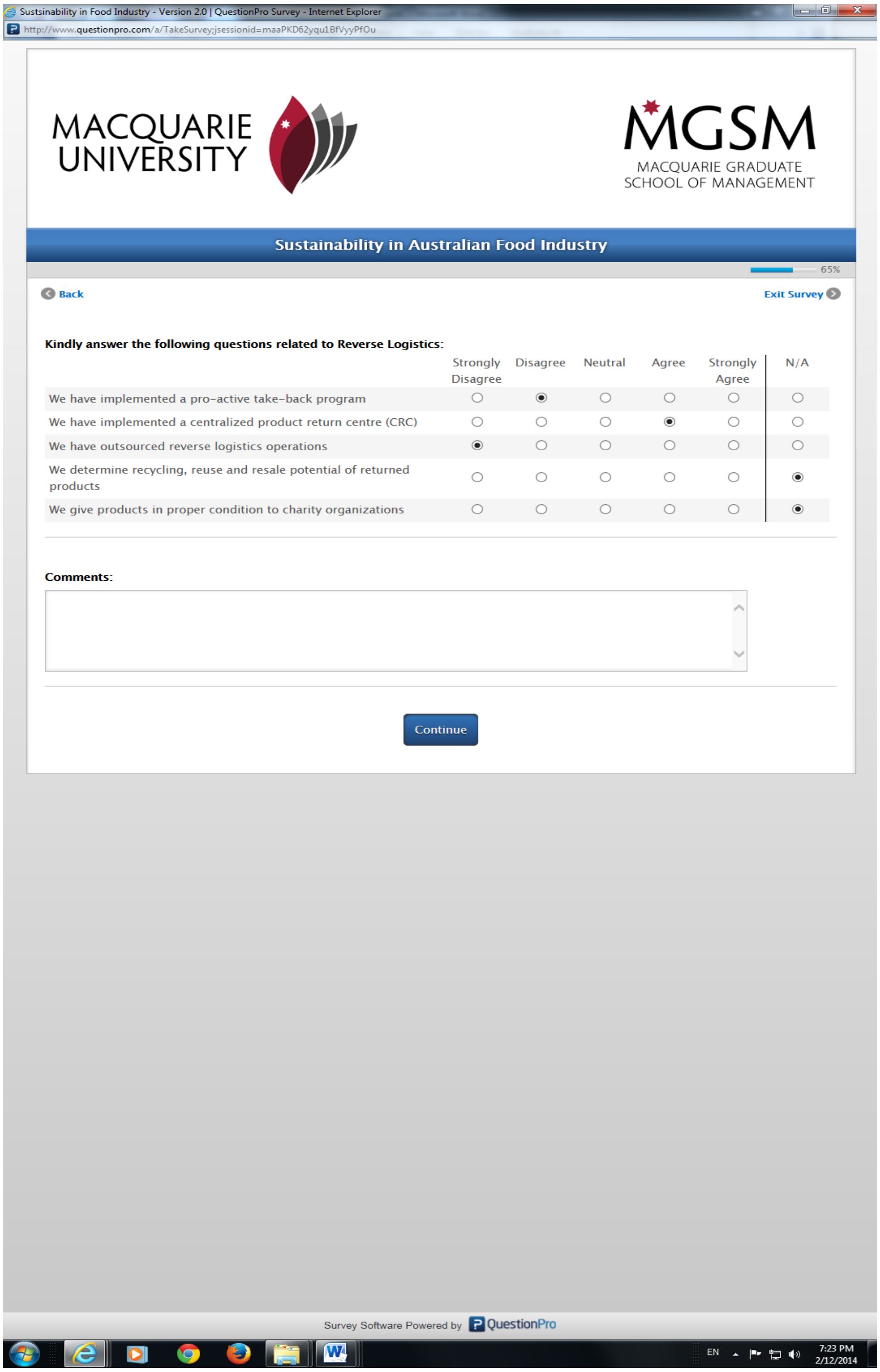
Questions Related to Reverse Logistics



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http://www.questionpro.com/a/TakeSurvey;jsessionid=maaPKD62yqu1BfVyyPfOu

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Exit Survey

Kindly answer the following questions related to Reverse Logistics:

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	N/A
We have implemented a pro-active take-back program	○	●	○	○	○	○
We have implemented a centralized product return centre (CRC)	○	○	○	●	○	○
We have outsourced reverse logistics operations	●	○	○	○	○	○
We determine recycling, reuse and resale potential of returned products	○	○	○	○	○	●
We give products in proper condition to charity organizations	○	○	○	○	○	●

Comments:

Continue

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Appendix 3: NVivo Software

NVivo Software

Manual analysis of qualitative data was not possible for this research as material related to sustainability, supply chain management, supply chain planning, procurement, manufacturing, transportation, warehousing, reverse logistics, exploratory factor analysis, confirmatory factor analysis, food industry and qualitative data analysis is so extensive that it is not imaginable to analyse with manual note taking/recording techniques. All these knowledge areas were studied from books, academic articles, industry publications, market reports, supply chain periodicals, company reports etc. Thus computer assisted qualitative data analysis software (CAQDAS) – **NVivo** was used for this research. It is a qualitative analysis software developed Qualitative Solutions and Research (QSR) company. It helps researchers in theory development by organizing and analysing qualitative data. Documents are imported into NVivo software quite easily in most of the prevalent formats (pdf, doc, rtf, digital videos, multimedia files etc.). Various data analysis tools help to perform deep analysis which leads to the development of theme and models.

Coding using Free and Tree Nodes

Coding is simply transforming data into understandable form or organizing data into categories/classes/codes that could facilitate analysis. In NVivo software **‘Nodes’** are similar to codes and a researcher initially develops **‘free nodes’** which represent emerging themes and these could be grouped into **‘tree nodes’** . Simply putting it, a tree node is like a parent node with various child nodes. It is similar to creating a hierarchy, classification or taxonomy of related concept/themes grouped under relevant categories.

Data Analysis Tools

NVivo software provides many options for data analysis such as broad brush coding, word frequency query, tree maps, tag clouds, etc. These tools help to explore, arrange, sort, classify and examine data through searching, linking, shaping and modelling. **Word frequency query** has multiple options to determine words that occur most frequently. For example, if the word 'balance' appears often then it can be easily saved along with its context in a node. Results of such content analysis can be seen visually through a **'word tree'** in which 'balance' will be shown with all its contexts in the form of branches coming out of the word. In this research the word 'balance' appeared with numerous contexts such as balanced score card, balance sheets, work/life balance, balance between competing transportation objectives, etc. Tree maps and **tag clouds** are also used to visually see the frequency of various words on relative basis and help to compare nodes by number of coding references.

Appendix 4 of this thesis has been removed as it may contain sensitive/confidential content

Appendix 5: Pairwise Chi-Square Difference Tests for the SSCM Sub-Constructs

Pairwise chi-square difference test for the SPlng sub-construct

Description	Chi-square statistics				
	Unconstrained model	d.f.	Constrained model	d.f.	Difference
ISCP with RM	15.722	8	80.691	9	64.969
ISCP with DSP	24.421	19	181.078	20	156.657
ISCP with PD	60.581	19	224.297	20	163.716
RM with DSP	19.488	19	163.400	20	143.912
RM with PD	58.194	19	218.246	20	160.052
DSP with PD	91.722	34	222.607	35	130.885

Note: All chi-square differences are significant (for 1 degree of freedom) at $p < 0.01$.
Unconstrained model indicates a model with correlation without constraint of variance. Constrained model indicates a model with correlation constrained to one.

Pairwise chi-square difference test for the SP sub-construct

Description	Chi-square statistics				
	Unconstrained model	d.f.	Constrained model	d.f.	Difference
PPP with OE	4.398	4	77.677	5	73.279
PPP with SSA	5.358	4	27.677	5	22.319
PPP with SWS	6.738	4	19.573	5	12.835
PPP with SO	7.878	4	21.264	5	13.386
PPP with SRC	0.810	1	43.693	2	42.883
OE with SSA	0.356	1	51.417	2	51.061
OE with SWS	0.094	1	12.951	2	12.857
OE with SO	5.754	2	48.542	3	42.788
OE with SRC	0	0	33.794	1	33.794
SSA with SWS	0	0	56.574	1	56.574
SSA with SO	0	0	50.532	1	50.532
SSA with SRC	0	0	15.126	1	15.126
SWS with SO	8.265	4	33.771	5	25.506
SWS with SRC	9.557	4	26.284	5	16.727
SO with SRC	0.451	1	58.427	2	57.976

Note: All chi-square differences are significant (for 1 degree of freedom) at $p < 0.01$.
Unconstrained model indicates a model with correlation without constraint of variance. Constrained model indicates a model with correlation constrained to one.

Pairwise chi-square difference test for the SM sub-construct

Description	Chi-square statistics				
	Unconstrained model	d.f.	Constrained model	d.f.	Difference
MPP with PCP	39.365	19	72.04	20	32.675
MPP with RC	16.188	19	41.806	20	25.618
MPP with PS	13.415	8	24.814	9	11.399
MPP with PRC	45.164	19	55.791	20	10.627
PCP with RC	14.031	8	32.954	9	18.923
PCP with PS	18.242	19	51.095	20	32.853
PCP with PRC	97.159	34	128.339	35	31.18
RC with PS	49.796	19	66.165	20	16.369
RC with PRC	25.012	8	43.681	9	18.669
PS with PRC	12.961	12.961	28.098	9	15.137

Note: All chi-square differences are significant (for 1 degree of freedom) at $p < 0.01$.
Unconstrained model indicates a model with correlation without constraint of variance. Constrained model indicates a model with correlation constrained to one.

Pairwise chi-square difference test for the ST sub-construct

Description	Chi-square statistics				
	Unconstrained model	d.f.	Constrained model	d.f.	Difference
TPP with TML	7.126	4	35.77	5	28.644
TPP with TRS	3.098	4	45.089	5	41.991
TPP with TS	33.332	4	48.393	5	15.061
TPP with TSM	1.151	1	92.488	2	91.337
TPP with TRC	0.047	1	29.258	2	29.211
TML with TRS	8.503	1	40.233	2	31.73
TML with TS	0.204	1	56.942	2	56.738
TML with TSM	0.501	1	106.210	2	105.709
TML with TRC	8.387	4	52.641	5	44.254
TRS with TS	3.026	4	45.089	5	42.063
TRS with TSM	38.739	8	52.047	9	13.308
TRS with TRC	9.283	4	46.287	5	37.004
TS with TSM	1.694	1	9.548	2	7.854
TS with TRC	4.522	1	41.232	2	36.71
TSM with TRC	3.412	1	48.244	2	44.832

Note: All chi-square differences are significant (for 1 degree of freedom) at $p < 0.01$.
Unconstrained model indicates a model with correlation without constraint of variance. Constrained model indicates a model with correlation constrained to one.

Pairwise chi-square difference test for the SW sub-construct

Description	Chi-square statistics				
	Unconstrained model a	d.f.	Constrained model b	d.f.	Difference
WD with WL	16.112	19	45.806	20	29.694
WD with WP	16.184	19	46.896	20	30.712
WD with WS	11.413	8	29.814	9	18.401
WD with OF	35.164	19	52.771	20	17.607
WD with MHE	19.245	19	59.095	20	39.85
WL with WP	17.121	19	42.886	20	25.765
WL with WS	18.166	19	41.806	20	23.64
WL with OF	18.410	8	36.884	9	18.474
WL with MHE	42.163	19	62.721	20	20.558
WP with WS	18.244	19	40.025	20	21.781
WP with OF	15.120	19	38.836	20	23.716
WP with MHE	12.444	8	56.894	9	44.45
WS with OF	43.154	19	62.742	20	19.588
WS with MHE	18.002	8	63.985	9	45.983
OF with MHE	18.233	19	40.058	20	21.825

Note: All chi-square differences are significant (for 1 degree of freedom) at $p < 0.01$.
Unconstrained model indicates a model with correlation without constraint of variance. Constrained model indicates a model with correlation constrained to one.

Appendix 6: Attributes of Reflective Versus Formative Constructs

Attributes of Reflective Vs Formative Constructs

Issue	Reflective Construct	Formative Construct
Causal Priority	Indicators are realised From construct to indicators	Indicators are explanatory From indicators to construct
Measurement Error	Established practices important at the item level	Statistical assessment is problematic, but should be done at the construct level
Internal Consistency	Indicators should possess internal consistency	Internal consistency is not implied
Correlations	Should be high	Not expected
Identification	"Rule of three"	Two emitting paths plus formative indicators
Error terms	Yes, at indicator level	No – only disturbances at construct level
Measurement Interchangeability	Removal of an item does not change the essential nature of the underlying construct	Omitting an indicator is omitting a part of the construct

Source: Freeze and Raschke (2007, p. 1484)