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The impact of supply chain process integration on business performance

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The Impact of Supply Chain Process Integration on Business Performance

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Abstract

Over the past century and accelerated since the end of the post WWII manufacturing boom, a number of forces acting upon manufacturing organisations have led to significant changes to underlying manufacturing philosophies used, to the technologies employed and to the manufacturing methods and practices applied. Such forces (Hammer and Champy, 1993, pp. 17) are related to organisational survival factors such as market share and price premiums, cost reductions, quicker response to new market demands, quicker response to competitor practices, operating equipment effectiveness, cycle time reductions and reductions to inefficiencies and material requirements.

As a result, manufacturing organisations now have an increased focus on specific competitive advantages, geographic spread and location, management of costs, relations with customers and suppliers and by no means least, the treatment and development of people (Porter, 1990, pp. 40~41). As well, in some industries more than others, there has been a progressive change in focus away for separate, arms-length entities along a common supply chain to a more integrated and collaborative view. (Christopher, 1998, pp. 5).

Supply Chain Management (SCM) as such, is by now recognised by many organisations as a means by which they can gain competitive advantage and improve their business results (Spekman et al., 1998, pp. 630). Effective SCM therefore can become a strategic factor in a firm's success (Cohen and Roussel, 2005, pp. 9). This is particularly the case as more companies link their advantages together and start to operate as supply networks of interdependent supply chain partners as opposed to separate, stand-alone entities (Spekman et al., 1998, pp. 632). Associated with such an approach is the integration of intra and inter-businesses processes in order to achieve such business-to-business linkage. As illustrated by companies such as Amazon, Dell, Hewlett-Packard, Wal-Mart, Shell Chemical and Georgia-Pacific Corp, an effective supply chain network can competitively outperform the standalone model (Lummus and Alber, 1997, pp. 10, Cohen and Roussel, 2005, pp. 10). This

superior performance manifests itself as performance advantages on a number of key supply chain performance measures (Shin et al., 2000, pp. 330).

Consistent with the theme of supply chain management, this research deals specifically with the order fulfilment processes operating within a supply chain and in particular the integration of those processes both horizontally and vertically within the chain. The key belief is that higher levels of such integration will assist organisations to improve their supply chain and overall business performance.

The major objective of this work therefore was to answer the question:

"How much and in what ways does the integration of supply chain logistics processes in manufacturing organisations impact upon business performance?"

The methodology used to address the above research question consisted firstly of conducting an exhaustive literature review. From that review, the main research hypotheses and three theoretical frameworks were proposed. The hypotheses and theoretical frameworks captured the ideas and findings of numerous researchers and writers with respect to variables and relationship structures that may help answer the research question. The main research hypotheses developed and tested therefore were as follows:

H_1: That the *integration* of supply chain logistics *processes* does significantly and positively impact supply chain and business performance.

H_2: That the *application* of supply chain management *principles* does significantly and positively impact supply chain and business performance.

H_3: That the *application* of *human 'social' principles/approaches* does significantly and positively impact supply chain and business performance.

Following the literature review, a survey instrument was designed and tested, contact details of target participants were obtained and finally the sequence of questionnaire related letters (including the questionnaire) was mailed out.

Responses were assessed for suitability (completeness and reasonableness), entered into Excel and later imported into SPSS ver. 13.0 for analysis. 210 usable responses were obtained from 230 returned questionnaires sent to 1050 supply chain professionals in 990 companies worldwide.

The results of the data analysis (principally via the use of structural equation modelling) showed conditional support for each of the research hypotheses and good support for the first of the proposed theoretical frameworks. Because of this, a simulation model of the first theoretical framework was developed such that the research results can: (a) be seen visually and in a dynamic way, (b) be used by others to test their mental models of supply chain 'DNA' against and to improve the robustness of their supply chain improvement plans and initiatives and (c) be used by educators to demonstrate dynamically the relationships between supply chain lever and outcome variables.

The second and third theoretical frameworks proposed were not supported.

Factor analysis was undertaken in order to reduce highly related variables to fewer underlying constructs. The factor analysis confirmed that such data-reduction was possible for the study's chosen variables such that the 10 dependent variables could be reduced to 5 variates and the study's 32 independent variables could be reduced to 8 variates.

The research conclusions are described including identification of conditional support for the three above hypotheses, confirmation of the best-fit theoretical model and affirmation that integration of supply chain logistics processes does positively influence both supply chain and business outcomes.

Implications arising from and limitations of the study are discussed, as are recommendations for further research.

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Publications and Conference Presentations Made as Part of This Research Work

Articles

1. Robertson, Peter. W., Gibson, Peter. R., Flanagan, John. T., *Strategic Supply Chain Development by Integration of Key Global Logistical Process Linkages*, International Journal of Production Research, 40, 16, (2002), pp. 4021-4040

2. Robertson, Peter W., *Adaptive Supply Chains: From Command and Control to Control Commands*, Supply Chain Week, MHD Supply Chain Solutions, 35, 3, (2005) pp. 60-66

Conference Proceedings

1. Robertson, Peter. W., Gibson, Peter. R., Flanagan, John. T., *Supply Chain Integrated Logistical Processes: Achieving the Key Logistical Process Linkages Required to Deliver Optimal Supply Chain Performance*, POMS 12th Annual Conference, Orlando Fl., 30th Mar to 2nd Apr, (2001), 13 pages

2. Robertson, Peter. W., Whalan, Bruce. D., *Supply Chain Velocity*, South East Asian Iron and Steel Institute Conference, Kuala Lumpur, Malaysia, Nov., (2001), 18 pages

3. Robertson, Peter. W., *e-Supply Chain Velocity*, Australia New Zealand Supply Chain Council's Supply Chain World Conference, Sydney, Australia, 3rd Dec., (2003), 14 Pages

4. Robertson, Peter. W., *Adaptive Supply Chains: From Command and Control to Control Commands*, Adaptive Supply Chains Conference, Sydney, Australia, 9th &10th Feb., (2005), 11 Pages

5. Robertson, Peter. W., *The Impact of Supply Chain Process Integration on Business Performance*, SMART Conference, Sydney, Australia, 1st & 2nd June, (2005), 27 Pages

6. Robertson, Peter. W., *The Impact of Social Issues on Supply Chain Performance in Manufacturing Organisations*, ANZAM Conference, Yeppoon, Qld., 13th & 14th June, (2005), 17 pages

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Abbreviations

Abbreviation	Meaning
Agile	Manufacturing Philosophy Calling for High Levels of Responsiveness to Customer Dynamics
AMOS	Structural Equation Modelling Software Program
ANOVA	Analysis of Variance Analysis
CR	Continuous Replenishment Style of Even Flow of Products to Match Consumer Demand
'DNA'	Used in This Study to Imply the Underlying Structure or Successful Pattern of Workings of Supply Chain Management
DP	Delivery Performance
DRP	Distribution Requirements Planning
ECR	Efficient Consumer Response Process Adopted Initially by US Grocery Industry and Included Introduction of Point of Sales Tracking Processes in Order to Align Product Make Program with Consumer Consumption Patterns.
EDLP	Every Day Lower Pricing
ithink	Systems Dynamics Based Simulation Software
JIT	Just in Time; Similar Manufacturing Philosophy to 'Lean'
Lean	A Manufacturing Philosophy Focusing on Elimination of Waste and Increasing Flow Velocity Through the Supply Chain
LT or L/T	Lead-time
MRP	Materials Requirements Planning
PoP	Point of Production
POS	Point of Sale
Pull	Kanban Style of Operating Philosophy Whereby an Upstream Unit Does Not Operate Unless Given a 'Pull' Signal From a Downstream Unit
Push	Manufacturing Philosophy Whereby Product is 'Pushed' Down the Supply Chain Almost Irregardless to Consumer Consumption Rates

QR	Quick Response to Customer Process Adopted by US Apparel Industry
SC	Supply Chain
SCM	Supply Chain Management
SCOR	Supply Chain Operations Reference Model
SEM	Structural Equation Modelling
Six Sigma	Business Improvement Program Using Structured Problem Solving and Statistical Methodology
SPSS	Statistical Analysis Software Program
TOC	Theory of Constraints
TPM	Total Productive Maintenance
TQC	Total Quality Control
TQM	Total Quality Management
VMI	Vendor Managed Inventory

Thesis Certification

I, Peter W Robertson, declare that this thesis, submitted in fulfilment of the requirements for the award of Doctor of Philosophy, in the Graduate School of Business and Professional Development, University of Wollongong, is wholly my own work unless otherwise referenced or acknowledged.

The document has not been submitted for qualifications at any other academic institution.

Peter W Robertson

22 May 2006

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1. Chapter 1 – Introduction

1.1 Background to the Research

The nature of manufacturing, the methods and practices used and the underlying philosophies adopted, have changed over the years. These changes have impacted manufacturing organisations significantly. Areas affected include the nature of manufacturing organisations' market offers, their products and services, their methods of manufacture and delivery, their assets and technologies employed. There is an increased focus on specific competitive advantages, geographic spread and location, management of costs, relations with suppliers and customers and by no means least, the treatment and development of people. There has been a slowly developing change in focus away from individual independent entities along a common supply chain to a more integrated view including identification of inter-dependencies and benefits to be gained from coordinating the chain's activities via much higher levels of inter-business collaboration (Christopher, 1998, pp. 12).

Porter (1990, pp. 41~42) advocates the coordination of complex global networks of company activities via linkages as a prime source of competitive advantage. Porter cites Japanese firms as being particularly practised at such linkage management (Porter 1990, pp. 42) for both intra and inter company connections. Supply chain management (SCM) is a set of practices aimed at managing and co-ordinating the supply chain from raw materials suppliers to the ultimate customer (Stevens, 1989, pp. 3). The objective of SCM is to improve the value offered to customers in a profitable way by improving the entire supply chain process (Lambert and Cooper, 2000, pp. 66). Perhaps the best way to illustrate the changes that have occurred and the shifting emphasis is to consider the timeline of developments and changes shown in Table 1.1 below.

Please see print copy for Table 1.1

Table 1.1: Historical Development of Manufacturing Paradigms

Value-adding networks (VANs) is a recent supply chain concept based on the notion of Internet based connected processes, visible, relevant, timely and accurate information, common goals and assessment measures of those goals and collective decision making (Davis and Fitzgerald, 2002, pp. 202). A diverse range of business sectors including apparel, automotive, electronics and retail, are developing functionality rich private e-based exchanges in order to further this approach to supply chain management. Such e-exchanges are used for a variety of business purposes such as purchasing (including on-line auctions), materials planning, product enquiries, product specifications, order enquiries, order placement, order status reporting, invoicing, product test results (eg chemical analysis, mechanical, electrical and/or non destructive test compliance with relevant standards) (Davis and Fitzgerald, 2002, pp. 202).

Ashall and Parkinson (2002, pp. 28) identified many of the factors that have caused or influenced companies to change and adapt in the manner outlined in Table 1.1. From Ashall and Parkinson's research, the predominant reasons are cost reductions, quicker response to new market demands, quicker response to competitor practices, cycle time reductions and reductions of inefficiencies and material requirements.

Table 1.2 summarises the typical reasons why organisations have pursued these changing styles or approaches over the years. Table 1.2 has been configured to show the *external* ‘environmental’ factors impacting on and thereby influencing organisations and also the *internal* organisational desires that are shaped and influenced both by the external business environmental factors and the competitive drive of the organisation.

Please see print copy for Table 1.2

Table 1.2: Reasons Organisations Undertake Change (Adapted from Ashall and Parkinson, 2002, pp. 28)

Epstein (1928, as quoted in Ashall and Parkinson, 2002, pp. 28) describes how the practice of mass production in manufacturing evolved in the automotive industry during the early 20th Century. Henry Ford adapted this approach to the assembly line production of the Model "T" Ford. In 1913, with standardised components delivered directly to individual workstations, Ford implemented his now famous moving production line.

Between 1950 and 1980 Eiji Toyoda and Taiichi Ohno (of Toyota Motor Company Japan) developed the manufacturing practices underpinning the concept of 'lean manufacturing' (Womack and Jones, 2003, pp. 237). Lean manufacturing is suited to those supply chains where the variability in demand levels is reasonably low and the product range offered to the market is not complex nor highly differentiated. However, in situations requiring fast response to changing and sometimes volatile customer demand and where differentiated high margin products are involved, the practice referred to as 'agile manufacturing' has evolved (Mason-Jones and Towill, 1999, pp. 70). A fuller description of these (and other) supply chain types is presented at Table 1.3 and at section 2.2.6 below.

These different macro approaches to manufacturing and their effect on supply chain management can be summarised as shown in Table 1.3:

Please see print copy for Table 1.3

Table 1.3: Effect That Flow-Line, Lean and Agile has on the Supply Chain (Ashall and Parkinson, 2002, pp. 29)

The fundamental assumption underlying the ‘flow line’ approach to manufacturing is that trading partners (suppliers and customers) are interchangeable and that they will take advantage of their position if they become powerful enough (Spekman et al., 1998, pp. 647~648). Additionally, a belief underlying the ‘flow-line’ practice is that maximum competition under the discipline of a free market, promotes a healthy and vigorous supply base predicated on the "survival of the fittest". A collaborative supply chain approach on the other hand, emphasises the need to integrate individual firms and units within each firm, into a coordinated network whose primary objective is to gain strategic advantage for the whole chain (Spekman et al., 1998, pp. 633~634).

The collaborative supply chain approach therefore, is an entirely different paradigm to 'flow line'. The extent of the difference may explain why some companies find it hard to make the transition (Spekman et al., 1998, pp. 646~647). An important outcome of this changed emphasis for management is the increased logistical complexity the transition from hierarchical internally focused manufacturing operations to a supply chain network can bring. Working together to deliver value for customers and the overall chain as well for the individual businesses (Stock et al., 2000, pp. 531) along the chain, is a far cry from each entity adopting a 'pass-the-parcel' approach. Managers have considerable re-learning to do in making this transition, especially if their working life experiences have been centred primarily in the 'flow line' (volume centric) world.

The Lean supply chain is one characterised by high flow velocity, low inventories and a keen focus on all forms of waste.

Agility is the ability to respond actively to change and to be able to respond effectively to uncertainty. This applies to both current day events and future likely events. Four main principles underpin agility: (i) delivering value to the customers; (ii) being ready for change; (iii) valuing human knowledge and skills; and (iv) forming virtual partnerships. (Gunasekaran, 1998, pp. 1223) The goal of an agile manufacturer therefore is "to present a solution to its customer's needs - and not just a product." (Gunasekaran, 1998, pp. 1224, Swafford et al., 2006, pp. 172)

Companies embrace supply chain integration to lift their operational performance in response to the industry forces impacting them and also to be the first to market with innovative products. (Yusuf et al., 2004, pp. 380)

Integration of supply chain processes enables the effective delivery of value-adding results for customers. Integration thus facilitates a "seamless chain along which information, knowledge, equipment and physical assets flow as if water." (Yusuf et al., 2004, pp. 381)

The aim of integration therefore is to enhance key supply chain outcomes and hence business performance (Yusuf et al., 2004, pp. 382)

An appreciation of the logistics side of the supply chain paradigm can be gained from consideration at first of just what it means. Starting with logistics management, this concept is defined by the Council of Logistics Management (as in Lambert and Cooper, 2000, pp. 67) as:

'Logistics is that part of the supply chain process that plans, implements and controls the efficient, effective flow and storage of goods, services and related information from the point-of-origin to the point-of-consumption in order to meet customers' requirements'.

Internal, individual company integration of logistics processes and their supporting technologies are important to the success of a firm, however *alone* they will not ensure sustainability in an environment continually seeking to optimise and leverage the whole chain from raw materials to ultimate consumer. New logistics processes and support tools must now link partnering organisations along the chain (Stock et al., 2000, pp. 532). Such logistics processes and technologies and their integration, are the subject of this research.

1.2 Research Problem and Hypotheses

The major objective of this work is to answer the question:

"How much and in what ways does the integration of supply chain logistics

processes in manufacturing organisations, impact upon business performance?"

The basic hypotheses therefore are:

H_1: That the *integration* of supply chain logistics *processes* does significantly and positively impact supply chain and business performance.

H_2: That the *application* of supply chain management *principles* does significantly and positively impact supply chain and business performance.

H_3: That the *application* of *human 'social' principles/approaches* does significantly and positively impact supply chain and business performance.

(The measures used to assess such business performance and social principles are described at section 2.2.2 and 2.3.2 below.)

1.3 Justification for the Research

Supply Chain Management (SCM) is by now recognised by many companies as a means by which they can gain competitive advantage and improve business results (Spekman et al., 1998, pp. 630). Effective SCM therefore becomes a strategic factor in a firm's success (Spekman et al., 1998, pp. 631). This is particularly the case as more companies link their advantages together and start to operate as supply networks of interdependent supply chain partners as opposed to separate, stand-alone, arms-length entities (Spekman et al., 1998, pp. 632). Associated with such an approach is the integration of intra and inter-businesses processes in order to optimise the whole. As illustrated by companies such as Hewlett-Packard, Wal-Mart and Georgia-Pacific Corp, an effective supply chain network can competitively outperform the standalone model (Lummus and Alber, 1997, pp. 10). This superior performance manifests itself as performance advantages on aspects such as supply chain lead time, delivery reliability, ability to respond to customer demand changes, cost and inventory levels (Shin et al., 2000, pp. 319). Effective SCM therefore becomes a strategic issue for competing organisations and is linked to value growth business results as shown in Figure 1.1 below.

Please see print copy for Figure 1.1

Figure 1.1: Supply Chain Management Impact on Business Returns (Evans and Danks, 1998, pp. 21)

Supply chain management is a multi-faceted concept. That is, in the broad sense SCM covers all aspects of a supply chain's activities from tier 'n' supplier to tier 'm' customer and includes all of the intra-business and inter-business processes that are linked with the flow of products and orders from raw materials to final consumer (Lummus and Vokurka, 1999, pp. 11). There are a number of definitions of supply chain management. For example, Ellram and Cooper (1993, pp. 1) describe SCM as "an integrating philosophy to manage the total flow of a distribution channel from supplier to ultimate customer". Monczka and Morgan (1997, pp. 69) define SCM as "starting with the external customer and managing all of the processes that provide said customer with value in a horizontal way". Monczka and Morgan's view is that supply chains, rather than firms alone, compete and that the strongest competitors "can provide management and leadership to the fully integrated supply chain including external customers, suppliers and suppliers suppliers". Lummus and Vokurka (1999, pp. 11~12) provide a summary definition of the terms *supply chain* and *supply chain management* as: "The supply chain is all of those activities involved in delivering a product from raw material through to the customer including sourcing raw materials and parts, manufacture and assembly, warehousing, inventory tracking, order entry, order management, distribution across all channels, delivery to the customer and the information systems necessary to monitor these activities. Supply chain management coordinates and integrates all of these activities into a seamless process. It links all of the partners in the chain including departments within an organisation and the external partners including suppliers, carriers, third party companies and information system providers. It encompasses the processes necessary to create demand, source, make to, and deliver to demand. In SCM, the entire process must be viewed as one system".

This research work deals specifically with the logistics processes (defined at section 1.1 above) within a supply chain and in particular the integration of those processes both horizontally and vertically within the chain. The belief is that higher levels of such integration will assist organisations to improve their supply chain performance and that such improved performance will flow ultimately to higher return-on-funds economic performance.

The justification for the work therefore, is that in pursuit of improvements to the final value they deliver to their customers and hence their competitive position, manufacturing organisations can use the answer to the research question to shape their supply chain strategies. Specifically, they will be able to make informed choices about (i) what supply chain principles and practices are attractive to pursue, (ii) what level integration of their supply chain logistics processes they should or might pursue, what those processes are, how they might go about integrating them and the likely results they would get should they decide to do so, (iii) what are some of the key socio issues involved in the effective running of a supply chain and how important are they to supply chain and business success and (iv) they will be able to 'visualise' such concepts and thus improves the quality of the mental models they hold around such concepts. Similarly, educators can use the results of the research as a demonstrator model of supply chain dynamics based upon actual and recent research. And finally, researchers can use the results as an extension of the existing supply chain research base, in order to further develop and extend the understanding of the field of supply chain management.

1.4 Methodology

A complete description of the methodology used for this work is presented in Chapter 3.0. An outline description is presented here so that the reader can gain an appreciation of the work undertaken and the order in which it was undertaken. The steps and sequence followed therefore can be described as:

1.4.1 An appraisal as to the felt-need for this work was undertaken (late 1999). That is, would it be of benefit to anyone, would it make a difference to the field of knowledge? In addition, an appraisal of the level of personal commitment to undertake the work was made; was it high enough, could it be sustained for a likely period of 5 to 6 years part-time?

1.4.2 Research proposal submitted (Jan 2000). Once the questions in 1.4.1 were satisfactorily answered, a research proposal was drafted and submitted to the University of Wollongong for approval. Such approval was granted in February 2000.

1.4.3 Research Question defined. Following approval to proceed, considerable time (3 months) was spent defining and achieving agreement on the specific research question to be addressed. Both research supervisors and employer sponsors wished to sign-off on the research question.

1.4.4 Research Design and Project Plan developed. The research design be summarised as follows:

Study Dimension	Description
Purpose of the study	Hypothesis testing
Type of investigation	Non-causal, correlational study
Extent of researcher interference	Minimal
Study setting	Non-contrived, field study
Unit of analysis	Organisational level
Sampling design	Stratified random sampling, 1050 supply chain professionals targeted
Time horizon	One-shot, cross-sectional study
Data collection method	Mail-out questionnaire
Measurement of Variables	Element definition, continuous and ordinal variables (5 point Likert scales)

Table 1.4: Summary Details of Research Design

Microsoft Project was used as a support tool in developing a full project plan.

1.4.5 Literature Review undertaken (May 2000 ~ Dec 2002). The literature review consisted initially of determining what sources of information were required, where they existed, how to access them and which locations contained the most appropriate literature. Once the sources were identified, the literature review source articles were collected. During this process, each article was read, numbered and catalogued and notes of the key findings made. A year after the literature review information collection began an outline of the literature review structure was composed. In parallel with the information collection, reading and summarising, the writing up of the literature review to that outline was undertaken and completed by the end of 2002.

1.4.6 Theoretical Frameworks developed. During early 2003 and using the literature review as reference, the theoretical frameworks that would be tested via survey and data analysis were defined.

1.4.7 A Web-based Survey Instrument designed, developed and tested (Mar 2003 ~ Dec 2003). This included the development of a web site to conduct the survey electronically. This step followed considerable background study and attendance at courses on the essential requirements for sound survey practice and questionnaire design. Details of the sample frame selected were defined.

1.4.8 Ethics Committee approval to undertake the survey obtained (Dec 2003).

1.4.9 Web-based survey attempted (Jan 2004 ~ Apr 2004). A pilot questionnaire was sent to 50 target participants, only 11 responded. The 11 were asked in follow-up telephone and e-mail conversations to provide their comments on their experiences in filling out the survey and the web process. Many issues were identified. A larger web-based survey was attempted; however only 19 usable responses were received from over 1000 enquiries sent to the published email addresses of randomly selected manufacturing companies. It was decided therefore to utilise a mail-out based survey.

1.4.10 Survey mail-out (June 2004 ~ July 2004). The paper-based questionnaire was completed (reduced in size and complexity from electronic version), tested and then mailed out to 1050 target participants in 990 different companies. Names and addresses of target participants were obtained from 7 different address lists.

1.4.11 Survey responses received (July 2004 ~ Sept 2004) and follow-up work (telephone and e-mail) undertaken as necessary for each response (Oct~Dec 2004).

1.4.12 Survey responses assessed for suitability (Nov~Dec 2004).

1.4.13 Data entered in Excel (Dec 2004 ~ Jan 2005) and then imported into SPSS (Feb 2005).

1.4.14 Data analysis conducted (Feb 2005 ~ May 2005). This included editing the data, checking for data entry errors, missing data analysis, data recoding (for negatively worded questions), data transformations (for non-normality variables) and validity and reliability checking. The main data analysis techniques were (i) descriptive statistics, (ii) analysis of variance (ANOVA), (iii) factor analysis and (iv) structural equation modelling.

1.4.15 Simulation model build undertaken (June ~ July 2005). A systems dynamics approach using 'ithink' software was used to build the simulation model of the data analysis results. The significant relationships found to exist in the data between the independent and dependent variables were built into the model as were the regression weights and squared multiple correlations found for each relationship.

1.4.16 Thesis written up (May ~ Aug 2005).

1.5 Outline of the Report

There are 6 main sections to this report i.e.:

1.5.1 Chapter 1, Introduction – This section explains the background to the research, the research question and main hypotheses. A justification for the research is presented followed by an overview of the methodology. Next is this report outline followed by the main definitions applicable to the report being "Supply Chain Management", "Logistics Management" and "Supply Chain Logistics Process Integration." Finally, the Introduction section closes with an explanation of the delimitations (description of boundaries) of scope, key assumptions used, a conclusion and a lead-in to Chapter 2.

1.5.2 Chapter 2, Literature Review – This section contains firstly an introduction and backward link to Chapter 1. Then details of the topic's parent discipline and a discussion on the immediate discipline (i.e. supply chain process integration) are presented. The theoretical models flowing from the literature review are then presented including specific hypotheses developed. The Literature Review section ends with a conclusion and lead-in to Chapter 3.

1.5.3 Chapter 3, Methodology – The Methodology sections contains details of the model and methodology justification, details of the research procedures used, ethical considerations and finally a conclusion and lead-in to the Data Analysis.

1.5.4 Chapter 4, Data Analysis – This section contains an introduction, a description of the data, details of corrections/conversions made, descriptive statistics results and discussion, an analysis of variance (ANOVA) results and discussion, a factor analysis results and discussion and a structural equation modelling analysis and discussion. Data patterns evident are discussed and considered against each research hypothesis. Finally the Data Analysis section conclusions are drawn including a lead-in to Chapter 5.

1.5.5 Chapter 5, Simulations – In this section an introduction explaining the justification for undertaking simulation modelling is presented followed by the scope and intent of the simulation work. The simulation infrastructure used is explained, the actual model built for this work is displayed and explained, the model 'Control Panel' shown and described, the results and explanations of several model runs presented and finally a conclusion to the chapter is made.

1.5.6 Chapter 6, Conclusions and Implications – The main body of the report concludes with this section. Conclusions are drawn about the separate hypotheses proposed and the research questions. Implications for theory, policy, for supply chain practitioners and for educators are made. Limitations of this research are described and finally ideas for further research are presented and discussed.

Ancillary to the main body of the report outlined above, necessary pre and post sections to the report such as title page, abstract, table of contents, list of tables and figures, abbreviations, definition of terms, acknowledgements, references and appendices are also included.

1.6 Definitions

The key terms used in this report and their definitions are as follows:

1.6.1 Supply Chain Management - The US-based “Global Supply Chain Forum” (Lambert and Cooper, 2000, pp. 66) defined supply chain management (SCM) as:

“…the integration of key business processes from end user through original suppliers that provides products, services and information that add value for customers and other stakeholders”.

1.6.2 Logistics Management - This concept is defined by the Council of Logistics Management (as in Lambert and Cooper, 2000, pp. 67) as:

“Logistics is that part of the supply chain process that plans, implements and controls the efficient, effective flow and storage of goods, services and related information from the point-of-origin to the point-of-consumption in order to meet customers’ requirements”.

1.6.3 Logistics Processes – For the purpose of this report Logistics Processes are defined as:

Those business processes covering the business activities of procurement, supply chain planning and scheduling, order and product flow management, transport, warehousing and distribution.

A high-level conceptualisation of these processes is demonstrated in the Supply Chain Council’s (2005) supply chain operations reference (SCOR) model shown at Figure 1.2.

Please see print copy for Figure 1.2

Figure 1.2: Supply Chain Council's High Level SCOR Model (Supply Chain Council, 2005)

1.6.4 Supply Chain Logistics Process Integration – Again, for the purpose of this report the definition is:

The combination, connection, linkage, unification of those Logistics Processes defined at point 1.6.3 above, via electronic or manual direct linkages such as feed-forward and feedback loops, or an integrated design that operates as a whole with no individual process demarcation.

1.7 Delimitations of Scope and Key Assumptions

1.7.1 Boundaries of Scope – The scope of this work will be explained from the point of view of what is in the scope and what is out of scope.

Firstly, those subject areas considered *in scope* are the logistics processes described at 1.6.3 above and their supporting processes. Such supporting processes include demand and capacity forecasting, order management, materials management, sales and operations planning, master production scheduling, unit scheduling and sequencing, inventory management, transport and distribution planning and scheduling. In scope also is the manner that organisations effect such supply chain operations reference model (SCOR) type activities, that is, are the processes linked together, how strong are those links and are the processes and the linkages managed manually or electronically. Also in scope are underlying supply chain management philosophies, methodologies, principles and practices. Such underlying archetypes include Push (Flow-line) Manufacturing, Lean Manufacturing (includes JIT and Kanban), Agile Manufacturing, Vendor Managed/Owned Inventory (VMI/VOS) and Theory of Constraints (TOC). Also in scope are a number of supply chain practitioner socio dimensions such as definition of job role networks (who does what and what are the inter-relationships, interactions and responsibilities between roles), shared vision, common mental models about what has to be done and how to go about it (Senge, 1994, pp. 203), individual personal mastery (competence, commitment, diligence) (Senge, 1994, pp. 147), skills/capabilities fit with role (Collins, 2001, pp. 41), team learning culture (working openly, collaboratively, sharing ideas, practices and information, remembering and applying (or not) what does work and what doesn't work) (Senge, 1994, pp. 238), level of training, political astuteness (awareness of organisational politics, power brokers, influencers and connections) and levels of senior sponsorship. Also in scope are the key business outcome measures used as the dependent variables in the study. These are measures to do with customer service levels, customer responsiveness (lead-times), flexibility to changing customer demand (time to respond to demand increases and decreases) and cash and profitability measures (days of inventory, cash-to-cash cycle time, product costs and return on capital margin). The business outcome measures are described in detail in Chapter 3 – Methodology.

Secondly, those subject areas considered *out of scope* are any factors relating to overall organisation strategy other than supply chain management strategy. Such things as organisational strategic intent, the basis of competition, overall core competencies, underlying competitive advantages, barriers to entry, strength of brand, patent protection and corporate values were not covered by this study. Individual company growth aspirations, target markets, target market segments, target localities, were not part of this study. Specific product and process technologies in use or the development/innovation processes used for such factors were not included in this study. Operational excellence factors (a large determinant of business and supply chain performance) other than consideration of operational improvement techniques covered in Chapter 2 -Literature Review, were not part of this study. People remuneration, rewards and recognition practices and amounts were not part of the study. Awareness of customer needs, suitability of offered products to those needs, segmentation of customers according to those needs, reliability of delivered product quality or issues to do with product promotion, pricing, sales and customer service, were not part of this study. Environmental and community matters were not part of this study. Finally, the study considered manufacturing organisations; service industries were therefore not included.

1.7.2 The Key Assumptions used are: Firstly that the conclusions reached with respect to the justification of this work are rigorous. Secondly, information and the theoretical frameworks distilled from the Literature Review are representative of that recorded within the field and that what is recorded is based upon research that is both valid and reliable. Thirdly, that the sample frame chosen is reasonably representative of the manufacturing supply chain practitioner population. Fourthly, that the responses received are representative of manufacturing organisations within that sample frame. Fifthly that the respondees were suitably competent practitioners. Sixthly that the questions asked are valid and reliable measures of the parameters assessed (this aspect is further covered at Chapter 3 - Methodology). Lastly that the data-analysis techniques used are appropriate for this type of study (summarised at Table 1.4 above and discussed in detail in Chapter 3) and the conclusions drawn from that analysis are statistically and logically correct.

1.8 Conclusion

As indicated at the beginning of this chapter, the nature and ‘modus-operandi’ of manufacturing organisations has been changing for some many years now. Such changes have been driven by a number of internal and external forces (Ashall and Parkinson, 2002, pp. 28). A more recent change is that of the application of supply chain management concepts. With this approach, companies along a common supply chain change how they deal with, treat and interact with other partner companies along the same chain. That is, adversarial ‘survival of the fittest’ type mentality is replaced with a cooperative and collaborative approach such that efficiencies and market place performance factors are improved. In this way, supply chain participants along the common chain see that other participants in the same chain as their partners and not an arms-length entity that they don't have to care about. In this way, supply chain to supply chain becomes the competitive model rather then single company against other single companies.

Flowing from that, this work chose to address the specific question of supply chain logistical process integration. The research question derived therefore was:

"How much and in what ways does the integration of supply chain logistics processes in manufacturing organisations impact upon business performance?"

Justification for the work revolves around the value potential that the answer to the research question can bring to supply chain practitioners, educators and researchers. That is, by answering the question, another piece of supply chain management underlying 'DNA' is uncovered, thus making it possible for the above groups to use such knowledge to enhance their performance or to further their work.

The explanations of methodology, report outline, key definitions, scope of work and assumptions sections above provide the reader with some guidance to help navigate the remainder of the report.

The next section (Chapter 2) covers the Literature Review and begins with an introduction to the overall subject, a description of the parent discipline (supply chain management considerations), a discussion of the immediate discipline (supply chain process integration) and the implications arising from the Literature Review for this study. Also included is coverage of the analytic models chosen, details of the research question and hypotheses proposed.

2 Chapter 2 – Literature Review

2.1 Introduction

The previous chapter of this report presented an introduction to the research topic and stated the research question of: "How much and in what ways does the integration of supply chain logistics processes in manufacturing organisations impact upon business performance?" The previous chapter also considered justifications for the research as well as an outline of both the methodology and the overall report itself. Also covered were the key definitions involved, the specific scope of the study and underlying assumptions. This chapter continues the knowledge building theme by presenting an appraisal of relevant literature concerning supply chain management and related issues and finishing with considerations specific to this work.

Supply chain management (SCM) as a concept widens the scope of focus from individual entities alone to one that encompasses the entire chain (Heikkila, 2002, pp. 3). Supply chain management therefore, coordinates the overall supply chain from raw material suppliers to the ultimate consumer. The objective of SCM is to improve the value offered to customers in a profitable way by improving the entire supply chain performance rather than optimising local performance of individual units along the chain (Heikkila, 2002, pp. 3).

The concept of global optimisation verses optimisation of local performance revolves around a realisation that the business performance of individual members of a supply chain, is a function of not only how efficiently they each execute their own processes, but is a function also of how well they collaborate with other members of the chain to optimise the overall value delivered (Rippenhagen, 2002, pp. 1, Roder and Tibken, 2006, pp. 1011). This value chain therefore is made up of all of the order generation to fulfilment activities including invoicing and payment deposited into a bank account. "This is described as a chain because each process is dependent or inter-dependent on the rest of the chain, and a failure in any one process affects all the businesses in the chain." (Rippenhagen, 2002, pp. 1)

Supply chain management's goal therefore, is to enhance customer service, reduce the supply chain's cash requirements and maximise profitability. To achieve this, the supply chain's interrelated processes need to be linked in such a way as to accelerate the velocity of the flow of goods down the chain and velocity and visibility of transactions up and down the chain (Rippenhagen, 2002, pp. 1).

The supply chain can be considered and used as an aspect of business that is a lot more than a simple utilitarian function however. That is, some companies are using management of their supply chain as a strategic and competitive weapon (Cohen and Roussel, 2005, pp. 9). Companies such as Wal-Mart, Dell, Amazon, Shell Chemical and Airbus are "rewriting the rules of competition in their industries." (Cohen and Roussel, 2005, pp. 9) Such leading companies know that "today's competitive edge is tomorrow's price of entry."

Some authors have suggested that the term be changed to demand chain management (Vollmann and Cordon, 1998, pp. 684~685). This suggestion puts the emphasis on the needs of the marketplace and customers first instead of starting with the supplier/manufacturer and working forward. In this research, the terms are treated synonymously.

SCM theory can be broadly divided into the two main categories of (i) supply chain structure and (ii) industrial networks and relationships (Heikkila, 2002, pp. 3). Heikkila (2002, pp. 16~17), contends that better business performance can be achieved by focusing on structural issues such as consolidation of customer and supplier bases, removing unnecessary processing or transport or storage steps and speeding up information and material flow velocities, and on relationship issues such as creation of long term partnerships with customers and suppliers in order to leverage the capabilities of the companies operating along the supply chain. I.e.:

Please see print copy for Figure 2.1

Figure 2.1: Supply Chain Issues Impacting Business Performance (compiled from Heikkila, 2002)

The importance of supply chain relationships noted above includes intra-company relationships as well as inter-company ones. For example, in their empirical research Hausman et al. (2002, pp. 252) found that ‘working together’ (between marketing and manufacturing) was an important predictor of profit performance and business goal attainment.

The strength of an organisation’s supply chain capabilities will co-determine its degree of sustainable competitive advantage over competitors (Lummus and Alber, 1997, p. 15). Supply chain capability thus, is as important to overall business strategy as is, say, product strategy. It is imperative therefore, that an organisation’s supply chain strategy is compatible with and linked to its business strategy. Linking supply chain strategy to business strategy involves making sure that the objectives of the supply chain are directly linked to company strategy and that such objectives are focused upon externally based targets rather than internal departmental ones (Lummus and Alber, 1997, pp. 16). It also involves defining the key business processes involved in producing a company’s product or service. Supply chain management then, encourages the active management of such processes across internal departments and across other supply chain partners namely, suppliers and customers, in order to deliver the externally based targets especially real customer value.

In this way, supply chain strategy can be viewed as a pattern of decisions related to demand management, planning of capacity, sourcing of product, conversion of materials to finished products, deployment of the finished products, delivery of the finished products and communications. All components of the supply chain therefore need to have the capabilities required to meet such strategic objectives. The most important objective of course, is that of delivering real customer value as determined by the customer (Lummus and Alber, 1997, pp. 15) i.e.:

Please see print copy for Figure 2.2

Figure 2.2: The Flow of Strategy (complied from Lummus and Alber, 1997)

Such ambitions of SCM manifest themselves as specific approaches or methodologies for organisations operating within the supply chain. For example, Stalk (1988, pp. 41~42) explains the case of Japanese manufacturing, in particular how it evolved from a low labour cost focus (economies of scale, focussed factories and flexible manufacturing) to *time based* competitive advantage. Womack and Jones (2003, pp. 230~246) describe in some detail how companies such as Toyota developed and applied “lean thinking” to their manufacturing processes aimed at reduction of all forms of waste. The Japanese defined ‘seven deadly wastes’: (i) errors/mistakes; (ii) over-production; (iii) unnecessary processing; (iv) unnecessary movement; (v) unnecessary transport; (vi) waiting time; and (vii) unnecessary inventories (Womack and Jones, 2003, pp. 43). Lean thinking is proposed as a “powerful antidote” to waste. Lean thinking is lean because it provides a methodology “to deliver more value to customers with less human effort, less equipment, less time and less space" (Womack and Jones, 2003, pp. 15).

Stalk (1988, pp. 42) describes companies as systems and decries traditional manufacturing as a mindset that requires long lead-times to resolve conflicts between various jobs or activities that are competing for the same resources. Long lead-times in turn require sales forecasts to support production planning. Such long lead-times make forecasting accuracy tenuous and resulting forecasting errors lead to higher inventories including the necessity for safety stocks at many points along the supply chain. Reductions in the seven wastes therefore, result in less waiting time, less inventories, shorter lead-times, less demand distortion and thus better synchronisation of production with actual customer demand and thus higher levels of customer service (Holmstrom, 1995, pp. 190).

Heikkila (2002, pp. 19) concludes that in order to sustain business success, the members of a supply chain must clearly understand the differing needs of customers, implement a supply chain structure designed in collaboration with customers and purposely build relationships with key supply chain partners. In addition, Heikkila (2002, pp. 19) stresses that good relationships contribute to better information flows; better information flows result in higher efficiency; understanding customer needs helps build relationships and cooperation; better cooperation leads ultimately to higher customer satisfaction; and higher customer satisfaction in turn, contributes to better relationships. Such an interconnection of factors can be visualised as shown in Figure 2.3. Of course, presenting the relationships in this way tends to suggest that they are only partly inter-related and that causality runs one-way only. Such assumptions are questioned and an alternative structure is suggested at Figure 2.8 below.

Starr (1991, pp. 17) stresses the importance of adaptability and specifically the speed of such adaptation i.e. how can firms learn how to respond quickly enough to changing conditions in order to regain competitive edge.

Please see print copy for Figure 2.3

Figure 2.3: Supply Chain Business Success Drivers (compiled from Heikkila, 2002)

Spekman et al. (1998, pp. 630) describe the transformation occurring in supply chains whereby suppliers and customers are becoming "inextricably linked" throughout the supply chain set of activities that manage the flow of raw materials from their supply point through the various value-adding steps to the final consumer. In such a linked system, success is no longer measured by a series of individual transactions; rather success is determined by the performance of the overall supply chain network. This research work provides an appreciation of the interdependencies at work in managing supply chains and the linkages necessary to improve overall supply chain effectiveness.

2.2 Parent Discipline and Classification Models

2.2.1 The Case For Supply Chain Management

The history of supply chain initiatives can be traced to the textile industry in the early to mid 1980's. Intense global competition saw the US apparel industry form the "Crafted with Pride in the USA" Council in 1984 (Lummus and Alber, 1997, pp. 8). This council initiated a supply chain study aimed at identifying ways of increasing the competitiveness and profitability of the industry. The council's study showed the lead-time of the apparel supply chain from raw material to consumer to be 66 weeks, 40 weeks of which were spent in the distribution channel. This long supply chain cycle time resulted in major losses to the industry due to the cash costs of carrying inventory and the service impact of not having "the right product at the right place at the right time".

As a result, a quick response (QR) strategy was devised for the apparel chain. QR in reality is a business-to-business arrangement whereby retailers and suppliers collaborate to respond more quickly to customer needs. Information technologies are sometimes used to bring 'visibility' to the information required to enable such collaboration. For example, retailers began installing point-of-sale (POS) scanning systems in order to transfer sales information rapidly to distributors and manufacturers (Bowersox and Close, 1996, pp. 492). In addition to sales information, information on promotions, discounts and forecasts were also shared up and down the chain.

In 1992, a group of US based grocery industry leaders set up the Efficient Consumer Response (ECR) Working Group (Lummus and Alber, 1997, pp. 8). Specifically, this joint industry working group was asked to investigate what cost and service improvements could be made in the grocery supply chain. The potential utilisation of more appropriate technologies and improved business practices were included in the brief. However, other than recommending electronic data interchange (EDI) and POS, little technology was required. Rather, a number of changed business practices were recommended targeted at a 37% inventory level reduction across the chain. These recommended business practice changes included tight integration of demand management with production scheduling and inventory management. In addition, the practice of 'continuous replenishment' (CR) was developed. CR called for a change from ***pushing*** inventory down the supply chain to ***pulling*** products onto the grocery shelves based on real consumption rates. Under CR practices, POS transaction information is forwarded directly to the grocery manufacturers allowing them to adopt a continuous replenishment just-in-time (JIT) type supply schedule to the retailers (Lummus and Alber, 1997, pp. 9).

Companies such as Procter and Gamble, Campbell Soup, Ralston, General Mills and Pillsbury decided to implement the recommendations and using a CR approach have achieved business improvements including increasing inventory turns ($Sales/$Inventories) from 10 to 50, reducing days of supply from 30 to 5 and increasing net margin from 5% to 7% (Lummus and Alber, 1997, pp. 9).

During the early 1990's, such approaches to supply chain performance improvement were also applied by companies such as Hewlett-Packard, Whirlpool, Wal-Mart, West Co., Becton Dickson, Baxter, and Georgia-Pacific Corp. (Lummus and Alber, 1997, pp. 9).

Spekman et al. (1998, pp. 630) describe the case of Ford Motors of the USA and explain that Ford is as successful as its ability to coordinate its supply network including steel, glass, plastics, rubber and electronic components in the manufacture of an automobile that has to compete in world markets against Japanese, German, French and other USA manufacturers. This is a very different paradigm to the one of traditional supplier management where the emphasis was on arm's length negotiations, formal (and usually short-term) contracts to achieve the lowest purchase price whilst assuring supply. Boeing, Black and Decker, Hewlett Packard and 3M, are examples of companies using this model whereby supply chain management is redefined as a process for designing, developing, optimising and managing the internal and external components of the supply system (Spekman et al., 1998, pp. 631). Such components include procurement of materials and services, manufacture of the product(s), transport, warehousing and distribution, customer service, performance measurement, managing information flows, order flows and cash flows.

Supply Chain Management (SCM) has therefore become an important issue for organisations over the past 20 years. Lummus and Alber (1997, pp. 3~4), maintain that there are a number of reasons for this:

Firstly, organisations along the same supply chain have realised that they each stand to gain/lose from the success/failure of the other companies along the chain. The entire network therefore needs to be carefully managed in order to assure the sustainability of the individual network members.

Secondly, as the world in many industries moves from a *supplier-driven* market to a *customer-pull* one. Customers have increasing choice over whom they buy from. Customers' expectations in regard to needed service levels and responsiveness to demand volatility have changed. Cost and return-on-capital-employed pressures, mean that companies can no longer afford to meet such heightened customer service expectations and changing demand requirements via distribution channels 'stocked to the gunwales' with inventory.

Thirdly, companies are slowly starting to realise that maximising the performance of one department or one unit along the supply chain, may well lead to less than optimal performance for the company.

Other early writers on the subject were aligned with this. For example Stevens (1989, pp. 3) was quite explicit on the purpose of managing the supply chain:

"… to synchronise the requirements of the customer with the flow of material from suppliers in order to effect a balance between what are often seen as the conflicting goals of high customer service, low inventory investment and low unit cost."

The US based Advanced Manufacturing Research (AMR) group developed a supply chain model for manufacturing organisations in response to the realisations that manufacturing organisations are changing their practices in the following ways:

(i) There is now greater sharing of information between suppliers and customers.
(ii) Horizontal business processes are now replacing vertical departmental functions.
(iii) There is a shift from mass production to customised products.
(iv) There is increased reliance on purchased services, purchased products and outside processing with a simultaneous reduction in the number of suppliers.
(v) There is a greater emphasis on organisational and process flexibility.
(vi) The necessity to coordinate processes across many sites is recognised.
(vii) There is recognition of the need for employee empowerment and the need for rules-based, real-time decision support systems.

(viii) New products introductions are driven more quickly.

Lummus and Alber (1997, pp. 9~10) describe aspects of just how the above-mentioned companies have actually applied SCM thinking to their businesses and the results obtained:

Hewlett-Packard (HP). During the 1990s HP linked its distribution and manufacturing processes. The process focus included changes in the way products were physically distributed and changes to HP's distribution requirements planning (DRP) system. The DRP system was redesigned to ensure consistency between customer orders and forecasts and to set the pace of the 'pull' along the supply chain.

Whirlpool. An executive team meeting in 1992 saw this whitegoods appliance manufacturer clearly articulate its SCM vision: "Winning companies will be those who come the closest to achieving an inter-enterprise pull system. They will be linked in a short cycle response mode to the customer". Using a combination of cross-functional teams, key product groups, single source agreements with suppliers based upon reliability of supply and the ability to assist in new product design, e-commerce communication methods with customers and suppliers and a new vice president logistics position, Whirlpool improved delivery reliability to 95%, inventories were reduced by 15 to 20% and lead-times were reduced to five days.

Wal-Mart. An early supply chain management leader, Wal-Mart engaged key vendor manufacturers in order to improve warehouse inventories via the introduction of *vendor-managed inventory* (VMI). Wal-Mart set an expectation standard of 100% delivery reliability on these supplies. In return, Wal-Mart's vendors receive continuity of supply contracts and favourable payments terms.

West Co., Becton Dickinson and Baxter. All medical products suppliers in the same supply chain, these three firms focussed on improving their supply chain relationships in the early 1990s. West Co. supplies rubber stoppers to Becton Dickinson, which in turn supplies medical products to Baxter. Single point responsibility was given to an executive in one of the companies (Becton Dickinson) to coordinate the implementation. Through such collaboration, the three companies made improvements to their supply chain's quality levels, delivery reliability, lead-times and costs.

Georgia-Pacific Corp. The early 1990s saw this company implement supply chain management practices within its set of decentralised building products businesses. Prior to that, material managers within each of its business units managed inbound and outbound material flows independently of each other. As a result, despatch priorities were uncoordinated and internal and external deliveries were unreliable. A centralised transport and logistics division was established to co-ordinate and improve the channel flow process for the company. As a result of this focus, freight costs were reduced by US$20 million/year.

Therefore, the interest and effort that has been and still is being applied to SCM means that companies can improve their customer service performance (delivery reliability, lead-times, flexibility to meet changing customer demands), improve their supply chain inventory performance and reduce costs.

2.2.2 Supply Chain Measures (Metrics)

Supply chain measures are a crucial dimension of SCM and they are used to determine if indeed the objectives of the supply chain are being achieved and the above-identified factors addressed (Otto and Kotzab, 2003, pp. 307). Such measures can be related to final organisational profitability or they can be those associated with the delivery of specific supply chain goals. For their research work, Otto and Kotzab (2003, pp. 308) chose to study the goal-oriented approach. Further, they distinguished between six different underlying supply chain management philosophies and developed a set of goals for each and their associated performance measurements.

The six underlying perspectives are:

(i) *Systems Dynamics*. The supply chain is an inter-connected set of processes that dynamically interact and influence one another. The nature and extent of the interaction and influence is defined by the relationships that exist between the processes and with the feed-forward and feedback loops that exist. Further, the results of the interactions are influenced by whether those loops are reinforcing or countervailing (Richmond, 2002, pp. 65). Each company in the chain is a formal transaction echelon and the entire chain is a sequence of these inter-dependent echelons.

(ii) *Operations Research*. The supply chain is perceived as a resource network. The flows across this network have to be programmed according to a specific objective function based on algorithms.

(iii) *Logistics*. The supply chain is a sequence of generic processes that need to be integrated in order to maximise supply chain performance.

(iv) *Marketing*. Supply chain management is the tool to effectively connect customers with products.

(v) *Organisation*. The supply chain is a set of inter-organisational relationships.

(vi) *Strategy*. Supply chain management is seen as a means to leverage supply chain capabilities and/or advantages in order to maximise returns.

The measurements Otto and Kotzab (2003, pp. 309~317) describe for each perspective can be summarised as shown in Table 2.1.

The researcher would argue, that a number of Otto and Zotzab's (2003) perspectives are quite similar to each other and that the differences between them in reality are small compared to the uniqueness inferred. For example, the three perspectives *Systems Dynamics, Logistics* and *Organisational* share many of the same 'standard problems', 'standard solutions' and 'performance measurements' referred to. Indeed, whilst the wording used by the authors is different between these perspectives, the meanings of some of the different terms are similar. For example 'time to adapt' shown under 'Systems Dynamics' is similar in meaning to 'flexibility' shown under 'Logistics'. 'Collaborative capacity planning' shown under 'Systems Dynamics' has parallels to 'horizontal integration' shown under 'Logistics'.

Please see print copy for Table 2.1

Table 2.1: Performance Measurements Suggested by Otto and Zotzab (2003, pp. 309~317) for Six Different Supply Chain Perspectives.

It is argued further, that many of the standard problems, standard solutions and performance measurements that are recorded as distinct to a perspective, are indeed complementary to each other. That is, the standard problems, standard solutions and performance measurements defined under ‘Systems Dynamics’ could equally apply and be added to the ‘Logistics’ perspective for example.

Otto and Zotzab (2003, pp. 316) conclude that given a number of different supply chain perspectives have been defined, different goals can be followed after choosing the perspective that an organisation wishes to adopt. The researcher would argue that the approach so described, ‘puts the cart before the horse’ to a certain extent. That is, rather than at first choosing a particular supply chain perspective from those described and then taking actions to implement it, it would be preferable after first having determined specific customer requirements and perhaps grouping customers into groups sharing similar requirements (Gattorna, 1998, pp. 4), to then design the supply chain based upon the unique needs of those customer groupings. In doing so, it may well be the case that features of several of the perspectives described by Otto and Zotzab (2003, pp. 309~317) are used in practice and that each customer grouping has its unique ‘perspective’ (which may be a combination of the six described by the authors). Indeed the authors allude to this and state that none of their perspectives is an optimal approach and that instead the different performance measurements should be combined (Otto and Zotzab, 2003, pp. 316). No attempt is made to describe how that could or should be done however.

The Supply Chain Council has developed a more widely accepted set of supply chain performance measurements over recent years. This work began as an idea launched by AMR and Pittiglio Rabin Todd and McGrath in 1996. The idea was to develop an industry wide and industry accepted Supply Chain Operations Reference-model (SCOR). Since that time over 750 companies have joined the Supply Chain Council and development work to build, develop, extend, and improve the SCOR model has continued. The SCOR model (version 7.0) consists of four nested levels of measures (Supply Chain Council, 2005, pp. 5, 6):

(i) Level 1: Process types. The main processes are Plan, Source, Make, Deliver and Return;

(ii) Level 2: Configuration level. From 30 core process categories, companies implement their operations strategy through the configuration they choose for their supply chain;

(iii) Level 3: Process element level. At this level specific process elements are defined, their inputs and outputs described, measures determined and systems capabilities required to support best practices are designed;

(iv) Level 4: Implementation level. This is a very detailed level. Companies implement specific supply chain management practices at this level.

The Level 1 SCOR measures are delivery performance, fill rate, perfect order fulfilment, order fulfilment lead-time, supply chain response time (cycle time), production flexibility (to changing levels of customer demand), total supply chain management costs, cost of goods sold, value-added productivity, warranty costs or returns processing costs, cash-to-cash cycle time, inventory days of supply and asset turns (Supply Chain Council, 2005, pp. 8).

For this research, the particular supply chain measures chosen are important because they will both shape the questions asked in the industry survey and define the subject and process focus by default.

2.2.3 Improved Customer Service via Supply Chain Management

One of the reoccurring themes in recently published literature is that the dynamics, the power balance along the supply chain, has substantially shifted. For example, Griffiths, Elson and Amos (2001, pp. 57) explain how the mass production paradigm of the early to mid 20th Century with its "emphasis on standardisation, resource utilisation and lower costs" is now giving way to both a realisation and an actualisation of greater organisational focus on customers and improvements to customer service. Increasingly, supplying companies are recognising the importance of being able to respond quickly and effectively to changing customer needs and changing patterns of customer demand (Griffiths, Elson and Amos 2001, pp. 58).

Whilst there is some evidence of customer tolerance differences that are country cultural based (Voss et al., 2004, pp. 225), consumer demands have progressively changed (Arjmand, and Roach, 2000, pp. 1) towards:

- Smaller buy quantities;
- Shorter order lead times;
- Customised products;
- Buying decisions postponed to be closer to the purchase point;
- Rewards from the buying experience;
- Fulfilment of customer needs.

There are a number of reasons why these changes occur. Griffiths, Elson and Amos (2001, pp. 58), Hamel and Prahalad (1996, pp. 29) suggest the following major factors:

- Globalisation has enabled access to more people with more money to spend. Better infrastructure, transport and communications have also made it easier to access such markets;
- Deregulation and the privatisation of public sectors in countries such as India, Russia and Brazil are both growing markets in those regions and opening them to competition;
- Barriers to entry are lower with easier access to lower installed cost technologies and the convergence of technologies across industries (e.g. communications and consumer electronics);
- Increased capacity, increased range of market offers, increased competition especially in mature industries/markets, has given customers much more to choose from;
- More customer ‘rights’ are being safeguarded via legislation.

In response to these changes, there is a growing realisation that companies can improve product and service differentiation through a greater focus on the end user, the customer, the wealth provider for the whole extended business enterprise (Griffiths, Elson and Amos, 2001, pp. 58). Aware that knowledge of customer needs is important, leading companies are shaping their supply chain strategies to match

those customer needs. The development of synchronised supply chains is a key feature of such customer-focused strategies (Renner, 2000, pp. 1). To bring product to diverse markets in shorter lead-times, companies require inventive and adaptable structures, enabled for change. Such organisations will be more open with fewer intra and inter company boundaries. They will be noted for their greater collaboration and new types of relationships (Griffiths, Elson and Amos, 2001, pp. 60).
Such considerations can be represented diagrammatically as:

Please see print copy for Figure 2.4

Figure 2.4: Shifting Supply Chain Power Balance (compiled from Griffiths, Elson and Amos, 2001, Hamel and Prahalad, 1996, Arjmand, Roach, 2000)

There are challenges however. That is, whilst the market-forces have changed and are continuing to do so, there are still remnants of the previous world present. For example, the mass production paradigm has not completely disappeared; it still pervades and constrains the way business thinks, acts and organises itself. These remnants act as constraints to organisations and therefore constraints to the provision of excellent customer service (Hamel and Prahalad 1996, pp. 60).

When a supplier sells a product or service to a customer they should provide an acceptable environment for the customer before, during and after the transaction. LaLonde and Zinszer (1975, pp. 20-21) refer to this as pre-transaction, transaction and post-transaction elements of customer service. They emphasise the importance of planning delivery activities to ensure service provision in terms of:

- Order processing, invoicing, order fulfilment.
- Performance measures e.g. delivery reliability, order lead-time.
- Corporate philosophy – a philosophy rather than an activity or set of performance measures.

The philosophy point is a crucial one. For many suppliers, customer service is something you do and something you measure yourself against. For others however, customer service is a way of life, a lived philosophy where the level of service is highly related to the needs and expectations of the customer and the perception of value assessed by the customer (Jackson et al., 2003, pp. 58). Such a philosophy is typified by attributes such as (Griffiths, Elson and Amos, 2001, pp. 65):

- A genuine focus on the customer and not the product or the output volume of the product;
- Tailored service provision via the integration and management of processes and resources;
- Much greater visibility (ease of access, speed of access, reliability of data) of relevant information;
- Heightened customer to supplier interactions and relationship building.

Important here, is the recognition that it is the customer's perceptions (rather than reality) that may well dictate customer-buying behaviour. (Christopher, 1998, pp. 24)

The changes described above, have led to an observed shift from a production-centric mindset to a consumer-centric one (Arjmand, Roach, 2000, pp. 1). As this closeness or customer intimacy increases (Renner, 2000, pp. 1), the members of supply chains will need to face up to a marketplace truism: "today's customers are not easy to please or to hold on to." Customers are increasingly more aware, more discerning, more demanding. If company 'A' cannot deliver up to their expectations, they will go to company 'B'. This changing supplier/customer/marketplace dynamic is leading to the "never quite satisfied customer." (Renner, 2000, pp. 1)

Customer service strategies therefore need to go beyond a set of performance standards (Griffiths, Elson, Amos, 2001, pp. 65). Service programmes therefore should define how an organisation will *act* in order to deliver excellent customer service rather than merely a statement such as “We will deliver what the customer wants”.

Gattorna (2003, pp. 4, 29) describes three basic problems with traditional customer service programmes:

(i) There is limited differentiation of customer service over competition.
(ii) Cost effectiveness of customer service programmes is seldom tested.
(iii) Such programmes tend to be common across customer groups.

Gattorna (1998, pp. 473) argues that different customer types actually place different types of demands on the businesses they source from. And importantly, that materials and finished products only move through the supply chain because of consumer behaviour at the end of the chain or the behaviour of certain parties within a particular channel. In order to meet these varying requirements Gattorna (1998, pp. 3) calls for business to adopt a new framework that integrates the formulation of logistics strategy with the supply chain’s human factors. Such human factors create the demand external to the firm and shape the key capabilities within the firm. Gattorna (1998, pp. 4) proposes a ‘strategic alignment model’ that links the external market dynamics, the firm’s strategic response to those dynamics and the firm’s internal capabilities and leadership style necessary to deliver the strategic response. This concept is illustrated in Figure 2.5 below.

Please see print copy for Figure 2.5

Figure 2.5: The Strategic Alignment Model (Gattorna, 2003, pp. 28)

Gattorna (1998, pp. 6) explains that the demand differences of the various customer groupings need to be matched by the capabilities of the supply chain. Specifically, different flows of product through the chain will be required and these different flow types will require tailored logistics responses or ‘multiple alignment’ capability. For example, an identical can of soda drink will flow along distinct pathways depending upon whether it is destined for a supermarket, a vending machine or a corner store. The supply chain’s logistics infrastructure therefore must have the capability of responding to these differentiated channels. In this way, the differentiation is effective when the customer believes that value has been added for him/her.

Delivering true differentiation to individual customers is not easy for organisations that are still geared towards mass production and maximum asset utilisation (Griffiths, Elson, Amos, 2001, pp. 58). Faced with competition and therefore greater customer choice, such organisations will find it difficult to retain their market share. Organisations and their supply chains therefore need to become focused on both knowing and meeting their customer’s true needs, seeking to treat the customer as a “group of one” and not “one of a group” (Griffiths, Elson, Amos, 2001, pp. 59). Such change, such response to customer’s requirements will need to be supported by changes to organisational strategy, mindsets, capabilities, processes, operations,

technology employed, skills and competencies of people, intra and inter company structures and relationships along the supply chain (Griffiths, Elson, Amos, 2001, pp. 65, Frohlich, Dixon, 2001, pp. 542, Froehle, Roth, 2004, pp. 2).
Sweeney (1991, as in Slack et. al., 1998, pp. 798) attempted to show the relationship between customer service and process design using the four quadrant matrix shown below:

Please see print copy for Figure 2.6

Figure 2.6: Sweeney's Generic Customer Service/ Process Design Strategies (1991, as in Slack et. al., 1998, pp. 798)

Organisations in the caretaker quadrant either will lose market share as a result of them losing competitiveness or they see little competitive advantage from the cost and effort required to differentiate themselves.

Organisations operating in the marketeer quadrant are aware of increased competition and are responding by raising their customer service offer. As these companies may not have the processes to support such improved offers, the offers will come at some cost to them, e.g. as higher inventory levels, changed stock ownership (e.g. Vendor Owned Stock) and changed payment terms.

Reorganisers actively change their processes in order to ready themselves for a forecast more competitive environment and/or to make themselves more efficient.

The innovator group seek to provide high levels of customer service *and* the businesses processes necessary to profitably support such service levels.

Some authors describe competitive concepts that are beyond customer service per se. For example, Ekdahl et al. (1999, pp. 403, 406) describe the concept of "true customer focus" and explain how such an approach involves the provision of specific service to specific customers. Such tailored service is a prerequisite for effective and efficient development activities aimed at delivering more value to customers and improving the supplier organisation's own profitability. Companies that become truly customer focused tend to trade off resource efficiencies in order to deliver increased responsiveness to their customers' demands. That is, instead of using resource efficiencies as an internal key performance indicator, it is more a priority for such companies, to have sufficient resources available to meet changing customer demands. This represents a distinct shift from an internal focus along with predominately internal measures to rather an external customer focus with a 'balanced' set of measures (i.e. balanced internal and external measures). Customer focussed organisations therefore, align themselves to meet the needs of their customers "before, during and after" their business transactions (Griffiths, Elson and Amos, 2001, pp. 65).

As customers expect, indeed demand, more value, a value-to-customer measurement is proposed as follows (Johansson et al., 1993 as in Mason-Jones, Naylor, Towill, 2000, pp. 54):

$$\text{Total Value} = \frac{[\text{quality} \times \text{service level}]}{[\text{cost } \times \text{leadtime}]}$$

Using such a model, it can be seen that, for example, improvements to quality and/or service levels may not result in improved value to customers if cost and/or lead-time increase at the same time. Ideally, the numerator terms should be increased and the denominator terms decreased for value growth to occur. Or at the very least, one term improved and the others held constant. (Mason-Jones et al., 2000, pp. 54).

Valueless activities arise when organisations do things that have no value to the customer. Valueless activities such as overproduction, waiting in queues, quality failures, failure to use common items in the manufacture of finished products, unnecessary processing, unnecessary movement, and unnecessary transport are all examples of valueless activities. Importantly, valueless activities not only add cost, they extend the supply chain lead-time. Longer lead-times not only result in higher inventories, they also invariably result in poorer response to customers (Tersine and Wacker, 2000, pp. 116).

Such "valueless variance" (Tersine and Wacker, 2000, pp. 119), for example when an error is made, a defect occurs, capacity is lost, demand variance is induced (e.g. from the use of long time-horizon forecasting or terms of trade that induce uneven buying patterns) or using planning processes based on averages, can lead to the "graveyard of customer satisfaction" (Tersine and Wacker, 2000, pp. 119).

The importance of customers and customer focus is indeed reinforced by a number of writers. For example Childerhouse and Towill (2000, pp. 337) maintain that whilst supply chains need to be integrated and must operate in a seamless manner, they must also be tailored to specific consumer requirements and the reliable delivery of the products involved in meeting those customer requirements. One of the key objectives of supply chain management is therefore reinforced, i.e. a key objective must be to satisfy end customer requirements. Evans and Danks (1998, pp 20) extend this argument and suggest that supply chain management can indeed be used to drive and enable the firm's business strategy. They describe four strategy dimensions that SCM can directly influence i.e., sourcing strategy, demand flow strategy, customer service strategy and supply chain integration strategy. By focusing on these four strategies, companies can put in place initiatives to build capabilities towards meeting market needs and integration with supply chain partners:

Please see print copy for Figure 2.7

Figure 2.7: Meeting Customer Needs Through Strategy (compiled from Evans and Danks, 1998)

Tersine, Harvey and Buckley (1997, pp. 1) describe predicates for customer satisfaction. They emphasise that quality alone will not achieve this. Indeed, in most of today's marketplace, conformance quality and dependable delivery are really minimum requirements. These authors describe how, changing world trade and global competition, has created a transition from a seller's market to a buyer's market. In a supplier's market what can be made can be sold. Whereas a buyer's market is a demand driven market where the customers have the option of whom they buy from and when. Additionally, the customer's threshold of minimum expectations is elevated. In this so-called "buyer's world", the points of differentiation change as shown in Table 2.2 below.

Please see print copy for Table 2.2

Table 2.2: Points of Customer Buying Differentiation (Tersine, Harvey and Buckley, 1997, pp. 2)

Chase et al. (2006, pp.31) emphasise the importance of competencies, technologies and a motivating people environment in order to deliver high levels of customer service. For many customers now, service quality is a 'must have' attribute required to obtain an order, however, alone, it will not guarantee winning of the order. Stanley and Wisner (2001, pp. 289) put the view that good internal service-quality across a supply chain creates a "service-profit-chain". Such a "service-profit-chain" can be expressed as:

profit and growth = f(customer loyalty)
customer loyalty = f(customer satisfaction)
customer satisfaction = f(satisfied and loyal employees creating value)
satisfied and loyal employees = f(high quality support services and policies)
high quality support services and policies = f(organisational capabilities)

The "responsiveness" differentiator shown at Table 2.2 above, is defined as the provision of products and services that (Tersine, Harvey and Buckley, 1997, pp. 3):

– *Completely satisfy customer requirements* (what they want, when they want it, where they want it, how they want it. The authors refer to this as 'exciting' the customer. The inference being that customers have to be 'thrilled' by the buying experience in such a way as to make them repeat buyers. Repeat buyers are, it is stressed, more likely to pay price premiums, can be less expensive to service and are good references for attracting new customers. This cycle therefore sets up a customer-base growth-reinforcing-loop. Of course this concept is not new and earlier authors Deming (1986, pp. 5) and Berry (1995, pp. 55) also described the need to "delight" customers.
– *Are fast to* market (new products meeting known customer needs are developed and delivered quickly to market).
– *Are fast to produce* (fast response to mix and volume changes, short supply chain cycle times).
– *Are fast to deliver* (in-market location, quick and easy order entry, same day delivery).

- *Are fast to service* (quick response to enquiries, after sales support, fast response to complaints and problems and convenient payment terms) (Tersine, Harvey and Buckley, 1997, pp. 3).

The authors describe such customer emphasis as a 'customer-centric orientation'.

In relation to the supply chain and its integration, in order to completely satisfy the requirements of *external* customers of the supply chain, *acceptable levels of satisfaction* is a presupposition for all *internal* customers of the chain also. That is, the level of perceived value obtained by external customers is the result of effective and collaborative efforts of many internal-supplier to internal-customer transactions (Tersine, Harvey and Buckley, 1997, pp. 3).

Moreover, this is a tenuous situation, especially as far as external customers are concerned. That is, it might take a long period of such high levels of customer value delivery before customer loyalty is developed (Tersine, Harvey and Buckley, 1997, pp. 3). And conversely, such loyalty may be lost very rapidly if the levels of customer service/responsiveness fall. In this regard, the authors stress that '*customer service is an attitude, not a department'*. Service is something extra in the customer's perception of value. It is more subjective and perhaps harder therefore to measure. It is nevertheless a vital requirement in the building of customer relationships. And those relationships are based on difficult-to-quantify factors such as trust, honesty, faith, respect and reputation (Tersine, Harvey and Buckley, 1997, pp. 3). Whilst these factors may be hard to measure, they are nevertheless very real to the customer. The strategic battleground for the future therefore is customer service/responsiveness/customer 'delight' (Jones and Sasser, 1995, pp. 89~90). Such a customer-attentive attitude is accomplished through responsiveness to continuously changing customer needs. In turn, supply chain capabilities (including collaboration to achieve higher performance on internal-supplier to internal-customer transactions) need to be developed in order to attain the flexibility required to meet those changing customer demands. Thus, the values and requirements of customers must take precedence over internal matters and really become the ethos of the organisation.

Such customer attentiveness it is suggested, will lead to both the safekeeping of existing customers and the growth of new ones.

Supply chain *design* has reached a new level of prominence as companies realise the potential value-add to customers from improved supply chain structure and underlying supply chain operating philosophy. This is bringing the supply chain issue to the surface and making it truly strategic for many companies (Korpela, Lehmusvaara and Tuominen, 2001, pp. 193). Organisations, especially those in highly competitive industries, are increasingly becoming aware that all parts of the supply chain need to work together if they hope to deliver to these heightened customer expectations (Griffiths, Elson and Amos, 2001, pp. 65). That is, the overall supply chain (as well as the individual members along the chain) must be responsive to customer requirements. Collaboration, integrated systems and continuous development by the supply chain members can not only meet such customer expectations, but also can potentially offer more (Ekdahl et al., 1999, pp. 410).

The expected service or delivery of the promised market offer can be considered as “hard” service elements and any additional features over and above these as “soft” service elements (Griffiths, Elson and Amos 2001, pp. 61). The authors present a slightly different interpretation of “hard” and “soft” attributes and describe how the “soft” service elements are not always easy to see or identify. That is, by their definition, the “hard” service elements are visible physical aspects and the “soft” service elements as non-physical. Using train travel as an example, hard services are things like car parking, the train station and the train itself. Whereas the soft elements are things like customer help/enquiry systems, ticket booking and payment process, quality of the carriages and facilities, competence and friendliness of the train staff and whether or not the train runs on-time (Griffiths, Elson and Amos, 2001, pp. 61). The authors argue that any hard-element-type competitive advantage that an organisation might build can be quickly matched by competition. They quote the example of the Honda V-tec engine, which was “copied” by two other Japanese auto-manufacturers within six months of its release. Soft elements on the other hand, are typically much more difficult to define, measure and manage. Similarly, they are more difficult to copy or match and so organisations that invest the time and effort to develop such soft element competitive advantages, usually find them quite sustainable.

Roth and van der Velde (1991, pp. 307) describe a service operations strategy made up of three main components: (i) *structural* (hard) factors such as assets employed and process technologies used, (ii) *infrastructural* (soft) factors such as policies and systems applied and (iii) internal and external *integration choices*. The authors differentiate between realised capabilities and intended capabilities and reinforce the importance of continuously removing any gaps between the two in order to remain competitive and win customer accounts.

The growing realisation of the strategic importance of the manner of design and execution of supply chains is against a backdrop of increasing competitive intensity (Christopher, 2000, pp. 207). To meet the associated challenges, companies need to be able to respond quickly and nimbly to change and volatility.

From a supply chain management point of view, organisations need to be able to respond faster both to volume change, variety change and preference change (Christopher, 2000, pp. 208). To a truly agile (nimble, lively, swift, responsive, active, fleet-of-foot) business, volatility of demand is not a problem as its processes, its organisational alignment and its supply chain relationships enable it to handle whatever varying demands are placed upon it.

Being able to offer unique or innovative services around the product offer can also be important. For example Heese et al. (2005, pp. 153) describe how the US firm Hills-Rom gained competitive advantage over its competition by deciding to offer a take-back and refurbishment of hospital grade electric beds. This decision gave Hills-Rom a cost competitive offer to new manual beds.

Figure 2.8 below captures the various ideas presented by the authors noted in this section.

As can be seen from the figure, business success is dependent upon the safekeeping of existing customers and the growth of new ones. In turn, this is dependent upon customer loyalty, which flows from customer satisfaction/ customer ‘delight’. Such customer satisfaction is a function of the strength of relationships developed and the delivery of real customer value.

Relationships in turn, grow from the enactment of key value-based behaviours (trust, honesty, respect etc.), the delivery of new fit-for-purpose products, quality customer service, supply chain capabilities (both technical and social) *and* importantly, are reinforced via a customer satisfaction feedback loop as shown on the diagram.

Likewise, the delivery of real customer value flows from the development and 'bringing to market' of new fit-for-purpose products, quality customer service and socio/technical supply chain capabilities. Such supply chain capabilities are considered crucial to the quality of the outcome delivered by the overall model shown in the diagram.

It is the socio/technical considerations of the "integration of supply chain processes" that is the subject of this research.

Please see print copy for Figure 2.8

Figure 2.8 : Business Success Via Customer Focus Via Organisational Capability (compiled from Johnson and Davis (1995), Griffiths, Elson and Amos (2001), Korpela et al. (2001), Evans and Danks (1998), Tersine and Wacker (2000), Lummus and Alber (1997), Holmstrom (1995), Womack and Jones (1996), Spekman (1998), Stevens (1989), Arjmand and Roach (2000), Christopher (2000), Gattorna (1998), Renner (2000), Ekdahl (1999), La Londe and Zinszer (1976), Stanley and Wisner (2001), Heikkila (2002), Roth and van der Velde (1991))

In response to this changing customer awareness, customer focus firms are moving from individual and disconnected supply chain processes towards more "coordinated and integrated design and control" of their supply chain(s) in order to deliver goods to the final customer at lower total cost with shorter lead-time and high delivery reliability (Korpela et al., 2001, pp. 193). Seamless real-time integration of key business processes is essential. This integration must be both horizontally across customer facing processes (eg marketing, selling and service) and vertically to the back end supply chain processes (Renner, 2000, pp. 4).
The 'push' (or 'flow-line') manner of operating supply chains typically manages the main activities of *source*, *make* and *deliver* independently of the other and buffers each activity with inventories. As the realisation has slowly grown that more advantage can be gained from improving a whole integrated chain rather than improving the performance of each part independently, supply chain logistics management has spread to a wider range of subject including the entire physical (materials) and non-physical (information) flows in both directions along the entire chain (Korpela et al., 2001, pp. 194).

2.2.4 Design of Supply Chains

Supply chain management is a multi-functional undertaking because it includes sales/marketing, planning, sourcing, scheduling, manufacturing and transportation (Nagurney et al., 2002, pp. 281). With such a diversity of functions and processes, the modelling and design of supply chains can be complex challenges. Lee and Billington (1993, pp. 835) convey the desire for decentralised models (discrete units or sections of the supply chain are modelled and then linked to adjacent units) as such models reduce complexity, especially in the study of long and complex supply chains. Many researchers and practitioners have put the view that the primary goal of supply chain design is to achieve optimal performance of the supply network (Nagurney et al., 2002, pp. 282, Meixel and Gargeya, 2005, pp. 537). Nagurney et al. (2002) developed an 'equilibrium' model of competitive supply chain networks. Specific behaviours and interaction effects of supply chain participants are modelled with this design tool. It can also be used to test the effectiveness of emergent supply chain designs.

Nagurney and Matsypura (2005, pp. 588) further developed a dynamic multi-tiered global supply chain network model that includes profit maximisation and risk minimisation for both supply side and demand side risks.

Whilst supply chain and supply network modelling is well advanced and researchers have addressed many difficult modelling issues individually, it is the view of Meixel and Gargeya (2005, pp. 547) that "few models comprehensively address outsourcing, integration and strategic alignment in global supply chain design." The authors therefore recommend further research to address such identified shortcomings.

Reithofer and Naeger (1997, pp. 224) describe the key elements of future supply chain networks as: "(a) Existing rigid, static, centralised hierarchical organisations will be replaced by flattened, network-like organisations; (b) Enterprises will be composed of widely autonomous but cooperating work units; (c) Work units will be distributed all over the world and will cooperate within virtual enterprises, and (d) Virtual enterprises will cover the whole product cycle from (*n*th) supplier to (*n*th) customer."

Hameri and Paatela (2005, pp. 54) suggest three supply network propositions i.e. firstly that supply network individual node operators are becoming more specialised and focused, secondly the such networks are becoming more dynamic in nature and this can actually lead to their contraction on occasions as well as their expansion, and thirdly industries and industry players who become flexible and able to respond rapidly to changing circumstances are better able to capture available marketplace opportunities. Smith et al. (2005, pp. 614, 615) suggest that management inertia (managers stuck in old ways of doing things) may be a significant factor limiting a firm's flexibility and responsiveness. Therefore firms who wish to become more responsive in a less 'panic-driven' way in times of heightened customer pressure, need to focus on reductions to management inertia.

Schonsleben (2000, pp. 35) developed a two dimensional model based on the dimensions 'duration of the delivery agreement' and 'intensity of cooperation'. It is Schonsleben's view that these two dimensions are important features of a supply chain network because they include the concept of working together for sustained periods in order to pursue performance improvements. Schonsleben’s model includes four different partnership strategies that companies follow dependent upon their position on the model matrix shown at Figure 2.9.

Please see print copy for Figure 2.9

Figure 2.9 Strategies of Cooperation in a Supply Network (Schonsleben, 2000, pp. 35)

Supply management (bottom right-hand corner of Figure 2.9) is defined as “a strategic and long-term reduction of the number of suppliers to achieve fast and easy operational order servicing. The choice of supplier is made in view of total costs.” (Schonsleben, 2000, pp. 35).

Supply chain management in this model is defined as the strategic and long-term cooperation of supply chain partners in the development of and the production of products and services that add value to customers (Schonsleben, 2000, pp. 36~37)

The *virtual* (implicit) *organisation* is one whereby a network of companies function as a common entity but do not constitute a company in a legal sense. In order to fulfil a customer’s needs several co-producers will act together and stand as a single company in order to fulfil that requirement, but will then separate again. Virtual organisations (networks) therefore must be able to form, separate and reform - in another configuration - quickly (Schonsleben, 2000, pp. 38).

Such a supply chain network (or ‘netchain’) can be visualised as shown at Figure 2.10.

Please see print copy for Figure 2.10

Figure 2.10: Example of a Generic Netchain (Lazzarini et al., 2005, pp. 19)

Barba et al. (1998, pp. 214~221) describe four principles that manufacturers should use to design and describe their supply chain networks. The *first* principle concerns focusing on creating maximum value for the customer. This requires the firm to look outside its traditional boundaries including improvements to sale channels. The *second* principle is that of striving to create win: win outcomes for *all* partners along the chain. This will require a shift from the ‘zero-sum’ mentality that has existed traditionally where only one channel participant can own the customer. The *third* principle is about creating growth opportunities for everyone. A good example of this is the practice where several dissimilar convenience store vendors will set up together near the on/off ramp of a freeway or alongside a major arterial road. In this way, they create greater demand for each other. The crucial *fourth* principle is that of developing trust-based working relationships among the chain partners. This may require participants to actively invest in the network, to share information about customer preferences and buying patterns and to undertake joint improvement initiatives for example.

Finally, Vonderembse et al. (2006, pp. 234) suggest a simple supply chain design based on product type and product like cycle. The main features of this approach are shown at Table 2.3 below:

Please see print copy for Table 2.3

Table 2.3: Supply Chain Classification Based on Product Type and Life Cycle (Vonderembse et al., 2006, pp. 234)

2.2.5 e-Enabling of Supply Chains

"A tsunami like change is overtaking global business – an irresistible force of communication called the internet." (Poirier and Bauer, 2000, pp. ix). Many companies are already creating internal (Intranet) and external (Internet) connections to establish new capabilities within their markets, changing the way business is conducted and refining roles and rules for how to work in this way. This approach to communications is likely to affect almost every business function and potentially all business processes. Business-to-business and business-to-customer transactions have already been impacted by this medium and this effect will likely be extended into the future (Poirier and Bauer, 2000, pp. 2).

Information and communications technology (ICT) is expected to make the flow of goods transparent (Bowersox and Daugherty, 1995, pp. 66~67) and allow for the integrated management of a physically integrated unit (LaLonde and Powers, 1993, pp. 2). Lee et al. (1997, pp. 546) point to the relevance of information exchange in managing a common supply chain problem, that of Forrester's bullwhip effect (covered at section 2.1.8 below). According to Lee et al. (1997, pp. 556), the use of electronic linkages to provide greater visibility of relevant information to partners along the supply chain can provide an important remedy to this effect.

In their empirical research work Paiva et al. (2002, pp. 387) found that relevance, timing and cost of information up and down the supply chain are important factors to managers trying to fulfil customer requirements.

When the supply chain concept is taken to its ultimate conclusion, best use of total supply chain resources, the partners in the chain are approaching optimisation, and that becomes the central purpose for the supply chain effort (Poirier and Bauer, 2000, pp. 51).

The process proceeds with the help of other companies that have also developed better supply chain practices. Now each firm works with a cadre of partners – suppliers, distributors and customers. In this later stage, the emphasis moves first to sharing best ideas and practices across what becomes a network of interaction, to then finding the means to build together new, profitable revenues for all constituents of the network (Poirier and Bauer, 2000, pp. 112). It is in this stage that the value of e-commerce comes into play.

For organisations to adapt to changes in their operational and competitive environments, they need to appraise and utilise appropriate and modern information systems (Griffiths, Elson and Amos, 2001, pp. 61). Traditional information systems can provide plentiful information but tend to be restrictive over the visibility of that information and so only a "select few" have ready access to it. In hierarchical organisations, this feature is desirable to such "select few" limited audience, as it reinforces their power-base within the structure. Web technology however, has the potential to change this imbalance. The rapid development of the Internet and of organisational intranets, now allows affordable access to worldwide communications. Supply chain members can thus share information and knowledge more readily using this technology. With this approach companies are no longer constrained by slow, cumbersome business-to-business communication systems such as EDI (electronic data interchange). Ways of doing business over interconnected networks using Web-based technologies will potentially have watershed implications for businesses and how they do business. Such changes could affect the design of organisational business processes, organisational structures and bring supply chain members "closer" to one another. These opportunities are generally referred to as e-Commerce, e-Business, e-business information systems and e-SCM - when used as solutions within supply chain processes.

From a supply chain management point of view, one of the major functions of such technology is the provision of easily accessible and accurate information which is crucial to the control and performance of the whole supply chain (Barut et al., 2002, pp. 161). An integrated and e-based logistics information system is a set of infrastructure and applications involving the management of all activities among all upstream and downstream supply chain members with the goal of optimisation of offered value propositions (Bauer and Poirier, 2001, pp, 3, Boyer et al., 2002, pp. 186). To enable the key roles in such a supply chain channel to carry out their duties effectively, timely visibility of relevant supply chain information is essential. The information thus supplied must be relevant to the logistics manager(s) and of sufficient reliability to be used in planning, implementing and control of the supply chain's logistical processes (Stefansson, 2002, pp. 136). Information systems therefore need to be designed with this capability in mind (Stefansson, 2002, pp. 135).

In a practical sense, such electronic links up and down the supply chain enable the rapid transmission and receipt of purchase orders, invoices and shipping advices between the supply chain partners. This gives potential to speed up the entire order fulfilment set of processes. Prior to the advent of the Internet, electronic data interchange (EDI) was the most common method of sharing such information. EDI however, did not achieve widespread use (Stefansson, 2002, pp. 136) largely because its implementation cost was/is too high for small and medium sized enterprises (SMEs) to bear. For example, in 1998, 96% of the USA's Fortune 1000 companies were using EDI, however 98% of the other companies were not (Stefansson, 2002, pp. 136). The availability of the Internet however, changes the affordability equation. Access to this technology can be via the public Internet, networks for company use only (Intranets) or networks for business partners (Extranets).

The rapid growth of usage of the Internet is unarguable, rising from 3 million users in 1994 to 300 million users in the year 2000 (as quoted in Stefansson, 2002, pp. 143). The number of Internet hosts over the same period increased from 1.5 million to 72.4 million. The Internet has demonstrated that it is reasonably reliable, lower cost and accessible alternative to EDI. And whilst there are still issues relating to security, message tracking, audit trails and authentication (Stefansson, 2002, pp. 143), practices such as message encryption, use of password security and the establishment of specific information ‘exchanges’ for the exclusive use of supply chain partners, are being developed to address such listed concerns.

There are two main categories of information shared electronically across such information networks. The first can be considered as *static* information such as product catalogues, product manuals, pricing information, technical specifications, standards compliance data and promotional material. The second can be considered as *dynamic* information such as order enquiries, order bookings, order status reporting, service orders on service providers, auctions, requests for information (RFI), despatch information, despatch confirmation, arrival confirmation, vendor managed/owned inventory status, customer and supplier schedules, invoices and bank account deposit confirmation (Stefansson, 2002, pp. 144).

van Hoek (2001, pp. 26) takes this concept further and proposes a framework for companies to follow towards the development of a full e-supply chain solution. The framework, including actual company examples, is shown at Figure 2.11 below. The assumption behind this framework is that e-supply chains will be developed so that companies can achieve practical benefits such as improved customer service, order-to-fulfilment cycle time reductions and reduced inventories and costs and improved flexibility to changing customer demands. van Hoek (2001, pp. 27) concludes, that for supply chain wide benefits to be achieved, then the flow of information up and down the supply chain must be considered as strategic and seamless (i.e the top right-hand corner of Figure 2.11, not the bottom left-hand corner).

Please see print copy for Figure 2.11

Figure 2.11: Towards the e-Supply Chain (van Hoek, 2001, pp26).

The linked constituents of the supply chain will discover an enormous opportunity to rapidly share information and knowledge cost effectively. The convergence of supply chain effort with e-commerce has the potential to finally realise the improvements possible from an integrated supply network and full supply chain optimisation (Poirier and Bauer, 2000, pp. 19).

Motwani et al. (2000, pp. 323) describe a process to assure the likelihood of successful system and applications development and implementation efforts as demonstrated at Figure 2.12:

Please see print copy for Figure 2.12

Figure 2.12: Five Phase Global Supply Chain Management Development Process (Motwani et al., 2000, pp. 323)

In order to ensure that the result delivered from application of the five steps is sustained (assuming the result is meritorious) it is necessary to have active leadership, employee training and sensible information systems technical infrastructure and people structures (Motwani et al., 2000, pp. 323).

Another aspect of the electronic era's influence is considered by Oliveira et al. (2002, pp. 732) as the so called 'knowledge-based view' (KBV) of a firm. KBV requires integration of factors such as customer intelligence, firm strategy and structure as opposed to physical asset considerations alone. This concept extends along the supply chain as well whereby one of the requisites for the supply chain partners is the focusing of specialised knowledge on the delivery of mutually beneficial outcomes. This involves the e-enabled collaborative building of relevant and necessary knowledge-based competencies and capabilities towards the delivery of common goals.

2.2.6 Supply Chain Performance Improvement Programs/ Underlying Supply Chain Operating Philosophies

There are a number of studied supply chain improvement programs that after being initially applied as improvement initiatives, have over time, in some companies, become embedded as their underlying operating/manufacturing philosophy. This section deals with such programs/philosophies.

Deming promoted the notion that unless something can be measured it cannot be improved (Deming, 1986, pp. 476). Importantly though, more than measures are required in order to actually achieve improvement. The simple existence of measures in isolation will not necessarily lead to improvement (Deming, 1986, pp. 88). They require the help of an improvement process or improvement methodology and its execution.

If an organisation's supply chain is incapable of meeting the changing customer expectations as outlined at 2.2.3 above, then the following symptoms can emerge

(Lummus and Alber, 1997, pp. 54):

- compressed margins on sales;
- substandard customer service performance;
- higher overhead costs;
- unreliable production processes;
- high changeover times (lost production);
- high inventory levels across the chain.

Lummus and Alber (1997, pp. 54) refer to this as a *strained* supply chain. The differences between a capable supply chain and a strained one can be summarised as shown in Table 2.4:

Please see print copy for Table 2.4

Table 2.4: Strained and Capable Supply Chain Characteristics (Lummus and Alber, 1997, pp54).

The entire supply chain is only as capable as the weakest link in the system. Each link in the product supply system therefore, must be individually capable of producing and delivering on-time what customers order. Where the supply chain is incapable of this, then extra costs must be carried in the form of inventory and the overheads necessary to manage that inventory. The alternative is customer stock-outs, an outcome that will ultimately lead to lost sales.

An array of improvement programs/methods/approaches/philosophies have been developed by manufacturing organisations over the years in order to lift overall organisational capability and thus, hopefully, business outcome performance. Examples of such programs are TQC, TQM, TPM, JIT, Lean, Six-Sigma, Theory of Constraints, Kaikara, Kaizen (Continuous Improvement), Reengineering, Restructuring and Benchmarking. Each such improvement approach is considered briefly below:

TQC (total quality control) is an improvement program focused primarily on product and service quality improvement (Deming, 1986, pp. 3). TQC uses a strong statistical base as part of its approach including run charts with upper and lower control limits, Pareto charts and cause-and-effect diagrams. TQC focuses strongly on improvements to process capability, process control and reduction of process variation. TQC also applies simple and effective improvement cycles such as the plan-do-check-act (PDCA) cycle, which is explained further below.

TQM (total quality management) represents further development in thinking and scope of TQC. TQM is a program aimed at continuously improving quality of products, services and processes by capitalising on the involvement of leaders, the workforce, customers and suppliers in order to meet or exceed customer expectations. Cua et al. (2001, pp. 678), compared six TQM studies and identified nine common TQM type practices:

(i) cross-functional product design;

(ii) process management;

(iii) supplier quality management;

(iv) customer involvement;

(v) information and feedback;

(vi) committed leadership;

(vii) strategic planning;
(viii) cross-functional training;
(ix) employee involvement.

TQM therefore, is focused on the elimination of defects and rework, the improvement of quality and delivery of products (Cua et al., 2002, pp. 675).

An extension to TQC/TQM is that of "Quality Tables" as developed by Yoji Akao at the Tokyo Institute of Technology during the 1960s (Adiano, Roth, 1994, pp. 26, 28). This approach developed into quality function deployment (QFD) the goal of which is to ensure that customer requirements are continuously mapped back to manufacturing product and process specifications.

TPM (total productive maintenance) is a manufacturing improvement program designed primarily to maximise equipment effectiveness throughout it entire life through the participation and motivation of the workforce (Nakajima, 1988, pp 1~2). Cua et al. (2001, pp. 677) compared six TPM studies and identified seven common TPM type practices:

(i) Autonomous maintenance.
(ii) Planned maintenance.
(iii) Equipment and equipment monitoring technology.
(iv) Committed leadership.
(v) Strategic planning.
(vi) Cross-Functional training.
(vii) Employee involvement.

TPM is focused on the reduction of waste caused by equipment problems such as equipment failure, unnecessary set-up and adjustment time, reduced speed, process defects and reduced yield.

JIT (just-in-time) is a manufacturing program with the primary goal of continuously reducing and ultimately eliminating all forms of waste (Ohno, 1988, pp. 59~60). Cua et al. (2001, pp. 677) compared six JIT studies and identified nine frequently cited JIT practices:

(i) set-up time reduction;
(ii) pull system production via use of kanban signals (a kanban is essentially a material bin or bucket or area that is used to tie (synchronise) same chain production units in order to minimise under and particularly over production);
(iii) just-in-time delivery by supplier;
(iv) functional equipment layout;
(v) daily schedule adherence;
(vi) committed leadership;
(vii) strategic planning;
(viii) cross-functional training;
(ix) employee involvement.

These JIT practices require employees to be trained to perform multiple tasks and to be involved in the improvement efforts. Organisational leadership in turn, must be committed to the improvement program and to the employee development required.

JIT thus is primarily focused on the reduction of waste in inventory and flow time (Cua et al., 2001, pp. 676).

At this point it is worthy to note the uniqueness and similarities between TQM, TPM and JIT. I.e. some of the practices are unique and some, especially the human factors of committed leadership, cross-functional training and employee involvement, are identical. The fact that planning is common to all of them reinforces its importance to the improvement model proposed by Shewhart and used by Deming (Deming, 1986, pp. 88) shown at Figure 2.13 below.

Please see print copy for Figure 2.13

Figure 2.13: PDCA Improvement Cycle for Supply Chain (Adapted from Deming, 1986, pp. 88)

A fifth common practice of TQM, TPM and JIT is that of two-way flow of information (Cua et al., 2001, pp. 677). Active information and feedback in TPM is considered essential in the work of McKone (1999, as in Cua et al., 2001, pp. 677). In JIT information and feedback is crucial where each station in the supply chain of manufacturing processes is tightly integrated with its upstream and downstream stations in order to establish flow rates, process and transfer batch sizes, set-ups and sequences (Cua et al., 2001, pp. 677). Cua et al. (2001, pp. 679) refer to the unique practices of each program as the ‘basic techniques’ and the shared ones as the ‘common practices’. The authors propose an integrating framework for TQM, JIT and TPM as shown in Table 2.5 below:

Please see print copy for Table 2.5

Table 2.5: An Integrating Framework for TQM, JIT and TPM (Cua et al., 2001, pp. 679)

Kaizen, the Japanese word for Continuous Improvement (CI) adopts the premise that ‘Nothing is so good that it cannot be better’. This concept highlights the ever-present risk of an external competitor who has, or will have, a superior customer offer (Tersine, Harvey and Buckley, 1997, pp. 5). CI therefore, is a set of values and beliefs, a mindset as it were, focussed on continuously improving the value delivered to customers and the building of organisational capability. The Japanese development of CI was spawned by the early work of Shewhart and Deming who were promoters of the Plan→ Do → Check → Act (PDCA) repeating improvement cycle. Deming visited Japan many times following WWII and started the Japanese on this improvement path (Deming, 1986, pp. 3~4).

Specific supply chain capabilities necessary to support the business strategy can be identified and targets can be set for the key measures of those attributes as shown in

Table 2.6 below. Such key measures are often referred to as key performance indicators (KPIs) (Lummus and Alber, 1997, pp. 59).

Please see print copy for Table 2.6

Table 2.6: Examples of Key Supply Chain Capability Measures and Targets (adapted from Lummus and Alber, 1997, pp. 59).

On another dimension, Continuous Improvement is the endorsement of change. The status quo in a CI environment is viewed as the ‘enemy’. CI focuses on small but incremental change in existing processes on a continual basis. Such small improvements over a period of time are cumulative. Importantly, the ideas for improvements come from people and teams within the organisation with the application technology being a secondary consideration.

As much as anything CI is an attitude to change. Organisations can of course adopt differing attitudes to change and in each case the consequences will differ. For example:

Please see print copy for Table 2.7

Table 2.7: Change Attitudes (Tersine, Harvey and Buckley, 1997, pp. 6)

Kaikaku is Lean Manufacturing's term for radical improvement. This approach is sometimes known as breakthrough kaizen. It involves intense questioning and re-examining of every aspect of a process. Any steps that can be eliminated are stopped. Any activities that are identified as "non-value but currently necessary" become targets for improvement (Womack and Jones, 2003, pp. 95).

TOC (theory of constraints) views organisations as systems consisting of resources that are linked by the processes they perform (Goldratt, 1990, pp. 35). Within that system, a constraint is defined as anything that limits the system from achieving higher performance relative to its goal (Goldratt, 1990, pp. 4). Intra and inter-organisational dependencies make the analogy of a chain, or network of chains, an appropriate description of such a system's processes. In the same way then that the chain is only as strong as its weakest link, then so too a manufacturing chain is governed towards meeting its goal by a single, or at most very few, constraints.

According to TOC, the simple purpose of a manufacturing organisation is to enable the entire organisation to meet its goal (Goldratt and Fox, 1986, pp. 18). The goal in turn is defined as "make money now as well as in the future." Making money as such, provides the funds to sustain ongoing operations and to fuel growth. TOC proposes three main measures of "making money" (Goldratt and Fox, 1986, pp. 28):

(i) *Throughout* (T) is defined as the rate at which an organisation generates money through sales. I.e. the manufacturer only adds value when a customer is prepared to pay for the products or services offered. It is important to note in this definition that throughput *does not equal* output or volume of production, it specifically relates to *sales*.

(ii) *Operating Expense* (OE) is defined as all of the money the organisation spends in order to turn inventory into throughput. OE includes all fixed costs and true variable costs. Profit then is simply (T – OE);

(iii) *Inventory* (I) is defined as the money that the system spends on things it intends to turn into throughput. Inventory here includes asset inventory such as plant and equipment and materials inventory such as raw materials, work-in-process and finished goods stock. Rate of return then is simply ((T – OE) ÷ I).

TOC offers a five-step improvement process (Goldratt, 1990, pp. 7):

(i) *Identify The System Constraint.*

(ii) *Decide how to Exploit the System Constraint* (how is the constraint to be 'treated' in order to maximise throughput).

(iii) *Subordinate Everything Else to the Constraint.* This can best be understood by considering Figure 2.14 below. The constraint resource once it is identified is used to set the pace (or drumbeat) of the process chain. Orders are only loaded onto the system up to the capacity of the constraint resource. In this way, the customer demand is 'pulling' on the system. The rope is used to signal the gate resource of the amount of raw materials to be released into the chain. In this way, only the amount of material that the constraint can consume is released into the chain. This integrated drum, buffer, rope mechanism controls the inventory level in the chain, ensures that the chain does not become overloaded and ensures via the strategic placement of buffers that the constraint resource is not starved of feed and delivery performance is assured.

(iv) *Elevate the System Constraint.* The constraint is enlarged either via more capacity, more materials or growing the market demand.

(v) *Remove (break) the Constraint.* When the constraint is "broken" (removed) go back to step one and identify the next constraint and so on.

Please see print copy for Figure 2.14

Figure 2.14: TOC based Synchronised, Integrated Flow Control (Adapted from Umble and Srikanth, 1990, pp. 172)

In the researcher's view, TOC and associated 'throughput accounting' are crucial SCM concepts and an important adjunct to Lean Manufacturing explained next.

Lean Manufacturing (or Lean Thinking) attempts to provide a more strategic framework for JIT type approaches to manufacturing (Womack and Jones, 2003, pp. 15). There are five main principles behind the concept of Lean Thinking (Womack and Jones, 2003, pp. 16):

First is the principle of precisely defining **value** in terms of specific products with specific capabilities offered at specific prices through a dialogue with specific customers. To do this, it is necessary for firms to rethink their strategies on a product-line basis with strong dedicated product teams (Womack and Jones, 2003, pp. 19).

Second is the identification of the **value-stream**. The value stream is the set of all the specific actions required to bring a specific product through the three critical management tasks of (a) problem solving from product concept to product launch; (b) information management running from order-taking through to delivery and invoicing of the product (or service) and (c) physical transformation starting at raw materials through to finished product *delivered* to the customer.

Third is the principle of **flow**. Looking along the entire value stream, how can the focus be put on the product and its needs rather than individual organisations and their individual assets? How can the *uninterrupted* flow of products and services along that stream be achieved in small-lot production?

Fourth is the principle of **'pull'**. This is simply the concept of letting the customer(s) pull from the supply chain instead of pushing products (often unwanted) onto the customer.

Fifth and last, is the principle of **perfection**. It takes a lot of effort to start a flywheel spinning, however once it reaches speed the energy required to keep it at speed is not as high and so the energy available within an organisation, excited by the results already obtained through a process its people are already familiar with, can be applied to even further improvements (Womack and Jones, 2003, pp. 25).

There are reportedly significant gains to be achieved from this lean approach. For example Womack and Jones (2003, pp. 27) claim that if a basic batch-and-queue production system is converted to continuous flow with effective pull by the customer then labour productivity can be doubled all along the supply chain. At the same time, it is claimed that manufacturing cycle times can be reduced by 90% and inventories reduced by 90%. Importantly, errors reaching the customer and scrap within the production process are typically halved, as are job related injuries. Time to market for new products can be reduced and capital investments reduced as greater effectiveness is achieved from existing assets. The authors quote numerous examples of companies adopting this approach who have achieved such results. The reference list includes, Doyle Wilson Homebuilders, Wiremold Co. Tesco, Toyota, Lantech and Porsche (Womack and Jones, 2003).

Some researchers have described the complementary benefits of applying programs such as TQM, TPM and JIT simultaneously. Roth and Miller (1992, pp. 73) for example contend that maintenance management is a substantial challenge for companies implementing JIT and TQM. Huang (1991, pp. 494) covers the importance of integrating JIT, TPM, quality control, and factory automation with worker participation. Imai (1986, pp.52) explains how TQC and TPM are essential customer focused foundations for a JIT program to be built on. Cua et al. (2001, pp. 683) received survey responses from 163 manufacturing plants located in the United States, Japan, Italy, Germany and the United Kingdom. The results of this study showed support for the three hypotheses proposed by Cua et al. (2001, pp. 680~681):

H1: Manufacturing plants that are identified as high performers have higher levels of implementation of both socially-oriented practices and technically-oriented techniques of TQM, JIT and TPM;

H2: Manufacturing plants that are identified as high performers have implemented practices from all three programs of TQM, JIT and TPM rather than from only one program;

H3: Different configurations of basic techniques and common practices affect specific measures of performance.

Six-Sigma is a more recent manifestation of the quality improvement programs starting with TQC albeit with a much stronger focus on business improvement results. Uppercase Six-Sigma is a business improvement program aimed principally at improvements to organisation's bottom-line profit performance. The program relies heavily on a lower case six-sigma structured-statistical and decision-making process that focuses on error reduction and process cycle-time reductions. The lowercase six-sigma connotation refers to a 6σ level of defects i.e. 1 item defective in 3.4 million units.

In response to strong competitive pressure from the Japanese and Scandinavians and in response to ongoing product quality problems, Motorola began the development of the Six-Sigma business improvement process in 1979 (Harry and Schroeder, 2000, pp. 9). Since that time, a number of companies notably General Electric, Allied Signal, Raytheon, Polaroid, Asea Brown Boveri, Johnson & Johnson, Du Pont, Ford Motor Co. and POSCO have all embraced Six-Sigma to some extent. It is claimed by the Six-Sigma advocates (Harry and Schroeder, 2000, pp. 2) that companies actively following a Six-Sigma approach and that achieve a one sigma shift improvement each year (up to the 4.8~5 six-sigma level) will achieve a 20% margin improvement, a

12~18% lift in capacity, a 12% headcount reduction and a 10~30% capital reduction *per year*.

There are 2 main Six-Sigma improvement focused processes i.e. (i) Design for Six Sigma (DFSS) and (ii) Define, Measure, Analyse, Improve and Control (DMAIC). DFSS is concerned with the design of products and processes that will fulfil customer requirements and that can be produced at six-sigma quality levels. DMAIC is a closed loop continuous improvement process that utilises and number of relevant statistical tools to help achieve its objectives (Harry and Schroeder, 2000, pp. 115, 143).

Reengineering (or business process redesign) is a 'from the ground up', redesign of business processes. It is undertaken in order to deliver step changes in business performance (Hammer and Champy, 1993, pp. 32). Reengineering's main emphasis is that of customer satisfaction. Cost reduction is a secondary focus. The primary aim is to remove needless waste or non-value added activities in core processes and to make significant deliberate improvements to processes in order to heighten customer satisfaction. Where continuous improvement takes existing products, processes and practices and improves them in an 'evolutionary manner', reengineering attempts to achieve step change in a 'revolutionary manner' (Tersine, Harvey and Buckley, 1997, pp. 6). Reengineering therefore is about drastic change rather than incremental improvement. It is difficult therefore to reengineer only one part of an organisation especially where that 'part' interfaces with many other organisational activities. Reengineering therefore must be taken in concert across an organisation or indeed across a whole supply chain and needs to flow from the overall business/supply chain strategy. The goal of reengineering through such activities is to "attain leadership in a unique, difficult or impossible to duplicate customer value proposition." (Tersine, Harvey and Buckley, 1997, pp. 6)

Reengineering therefore is a very ambitious business improvement approach. And it is this very nature of the undertaking that presents obstacles to its progress. That is, reengineering requires the ability to use insight and imagination to challenge the rules and assumptions of the entire business. Not everybody within organisations has such abilities. Furthermore, many people within the organisation feel threatened by any campaign with such far-reaching impacts, especially if those impacts affect individual jobs. An interesting dilemma is therefore set up. That is, firms that are unwilling or unable to reengineer their business process are more likely to spiral downwards in business performance, whilst at the same time some of the intra-firm dynamics set up by the application of the reengineering process itself will fetter an organisation's efforts to achieve all that can be achieved through the use of the approach. For example, in a study of 100 companies, Hall, Rosenthal and Wade (1993, as in Waller, 1999, pp. 187) claim that reengineering is not universally successful and quote a number of instances where it has failed. The authors reinforce the importance of senior business sponsorship to the success of reengineering efforts.

Restructuring, another form of business improvement activity, is different again to Continuous Improvement. Restructuring usually tends to focus on changes to organisational numbers and reporting arrangements and is usually carried out as a cost cutting exercise in response to falling markets, declining share, margins, and/or stagnant growth. Restructuring has been variously referred to as de-layering, downsizing, and rightsizing. Some authors refer to it as little more than corporate anorexia because the emphasis is on cost reduction rather than revenue generation. It makes the business thinner but not necessarily healthier (McKinley et al., 1995, pp. 34~36). On the other hand, sometimes well designed restructuring can be beneficial (Lummus and Alber, 1997, pp. 65). For example Kendall Healthcare Products Company implemented supply chain management concepts with its customers, but at first built its own information and organisational infrastructure to support the initiative. Continuous Replenishment Planners were added to Kendall's structure and given the responsibility of managing the inventory replenishment to every location along the supply chain, managing forecasts and providing customer service and support.

Other organisational changes may involve such things as the number and/or location of supply chain nodes, changing suppliers, closing/opening/relocating plants, distribution centres and retail outlets (Lummus and Alber, 1997, pp. 65~66).

Benchmarking is also touted as an improvement methodology. Benchmarking is often used as a mechanism for making comparisons and evaluating improvement possibilities. Benchmarking compares the best practices and results of other (usually leading) companies either in the same or different industries or both, and those comparisons are then used to identify performance gaps that management may decide to close. Tersine, Harvey and Buckley (1997, pp. 7) make the point that benchmarking ideally should be used to obtain a position of performance leadership and not simply used as a 'catch-up' technique.

Robinson and Malhorta (2005, pp. 319) introduce the concept of Supply Chain Quality Management (SCQM) and define it as:

"SCQM is the formal coordination and integration of business processes involving all partner organisations in the supply channel to measure, analyse and continually improve products, services and processes in order to create value and achieve satisfaction of intermediate and final customers in the marketplace."

After reviewing numerous relevant journal articles on supply chain and quality management, the authors propose a taxonomy of SCQM themes (Robinson and Malhorta, 2005, pp. 330). They categorise intra-organisational themes (internal process integration, strategy, quality leadership and practices) as traditional quality management research and inter-organisational themes (external process integration, communication and partnership, supply chain quality leadership and practices) as SCQM research. The researcher would argue that SCQM might better be defined as simply the application of quality management improvement methodologies to all supply chain related matters. The taxonomy offered whilst helpful, probably does not gain substantially from the suggested internal/external split and therefore again might more simply be stated as the themes of process integration, strategy, communication and collaboration, quality leadership and quality practices to *all* related supply chain matters (internal and external).

Of course, such improvement initiatives as described above, will invariably result in some form of change. And change introduces a whole range of other issues that organisations must deal with (Tersine, Harvey and Buckley, 1997, pp. 7). For example, stress and anxiety can often result from the need to do things differently. Further, if the change to an organisation is substantial and results in, say, redundancies, then this can cause considerable emotional hardship for both the people made redundant and for the survivors. In such situations, organisations risk diminished loyalty and morale. Moreover, the survivors themselves may leave on the belief that "they could be next" if they stay (Tersine, Harvey and Buckley, 1997, pp. 8). If organisations are not careful in such situations, a 'death spiral' situation can develop. That is, good people leave in addition to those made redundant, people outside hear news of the downsizing and associated human turmoil and so are disinclined to apply for positions with the organisation. Morale and competencies can then fall further, leading to a loss of focus on the organisation's basic competitive drivers. This path can thus result in the organisation's potentially greatest intangible asset, namely its people, being disenfranchised with it. In such circumstances of course, the total costs of the change program, may be greater than the benefits and indeed cause a reduction in the corporation's value (Tersine, Harvey and Buckley, 1997, pp. 8).

Companies undertaking change programs can however, undertake preventative measures to ameliorate such risks. For example actions such as (i) active and present senior management sponsorship (Deming, 1986, pp. 248), (ii) managing both the *extent* and *rate* of change, (iii) having competent change team members, (iv) effective information and communication processes, and (v) devolved authority to the change teams for active decision-making, can increase the probability of change program success (Tersine, Harvey and Buckley, 1997, pp. 10).

Supply chain maturity is considered by Yusuf et al. (2004) as illustrated in Figure 2.15 below:

Please see print copy for Figure 2.15

Figure 2.15: Stages of Supply Chain Maturity (Venkatraman and Henderson, 1998, as in Yusuf et al., 2004, pp. 383)

Going from stage 1 to stage 3 in Figure 2.15 would see a bias for action ranging from individual unit to inter-organisational units. Similarly, performance objectives would mature from operating efficiency through economic value added, to long-term survival focus (Yusuf et al., 2004, pp. 383)

2.2.7 Supply Chain Planning and Scheduling

Supply chain planning and scheduling is quite an involved topic the main components of which are shown at Figure 2.16.

The ‘Strategic Network Planning’ layer in Figure 2.16 is a planning activity that attempts to match future business capabilities and capacities with long-range forecasts of market and product demand. This must include of course, consideration of an organisation’s longer-term direction, aspirations and thus strategies (for example, a company might decide to indeed have no future productive capacity and therefore outsource it completely). The ‘Master Planning’ layer is a mid-term planning activity usually using aggregate data that attempts to optimise a number of objective functions (Kreipl, 2004, pp. 81). Such functions are for example earnings, service delivery levels and cash requirements. Such a process can become quite complex where there are many products and several points of production alternatives in a given supply chain network. Time ‘rests’ (time increments) are usually longer for the Master Planning layer and the time horizon is usually longer than the scheduling processes. The output of the Master Planning layer is primarily an optimised plan that assigns resources (material or equipment time) to the product ‘families’ used, product loadings to the various facilities and stocking point inventory levels. This output is normally then used as an input to the shorter-term scheduling processes (Kreipl, 2004, pp. 82).

At the scheduling layers the optimisation process is repeated (albeit with usually many more trade-offs to manage) with a much lower level of product disaggregation, shorter time ‘rests’ and a shorter time horizon. The scheduling layer must also recognise and follow nominated unit scheduling or sequencing ‘rules’ and accommodate identified critical constraint resources (bottlenecks).

Please see print copy for Figure 2.16

Figure 2.16: Supply Chain Planning and Scheduling Matrix (Meyr et al., 2002, pp. 99, as in Stadtler, 2005)

Feed-forward and feedback mechanisms need to built into the planning and scheduling set of processes used. Such mechanisms facilitate the undertaking of necessary optimisation iterations that may be required because of identified problems at some point in the plan or schedule (eg plant over-load, stockout), or due to new information becoming available or because errors were found in some part(s) of the input data (Kreipl, 2004, pp. 83).

Such processes for long and complex supply chains can be quite challenging to design and implement. If many of the supply chain stages in a long supply chain belong to the same company, then an opportunity exists to include the stages into a single overall planning and scheduling set of processes (Kreipl, 2004, pp. 81). If however, the various stages belong to several different companies, then the design, implementation and ongoing management of an overall supply chain model may be technically very challenging and perhaps even overwhelming from a cultural point of view. An alternative approach to one big model therefore may be the request-negotiation-agreement type process that is conducted at each company-to-company interface along the chain. Whilst this approach make be more culturally acceptable, it can be very time consuming and prone to sub-optimisation if various parties along the chain engage in 'power' politics.

Numerous software companies have 'packaged' such planning and scheduling processes and offer them for sale under the banner of Advanced Planning and Scheduling solutions (APS). APS is not a universal business panacea however. APS applications are still under development to improve their 'fit' with supply chain management requirements. Hierarchical, time based and 'bucket' of orders and production lot principles may not be the most appropriate mechanism for achieving inter-company process integration. Lastly, few examples exist whereby APS has been entirely embedded within and intrinsically linked to *all* of the order-generation-to-fulfilment processes. (Stadtler, 2005, pp. 582) Such order-generation-to-fulfilment processes can be visualised as shown at Figure 2.17.

Please see print copy for Figure 2.17

Figure 2.17: Typical Order Generation to Fulfilment Transactions (adapted from Grackin, 2002, pp. 44)

Some conclusions can therefore be drawn from the above considerations. Firstly, the relevant supply chain in a customer-driven world extends beyond the ‘traditional’ organisation to include suppliers, customers and service providers along the length of the chain. Secondly, in delivering up the power of such a supply chain concept, there needs to be greater emphasis on understanding processes than so much on understanding and building of organisational functions. Delivery reliability, lead-time responsiveness, flexibility to changing customer requirements and unexpected events, quality of products and services, costs, supply chain flow rates and inventory levels are mostly determined by the processes used to design, build and deliver them (van Wezel et al. 2006, pp. 298). Thirdly, the integration of these processes is a considerable challenge facing organisations mainly because innovative ideas never lack for reasons why they *cannot* be done. And so in managing the transitions necessary for organisations facing this choice, specific strategies around risk, power and leadership will need to be carefully considered, crafted and implemented.

2.2.8 Inventory Considerations in Supply Chains

Inventory in a manufacturing organisation, typically consist of *supplies* (consumables that are not part of the final product, eg for a paper manufacturer these could be such things as rolls, lubricants, energy), *raw materials* (purchased items that are 'transformed' into the final product eg wood pulp), *work-in-process* (WIP) (partially completed finished goods) and *finished goods* stock (items that are the final product available to sell, distribute or stock) (Tersine, 1994, pp. 3~4).

Inventory exists because a number of functional factors are achieved via its existence. The relevance and validity of these factors can be argued, however they mostly are (Tersine, 1994, pp. 7~8):

Inventory as *working stock*. Purchasing inventory in 'lots' is usually practiced as this technique provides the opportunity to minimise ordering and holding costs, achieve quantity discounts, and/or qualify for favourable freight rates. This inventory is therefore typically held in advance of usage.

Safety stock. Basically this is inventory held to buffer against variability of supply and demand. Unreliable supply chains require higher levels of safety stock in order to assure customer delivery reliability;

Anticipation stock is stock pre-built for events such as seasonal demand, promotions or known plant outage;

Pipeline stock is essentially all work-in-process inventory i.e. being processed, waiting to be processed or being transported;

Decoupling stock decouples one operating unit from the next so that each can operate more independently. This may be a legitimate requirement driven by process technology limits on batch sizing/scheduling rules for example;

Psychic stock is typically point-of-sale display inventory carried to stimulate demand (eg latest model cars in dealerships held to stimulate interest or latest apparel fashions held in brand-name stores).

The actual levels of inventory carried to fulfil the above functions, can be compounded by factors such as (Waller, 1999, pp. 765~766):

The repetitiveness of orders (i.e. are they single one-off orders or repeat orders);
The supply source (inside the organisation or outside);
The pattern of demand (constant, variable, dependent, independent);
Lead time performance of the supplier (constant, variable);
Systems and methodologies used to control the inventories.

The ‘social’ issues existing within an organisation can further complicate these technical considerations. For example, Table 2.8 below shows the typical inclinations towards inventory shown by different organisational departments or functions in a hierarchical or functional type of organisation:

Please see print copy for Table 2.8

Table 2.8: Departmental Orientations Toward Inventory (Tersine, 1994, pp. 17)

Inventories therefore can be a source of conflict between different managers in an organisation. The conflict typically arises because the different managers have different roles to play and different measures they each have to deliver. For example, sales might say: “I can’t sell from an empty wagon, I can’t keep my customers if we continue to have stock-outs.” The production manager might say: “You’ll get your product in the next batch, I cannot reduce my batch sizes because I experience high first time losses with each new set-up and anyhow, larger batches keep my per unit costs down.”

As Tersine (1994, pp. 17) so aptly describes it: “Inventory management should be *everybody’s* concern. However it is not uncommon to find everybody’s concern *nobody’s* responsibility.”

2.2.9 **‘Bullwhip’ Effect in Supply Chains**

Mather (1993, pp. 36~37) states that most company managers would like sales/marketing to provide them with a stable predictable demand pattern growing at a pace they can accommodate. Unfortunately what they often experience is a demand situation that is unstable, unpredictable and declining. Indeed many marketing programmes run by a company actually cause much of the demand volatility seen. As Mather (1993, pp. 37) observes: “… almost every sales and marketing programme is designed to rile the marketplace, making it erratic and unpredictable.” Other parts of the same company respond to this by implementing programs to improve the flexibility of the factory, adding inventory cushions and increasing capacity to meet peak demand levels, all of which add cost.

One of the main systems issues in supply chains is the management of variability referred to as the ‘*bullwhip’* (or Forrester/whiplash/whipsaw) effect. As shown at Figure 2.18, this relates to the phenomenon where, for the same supply chain, demand levels experienced by the upstream suppliers tend to have much larger variations than sales levels to the final customer. This observed demand distortion propagates upstream in an amplified form (i.e. variance amplification). This phenomenon is partially caused by information flow constraints existing between supply chain partners (Heikkila, 2002, pp. 5).

Order information and supply information flows have a direct impact on the production scheduling, inventory control and delivery plans of individual members along the supply chain. Observed demand amplification therefore will directly impact these processes.

Please see print copy for Figure 2.18

Figure 2.18: The Bullwhip Effect in Supply Chain Management. (Adapted from Carlsson and Fuller, 2001, pp. 3)

Such amplification owes its behaviour to the following main characteristics (Forrester, 1961; Lee et al, 1997, pp. 548):

- structure of the system;
- delays in communication;
- demand signal processing;
- rationing game;
- order batching and
- price variations.

Metters (1997, pp. 99~100) concludes that lack of or slow inter-company communications are at the root of the problem. As such, solutions to the bullwhip effect often involve improving the abilities to coordinate supply chain activities, reduce lead-times and lift their demand and supply information transmission capability.

Customer demand therefore can be quite volatile due to (Lummus and Alber, 1997, pp. 12):

(i) Customer buying habits change over time, including for example, seasonality and cyclicality, and
(ii) Changes arising from initiatives or policy decisions made by either partners in a supply chain or competitors.

Customer buying habit change is sometimes quite fickle as consumers change their preferences due to a range of internal and external stimuli. Supply chain participants cannot easily influence this type of demand change. Demand change caused by internal company initiatives however, including marketing promotions designed to lift customer demand or to retain customer loyalty, can be directly influenced by supply chain partners. Such marketing promotions include (Lummus and Alber, 1997, pp. 12):

(i) Mass marketing;
(ii) Trade promotions;
(iii) Consumer promotions, and
(iv) Payment terms.

Whilst the companies involved can directly influence the above marketing initiatives, the resultant consumer demand changes attributable to the promotional activity are much more uncertain. Any demand increases that do happen may be supplied from safety inventory. Demand decreases on the other hand run the risk of increasing inventory. If demand does indeed increase to a level that exceeds on-hand safety buffers, then there is a high likelihood of stock-outs through the chain unless the chain is very responsive. A demand greater than capacity situation can be incredibly costly to recover from and may include overtime requirements, premium transport cost penalties and even production outsourcing costs (Lummus and Alber, 1997, pp. 13). In order to represent the actual profitability of the promotion therefore, such additional costs should be netted against any increases achieved.

Some companies have opted out of such promotional programmes in order to avoid such supply chain demand disturbances. They have used instead the practice of everyday low pricing (EDLP). This practice has proved to be very successful for companies such as Proctor and Gamble, Toys R Us, Home Depot, Wal-Mart and Woolworths. Such companies have however very deliberately developed supply chain models that are superior to their competition especially in terms of cost performance in order to maintain acceptable sales margins (Lummus and Alber, 1997, pp. 15). Companies using the EDLP believe the approach leads to long run profitability as consumers are more attracted to a consistent price level model (Lummus and Alber, 1997, pp. 15).

2.2.10 Possible Future Directions in Supply Chain Management

Rather than being buried amongst the operations of individual units and sales (Korpela et al, 2001, pp. 146), supply chain management is more and more seen as a value-adding process that directly supports (indeed enables) the primary goal of organisations i.e. to be competitive in terms of high customer service levels, high quality, competitive price, and flexibility in responding to changing market demands. Thus, the focus of logistics groups (both manufacturing logistics and transport logistics) is now more towards providing better service for customers instead of focussing alone on the minimisation of total logistics costs or the maximisation of profit for just the supplier. Additionally, more emphasis is now placed on proper management and coordination of the whole chain rather than optimising the local parts (Korpela et al, 2001, pp. 145). Now that the new decade is well underway, another wave of change is sweeping over supply chain partners in most firms. Whilst there will be varying views on the subject, one emerging view is that of supply chain alignment – the integration of all key processes and cultures so that the supply chain operates a single integrated customer service effective and cost effective value-adding system (Gattorna, 1998, pp. 2). Another view is that supply chain management can both drive and enable the business strategy of many firms (Evans and Danks, 1998, pp. 20~21).

The power of these approaches can already be seen in the success of companies like Wal-Mart, Coca-Cola and Dell Computer. These companies have adopted leading supply chains practices for at least the last decade and have easily outperformed their competitors in terms of shareholder value-add over that period (Evans and Danks, 1998, pp. 21). Together with operating excellence and the ability to change readily, these features of supply chain management if embraced and applied will see companies competitive in a tough marketplace.

Supply chain partners to improve their business performance often use *collaborative* practices. A study conducted by Simatupang and Sridharan (2004, pp. 490) surveyed 400 targets (200 retail and 200 supplier companies) and received 76 usable responses. The results of their analysis confirmed the positive relationship between levels of collaboration and supply chain performance. The authors found that the more collaborative firms engaged in better information sharing, decision synchronisation and incentive alignment. Performance outcomes enhanced were found to be service delivery, inventory and responsiveness (Simatupang and Sridharan 2004, pp. 499). Using collaboration and performance indices, Simatupang and Sridharan identified four profile quadrants, namely, efficient, underrating, prospective and synergistic. They propose that supply chain participants should use this model to benchmark themselves against and take corrective action if they find their rating unsatisfactory.

Lee (2004, pp. 2) describes what he calls the ‘triple A’ supply chain. The first ‘A’ is *agility*. Supply chains are quick, nimble and responsive to changes in either demand or supply. The second ‘A’ is *adaptiveness*. As the business environment changes around them, so too must the supply chain members change and adapt to the new conditions they find themselves in. The third ‘A’ is *alignment*. The interests of all members in the chain need to be aligned such that optimisation of the chain’s performance increases their performance also.

Miguel and Lejeune (2005, pp. 90) offer a more comprehensive supply chain typology they label as the *4C’s* in supply chain management:

(i) *Communicative* supply chain. Each entity in this type acts independently and autonomously. Communication occurs but only on a ‘nearest neighbour’ basis. Integration under this type is low.

(ii) *Coordinated* supply chain. Here a supply chain leader dominates the others supply chain members. Supply chain practices and integration are adopted, however largely at the direction of the dominant player.

(iii) *Collaborative* supply chain. In this type, members agree on common objectives. Trust is high and relationships between the supply chain partners are important. Information important to the performance of the overall chain is freely shared.

(iv) *Co-opetitive* supply chain. This is a combination of collaboration and competition. The under-pining belief is that competitors can benefit when they work together (legally). Such relationships may lead for example to joint technological development and acquisition.

Adaptive supply chains are another likely future development area competitive organisations to pursue (Vasara et al. 2003, pp. 128). There are two main considerations with respect to required adaptive supply chain features i.e. (i) the supply chain alignment and control philosophy and (ii) the steps required to achieve adaptiveness. Taking these in turn:

(i) Supply Chain Alignment and Control Philosophy. In the traditional supply chain, the alignment and control philosophy can best be described as hierarchical command and control i.e.:

Please see print copy for Figure 2.19

Figure 2.19: Hierarchical Traditional Supply Chain (Researcher, 2005)

Each entity along the supply chain is controlled via a top-down hierarchy and collaboration between the supply chain partners can be quite limited.

Conversely, in the adaptive supply chain, the alignment and control philosophy can be completely different i.e.:

Please see print copy for Figure 2.20

Figure 2.20: An Agent-Based Adaptive Supply Chain Network (Jensen and Dugan, 2003, pp. 8)

The characteristics of an adaptive supply chain can be described as per Figure 2.20. That is, a linked-set of adaptive agents make up the chain. Agents within the network can be designed to fulfil specific tasks such as ordering materials, scheduling, dispatch and so on (Fox et al., 2000, pp. 166~167). Agents can also be configured with negotiation protocols such that decision-making (in accord with such protocols) between agents is possible (Reaidy et al. 2006, pp. 124). Such a network requires global and real time visibility of actual events in order to function effectively. Continuous monitoring and modelling must be performed to evaluate different ways of achieving the supply chain goals better and faster through feedback and adaptation. Local decision-making identifies win: win solutions with peers. A mix of top-down and bottom-up optimisation principles aligns local goals with overall goals.

Importantly, such an alignment does not rely on a command-and-control hierarchy. Rather, each node is programmed with its necessary control-commands. For example, from commencement of their construction, anthills usually end up as completed articles. However there is no centralised command-and-control centre for the ants when building such nests. Rather each ant is programmed with simple rules such as: “Stand between two other ants and pass along anything that is handed to you.” (Radjou, 2002, pp. 5). Examples of such control-commands exist for armed forces personnel throughout history. Under the command of Horatio Nelson for instance, the control-command for Captains of the English ships was to “Break the line, get close to the enemy quickly and sink them.” Prior to this, the English Captains looked to the flagship for their instructions. Nelson therefore, completely changed the command-and-control model. Under Alexander the Great, the foot soldier’s control-command was simply “Go forward and kill the enemy.” Such control-commands are simple, straightforward and unambiguous. Once the agent is programmed to fulfil its task, no further instructions are necessary unless some form of intervention is required.

(ii) Steps Required to Achieve Adaptiveness. Henrich and Betts (2003, pp. 80) in their book “Adapt or Die” provide a good framework of the transition steps required in moving to an adaptive supply chain model i.e.:

Please see print copy for Figure 2.21

Figure 2.21: Steps to an Adaptive Supply Chain (Henrich and Betts, 2003, pp. 80)

Finally, French and LaForge (2006, pp. 272) describe the notion of completely closed-loop supply chains for the purpose of adequately covering and managing waste disposal and product re-use. In such a case the SC focus is from the customer back to the relevant plant, then through any necessary reconditioning or re-use and back to the customer again. This concept not only embraces SC efficiencies and customer service, but aspects of SC social responsibility as well.

2.3 Immediate Discipline

2.3.1 Integration of Supply Chain Logistics Processes

Successful businesses need to continuously reinvent themselves (McAdam and McCormack, 2001, pp. 113). Industry deregulation is occurring globally and coupled with a corporate expansion mindset, has opened new markets to new competitors. To be or to stay successful therefore, companies must improve both their offer to the marketplace and their delivery of that offer. And, they must do that profitably (McAdam and McCormack, 2001, pp. 116).

Additionally, in the emerging competitive environment, manufacturing businesses are no longer competing as stand alone entities. As supply chains lengthen, or more accurately, supply networks broaden, with a reduction in the number of participants within any supply chain, (through amalgamations, alliances and minimisation of suppliers), competitive survival depends on the end-to-end effectiveness of any given chain or indeed, across the network of multiple businesses and relationships (Lambert and Cooper, 2000, pp. 69).

Simchi-Levi, et al (2000, pp. 10) have reported that manufacturing success at National Semi-Conductor, Wal-Mart and Procter & Gamble illustrate that integration of supply chains is possible, bringing about significant benefits to company performance and more particularly, customer service and thus market share. This thinking is still in its development stages but it has been shown that there are more significant potential opportunities to capture the synergy resulting from intra-and inter-company integration and management.

Bennetton of Italy for example is an international apparel company that achieves excellent supply chain results and yet Bennetton itself is not a manufacturer. Rather, Bennetton is a merchandiser and distributor and achieves high levels of customer service and low rates of redundant inventories because of the point-of-sale initiated 'pull' system is integrated back up the supply chain. That is, Bennetton monitors the detail of each sale happening in its retailers' outlets and signal its manufacturers to make specific products in accord with the actual consumption details. (Motwani et al., 2000, pp. 322)

As the above-mentioned consolidation of manufacturing industry participants and globalisation of markets continues (Zimmer, 2002, pp. 1), companies are focussing on their core competencies and required capabilities. Legally and economically independent companies involved in the supply chain value-add process find that not only is increased cooperation necessary between them, so to is the coordination of logistical decisions (Zimmer, 2002, 14~15). Traditional logistics influenced the flow of information, materials, capital and manpower in the internal supply chain, whereas more recently this influence extends both internally and externally along the chain in order to provide the maximum value to the supply chain's customers at minimal total cost. The closer the parties are linked together along the supply chain, the more important is this coordination role (van der Vaart, 2004, pp. 22).

The US-based "Global Supply Chain Forum" (Lambert and Cooper, 2000, pp. 66) defined supply chain management (SCM) as:

"...the integration of key business processes from end user through original suppliers that provides products, services and information that add value for customers and other stakeholders".

As can be seen from the above definition, SCM now includes a much wider area than simply manufacturing supply and demand. SCM concerns the integration and management of key business processes across the supply chain, from product design to final delivery and from customers to suppliers through service providers and strategic partners (Lambert, Cooper, 2000, pp. 68). Importantly, whilst SCM does include the integration of inter organisational business processes, it can also stretch further than this. It reaches customers, suppliers and key service providers in all aspects of intra and inter-organisational relationships (Gardner, 2001, pp. 2). This can include the values and beliefs that underpin the business models adopted by the supply chain partners (Gardner, 2001, pp. 2).

Critical to coordinating the supply chain is managing the link between each node within the chain in order to synchronise the entire chain (Lummus and Alber, 1997, pp. 15). Companies manufacturing products have come to the realisation (Lummus and Alber, 1997, pp. 16) that the price they can obtain for their products is no longer set by the formula:

price = $\sum$ (raw materials costs, internal processes costs, margin)

Rather, it is the case today in competitive industries that the price companies can obtain from the marketplace determines both the nature of their processes and brings increasing focus on the cost and supply methods of their input services and materials. The entire whole-of-chain delivery processes therefore have to be viewed as one system if companies are to succeed in such a demand driven environment (Lummus and Alber, 1997, pp. 72).

A term used to describe the ability of an organisation to adequately respond to changing demand and being able to match supply to such demand, is that of manufacturing flexibility (Weeks and Crawford, 1994, pp. 34). Key to this flexibility is a process that tightly integrates demand management, production scheduling and inventory deployment such that the organisation can better utilise information, products resources and inventory. Figure 2.22 below provides an illustration of this concept as applying to the core business process of order fulfilment.

Please see print copy for Figure 2.22

Figure 2.22: The Concept Of Supply Chain Management Applying to the Core Business Process of Order Fulfilment With Associated ‘Flows’ of Information, Materials and Financials Up and Down the Supply Chain (Adapted from Lee, 2000, pp. 32).

The integration of supply chain processes is typically neither an easy nor a high-speed activity. Stevens (1989, pp. 6) suggests four levels or stages of such integration:

Stage I is described as those companies that give responsibility for the different activities in the supply chain to separate, ‘independent’ departments. There is no or very little integration of supply chain processes at this level.
Stage II is described as functional integration where some of the departments may be combined and there is a stronger focus on raw material flows, however work-in-process and finished goods material flows and order flows are still very much a ‘pass-the-parcel’ approach.
Stage III involves integrating the flow of material and orders along the company’s own chain.
Stage IV is the final goal of full integration of relevant supply chain processes both intra-company and inter-company across the entire chain.

In getting to stage IV, companies need to understand their competitive environment completely, they need to analyse their own supply chain and its performance and relevance to that competitive environment and they need to develop and implement a definite strategy and tactical plan in order to arrive (Stevens, 1989, pp8).

In October 1998, the Council of Logistics Management (Lambert and Cooper, 2000, pp. 67) updated their definition of Logistics as follows:

'Logistics is that part of the supply chain process that plans, implements and controls the effective flow and storage of goods, services and related information from the point-of-origin to the point-of-consumption in order to meet customers' requirements'.

Fisher, Raman and McClelland (2000, pp. 115), state that the key objective of retailing is being able to *offer the right product at the right place at the right time for the right price*. The researcher argues that in terms of customer service performance, this is indeed a crucial goal for most organisations offering goods and services to consumers. It is especially the goal of manufacturing and transport logistics personnel in those businesses, because those groups (in concert with Sales, Operations, and Customer Service) are charged with the responsibility of managing their organisation's 'Order Fulfilment' processes. Typical functional responsibilities for major steps along the order fulfilment processes are shown at Figure 2.23.

A question that arises relates to the *integration* of these supply chain logistics processes. That is, is the integration of supply chain logistics processes a genuine value-adding exercise, one focused on improving real business enterprise outcomes and/or helping to solve real business enterprise problems? I.e. will the integration of supply chain logistics processes indeed move organisations closer to their ultimate customer service/supply chain management goals and what specifically are those goals (Pagell, 2004, pp. 4)?

Please see print copy for Figure 2.23

Figure 2.23: Typical Supply Chain Order-Fulfilment Processes (Idea captured from Jones, 1994, pp. 28)

Kobayashi et al. (2003, pp. 771~773) propose a process integration solution to such requirements. The authors describe a production planning and sourcing planning integrated set of processes applied to an assembly manufacturer. The authors claim both business outcome improvements as well as system development and implementation lead-time reductions in their case study appraisal.

Fisher, Raman and McClelland (2000, pp. 118~121) describe four basic criteria that must be accomplished in organisations in order to achieve crucial supply chain goals. *First*, there has to be a sound and reliable process in place for the generation of demand forecasts. *Second*, there must be high supply chain speed. Products must be able to be brought to market with short enough lead times such that they are not obsolete by the time they get there and so that they fulfil the peak demand period(s). *Third*, there must be good inventory planning. *Lastly*, the whole supply system is dependent upon timely, relevant and high quality information. Prima facie, Fisher, Raman and McClelland's *four* criteria for success do not seem to relate to the question of integration of Supply Chain Logistics Processes. However, taking each of the criteria in turn:

(i) A sound process for the generation of demand forecasts must include other members of the supply chain, especially customers. The classic demand- forecast induced “Bullwhip Effect” (shown in Figure 2.18) is at its most out-of-control point when the linkages up and down the supply chain are non-existent (Lee, Padmanabhan and Whang, 1997, pp. 556).

Any robust process for better demand forecast reliability, must include the flow of demand information across supply chain linkages emanating preferably from the furthest downstream point. Expressed another way, the final consumer’s rate of consumption needs to be made available to all participants in the supply chain simultaneously – where all relevant information is easily accessible by any participant in the supply chain at any time.

(ii) Supply Chain Speed. Superficially, this is about getting products or services through the supply chain faster and thus reducing lead-times and residency times. Again, this can only be achieved from an end-to-end supply chain point of view if it is coordinated up and down the entire chain. Any constraints or blockages will simply slow the flow and defeat the purpose. It is a time-honoured saying, but still true nevertheless that the chain is only as good as it’s weakest link. Constraint resources will determine a supply chain’s product or service flow-rate across/through the chain (Umble and Srikanth, 1990, pp. 81). These constraints resources are the bottlenecks or flow rate inhibitors (the ‘weak links’).

Please see print copy for Figure 2.24

Figure 2.24: A Simple Supply Chain Illustrating the Constraint Resource (Bottleneck Unit is Process 2) (Robertson, 2001)

Indeed, Fisher, Raman and McClelland (2000, pp. 124) themselves, describe with examples how the companies they studied collaborated *within a supply chain structure* to improve lead time and time to market performance by working together on capacity reservations, inventory holding amounts, locations of those inventories and "debugging" flow problem areas.

(iii) Inventory Planning. This is directly connected to Forecasting and Supply Chain Speed above. Lost sales from stock-outs, are preventable obviously by having the right product at the right place at the right time. This can be achieved via more reliable capacity and demand forecasts, via de-bottlenecking the supply chain flows, and via more competent and sophisticated inventory management algorithms eg Safety Stock calculations, Multi-Echelon Inventory Management, Vendor Managed Inventory (VMI) (sometimes called Flowed-Delivery) and Just-In-Time (JIT) approaches.

(iv) Accurate Available Data. Again, the top three criteria are all related to and in reality can only be accomplished competently if the required data is both available and accurate. As Fisher, Raman and McClelland (2000, pp. 121) state, much point-of-sale (POS) information that is currently collected is not widely disseminated. This dissemination needs to occur with customers, suppliers, transporters and warehouses. The authors conclude by stating that companies like Wal-Mart and Amazon.com, showed the way for supply chain design and flow of information and products for the 1990s. They suggest that the next breakthrough will occur with the companies that can best access the supply chain transaction data and turn it into action (Fisher, Raman and McClelland, 2000, pp. 124).

Rosenzweig and Roth (2004, pp. 356) argue that an effective supply chain must be built on a string of individual entity competencies and capabilities. Such capabilities (for example, product quality, delivery reliability, volume flexibility and lower costs) need to be built (and typically are built) in a timed progression. Further, that each step of the progression will require "higher levels of process integration and coordination, beginning with the shop floor and expanding to the (entire) supply chain."

A study conducted by Frohlich and Westbrook (2001, pp. 187~188), undertook an extensive survey of some 322 international manufacturing companies (International Manufacturing Strategy Survey, 1998). They set out to prove or disprove the assertion that "The most successful manufacturers seem to be those that have carefully linked their internal processes to external suppliers and customers in unique supply chains."

The authors developed a novel way of describing the bias that the manufacturers had towards either the supply end, or the customer end, or none, or both. They listed five such 'facing' categories: (1) 'inward facing'; (2) 'periphery facing'; (3) 'supplier facing'; (4) 'customer facing'; (5) 'outward facing' (Frohlich and Westbrook 2001, pp. 190).

The strategic issue they assessed was one of direction and degree. I.e. in which direction were the manufactures focussing in building their integration and to what degree. This concept was represented graphically as an arc with the direction of the segment indicating the upstream or downstream "leaning" or both, and the degree of the arc indication the extent of integration, hence 'Arcs of Integration' was coined:

Please see print copy for Figure 2.25

Figure 2.25: Arcs of Integration (Frohlich and Westbrook, 2001, pp. 187)

Frohlich and Westbrook (2001, pp. 188) then used eight 'integrative activities' and correlated them against nineteen business outcomes for each business.

The eight 'integrative activities' were (1) Access to Planning systems; (2) Sharing production plans; (3) Joint EDI access/networks; (4) Knowledge of inventory/mix levels; (5) Packaging customisation; (6) Delivery frequencies; (7) Common logistical equipment; (8) Common use of third-party logistics.

The nineteen business outcomes were (1) Market share; (2) Profitability; (3) Return on Investment (ROI); (4) Average unit manufacturing cost; (5) Materials and overhead costs; (6) Manufacturing lead time; (7) Equipment changeover time; (8) Procurement lead time; (9) Delivery lead time; (10) Inventory turnover; (11) Direct labour productivity; (12) Customer service; (13) Customer satisfaction; (14) Conformance quality; (15) Product variety; (16) Speed of product development; (17) Number of new products developed; (18) On-tine delivery; (19) Supplier quality.

The results of their analysis showed that their hypothesis "Companies with the greatest arcs of supplier and customer integration will have the largest rates of performance improvement" was "strongly supported". The sub-set of outwardly facing manufacturers clearly recorded greater rates of performance improvements in comparison to the inward facing group. The outward facing supply chain strategy also consistently outperformed the periphery, supplier and customer facing strategies. Whilst they did not take this study to the extent of developing a causal relationship (i.e. identifying root cause), they did nevertheless establish statistically that the relationship exists. Frohlich and Westbrook (2001, pp. 194) do offer some possible reasons for the relationship so identified. Mainly: (1) Better supply chain coordination reduces uncertainty and less uncertainty reduces over-production, waiting, transportation, unnecessary processing steps, stocks, motions and defects; (2) Supply chain cooperation leads to higher speed flows via improvement to bottleneck resources and flow paths; (3) There are more gains to be made the wider the area of improvement focus. Thus, if the whole supply chain is considered, then potentially greater ranges of improvements are possible.

Stock, Greis and Kasarda (2000, pp. 532), conducted a similar study to that above whereby they attempted to understand the relationship between enterprise logistics fit with supply chain structure and organisational performance. They received 75 usable responses out of 1000 questionnaires mailed and found a "clear positive relationship between operational performance and fit between logistics integration and geographical dispersion of a firm's supply chain.

The researchers studied specifically the alignment of logistics practices and supply chain architectures using the notion of 'fit'. There were two elements of supply chain structure considered i.e. (1) Channel Governance and (2) Geographical Dispersion.

Channel Governance was differentiated into networks, hierarchies and markets (Figure 2.26). Networks were defined as having strong supply chain links but low vertical integration; Markets were defined as having weak supply chain links and low vertical integration and Hierarchies were defined as high on both dimensions.

Please see print copy for Figure 2.26

Figure 2.26: Configurations of Supply Chain Channel Governance (Stock et al., 2000, pp. 535)

Geographical dispersion refers to the extent to which the elements in a firm's supply chain are located across a wide range of geographical regions.

Stock, Greis and Kasarda (2000, pp. 537) thus tested two hypotheses in their study:

H_1. Performance will be higher in firms achieving a fit between logistics integration and geographical dispersion; and,

H_2. Performance will be higher in firms achieving a fit between logistics integration and channel governance.

From Stock, Greis and Kasarda's research analysis, H_1 was strongly supported, whereas H_2 was found to be the opposite. For H_2, it was found that firms that employed either enterprise logistics *or* a network structure (but not both) had higher financial and service performance than firms characterised by both enterprise logistics *and* network structure. Also, firms that had one or the other were better than firms that had neither.

The authors explain that the different result for the channel governance case may be influenced by their view that enterprise logistics and network structure are similar in nature but opposite in tactics (Stock, Greis and Kasarda 2000, pp. 544). That is, a network relies heavily on social connections; enterprise logistics rely heavily on technology connections. The redundancy in communication and co-ordination mechanisms may create a confounding organisational burden.

Rosenzweig et al. (2003, pp. 438) introduce the concept of integration intensity and define such a construct to include not only 'outward facing' type integration but internal-to-the-organisation integration also. The authors (pp. 448, 450) corroborate the studies above and demonstrate a positive relationship between integration intensity and product quality, delivery reliability, process flexibility and cost. They also found a positive relationship between integration intensity and firms' economic performance (albeit the R^2 value for this was fairly low at 14%).

Enterprise logistics it would seem, works better when applied to a geographically dispersed supply chain where normal human social connections are harder to form.

Tellingly, the researchers conclude that the understanding of how supply chain structures and logistics interact may be as much about the social dimensions of supply chain design and the focal roles therein, as it is technologically determined. They go on to say that inter-organisational relationships and communications are examples of the human facets of supply chain management that need to be better understood. Such conclusions lead to the next section on social considerations.

Robertson, Gibson and Flanagan (2002, pp. 4026~4036) describe a structured and integrated planning and scheduling system via case study example. The model chosen by the authors is that conceived by a large Asia: Pacific based manufacturing company. The company has developed a multi-levelled planning and scheduling model starting at the *sales and operations planning* level through *master production scheduling*, *master scheduling* and finally detailed *unit scheduling*. Specific feed-forward and feedback linkages are described, as are the time periods, time 'rests' and level of product aggregation/disaggregation used at each level. Additionally, the authors developed a nested set of algorithms showing the inputs, processes and outputs for each planning/scheduling level. The authors conclude that whilst such linked processes contribute to better synchronisation and coordination of supply chain logistical processes, the actualisation is highly dependent on the social questions concerning relationships, communications, change and organisational mindset (Robertson, Gibson and Flanagan, 2002, pp. 4031).

A view proposed by van Donk and van der Vaart, (2005, pp. 107), is that the scope and level of integration found in modern day supply chains, is driven primarily by levels of uncertainty in demand of volume and product mix. With low levels of uncertainty on these dimensions, their view is that integration is by and large unnecessary. As uncertainty increases, then so does the need for cooperation and coordination. The latter two in turn enabled via integration. The writers also express the opinion that 'shared resources' will affect the level of supply chain integration. Their belief is that in the situation where a single supplier has multiple customers (their definition of 'shared resources') then integration will be more difficult because of the added complexities involved in trying to link many with one.

2.3.2 Social Considerations in Supply Chain Management

“The heartbeat of sustained competitive advantage springs primarily from ‘people-ware’ not from hardware or software.” (Tersine, Harvey and Buckley, 1997, pp. 4) The responsibility for the development of such ‘people-ware’ begins with organisational leaders (Tersine, Harvey and Buckley, 1997, pp. 5) and that at a human relationship level, leaders must foster intra- and inter-team relationships that are based on trust, respect, dignity and a certain amount of risk taking.

Trust and commitment thus are important for effective supply chain management to exist (Lee and Billington, 1992, pp. 65, Goffin et al. 2006, pp. 203). Trust is built through experiences that grow confidence in supply chain partners to do what they say and the availability of evidence confirming a willingness to forego opportunistic behaviour (Spekman et al., 1998, pp. 634). Commitment is the belief that the trading partners are willing to devote energy towards sustaining the relationship. That is, through commitment partners dedicate resources to sustain and further the goals of the supply chain (Spekman et al., 1998, pp. 647).

Using social exchange theory as their basis, Griffith et al. (2006, pp. 86, 88) present a supply chain relationship model comprising the main factors of procedural justice (perceived fairness of the SC process), distributive justice (perceived fairness of the SC economic outcome), long-term view, relational behaviours, conflict levels and satisfaction levels against SC performance. The results of empirical research conducted by the authors show quite reasonable support for their defined model.

From a social perspective, another important dimension for effective supply chain management is the role of the manager and the relationship between the manager and his or her team. In a hierarchical organisation, the master/servant mentality that typically exists stifles those features (talent, creativity and ingenuity) necessary for supply chain success (Tersine, Harvey and Buckley, 1997, pp. 5). The shift to a team focus however, represents a change in orientation from manager to leader. Instead of command and control managers, leaders create direction for the team members, clearly describe the expectations placed on the team and then motivate and inspire people to undertake challenges and changes that will lead to higher levels of performance on the team's key measures (Ford and Fottler, 1995, pp. 22~23). Leaders need to be coaches and mentors, not bosses, and must be capable of describing alternative futures in an inspirational manner. Consistent with the leader-as-coach model, leaders need to develop people's capabilities through promotion of learning and competency building. Equally important, leaders need to demonstrate active support and use recognition techniques in order to make the actual delivery of results an exciting experience for their people. (Tersine, Harvey and Buckley, 1997, pp. 5).

As an added emphasis to the importance of leadership, Deming (1986, pp. 59) promoted the belief that a key imperative for organisational leadership is to "drive out fear". Leaders must break down any atmosphere of fear and especially any anxiety or fear-of-failure behaviour that can quite often be initiated by change and uncertainty (Stacey, 1996, pp. 414). Stacey's description (1996, pp. 416~418) of the behavioural dynamics is depicted in Figure 2.27:

The 'Change Learning and Resistance' system is made up of a series of nested feedback loops. The rational loops in the centre operate when dealing with repetitive type situations or situations that are known and there exists fairly high levels of certainty around what is being addressed. In this type of environment, the outer loops "fade into the background" (Stacey1996, pp. 416~418). However, when situations arise that are new and/or different whereby uncertainty exists in regards to understanding the situation, knowing how to deal with it, the possible outcomes that may be generated, then it is the outer loops that come into play. When this happens leaders can no longer rely on their authority to deal with it. This is quite a dangerous time for leaders i.e. because of the nature of feedback loops, amplifications can occur leading to potentially unstable and perhaps even uncontrollable conditions (Stacey1996, pp. 416~418). Stacey's description therefore alludes to the importance not only of organisational politics, but also the issue of their intensity and volatility dependent upon the stability or otherwise of the current day business environment. In an uncertain, unstable environment therefore, such forces may negate any business advantage promised by a correct and appropriate *technical* supply chain solution.

Please see print copy for Figure 2.27

Figure 2.27: Change Learning and Resistance (Stacey, 1996, pp. 417)

As well as the emphasis being placed upon change and the need for involvement/engagement of people and teams, is a shift in scope of responsibility. With flatter organisational structures, the responsibilities between the compressed layers are becoming more obscure. An individual’s role is being broadened from narrow task scope to multi-functional to cross-functional, thus it is important to create an environment and a structure that is built on a culture of inclusiveness and collaboration and not one based upon exclusivity and isolation. In fully achieving organisational purpose and objectives there are a number of important predicates (Glazer et al., 1992, pp. 212~213) that can be summarised as:

- Combined knowledge of many people.
- Integration of business processes.
- Clear role networks.
- Clear understanding of the inputs, the product and/or service.
- Transformational steps and the outputs.
- Understanding other's functional perspective, and
- Appropriate interactions between relevant people.

Gattorna (2003, pp. 5~6) maintains that traditional organisation structures can be obstructive to developing necessary social competence in an organisation. That is, traditional hierarchical structures suffer often from poor and uncoordinated communications and the master/servant relationships in such structures can stifle creativity and innovation as mentioned above. Usual remedies to the hierarchy are flat 'downsized' structures (Griffiths, Elson and Amos, 2001, pp. 62). Whilst this remedy may save costs, it can force the loss of key middle managers that previously shouldered the responsibility for problem solving, change management and compliance with basic operational standards. In addition, such middle managers may be the 'keepers' of an organisation's 'people-ware' elements. If these are lost along with the middle manager(s), it may take the organisation a long time to recover (Griffiths, Elson and Amos, 2001, pp. 62).

Griffiths, Elson and Amos (2001, pp. 64), propose an organisational model for the enabling of true customer focus culture. In this model (Figure 2.28) the inverted structure ensure that the levels in each organisation that need to be communicating are indeed the ones that are. This communication alignment aids refinement of the value-proposition agreed between customer and supplier and the delivery of that offer. e- Technologies provide the rapid and visible communications necessary to assist the functioning of the model including rapid response to changing supply chain (including customer demand) conditions.

Some organisations have taken this concept beyond the generic stage and have applied it to the formation of customer cells focused on individual customers as opposed to customer or products groups (Griffiths, Elson and Amos, 2001, pp. 65). Such solutions are typified by (i) clear customer focus, (ii) tailored product/service provision, (iii) fewer intra- and inter-business demarcations and (iv) fast, reliable, cost effective communication systems.

Please see print copy for Figure 2.28

Figure 2.28: Customer-Supplier Interaction Model. (Griffiths, Elson and Amos, 2001, pp. 64)

In addition to organisational leaders, there are other levels of the organisation whose jobs and job requirements can dramatically impact an organisation's ability to deliver customer value and satisfactory business outcomes. For example, classical descriptions of the plant manager's role (Westbrook, 1995, pp. 6) "emphasise planning, organising, controlling, strategic thinking and problem solving – a cerebral, logical, and above all, orderly set of activities." Observations of such managers at work however have shown that their work is "tactical, reactive, sometimes frenetic and with little time spent on planning or policy development." (Westbrook, 1995, pp. 6) Such managers are subject to "constant interruptions, hold short face-to-face meetings that flit from topic to topic and respond to the initiatives of others far more than they initiate themselves." In such circumstances, the managers usually "compromise rather than optimise" (Westbrook, 1995, pp. 7). The nature of the work in a volatile production or market environment then, often becomes reactive and stressed.

In the manufacturing companies studied by Westbrook (1995, pp. 9), disturbances were "an inevitable aspect of the environment." Such disturbances were caused by instabilities in the overall production and supply chain processes and in turn the instability was induced by *variety, variation and volume*. Differing product types and process routings caused the main variety instabilities. Variation was observed in customer demand levels, lead-time and delivery reliability of supplies, product quality, transport availability and plant and people performance (Westbrook, 1995, pp. 9). Volume instability was associated with order levels, number of order items in progress and information requirements (e.g. product/order enquiries, order information, plans, schedules, reports, product information, customer requirements, product specification, product analysis, properties tolerance limits, despatch documentation, invoices).

In addition to the abovementioned instabilities, production managers are often confronted with conflicting priorities. For example, on one hand a manufacturing plant may have a very clear volume target to meet. This can be volume per hour, per shift (turn), per day, per week etc. On the other hand, customer due dates may also have a high priority for the same manager. Senior management may indeed want both targets to be met and reinforce this with reward/incentive programs. In this environment, the plant manager must make a trade-off between service level, and productivity goals. Westbrook (1995, pp. 12) terms this trade-off process 'priority management' and defines it thus:

"Priority management is the allocation of resources, or the expression of preference, to specific order or order groupings (whether supplies, production, or customer orders), in response to current pressures on operational productivity and/or customer service, with the aim of relieving those pressures while at the same time promoting, or minimising the deleterious impact upon the wider economic and strategic goals of the company."

Regrettably, the attitudes and measures of the various functional groups responsible for managing supply chain processes in most 'traditional' companies are not always aligned; indeed there is often conflict that impedes integration across the chain (Stevens, 1989, pp. 3). Fellow members of the same supply chain can often be viewed as the enemy rather than a valued partner (Macbeth and Ferguson, 1994, as in Towill and McCullen, 1999, pp. 85). For example, in their case study paper on APS Berk Pharmaceuticals, Belk and Steels (1998, pp. 129) describe their desire to replace the "adversarial and subjective "win-lose" demand-arbitration process with a "win-win", policy driven and objective system" in their efforts to improve that company's supply chain management processes. They go on to explain that the largest hurdles they had to overcome with their work, were not so much to do with "system bugs or data errors", but rather unacceptance by the operatives that changes were necessary. They found it necessary to educate the operatives both in terms of the new system and the new culture it required and they also needed to overcome the "pure resentment" that some of the operatives had arising from fear and suspicion that the changes were aimed primarily at erosion of their empires (Belk and Steels, 1998, pp. 133). Although the value of better human relationships is difficult to calculate in terms of absolute supply chain performance, there is little doubt that this can enable enormously effective supply chains, that competitors find very difficult to emulate.

A number of writers have proposed socio-models based upon research they were part of or from organisational encounters they have experienced. For example and firstly, The 'Good-To-Great' research team (Collins, 2001, pp. 8) studied 11 companies they had identified as transitioning from a 'good' level of performance to a 'great' level of performance (cumulative returns at least 3 times the market for 15 years beyond a transition point). From that analysis, the research team identified 7 factors that they concluded were common to the 11 'great' companies. The 7 factors identified (Collins, 2001, pp. 12~13) can be summarised as:

1. Level 5 Leadership – Self-effacing, quiet, reserved, determined, competent and present (in attendance) leaders.
2. Having the 'Right People on the Bus' – Skills, competencies, attitude - fit with job.
3. Confront the Brutal Facts – Confront current reality whilst never losing faith that one (and/or many) can and will prevail.

4. Hedgehog Concept – What is it that the organisation can be best in the world at? Is the organisation passionate about that? And, can the organisation make any money out if it? Using that knowledge to guide all organisational efforts.
5. Culture of Discipline – Not “tyrannical disciplinarians”, but rather disciplined people, disciplined thought and disciplined actions.
6. Technology Accelerators – A “crawl, walk, run” approach to the application of relevant technologies. Technology is used as an accelerator of momentum, not a creator of it.
7. Turning the Flywheel – Sustained ‘Good to Great’ doesn’t happen overnight, rather it is a cumulative process, step by step, action by action, turn by turn of the flywheel, building momentum.

A number of these factors are ‘people-ware’ related i.e. numbers 1, 2, 3, part of 4 and 5 can be categorised as socio-related factors.

Secondly, Kouzes and Posner (2002, pp. 22) propose a 5-practices/10-commitments leadership model they describe as important to successful organisational performance. Their model in summary can be viewed as:

1. Model the Way – Firstly ‘find voice’ by clarifying personal values, then set the example by actually living by those values.
2. Inspire a Shared Vision – Imagine exciting possibilities for the future. Enlist others in that vision.
3. Challenge the Status Quo – Search for improvement opportunities, experiment and take some risk, strive for small wins to begin with.
4. Enable Others to Act – Actively enable collaboration and empower others to achieve their objectives.
5. Encourage the Heart – Actively recognise individual achievement and especially excellence. Celebrate wins and build a spirit of community.

Lastly, Senge (1994, pp. 6~10) outlined 5 'disciplines' important to organisational performance. The 5 disciplines can be summarised as:

1. Shared Vision - A shared picture of a future desired state.
2. Common Mental Models – Internal pictures and assumptions of how things work. Common understanding of what has to be done to achieve the shared vision and how to go about it.
3. Personal Mastery - Commitment, diligence, professionalism, take their job seriously, customer focussed, performance orientated, continuously improving, up-skilling and learning.
4. Team Learning - Working openly, collaboratively and energetically as a team, inclusive of others, share information, share best practices, remember and apply what works and what doesn't work, adopt and adapt the ideas of others.
5. Systems Thinking - Integration of the first four disciplines into a coherent set of sustained practices.

2.4 Analytical models

Arising out of the literature review, 3 main theoretical models were derived for subsequent testing.

From the work of writers such as Lummus and Alber (1997), Lambert and Cooper (2000) and Simchi-Levi (2000), a set of supply chain focus attributes were defined and captured in questions 17 to 26 of the questionnaire (Appendix 3). Similarly, for writers such as Zimmer (2002), Stevens (1989), Fisher, Raman and McClelland (2000), Frohlich and Westbrook (2001) and Stock, Greis and Kasarda (2000), a set of supply chain integration and information related aspects were described in questions 27 to 39 of the questionnaire. From the work of the writers shown in section 2.3.2 above, a set of socio-dimensions were depicted in questions 40 to 48 of the questionnaire. These questions i.e. 17 to 48 were the independent variables of this study. The dependent variables were defined (as shown at questions 7 to 16 of the questionnaire) from the work of writers such as Evans and Danks (1998, pp. 21), Chase, Jacobs and Aquilano (2004, pp. 29) and the Supply Chain Council (2001, pp. 6).

The theoretical frameworks were developed including identification of the dependent, independent, possible moderating and intervening variables. Three different relationship models were developed in the following manner: (a) relevant variables from the literature review were identified and labelled, (b) descriptions were made of how the variables relate to one another, (c) the nature and direction of the relationships were theorised, (d) explanations were recorded as to why those relationships could be expected, and (e) schematic diagrams of each model proposed was drawn.

Few of the above writers make any attempt to draw structural models of the relationships between the variables they describe and include. And so the 3 frameworks proposed below, represent structural relationships that have not been specifically addressed in previous research in the manner shown:

Please see print copy for Figure 2.29

Figure 2.29: Theoretical Framework 1 – Groups of Independent Variables Influencing Separately the Dependent Variables

Please see print copy for Figure 2.30

Figure 2.30: Theoretical Framework 2 – One Group of Independent and Groups of Intervening Variables

Please see print copy for Figure 2.31

Figure 2.31: Theoretical Framework 3 – Two Independent and One Intervening Variable

2.5 Research Questions

The primary and secondary questions arising from the research submission, the literature review and the proposed frameworks above therefore are:

Primary research question:

How much and in what ways does the integration of supply chain logistics processes in manufacturing organisations impact upon business performance?

Secondary research questions:

How much and in what ways does the application of underlying supply chain principles impact upon supply chain and business performance?

How much and in what ways does the application of socio-principles and practices impact upon supply chain and business performance?

2.6 Hypotheses

H_1: That the *integration* of supply chain logistics *processes* does significantly and positively impact supply chain and business performance.

H_2: That the *application* of supply chain management *principles* does significantly and positively impact supply chain and business performance.

H_3: That the *application* of *human 'social' principles/approaches* does significantly and positively impact supply chain and business performance.

2.7 Literature Review Conclusions

At the beginning of this literature review chapter, it was mentioned that supply chain management as a concept has progressed from the notion of single-entity competition to that of supply chains competing against other supply chains. In doing so, the importance of customer focus and an unending ambition that all organisational activities are targeted in some way towards the delivery of customer value was emphasised. Indeed, one of the key assumptions of Lean Manufacturing as described in the chapter, is that if any activity or process is being conducted for a reason other than to deliver value to a customer then it should not be conducted; it should be stopped.

In order to excel on the requirement of customer value delivery, organisations must undertake to build up their capabilities and competencies. These are both technical capabilities and competencies and socio ones also. A range of improvement programmes are now available to assist organisations in their pursuit of such goals, these were also covered in the review above.

Stadtler captures the essence of supply chain management in his supply chain ‘house’ analogy as displayed at Figure 2.32. The goals are shown on the roof of the house supported by the two pillars ‘integration’ and ‘coordination’ and resting on a foundation of key functional competencies.

Please see print copy for Figure 2.32

Fig. 2.32. House of SCM (Stadtler, 2002, pp. 10, as in Stadtler, 2005, pp. 576)

To the immediate discipline and the question of supply chain process integration, it was described how many organisations such as at National Semi-Conductor, Wal-Mart and Procter & Gamble have embraced the concept of supply chain process integration in order to improve their competitive position and hence their business performance. Included with the technical aspects of this process integration are the supply chain social considerations also. Many writers remark on the socio related difficulties that organisations face with respect to the actualisation of technical solutions to supply chain (or overall business) improvement (Macbeth and Ferguson

(1994) as in Towill and McCullen (1999), Belk and Steels (1998), Shapiro (2001)).

Finally, the literature review findings were interpreted into a set of relevant dependent and independent study variables and the underlying relationship structures were conceptualised as the three theoretical frameworks shown above. Additionally, 3 specific research questions and 3 main research hypotheses were developed for testing.

The next chapter considers the detail of the methodology of this study. That is, the methods of data collection, data entry, data checking, data analysis and simulations undertaken. Also included in the methodology chapter are the ethical considerations for this work and a conclusion to the chapter.

3 Chapter 3 – Methodology

3.1 Introduction

The previous chapter presented a review of the literature relevant to the topic of this thesis. The development of supply chain management as a discipline was explained. Within that discipline, the importance of customer focus, the need to build organisational competence and capabilities to deliver customer value and the main improvement techniques available were described. The immediate discipline of supply chain process integration including the socio and technical aspects of this were discussed. This coverage lead to the description of the theoretical frameworks, the research questions and the research hypotheses proposed for testing.

The area of research interest for this study was identified from observations the researcher made in the field of supply chain management (SCM) over the decade of the 1990s. Changes in attitudes and style of supply chain operation in manufacturing organisations began in the late 1980's and gathered momentum throughout the 1990s (Porter, 1990, pp. 41, 42). This followed early thought leaders such as Stalk (1988) and Stevens (1989) and the example set by the pioneers of SCM such as Wal-Mart and Toyota. The establishment of the Supply Chain Council by AMR and others in 1996 provided an industry forum where such approaches could be (and were) developed.

A literature review was conducted on both the parent discipline of supply chain management and the immediate discipline of the integration of supply chain logistics processes. This review was conducted electronically using search methods of on-line databases and journals. The main journals interrogated were; (i) Journal of Operations Management, (ii) Production and Operations Management (POMS), (iii) International Journal of Logistics Management, (iv) International Journal of Operations and Production Management, (v) International Journal of Production Economics, (vi) International Journal of Production Research, (vii) International Journal of Agile Management Systems.

This chapter therefore, describes the methodology to be used in undertaking that testing including justification for the methodology, details of the methodology itself, ethical considerations for the research and chapter conclusions.

The methodology described is one consistent with a correlational, hypotheses-testing cross-sectional field-study (Sekaran 1992, pp. 98~112). Details of the data collection process used are provided including the unit of analysis and pilot studies undertaken. Questions to do with reliability and validity are addressed.

Data checking processes followed are described including data transformations, recoding techniques used for reverse questions and a discussion around the missing data found in the survey response.

Finally, the main data analysis techniques used are outlined including discussion as to why such techniques were selected over others.

3.2 Justification for the Methodology

Real-life constraints on access ability to operating supply chains as discussed at section 3.3.2 below, guided this study towards a minimal interference, non-causal correlational hypotheses testing model. A description of the main study dimensions of this work therefore can be seen at Table 3.1. The justification for the selection of the study descriptors shown in the table is taken from relevant research methodology literature. For example Sekaran (1992, pp. 98~112) describes with the use of examples the approach to be used with a study and set of research questions such as this. The answers provided under the heading 'Description' in Table 3.1 were developed using the guidelines provided in this reference. Additionally, Baker (1991, pp. 30~40) provides a similar coverage of the research methodology parameters that must be considered in undertaking an analysis of this type. The main research processes used in study therefore are consistent with a correlational, cross-sectional, hypothesis testing type study as recommended by the literature for the hypothetico-deductive quantitative approach used in the study (Sekaran 1992, pp. 15~20).

Study Dimension	Description
Purpose of the study	Hypothesis testing
Paradigm	Positivist
Type of investigation	Non-causal, correlational study
Extent of researcher interference	Minimal
Study setting	Non-contrived, field study
Unit of analysis	Organisational level
Sampling design	Stratified random sampling, 1050 supply chain professionals targeted
Time horizon	One-shot, cross-sectional study
Data collection method	Mail-out survey questionnaire
Measurement of Variables	Element definition, continuous and ordinal variables (5 point Likert scales)

Table 3.1: Description of the Study's Main Characteristics

3.3 Methodology Used

3.3.1 The Purpose of the Study

The purpose of this study is to try to understand and explain the nature of the relationships that exist among the supply chain and business outcome related variables considered. The variables used in the study were identified from the literature review as being those variables most needed in order to answer the research questions posed at section 2.5 above.

3.3.2 Type of Investigation

Ideally, the researcher for this work would have preferred to identify *cause* for the observed variation to the business outcome variables considered. However such a casual study would require some level of field experiments. However, it is considered that operating supply chains are the lifeblood of most manufacturing businesses and so to obtain senior executive approval to experiment with manipulations on their live supply chains (especially where this may involve several companies along the same chain) was considered highly unlikely. Lab experiments could have been used to undertake a causal study, however questions would have been raised about the relevance of a small one-off laboratory study to a complex and dynamic supply chain world. As the identification of specific *cause* for the questions asked was therefore beyond the resources available to the researcher, a correlational field study type, utilising a minimal interference industry survey, was selected.

3.3.3 Unit of Analysis

For the majority of the data analysis, the individual responses to the survey are used as an individual data source. The exception is the analysis of variance (ANOVA) where the responses are grouped in accord with the organisational descriptor variables. These variables are shown as questions 1 to 6 in the questionnaire (Appendix 3).

3.3.4 Time Horizon

This was a once-off data capture cross-sectional study. The survey questionnaire was sent out during June 2004 and the responses received back from July 2004 until September 2004.

3.3.5 Measurement of Variables

The variables used in the study can be defined from the individual questions asked in the questionnaire.

To obtain some idea of the nature of the organisation being surveyed, a number of descriptor variables were asked at the beginning of the questionnaire i.e. questions 1 to 6 sought information as to the type of industry, the location, facilities dispersion, level in the organisation etc. Questions 1 to 5 were scaled as nominal variables and question 6 (annual sales) was scaled as a continuous (or interval-scaled) variable. Because of the fairly straightforward nature of the content of these questions, no individual definitions or clarifications were provided.

Questions 7 to 16 are the dependent or outcome variables of the study. They were derived from the literature review and in particular from the work of writers such as Evans and Danks (1998, pp. 21), Chase, Jacobs and Aquilano (2004, pp. 29) and the Supply Chain Council's SCOR model (2005, pp. 8) as explained in section 2.4. Questions 7 to 14 are scaled as continuous variables; question 15 (product costs) is scaled as an ordinal variable. For each of these questions, a definition of the term was included in the questionnaire and where appropriate an equation for the variable was listed with the question.

Questions 17 to 26 represent the operationalisation of the supply chain principles related independent variables. Again, these were derived from the literature review. Question 17 was scaled as a nominal variable (4 unscaled alternatives) and questions 18 to 26 were scaled as 5-point Likert scale ordinal variables. To assist respondent's interpretation of terms, a diagram of the different supply chain operating principles tested was included for question 17. Again, because of the relatively straightforward nature of questions 18 to 26, no definition of terms used was supplied for these questions.

Questions 27 to 39 represent the operationalisation of the levels of integration of supply chain logistical processes related independent variables. They were also derived from the literature review. All of these questions were scaled as 5-point Likert scale ordinal variables. To assist respondent's interpretation of these questions, 2 diagrams were included at the beginning of the section and clarification comments were also added to individual questions to minimise misunderstanding and/or ambiguity.

Questions 40 to 48 represent the operationalisation of the supply chain logistics personnel socio-related independent variables derived from the literature review. All of these questions were scaled as 5-point Likert scale ordinal variables. To assist interpretation of these questions, clarifying descriptions were added to 5 of the 9 questions.

3.3.6 Validity

Content Validity – Content validity exists when the scale items actually represent the domain of the concept being measured. Content validity was assured in two ways. Firstly, the comprehensive literature review was relied upon to provide indicators of the concepts tested. Secondly, a number of redundant type questions were included in the questionnaire that were related to the same concept in order to test for cross-correlations. Questions testing the same concepts were 7 & 8, 9 & 10, 11 & 12, 13 & 14, 19, 21 & 25.

Criterion Validity – This exists when the measure adequately differentiates results on a criterion it is expected to predict. Concurrent validity was tested for during data analysis to determine if the scales discriminate between individual or between groups of individuals e.g. from different manufacturing industries on the same criterion. As shown in the results of the ANOVA analysis in Chapter 4, such discriminations were achieved. Criterion Validity was also established via the results of the structural equation modelling where dependent variables were explained by independent variables.

Construct Validity – This exists when the results from the use of the measure fit the theories it was designed around. Factor analysis was primarily relied upon to test for construct validity. As can be seen from the results of the factor analysis in Chapter 4, construct validity was established via the clear differentiation of factor loadings between groups of variables *not expected* to be correlated, and, particularly the case for the dependent variables, high factor loading levels were achieved on those variables that *were expected* to be correlated (as listed in Content Validity above).

3.3.7 Reliability

The reliability of a measure is how well the concept in questions is being measured. That is, validity asks are we measuring the right thing and reliability asks how accurately and consistently are we measuring it.

The inter-item test of reliability used in this study was Cronbach's alpha. Cronbach's alpha values were calculated for those variables considered to be indicative of the same concept. Cronbach's alpha values of 0.625 to 0.864 were calculated for pair variable comparisons (e.g. reflect square-root Delivery performance Vs reflect square-root Perfect Order Fulfilment). Sekaran (1992, pp. 287) describes Cronbach's alpha values of <0.6 to be indicative of poor reliability, between 0.6 and 0.7 as acceptable and > 0.7 indicative of good reliability.

3.3.8 Data Collection Methods

The primary data collection method for this study was an industry survey questionnaire. This method was chosen over other methods (such as interviewing or direct observations) because of the advantages it offers concerning available time for respondents and the researcher, convenience for the respondents, geographical area coverage, energy levels required and costs (Sekaran, 1992, pp. 189, 201).

The style of questions asked in the questionnaire was shaped by the nature of the variable investigated. That is, where objective variables such as geographical location, manufacturing industry or annual sales were involved, then a single direct question usually with a nominal or ordinal scale was used. Where the questions involved variables that were more subjective in nature where for example the respondent was asked to give their estimate for say the level of 'team learning' then a Likert scale was used and supported by descriptions, definitions and diagrams (concerning the question) in the questionnaire. All of the questions in the questionnaire were closed questions. The 5-point Likert scale was selected for questions 18 to 48. The 5-point scale was used because previous research has indicated that 5 points is just as reliable as 7 or 9 points (Elmore and Beggs, 1975, as in Sekaran, 1992, pp. 168).

In order to prevent the respondents mechanically ticking one side of the Likert scale questions, 12 out of 31 of the questions were worded negatively. None of the questions were worded as a leading question or expressed in emotional terms or cast in terms of social desirability.

The sequencing of the questions in the questionnaire was such that the 'Part I' questions were made up of the more general and easier business descriptor questions followed the dependent variable questions. The ‘Part II’ supply chain principle questions followed, then the ‘Part III’ supply chain logistics process integration question and lastly the ‘Part IV’ logistics personnel socio consideration questions.

Respondents were given the opportunity to add their name and email address to the survey if they wished to receive a copy of the aggregated results of the study.

Brief instructions were added to the 2nd page of the questionnaire (the first page a title page) and the questionnaire was printed off on lilac coloured paper in order to improvement its visual appearance.

Following 2 web based survey attempts (discussed below) and a formal questionnaire interview review (undertaken by fellow student in a survey design class), both the original questionnaire and the individual questions were simplified and clarifications added to the questionnaire to make the questions less ambiguous. Again, based upon feedback from these activities, the length of the questionnaire was curtailed such that a respondent could complete it in around 15 minutes. This time limit was considered a go/no-go test for many potential respondents.

The population frame for this study was essentially manufacturing companies worldwide. The individual elements within that frame were supply chain practitioners with titles such as: VP (or Manager or Analyst) Logistics, VP (or Manager or Analyst) Supply Chain, VP (or Manager or Analyst) Materials, VP (or Manager or Analyst), Operations Planning (or Production Planning). The sample frame was defined by the use of seven separate address lists. These lists were interrogated in order to identify target participants (only supply chain practitioners were used from the lists, therefore industry consultants and educators who are also members of the associations involved, were not included). The address lists were: (i) US based Supply Chain Council, (ii) International Iron and Steel Institute, (iii) South East Asia Iron and Steel Institute, (iv) Lean Network (Aust.), (v) Australian branch of an international consulting firm, (vi) Yahoo Finance web site (including Hoovers.com) and (vii) BlueScope Steel. This sample design used was used primarily out of necessity. That is, attempts at a simple random sampling design using the Internet based survey simply did not work. The availability of extensive address lists necessary to support a mail out survey using a truly random sampling design is very limited without considerable expense. The sampling design used for this work therefore can be appropriately described as non-probability quota sampling. By definition this limits the generalisability of the research findings (Sekaran, 1992, pp. 236), however this concern must be balanced by the fact that 7 separate address lists were used covering a range of industries, geographies, facility types, size and practitioner types across 210 usable responses as evident in the descriptive statistics results shown in Chapter 4.

A sample size target for the survey was set at 200. This number was chosen after due consideration of the level of 'statistical power' required against the cost and time constraints concerning data collection. Hair et. al. (1998, pp. 12) suggest target levels for power to be 80% with alpha levels of at least 0.05. For a sample size of 200 therefore, a power level of 99.8% would be possible if the 'effect size' (the difference of means between groups or the correlations between variables) was moderate (0.5). For the same 200-sample size, a power level of 52% would be possible if the effect size was small (0.2). Hair et al. go on to describe (pp. 11): "As one would expect, a larger effect is more likely to be found than a smaller effect, and thus to impact the power of the statistical test." In addition, Sekaran (1992, pp. 253) suggests that for most research, sample size should be >30 and < 500. Further, for multi-variate research, the sample size should be at least 10 times as large as the number of variables in the study. Taking the results of the principle components factor analysis conducted for the study, the variables were reduced to 8 independent variates and 5 dependent variates giving a total of 13 thereby giving a result of (10 * 13 = 130) thus satisfying the guideline.

The process followed in obtaining the survey result can be described as: Initially, a web site was set up and a pilot study was undertaken with 50 target participants whereby the participants filled out the questionnaire on-line and then submitted the results back to the web site. 11 participants responded to this pilot study. In addition to the responses to the individual questions, follow-up telephone interviews with 7 of the 11 respondees were undertaken in order to assess their reaction to the questionnaire. Their responses to the pilot questionnaire were consistent i.e. (i) the questions were too 'intense' (a lot of assumed knowledge was required in order to complete them), (ii) the questionnaire was too long, (iii) the website suffered technical problems (sometimes could not be 'opened' successfully). The questionnaire was therefore shortened and simplified and another web based survey undertaken. This time over 1000 enquiries were made to the email addresses of international manufacturing companies selected randomly with a request that the email be forwarded to the equivalent of the Vice President Supply Chain. In addition, the Supply Chain Council emailed a request to its practitioner membership as did APICS (Aust.) and the Lean Network (Aust.). Only 19 responses were received from this attempt. It was decided therefore to attempt a mail out survey.

In order to improve the response rate for the mail out survey a number of techniques were adopted i.e. (i) a pre-notification letter was mailed to each target participant introducing the researcher, explaining the purpose and the methodology and advising them that the questionnaire was to be posted to them 1 week later. It was carefully spelt out that they were under no obligation whatsoever to respond and that if they did respond that their responses would be kept confidential and the results published only in aggregate form. A small incentive list was also described to them whereby they would go into a draw for a number of prizes should they complete and return the survey. One week later the questionnaire itself was mailed to the targets including a survey letter, a return address envelope prepaid for Australian respondees and with a postage remittance chit for international respondees. One week after that, a follow up letter was mailed to each target. Using this process, 1050 target respondents in 990 separate companies received 3,150 letters over a period of 3 weeks.

Many responses to the letters were received between the time of sending the pre-notification letter to the time of sending the follow-up letter regarding advice that the person sought had left the company or that the letters should be redirected to more appropriate officers. As each such advice was received the mailing list was updated. Completed survey questionnaires began to arrive at the return postal address (University of Wollongong, Wollongong Campus) one week after the survey letter was sent and continued to arrive up until 3 months later (albeit the bulk (75%) were returned within 6 weeks). Considerable time was spent following up on obvious returned-survey errors and omissions. Such follow up took place mainly via email and in some cases via telephone. The data was initially entered (manually typed) into

Excel and later imported into SPSS when that software became available on the researcher's PC.

3.3.9 Data Analysis

Editing the Data – Each returned questionnaire was inspected to assess its suitability for use in this study. Some respondents missed whole pages of questions; some missed one or two questions. Some answered almost every Likert scale question in the middle of the range (i.e. 'neutral'). Some entered responses that seemed to be unreasonable (too high a value or too low a value). For every 'anomaly' found whereby the respondent had supplied their name and/or their email address, follow up was undertaken with them in order to clarify/correct the issue. Approximately 75% of respondents replied to such follow up requests, however their response times were long (2 to 5 weeks) and invariably required reminders before they responded. Post the data editing, 215 completed questionnaires were available for coding and data entry. Common non-response items were question numbers 8: Perfect Order Fulfilment, 14: Cash-to-cash Cycle Time, 15: Product Costs and 16: %Return-on-Capital-Margin.

Coding the Data – For questions 1 to 5 and 17 the answers were simply coded using integer numbers starting at 1 for the top of the list response and 'n' for the 'n$^{th'}$ response. So taking question 3 as an example, 'Food, beverage and tobacco manufacturing' was coded as '1' and 'Other manufacturing' was coded as '10'. For questions 6 to 14 and 16 (continuous variables) the as supplied numbers from the survey questionnaires were used. For question 15 (product costs), 'Lower ¼' was coded as '1' through to 'Upper ¼' coded as '4'. For questions 18 to 48, the Likert scale responses were coded as '1' for 'Strongly disagree' through to '5' for 'Strongly agree'.

Recoding Variables – Negatively worded questions (as explained in section 3.3.8 above) were recoded such that their scale orientation was consistent with the other questions. Questions 1 and 2 were also recoded such that the larger entity and the higher organisational level received the higher code value.

Transforming Variables – All of the variables were assessed for normality and 7 of them were found to be substantially skewed. Thus 'Delivery Performance' and 'Perfect Order Fulfilment' were transformed to their 'reflect square root' result, 'Manufacturing Lead-time', 'Offered Lead-time', 'Time to Respond to a 20% Demand Increase' and 'Time to Respond to a 20% Demand Decrease' were all transformed to the log equivalent value and lastly 'Days of Inventory' was transformed to its square root equivalent value.

Missing Data – In order to minimise the effect of missing data, the SPSS feature 'Exclude cases pair-wise' was used. This feature does not calculate replacement vales for missing data, rather it considers each data pair before deciding to use or not use the record as opposed to elimination from analysis of a record with any missing values.

Descriptive Statistics – Mean, standard deviation, skewness, std. error of skewness and range were calculated for each continuous variable in the data. Frequency, mean and standard deviation were calculated for each nominal and ordinal variable in the data. Histogram plots with superimposed normal curves were constructed for all variables in the data. These results and their discussion are presented in Chapter 4 below.

Analysis of Variance (ANOVA) – An analysis of variance was conducted on the data using the business descriptor variables at the beginning of the questionnaire (questions 1~6) as the factors tested. That is, the ANOVA technique was used to determine if any significant difference existed in the data between these descriptor variable groups.

Factor Analysis – Principal components factor analysis was used to reduce highly related factors to fewer underlying constructs. For most cases, factors were extracted with an eigen value of ≥ 1.0. The exceptions being the dependent variable factors where eigen values of ≥ 0.974 were used as this improved the 'sensibility' of the factor analysis. Cut off for the factor loading was set at 0.40 per the factor loading statistical significance (0.05) guidelines specified in Hair et al., (1998, pp. 112) for a sample size of 200.

Structural Equation Modelling (SEM) – In order to test for strengths of possible relationships and to confirm the structure of those relationships, structural equation modelling was used. "SEM models consist of observed variables (also called manifest or measured variables) and unobserved variables (also called underlying or latent variables) that can be independent (exogenous) or dependent (endogenous) in nature (Shah, Goldstein, 2006, pp. 149)." SEM was chosen because of its ability to examine a series of dependent relationships simultaneously and to do so comprehensively (Hair et al., 1998, pp. 578). SEM is mostly a confirmatory technique (Tabachnick and Fidell, 2001, pp. 659) in contrast to exploratory factor analysis and so is ideal for testing hypothesised relationships among variables.

SEM path analysis was conducted firstly on the manifest variables of the study whereby each of the 'Part II' 'Part III' and 'Part IV' independent variables was regressed against all of the dependent variables. AMOS 5.0 software was used to perform these analyses. A feature of AMOS 5.0 called 'Specification Search' was used to confirm the theoretical frameworks 1~3. Specification Search is a technique available in AMOS 5.0 that enables the researcher to identify nominated pathways in any given model. For a n^{th} pathway model, AMOS 5.0 then carries out 2^n iterations to test all combinations of those specified pathways and presents a series of goodness-of-fit measures that can then be interrogated to identify the best-fit pathway configuration within a given (hypothesised) model design.

For the theoretical framework 1, both manifest variable model runs and factor score (obtained from factor analysis explained above) model runs (using 'Specification Search' and the same model structure) were conducted. This was undertaken to ensure that all-important individual manifest variable relationships were captured for this framework. Manifest variable runs were *not* conducted for the theoretical frameworks 2 and 3, as the resultant models were very complicated and beyond the limitations of the hardware and software available. Factor score runs (fewer constructs) were therefore used to confirm theoretical frameworks 2 and 3.

3.3.10 Simulation

Simulation is a technique used to reproduce the behaviour of a system (Krajewski and Ritzman, 1992, pp. 875). This usually involves the development of a descriptive model of the process to be simulated. Input variables (influence variables) can then be changed to assess the impact on output variables (effect variables).

There are two main types of simulation techniques available to researchers. I.e. *deterministic* simulation describing a system's dynamic behaviour and *stochastic* simulation (sometimes called Monte Carlo simulation) that models random variations to input parameters. (Shapiro, 2001, pp. 463). The type chosen for this research was deterministic simulation (a) because randomness was not a prime consideration of this work and (b) the construction time and complexity required of a stochastic model were beyond the time constraints of the researcher.

Deterministic simulation involves *state* variables that describe the system over the simulation time period. Equations are used to determine how these state variables change over time and/or under the influence of other state, data or decision variables. Such models therefore assist the interpretation and understanding of complex systems including structure, lag and feedback effects (Shapiro, 2001, pp. 463).

Simulation was undertaken so that the study results can be visualised and made available to practitioners and educators in an easy to understand environment and in a model that will replicate the major findings of the study.

Simulation was used instead of optimisation techniques because the relationships between the variables in the study are reasonably complex and non-linear. Simulation was also used for this work as it offers a technique to conduct extensions to the research without disrupting real systems as discussed at 3.3.2 above. Simulation analysis also enables *time compression* whereby outcome estimates can be gained (assuming a reasonably robust representation of the system being modelled exists) in a fraction of the time required for data gathering from an on-line system.

The concept of Systems Dynamics was used to construct a simulation model of the results of the data analysis undertaken for this study. Details of this approach, the software and model infrastructure used are describes at Chapter 5 below.

3.4 Ethical Considerations

Throughout this study care has been undertaken to ensure that appropriate ethical standards have been observed. For example, in attempting to influence individuals to participate in the research, no coercion or social pressure was used. Questions design was carefully considered so that emotional statements were avoided and to ensure that no demeaning questions were asked (Sekaran, 1992, pp. 125).

For all initial interactions with participants and potential participants, the true purpose of the research was defined in both the pre-notification letter and the survey letter sent to them. This purpose was not altered during the course of the research.

None of this research involved experimentation of any kind with any of the participants or target participants.

It was carefully explained to the participants in each of the letters sent to them that participation in this research was optional and that it was their decision as to whether they did so or not. They were advised however, that should they agree to participate, then the results they provided would be used as part of the study data analysis including publication of the results in aggregate.

The undertakings given to participants whereby their individual responses would be kept confidential and the results only published in aggregate have been honoured.

No control groups were used in the study and so the withholding of study results from control groups was not an issue for this work.

Finally, approval from the University of Wollongong's Ethics Committee to undertake the study's survey was sought and given.

3.5 Conclusion

This chapter has considered the methodology used in the study. Included in the chapter is a justification for the methodology, details of the methodology itself, ethical considerations for the research and chapter conclusions.

The justification for the methodology centres on the nature of the hypothetico-deductive quantitative approach used in the study. As explained, this is not a causal study and so the methodology described is appropriate for a minimal-interference hypothesis-testing study such as this.

Numerous dimensions to the nature of the questions, the data capture process and the data analysis techniques used were covered in this chapter. In addition, the type of and reasons for the simulations undertaken were described. Finally, the relevant ethical considerations were discussed.

The next chapter sees the application of the above methodology for the data analysis part of this work. That is, the processes described above are used to interrogate the data and to address the study's hypotheses and research questions.

4 Chapter 4 – Analysis of Data

4.1 Introduction

The last chapter explained the methodology used in this study. This chapter sees the application of the data analysis part of the methodology explained in Chapter 3. That is, the data analysis processes described in that chapter are used to interrogate the data and to both address the study's hypotheses and answer the research questions.

Following the data collection task (per method explained at 3.3.8 above), the first step in the data analysis process was to actually prepare the data for analysis. This involved editing the data, addressing missing data, entering the data, checking for data entry errors, recoding negatively worded questions and checking for normality and transforming non-normally distributed variables. Descriptive statistics were then used in order to obtain a 'feel' for the data, data reliability and validity were checked, an analysis of variance between relevant groups responding to the survey was undertaken and finally the data was interrogated for evident relationships using structural equation modelling (SEM).

Following the above, summaries of the results were produced in order to look for patterns of relationships. From these, conclusions with respect to the research hypotheses and research questions were drawn. Those conclusions are presented at the end of the chapter.

4.2 Data Analysis Subjects

4.2.1 Editing the Data

The data for this study was provided via a paper based survey questionnaire. Each of the returned questionnaires was thus edited manually. This involved firstly opening each envelope and checking the contents. Most of the returned envelopes contained only the questionnaire. Some contained the questionnaire and separate written notes that were provided by the respondents as clarifying statements. Of the overseas-to-

Australia returned envelopes, only 1 respondent requested reimbursement for postal costs.

Each returned questionnaire was checked for completeness and reasonableness. Completeness meant checking for missing answers and ascertaining if the respondent had provided contact information (name and email address). Reasonableness meant checking for values supplied in answer to each question to ensure that (a) the value supplied fell within an appropriate *range* (e.g. percentages ≤ 100%, lead-time days within reason of manufacturing industry relevant), and (b) that the *pattern* of response was reasonable (e.g. 1 respondent answered the majority of the Likert scaled variables as 'neutral', a pattern that represented an outlier to the other responses).

In each case where either answers were missing, or the value supplied to a question(s) appeared suspect, or the pattern of responses did not fit the majority of responses (or some combination of those outcomes) *and* a name or email address was supplied, then the apparent anomaly was followed up with the respondent concerned.

This whole process of data editing was tedious and very time consuming. Many people where follow-up was attempted were reluctant to respond. Some answered promptly, however the majority required additional follow-ups before they responded or did not respond to the follow up at all. The reasons for this was obtained from several of the respondents who stated that they were either too busy with other higher priority work, were waiting on others to supply them with data, were concerned about confidentiality of the information (not so much because they were distrusting of the researcher but rather because it was against their Company's policy to give out such information and they didn't want to get themselves into trouble), or they were simply not sure of the correct answer.

Once the data was edited to the extent possible, it was coded and then manually entered into Excel and checked for data entry errors. It was then copied into SPSS (when that software eventually became available on the researcher's PC after a long lead time on the order). The coding involved using integer numbers for categorical type responses using 1 for the first (top or left-most) response and 'n' for the 'nth' (bottom or right-most) response. So taking question 3 (manufacturing segment) as an example, ‘Food, beverage and tobacco manufacturing’ was coded as ‘1’ and ‘Other manufacturing’ was coded as ‘10’. For questions 6 to 14 and 16 (continuous variables) the as supplied metric numbers from the survey questionnaires were used. For question 15 (product costs), ‘Lower ¼’ (lowest costs) was coded as ‘1’ through to ‘Upper ¼’ (highest costs) coded as ‘4’. For questions 18 to 48, the Likert scale responses were coded as ‘1’ for ‘Strongly disagree’ through to ‘5’ for ‘Strongly agree’.

The data for negatively worded questions (i.e. question numbers 1, 2, 19, 20, 21, 22, 24, 25, 26, 36, 38, 40, 41, 45). The SPSS recode feature was used to obtain this result.

Some of the variables were found to exhibit non-normal distributions. Based on the shape of the distributions found (Tabachnick and Fidell, 2001, pp. 83) the non-normal variables were transformed as follows:

Question 7: Delivery Performance and Question 8: Perfect Order Fulfilment were transformed using the reflect square-root equation where: transformed variable = sqrt(k-x) where k = (max possible value of x) + 1 and x = untransformed variable value.

Question 9: Manufacturing Lead-time, Question 10: Offered Lead-time, Question 11: Time to Respond to a 20% Demand Increase and Question 12: Time to Respond to a 20% Demand Decrease were all transformed to log(x) variables.

Question 13: Days of Inventory was transformed to a sqrt(x) variable.

Checking for outliers resulted in 5 responses being removed from the sample. 1 on account of all ‘neutral’ responses to the Likert scaled variables and 4 on account of unique business types i.e. 2 shipbuilders, 1 submarine builder and 1 defence equipment assembler; all operating very long lead time, single-unit batch supply chains. This left a usable sample of 210 responses.

4.2.2 Statistical Techniques Used

The statistical techniques used can be summarised as follows: Firstly, descriptive statistics were used in order to from an appraisal about the response results achieved. To do this a combination of mean standard deviations, skewness, frequencies and histogram plots were used. The histograms plots were overlaid with an approximate normal distribution curve for the data. Cronbach's alpha values were also calculated in order to assess the reliability dimensions of the data results.

An analysis of variance (ANOVA) was conducted in order to ascertain if any significant differences existed between the groups of respondents as defined by the business descriptor questions 1 to 6.

A factor analysis was undertaken in order to determine if any sensible data reductions were possible.

Finally, an extensive set of structural equation modelling was undertaken in order to confirm the structure and the relationships proposed with theoretical frameworks 1 to 3 including the preparation of summary tables of SEM results.

The results of all of the data analyses including discussion of results for each set and conclusions are now described below.

4.2.3 Descriptive Statistics

The following descriptive statistics results are presented relating to the response received on each of the 48 questions in the questionnaire. A discussion of the salient observations arising from the descriptive results is presented at the end of the section (i.e. following Figure 4.26 below).

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Business Unit	43	20.5	20.8	20.8
	Division	57	27.1	27.5	48.3
	Whole Company	107	51.0	51.7	100.0
	Total	207	98.6	100.0	
Missing	System	3	1.4		
Total		210	100.0		

Table 4.1: Q1 - Response Depth of Respondees (i.e. answered for Business Unit, Division or Whole Company)

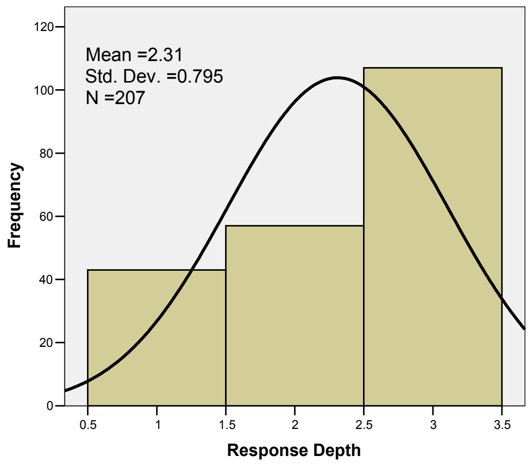


Figure 4.1: Q1 - Response Depth of Respondees (i.e. answered for Business Unit, Division or Whole Company)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Other	12	5.7	5.7	5.7
	Analyst	7	3.3	3.3	9.1
	Manager	118	56.2	56.5	65.6
	Vice President	41	19.5	19.6	85.2
	President	4	1.9	1.9	87.1
	CEO	27	12.9	12.9	100.0
	Total	209	99.5	100.0	
Missing	System	1	.5		
Total		210	100.0		

Table 4.2: Q2 - Respondees Position in Organisation

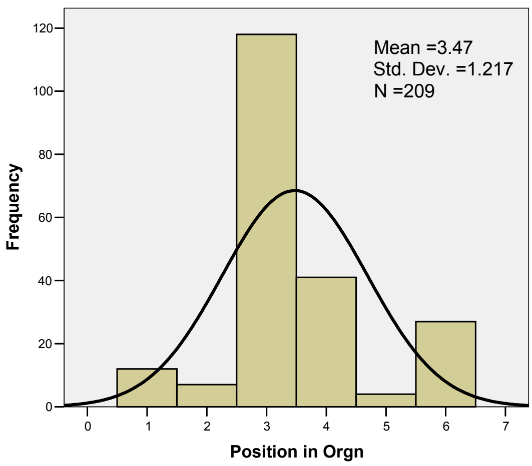


Figure 4.2: Q2 – Histogram of Respondees Position in Organisation

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Food, beverage, tobacco	34	16.2	16.3	16.3
	Textile, clothing, footware, leather	4	1.9	1.9	18.2
	Wood and paper	12	5.7	5.7	23.9
	Printing, publishing, recorded media	5	2.4	2.4	26.3
	Petroleum, coal, chemical	29	13.8	13.9	40.2
	Non-metallic minerals	2	1.0	1.0	41.1
	Metallic products	61	29.0	29.2	70.3
	Machinery & equipment	9	4.3	4.3	74.6
	Electronic & electrical appliances	21	10.0	10.0	84.7
	Other	32	15.2	15.3	100.0
	Total	209	99.5	100.0	
Missing	System	1	.5		
Total		210	100.0		

Table 4.3: Q3 - Manufacturing Segment of Respondees' Organisation

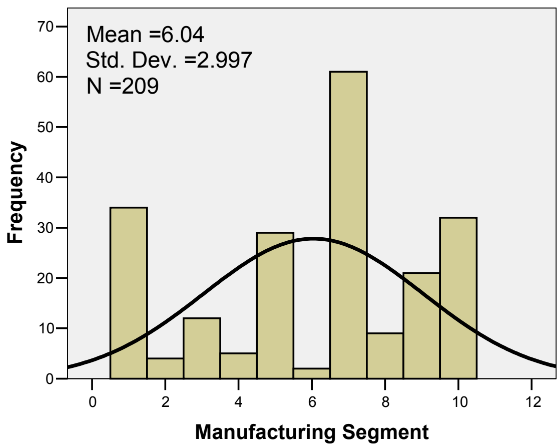


Figure 4.3: Q3 – Histogram of Manufacturing Segment of Respondees' Organisation

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Africa	1	.5	.5	.5
	Central/South America	2	1.0	1.0	1.4
	Mid East	0	0	0	
	North America	21	10.0	10.0	11.5
	North Asia	8	3.8	3.8	15.3
	Oceania	99	47.1	47.4	62.7
	South Asia	16	7.6	7.7	70.3

	Soviet	0	0	0	
	Sub-continent	0	0	0	
	UK/Europe	16	7.6	7.7	78.0
	Global	46	21.9	22.0	100.0
	Total	209	99.5	100.0	
Missing	System	1	.5		
Total		210	100.0		

Table 4.4: Q4 - Location of Manufacturing Facilities

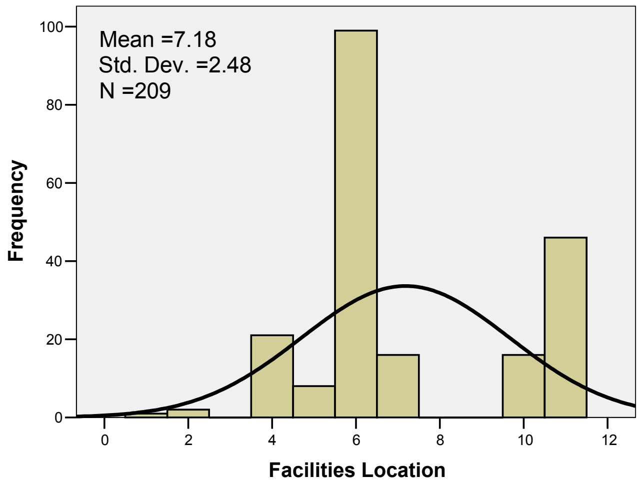


Figure 4.4: Q4 – Histogram of Location of Manufacturing Facilities

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Single Site	44	21.0	21.0	21.0
	Multi-domestic sites	76	36.2	36.2	57.1
	Multi-national sites	90	42.9	42.9	100.0
	Total	210	100.0	100.0	

Table 4.5: Q5 - Location Type

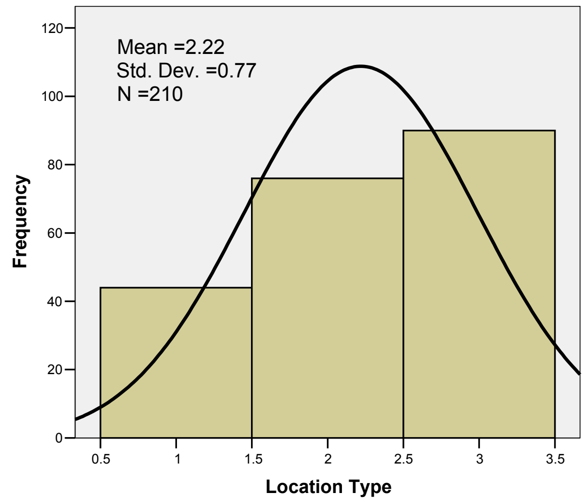


Figure 4.5: Q5 – Histogram of Location Type

N	Valid	201
	Missing	9
Mean		2127.93
Std. Deviation		5179.613
Skewness		7.612
Range		59998

Table 4.6: Q6 - Annual US$M Sales

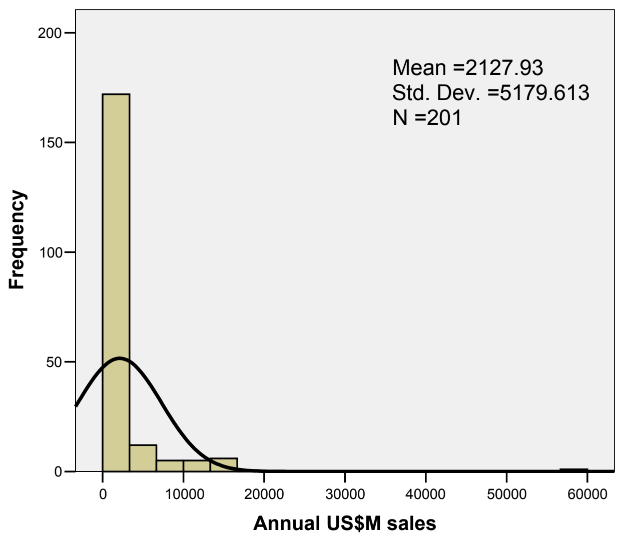


Figure 4.6: Q6 – Histogram of Annual US$M Sales

		% Delivery Performance	% Perfect Order Fulfilment	Mfg Lead-Time (days)	Offered Lead-Time (days)
N	Valid	205	197	204	205
	Missing	5	13	6	5
Mean		90.34	82.84	20.23	11.449
Std. Deviation		8.727	15.627	29.913	15.3456
Skewness		-2.122	-1.697	3.059	2.595
Std. Error of Skewness		.170	.173	.170	.170
Range		55	100	200	95.0

Table 4.7: Q7~Q10 - Delivery Performance, Perfect Order Fulfilment and Lead-Time Results

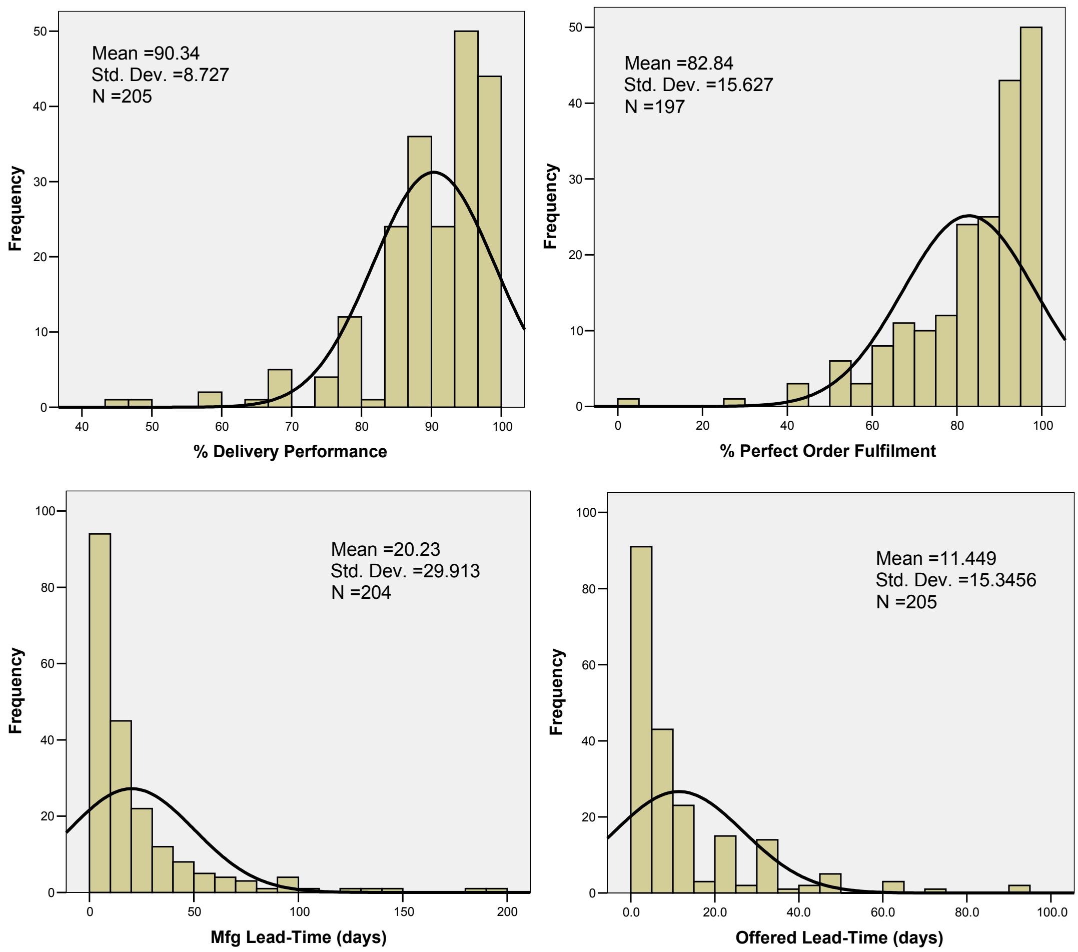
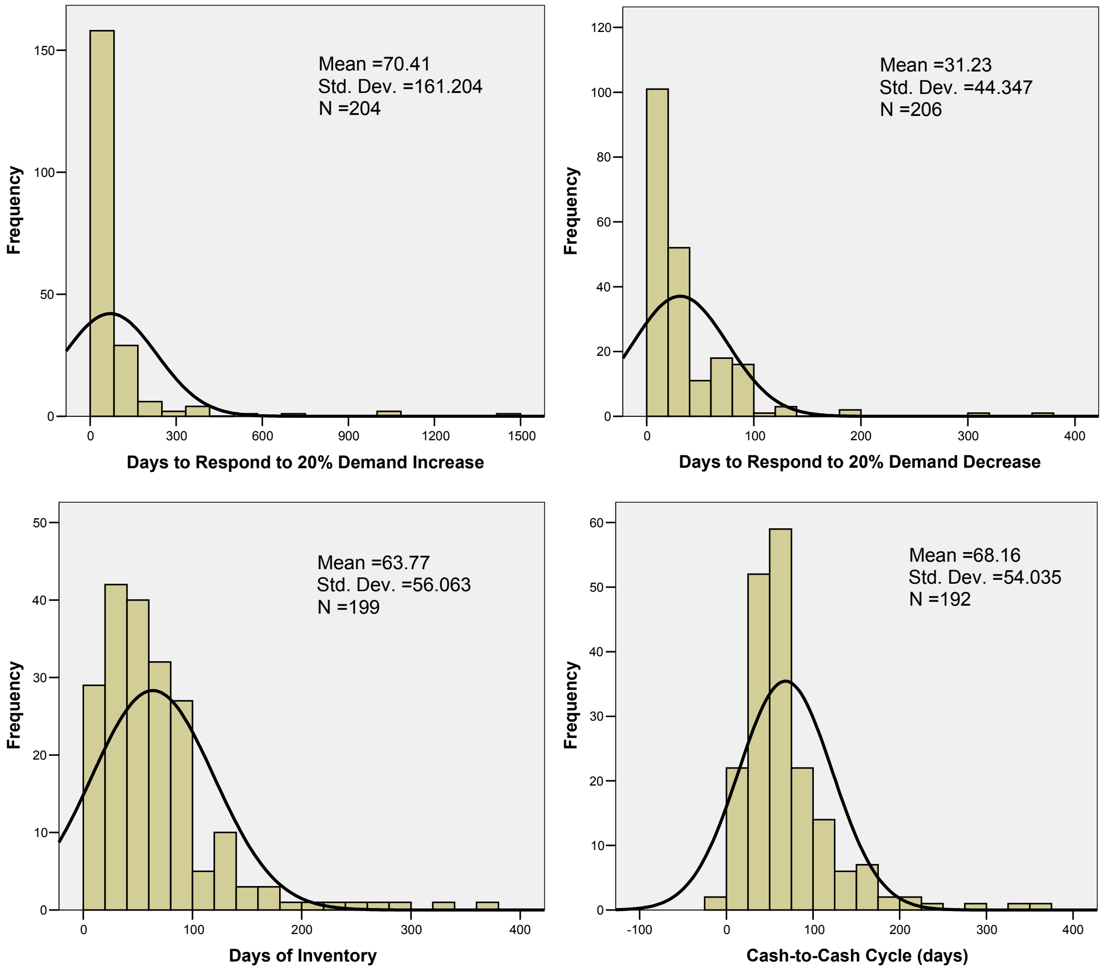


Figure 4.7: Q7~10 – Histograms of Delivery Performance, Perfect Order Fulfilment, Manufacturing and Offered Lead-Time Results

		Days to Respond to 20% Demand Increase	Days to Respond to 20% Demand Decrease	Days of Inventory	Cash-to-Cash Cycle (days)	% Return-on-Capital Margin
N	Valid	204	206	199	192	195
	Missing	6	4	11	18	15
Mean		70.41	31.23	63.77	68.16	9.53
Std. Deviation		161.204	44.347	56.063	54.035	8.574
Skewness		5.668	3.821	2.451	2.336	1.349
Std. Error of Skewness		.170	.169	.172	.175	.174
Range		1460	365	365	370	57

Table 4.8: Q11~Q14 and Q16 - Flexibility, Days of Inventory, Cash-to-Cash Cycle and Return-on-Capital-Margin Results



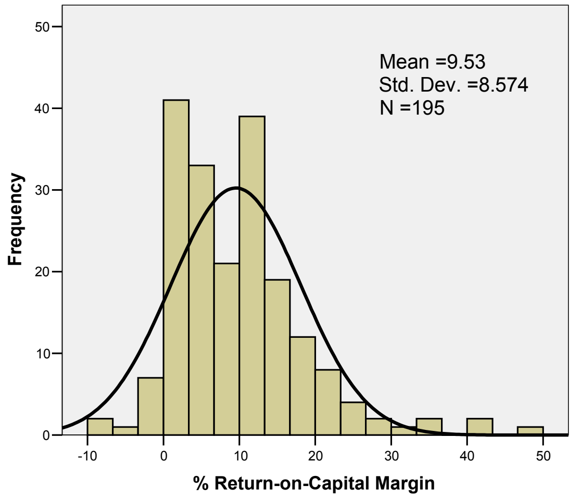


Figure 4.8: Q11~Q14 and Q16 – Histograms of Flexibility, Days of Inventory, Cash-to-Cash Cycle and Return-on-Capital-Margin Results

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Lower quartile	40	19.0	20.5	20.5
	Second quartile	70	33.3	35.9	56.4
	Third quartile	64	30.5	32.8	89.2
	Upper quartile	21	10.0	10.8	100.0
	Total	195	92.9	100.0	
Missing	System	15	7.1		
Total		210	100.0		

Table 4.9: Q15 – Product Cost Quartiles

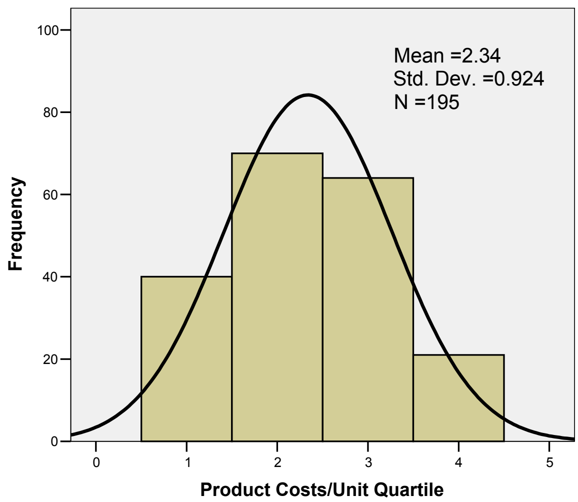


Figure 4.9: Q15 – Histogram of Product Cost Quartiles

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Production Push	57	27.1	27.7	27.7
	Kanban Pull	49	23.3	23.8	51.5
	Agile	92	43.8	44.7	96.1
	Other	8	3.8	3.9	100.0
	Total	206	98.1	100.0	
Missing	System	4	1.9		
Total		210	100.0		

Table 4.10: Q17 – Supply Chain Operating Principle Used

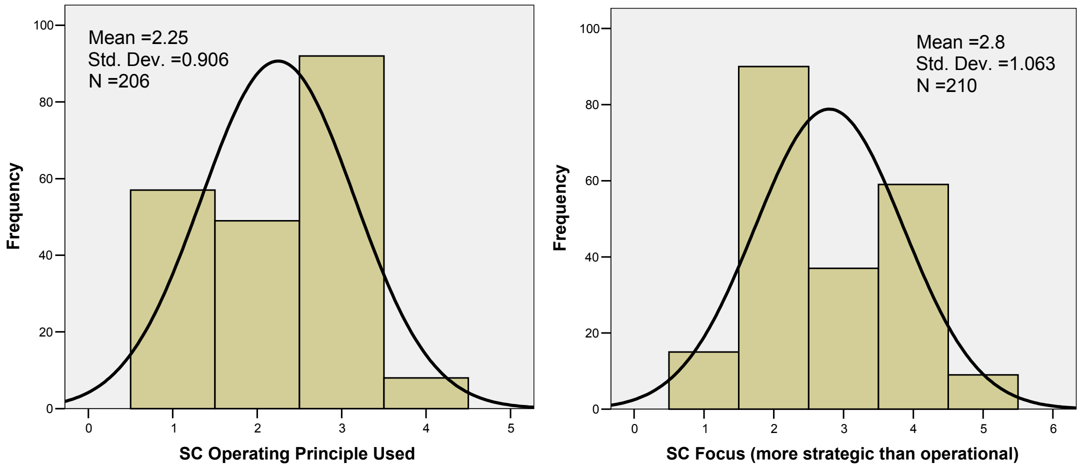


Figure 4.10: Q17~Q18 – Histograms of Supply Chain Operating Principle and Supply Chain Focus Used

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	15	7.1	7.1	7.1
	Disagree	90	42.9	42.9	50.0
	Neutral	37	17.6	17.6	67.6
	Agree	59	28.1	28.1	95.7
	Strongly agree	9	4.3	4.3	100.0
	Total	210	100.0	100.0	

Table 4.11: Q18 – Supply Chain Focus More Strategic Than Operational

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	6	2.9	2.9	2.9
	Disagree	69	32.9	32.9	35.7
	Neutral	28	13.3	13.3	49.0
	Agree	84	40.0	40.0	89.0
	Strongly agree	23	11.0	11.0	100.0
	Total	210	100.0	100.0	

Table 4.12: Q19 – Supply Chain Goals More Customer Than Internally Aligned

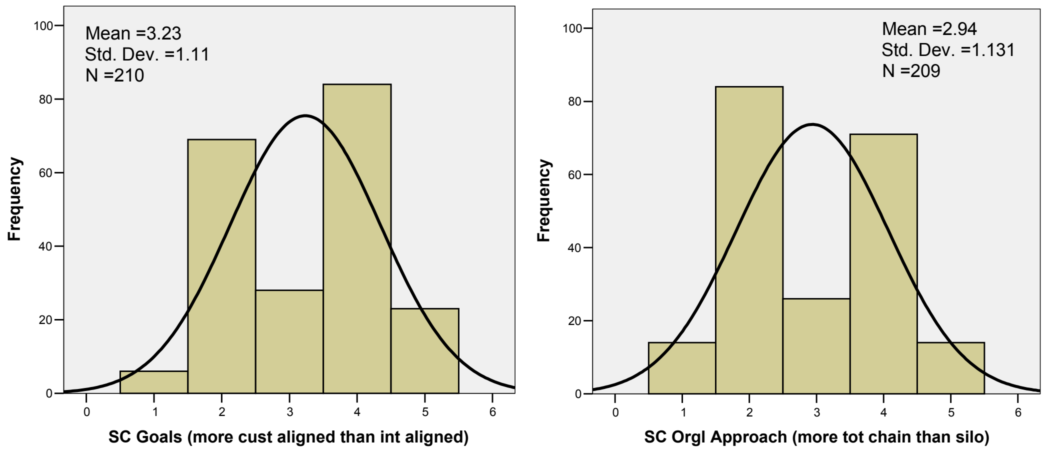


Figure 4.11: Q19~Q20 – Histograms of Supply Chain Goals and Supply Chain Organisational Approach

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	14	6.7	6.7	6.7
	Disagree	84	40.0	40.2	46.9
	Neutral	26	12.4	12.4	59.3
	Agree	71	33.8	34.0	93.3
	Strongly agree	14	6.7	6.7	100.0
	Total	209	99.5	100.0	
Missing	System	1	.5		
Total		210	100.0		

Table 4.13: Q20 – Organisational Approach More Total Chain Than Silo

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	2	1.0	1.0	1.0
	Disagree	31	14.8	14.8	15.7
	Neutral	27	12.9	12.9	28.6
	Agree	93	44.3	44.3	72.9
	Strongly agree	57	27.1	27.1	100.0
	Total	210	100.0	100.0	

Table 4.14: Q21 – Customer Relationships More Cooperative Than Adversarial

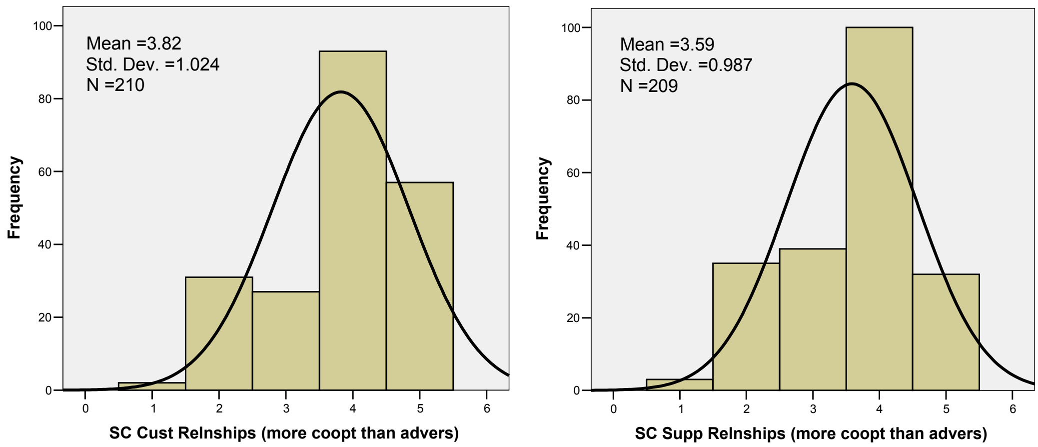


Figure 4.12: Q21~Q22 – Histograms of Supply Chain Customer Relationships and Supply Chain Supplier Relationships

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	3	1.4	1.4	1.4
	Disagree	35	16.7	16.7	18.2
	Neutral	39	18.6	18.7	36.8
	Agree	100	47.6	47.8	84.7
	Strongly agree	32	15.2	15.3	100.0
	Total	209	99.5	100.0	
Missing	System	1	.5		
Total		210	100.0		

Table 4.15: Q22 - Supplier Relationships More Cooperative Than Adversarial

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	13	6.2	6.2	6.2
	Disagree	66	31.4	31.6	37.8
	Neutral	51	24.3	24.4	62.2
	Agree	65	31.0	31.1	93.3
	Strongly agree	14	6.7	6.7	100.0
	Total	209	99.5	100.0	
Missing	System	1	.5		
Total		210	100.0		

Table 4.16: Q23 – Supply Chain Strategy is Well Defined and Clear

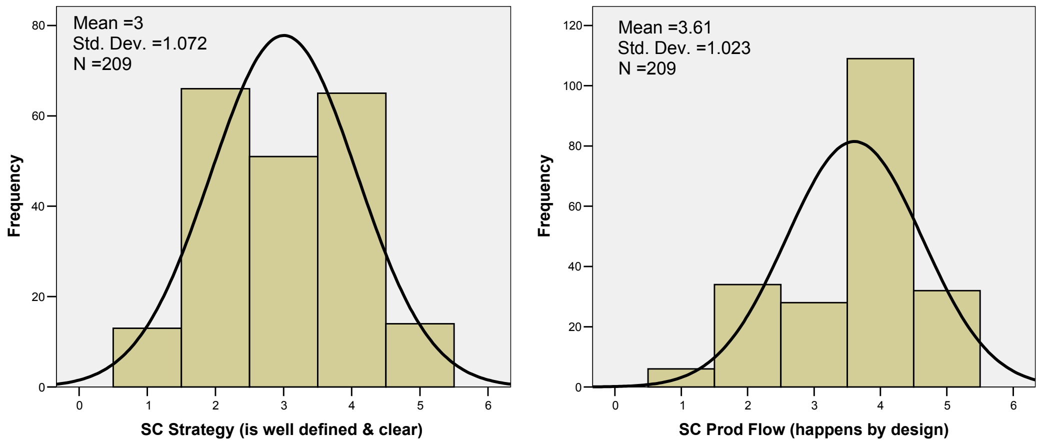


Figure 4.13: Q23~Q24 – Histograms of Supply Chain Strategy and Supply Chain Product Flow

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	6	2.9	2.9	2.9
	Disagree	34	16.2	16.3	19.1
	Neutral	28	13.3	13.4	32.5
	Agree	109	51.9	52.2	84.7
	Strongly agree	32	15.2	15.3	100.0
	Total	209	99.5	100.0	
Missing	System	1	.5		
Total		210	100.0		

Table 4.17: Q24 – Supply Chain Product Flow Happens by Design

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	2	1.0	1.0	1.0
	Disagree	45	21.4	21.5	22.5
	Neutral	40	19.0	19.1	41.6
	Agree	98	46.7	46.9	88.5
	Strongly agree	24	11.4	11.5	100.0
	Total	209	99.5	100.0	
Missing	System	1	.5		
Total		210	100.0		

Table 4.18: Q25 - Organisation is More Customer/Supplier Facing Than Internal Facing

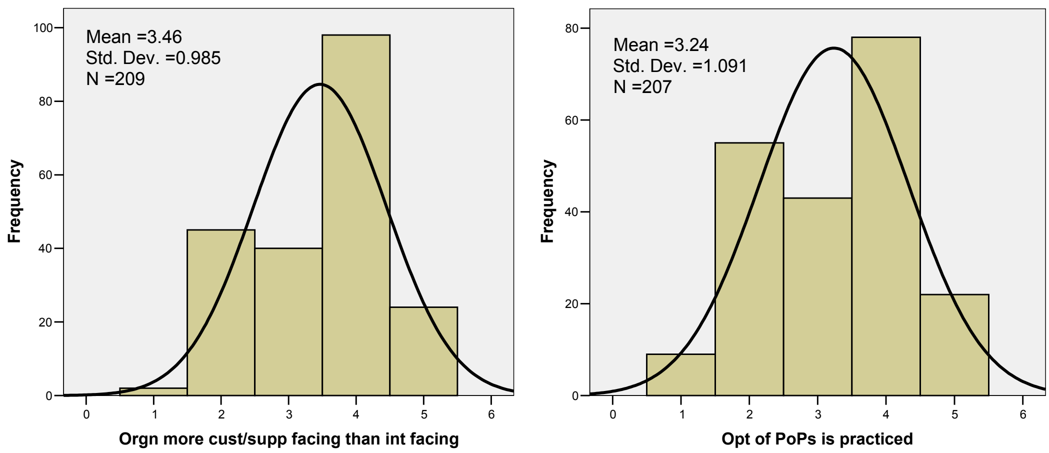


Figure 4.14: Q25~Q26 – Histograms of Organisational Facing and Optimisation of Points of Production Practice

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	9	4.3	4.3	4.3
	Disagree	55	26.2	26.6	30.9
	Neutral	43	20.5	20.8	51.7
	Agree	78	37.1	37.7	89.4
	Strongly agree	22	10.5	10.6	100.0
	Total	207	98.6	100.0	
Missing	System	3	1.4		
Total		210	100.0		

Table 4.19: Q26 – Optimisation of Points-of-Production is Practiced

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	3	1.4	1.4	1.4
	Disagree	31	14.8	14.8	16.3
	Neutral	25	11.9	12.0	28.2
	Agree	111	52.9	53.1	81.3
	Strongly agree	39	18.6	18.7	100.0
	Total	209	99.5	100.0	
Missing	System	1	.5		
Total		210	100.0		

Table 4.20: Q27 – Planning and Scheduling Conducted Extensively

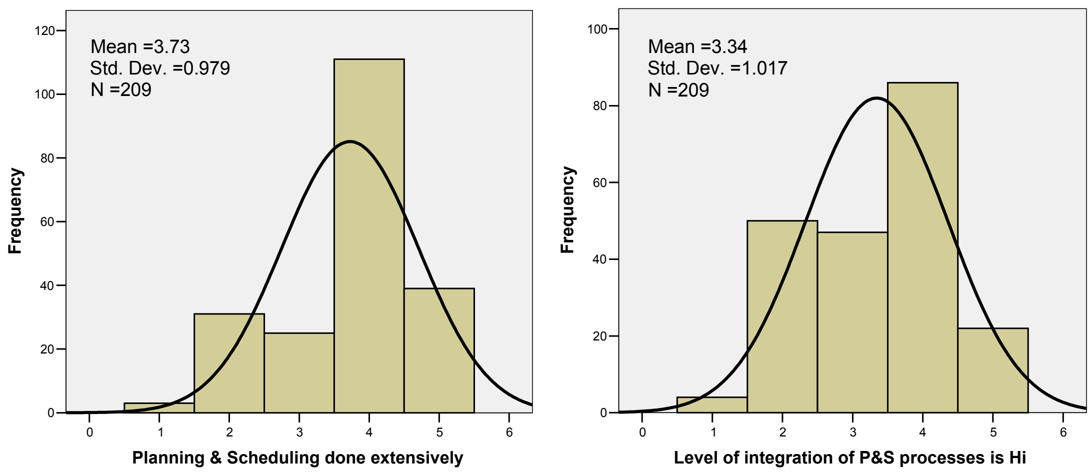


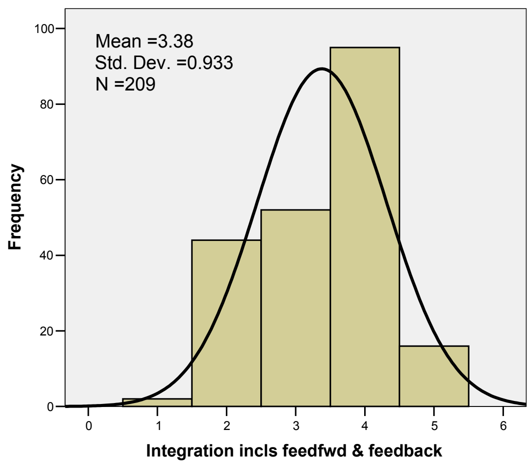
Figure 4.15: Q27~Q28 – Histograms of Planning & Scheduling Extent and Level of Planning & Scheduling Integration

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	4	1.9	1.9	1.9
	Disagree	50	23.8	23.9	25.8
	Neutral	47	22.4	22.5	48.3
	Agree	86	41.0	41.1	89.5
	Strongly agree	22	10.5	10.5	100.0
	Total	209	99.5	100.0	
Missing	System	1	.5		
Total		210	100.0		

Table 4.21: Q28 – Level of Integration of Planning & Scheduling Processes is High

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	2	1.0	1.0	1.0
	Disagree	44	21.0	21.1	22.0
	Neutral	52	24.8	24.9	46.9
	Agree	95	45.2	45.5	92.3
	Strongly agree	16	7.6	7.7	100.0
	Total	209	99.5	100.0	
Missing	System	1	.5		
Total		210	100.0		

Table 4.22: Q29 – Process Integration Includes Feed-forward & Feedback



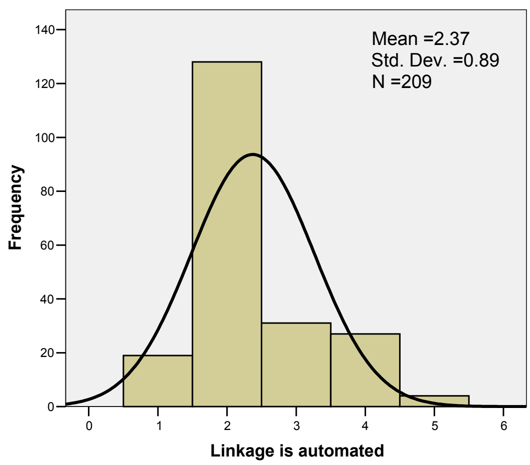


Figure 4.16: Q29~Q30 – Histograms of Extent of Feed-Forward and Feedback Linkages and Linkage Automation

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	19	9.0	9.1	9.1
	Disagree	128	61.0	61.2	70.3
	Neutral	31	14.8	14.8	85.2
	Agree	27	12.9	12.9	98.1
	Strongly agree	4	1.9	1.9	100.0
	Total	209	99.5	100.0	
Missing	System	1	.5		
Total		210	100.0		

Table 4.23: Q30 – Processes Linkages are Automated

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	13	6.2	6.3	6.3
	Disagree	43	20.5	20.7	26.9
	Neutral	30	14.3	14.4	41.3
	Agree	109	51.9	52.4	93.8
	Strongly agree	13	6.2	6.3	100.0
	Total	208	99.0	100.0	
Missing	System	2	1.0		
Total		210	100.0		

Table 4.24: Q31 – Planning and Scheduling Integrated with Other SC Processes

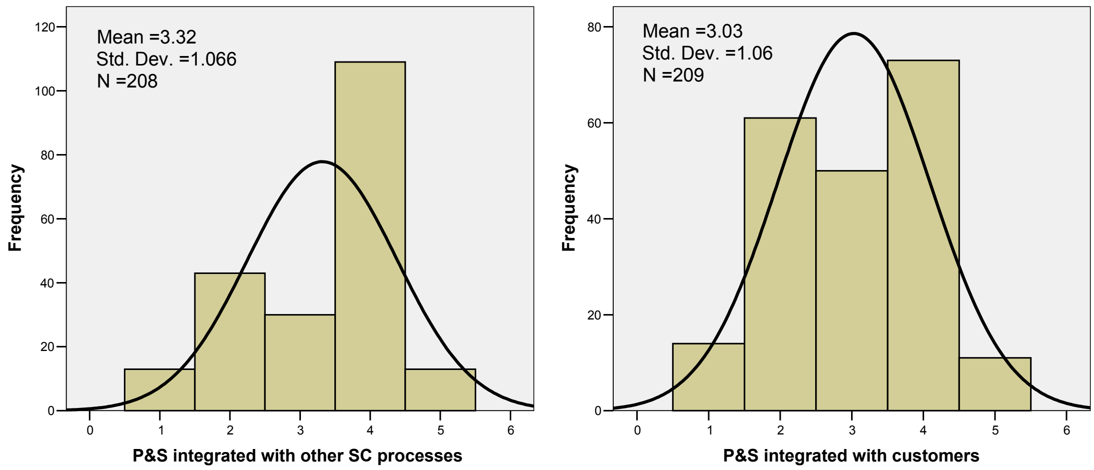


Figure 4.17: Q31~Q32 – Histograms of Planning & Scheduling Process Integration with Other Supply Chain Processes and with Customers

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	14	6.7	6.7	6.7
	Disagree	61	29.0	29.2	35.9
	Neutral	50	23.8	23.9	59.8
	Agree	73	34.8	34.9	94.7
	Strongly agree	11	5.2	5.3	100.0
	Total	209	99.5	100.0	
Missing	System	1	.5		
Total		210	100.0		

Table 4.25: Q32 – Planning & Scheduling Processes Integrated with Customers

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	5	2.4	2.4	2.4
	Disagree	48	22.9	23.0	25.4
	Neutral	51	24.3	24.4	49.8
	Agree	90	42.9	43.1	92.8
	Strongly agree	15	7.1	7.2	100.0
	Total	209	99.5	100.0	
Missing	System	1	.5		
Total		210	100.0		

Table 4.26: Q33 – Planning & Scheduling Processes Integrated with Suppliers

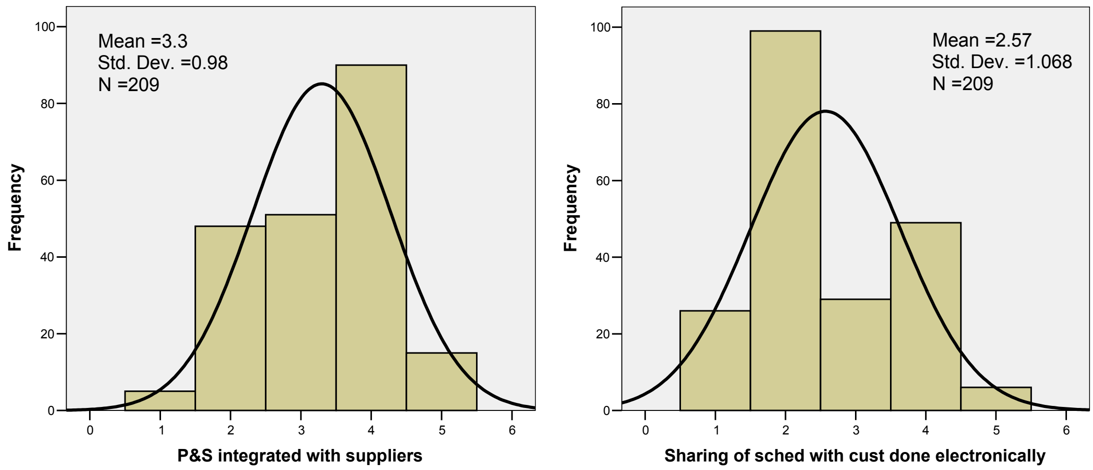


Figure 4.18: Q33~Q34 – Histograms of Planning & Scheduling Process Integration with Suppliers and Electronic Sharing of Schedules with Customers

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	26	12.4	12.4	12.4
	Disagree	99	47.1	47.4	59.8
	Neutral	29	13.8	13.9	73.7
	Agree	49	23.3	23.4	97.1
	Strongly agree	6	2.9	2.9	100.0
	Total	209	99.5	100.0	
Missing	System	1	.5		
Total		210	100.0		

Table 4.27: Q34 – Sharing of Schedules with Customers Achieved Electronically

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	19	9.0	9.1	9.1
	Disagree	90	42.9	43.3	52.4
	Neutral	32	15.2	15.4	67.8
	Agree	53	25.2	25.5	93.3
	Strongly agree	14	6.7	6.7	100.0
	Total	208	99.0	100.0	
Missing	System	2	1.0		
Total		210	100.0		

Table 4.28: Q35 – Sharing of Schedules with Suppliers Achieved Electronically

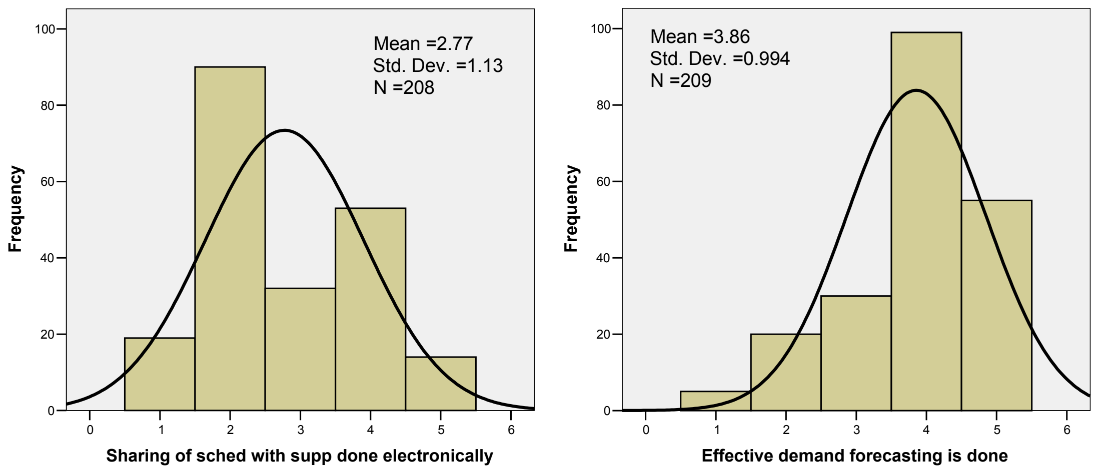


Figure 4.19: Q35~Q36 – Histograms of Electronic Sharing of Schedules with Suppliers and Effective Demand Forecasting

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	5	2.4	2.4	2.4
	Disagree	20	9.5	9.6	12.0
	Neutral	30	14.3	14.4	26.3
	Agree	99	47.1	47.4	73.7
	Strongly agree	55	26.2	26.3	100.0
	Total	209	99.5	100.0	
Missing	System	1	.5		
Total		210	100.0		

Table 4.29: Q36 – Effective Demand Forecasting is Conducted

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	26	12.4	12.6	12.6
	Disagree	75	35.7	36.2	48.8
	Neutral	35	16.7	16.9	65.7
	Agree	63	30.0	30.4	96.1
	Strongly agree	8	3.8	3.9	100.0
	Total	207	98.6	100.0	
Missing	System	3	1.4		
Total		210	100.0		

Table 4.30: Q37 – e-Logistics is an Active and Key Supply Chain Strategy

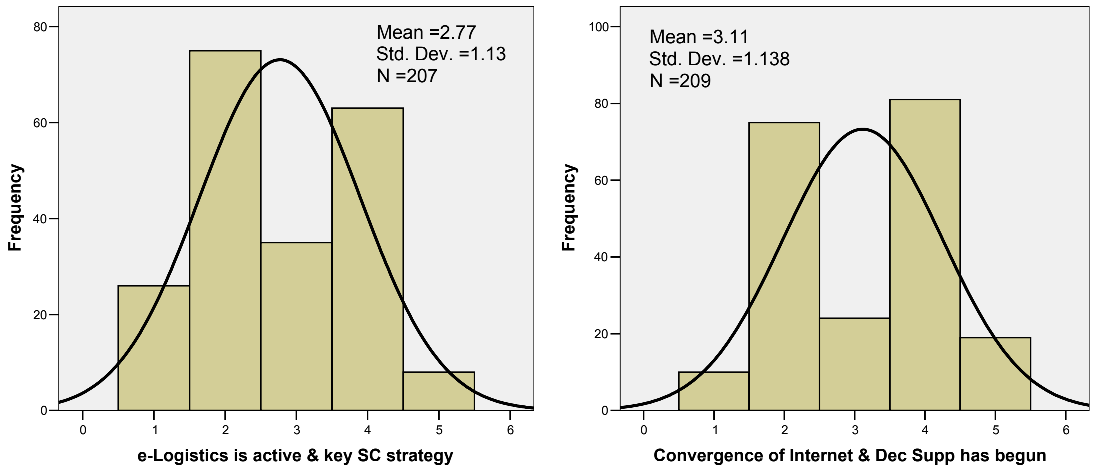


Figure 4.20: Q37~Q38 – Histograms of e-Logistics Strategy and Convergence of Internet and Decision Support Systems

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	10	4.8	4.8	4.8
	Disagree	75	35.7	35.9	40.7
	Neutral	24	11.4	11.5	52.2
	Agree	81	38.6	38.8	90.9
	Strongly agree	19	9.0	9.1	100.0
	Total	209	99.5	100.0	
Missing	System	1	.5		
Total		210	100.0		

Table 4.31: Q38 – Convergence of Internet and Decision Support Systems has Begun

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	19	9.0	9.1	9.1
	Disagree	72	34.3	34.4	43.5
	Neutral	45	21.4	21.5	65.1
	Agree	57	27.1	27.3	92.3
	Strongly agree	16	7.6	7.7	100.0
	Total	209	99.5	100.0	
Missing	System	1	.5		
Total		210	100.0		

Table 4.32: Q39 – Transaction Processes with Customers and Suppliers are e-Enabled

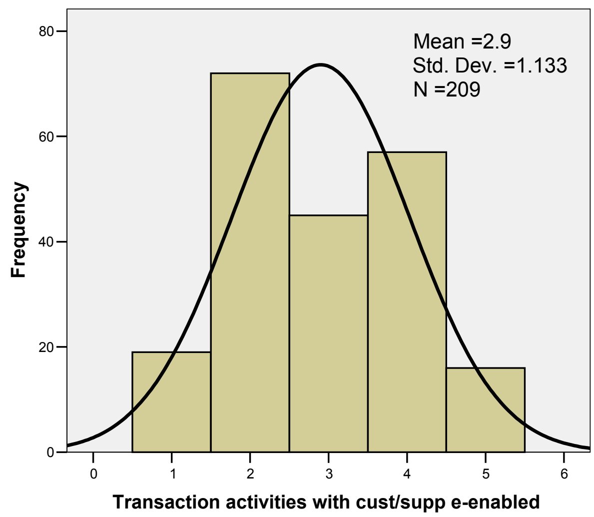


Figure 4.21: Q39 – Histogram of e-Enabling of Customer and Supplier Transactional Activities

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	2	1.0	1.0	1.0
	Disagree	38	18.1	18.3	19.2
	Neutral	26	12.4	12.5	31.7
	Agree	122	58.1	58.7	90.4
	Strongly agree	20	9.5	9.6	100.0
	Total	208	99.0	100.0	
Missing	System	2	1.0		
Total		210	100.0		

Table 4.33: Q40 – People Role Networks are Well Understood

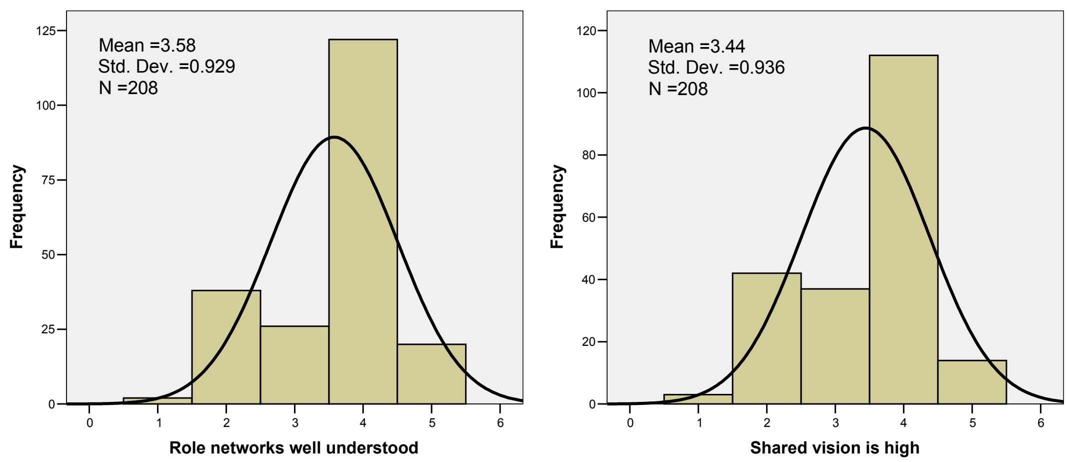


Figure 4.22: Q40~Q41 – Histograms of Role Network Understanding and Shared Vision

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	3	1.4	1.4	1.4
	Disagree	42	20.0	20.2	21.6
	Neutral	37	17.6	17.8	39.4
	Agree	112	53.3	53.8	93.3
	Strongly agree	14	6.7	6.7	100.0
	Total	208	99.0	100.0	
Missing	System	2	1.0		
Total		210	100.0		

Table 4.34: Q41 – Shared Vision is High

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	4	1.9	1.9	1.9
	Disagree	52	24.8	25.0	26.9
	Neutral	60	28.6	28.8	55.8
	Agree	84	40.0	40.4	96.2
	Strongly agree	8	3.8	3.8	100.0
	Total	208	99.0	100.0	
Missing	System	2	1.0		
Total		210	100.0		

Table 4.35: Q42 – Common Mental Models are Clear and Aligned

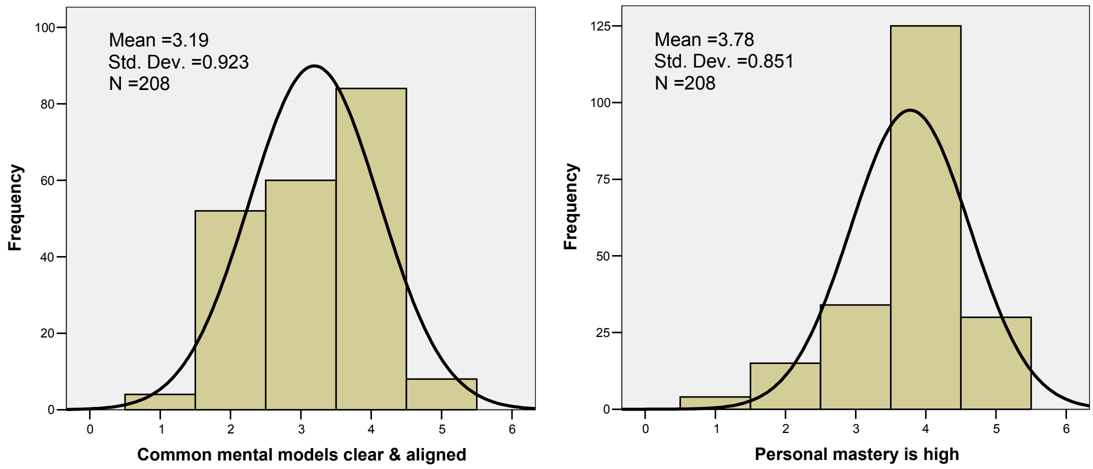


Figure 4.23: Q42~Q43 – Histograms of Common Mental Models and Personal Mastery

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	4	1.9	1.9	1.9
	Disagree	15	7.1	7.2	9.1
	Neutral	34	16.2	16.3	25.5
	Agree	125	59.5	60.1	85.6
	Strongly agree	30	14.3	14.4	100.0
	Total	208	99.0	100.0	
Missing	System	2	1.0		
Total		210	100.0		

Table 4.36: Q43 – Personal Mastery is High

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	4	1.9	1.9	1.9
	Disagree	30	14.3	14.4	16.3
	Neutral	55	26.2	26.4	42.8
	Agree	104	49.5	50.0	92.8
	Strongly agree	15	7.1	7.2	100.0
	Total	208	99.0	100.0	
Missing	System	2	1.0		
Total		210	100.0		

Table 4.37: Q44 – Have the Right People 'On The Bus'

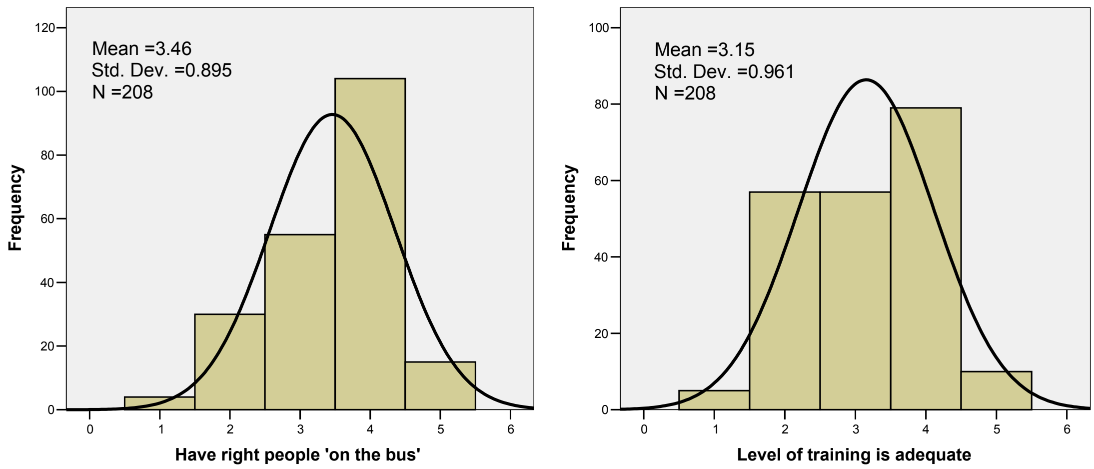


Figure 4.24: Q44~Q45 – Histograms of Having the Right People 'On the Bus' and Training Adequacy

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	5	2.4	2.4	2.4
	Disagree	57	27.1	27.4	29.8
	Neutral	57	27.1	27.4	57.2
	Agree	79	37.6	38.0	95.2
	Strongly agree	10	4.8	4.8	100.0
	Total	208	99.0	100.0	
Missing	System	2	1.0		
Total		210	100.0		

Table 4.38: Q45 – Level of Training is Adequate

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	1	.5	.5	.5
	Disagree	35	16.7	16.8	17.3
	Neutral	59	28.1	28.4	45.7
	Agree	99	47.1	47.6	93.3
	Strongly agree	14	6.7	6.7	100.0
	Total	208	99.0	100.0	
Missing	System	2	1.0		
Total		210	100.0		

Table 4.39: Q46 – Team Learning is High

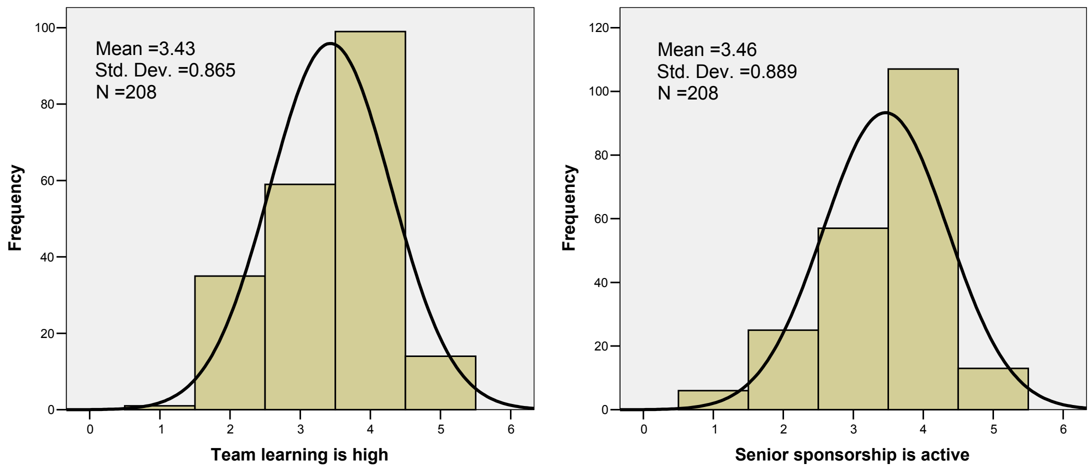


Figure 4.25: Q46~Q47 – Histograms of Team Learning and Senior Sponsorship

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	6	2.9	2.9	2.9
	Disagree	25	11.9	12.0	14.9
	Neutral	57	27.1	27.4	42.3
	Agree	107	51.0	51.4	93.8
	Strongly agree	13	6.2	6.3	100.0
	Total	208	99.0	100.0	
Missing	System	2	1.0		
Total		210	100.0		

Table 4.40: Q47 – Senior Sponsorship is Active

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	4	1.9	1.9	1.9
	Disagree	33	15.7	15.9	17.8
	Neutral	64	30.5	30.8	48.6
	Agree	99	47.1	47.6	96.2
	Strongly agree	8	3.8	3.8	100.0
	Total	208	99.0	100.0	
Missing	System	2	1.0		
Total		210	100.0		

Table 4.41: Q48 – Political Astuteness is High

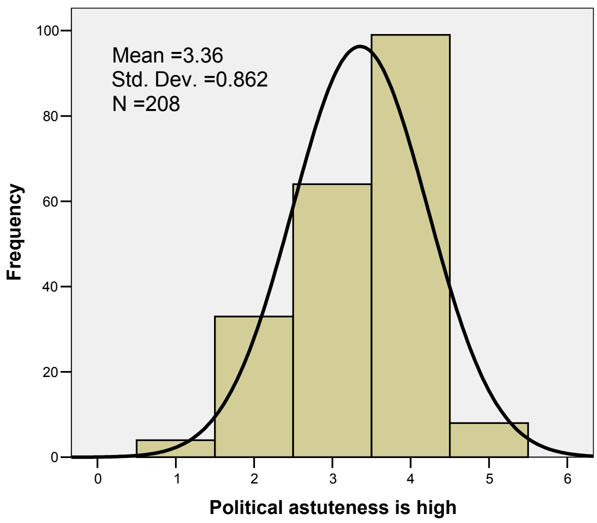


Figure 4.26: Q48 – Histogram of Political Astuteness

4.2.4 Discussion of Results - Descriptive Statistics

From the responses received, 51% of the respondents answered on behalf of their whole company and 56% of them reported from a manager level in their organisation. Surprisingly, of the 210 respondents 27 (13%) were CEO level. I.e. given the time pressures that many people complained about in relation to filling out the questionnaire, it was surprising to see so many CEOs actually taking the time to reply.

Responses were received from 10 manufacturing segments, the main 5 being Food and Beverage 16%, Petroleum 14%, Metallic Products 29%, Electronics/Electrical 10% and Other 15%. Facility locations of the reported companies were mainly North America 10%, Oceania 47%, South Asia 8%, UK/Europe 8% and Global 22%. Supporting the reasonably high Global number, 79% of the companies reported their sites as Multi-domestic/Multi-national.

The mean Annual Sales of the reported companies is US$2B. However 1 company reported Annual Sales of US$60B thus skewing the distribution to the right.

The first of the dependent variables i.e. Delivery Performance (DP) and Perfect Order Fulfilment results are skewed to the left with means of 90% and 83% respectively. Lead-time results are skewed to the right with Manufacturing Lead-Time mean of 20 days and Offered Lead-time mean of 11 days. Flexibility results are also skewed to the right with Time to Respond to 20% Demand Increase mean of 70 days and Time to Respond to 20% Demand Decrease mean of 31 days.

Days of Inventory (DOI) results are skewed to the right with the average DOI of 64 days. The Cash-to-Cash Cycle result shows a more normal distribution with a mean of 68 days. Similarly, the Product Cost/Unit Quartiles result is reasonably normal with a mean of 2.3 (2 being second quartile costs) and the Return on Capital Margin result is also normal with a mean of 10%.

The first of the independent variables i.e. Supply Chain Principles in use shows that most companies (45%) indicated they are operating Agile type supply chains. Interestingly, 50% of respondents disagreed that their Supply Chain Focus was more strategic than it was operational and only 32 % agreed with the statement. It would seem therefore, that for this sample of manufacturing companies, their focus is still more on the operational aspects of their supply chain rather than bringing a strategic focus to it.

The results for the Supply Chain Goals, Supply Chain Organisational Approach and Supply Chain Strategy questions all show a bi-modal pattern indicating some divergence around these issues. Other bi-modal results were obtained for e-Logistics, Convergence of Internet and Decision Support Tools and e-Enabled Transaction Activities. Further considerations on these e-related type issues are presented in the discussion of the data analysis below.

Most respondents agreed that their customer and supplier relationships are more cooperative than they are adversarial and this result is reinforced by a similar response to the Customer/Supplier Facing question.

The respondents indicated that their organisation's Planning and Scheduling activities are generally carried out quite extensively however more variability of response is evident around the question of the Level of Integration of these processes. Whilst the integration that does exist includes both Feed-forward and Feedback and that planning and scheduling processes are reasonably Integrated with Other Supply Chain Process and Integrated with Customers and Suppliers, the Nature of the Linkages is not completely automated.

Demand Forecasting seems to be an active (and perhaps well established) process with three quarters of the respondents indicating that their organisation conducts effective demand forecasting.

The Socio independent variable questions were all answered in a similar manner with a mode of 4 (agree) and a mean of ranging from 3.15 to 3.78. Only Common Mental Models and Levels of Training results showed any variance from the other Socio related questions, both with lower means of 3.19 and 3.15 respectively.

4.2.5 Analysis of Variance (ANOVA) Testing of Descriptor Variables

An analysis of variance analysis (ANOVA) was conducted on the survey data in order to test for differences between means on each of the business descriptor variables (i.e. Response Depth, Position in Organisation, Manufacturing Segment, Facilities Location, Location Type and Annual Sales). The results of the ANOVA analysis are summarised in Table 4.42 to 4.46 below. Tables 4.43 to 4.45 show the factor considered, which of the variables (questions 7 to 48) show to have mean differences for that factor and then in the right-hand columns are the details of the specific factor elements found to be different. So taking the third record in Table 4.43 as an example, the factor considered is Manufacturing Segment, mean differences were detected for the log(Offered Lead-Time) variable (for which the degrees of freedom, F and p for that difference are shown) and then at the right of the table, the factor elements exhibiting the difference are listed (in this case, within the Manufacturing Segment, Offered Lead-Time is different for the Food/Beverage and Metallic Products segments at the $p = 0.041$ level with Food/Beverage being lower than Metallic Products by $10^{0.36}$ or 2.3 days. Table 4.46 summarises the findings further listing the frequencies of the differences found for $p \leq 0.05$ and for $p \leq 0.001$.

To arrive at these results 42 separate ANOVA runs were conducted using SPSS 13.0. A MANOVA analysis was attempted, however SPSS gave error messages to the effect that the task was too big.

To guard against the introduction of type I errors (Pallant, 2005, pp 200) possible with so many ANOVA runs, a Bonferroni adjustment was made to the alpha level used. 0.05 alpha was divided by 42 (the number of comparisons made) to set an alpha significance test level of 0.001.

4.2.6 Discussion of Results - ANOVA Analysis

At a $p \leq 0.05$ level, 36 significant differences between means were determined. Of these, 14 are Manufacturing Segment related, 9 are Location Type related, 6 are

Facility Location related, 3 are Response Depth related, 2 are Position in the Organisation related and 2 are Annual Sales level related.

At the p ≤ 0.001 level however (the alpha level calculated after the Bonferroni adjustment as the significance level to test against), only 5 significant variable differences were determined as follows:

<table>
<tr><th>Factor</th><th>Variable</th><th>Factor Element</th></tr>
<tr><td rowspan="4">Manufacturing Segment</td><td rowspan="2">Political Astuteness</td><td>Food/Beverage</td></tr>
<tr><td>Petroleum</td></tr>
<tr><td rowspan="2">Cash-to-Cash Cycle</td><td>Food/Beverage</td></tr>
<tr><td>Machinery</td></tr>
<tr><td rowspan="4">Location Type</td><td rowspan="2">Planning & Scheduling Done Extensively</td><td>Single</td></tr>
<tr><td>Multi-national</td></tr>
<tr><td rowspan="2">Process Integration incl Feed-fwd & Feedback</td><td>Single</td></tr>
<tr><td>Multi-national</td></tr>
<tr><td rowspan="2">Response Depth</td><td rowspan="2">Days of Inventory</td><td>Business Unit</td></tr>
<tr><td>Whole Company</td></tr>
</table>

Table 4.42: Five Variables Found to Have Differences in their Means at p ≤ 0.001 Level

Graphs of the above five variables found to have significantly different means (p≤ 0.001) are shown at figures 4.27 to 4.31 below. In summary, the results of the ANOVA analysis show that for companies reported in the survey:

(i) Days of Inventory results for those respondents reporting a Business Unit perspective are lower (better) than Days of Inventory results for those respondents reporting a Whole Company perspective.

(ii) Food/Beverage companies in the survey were lower (better) than Machinery companies on Cash-to-Cash Cycle times and higher (better) than Petroleum companies on Political Astuteness.

(iii) Planning, Scheduling and Feed-forward/Feedback Process Integration are higher (better) on reported single site operations than they are on reported Multi-national site operations.

Factor	Dependent Var	df_1	df_2	F	p	Factor Element Differences	p	Delta
Manu Segment	refsqrtDP	9	194	2.16	0.030	none		
Manu Segment	logMfgLT	9	193	2.60	0.008	none		
Manu Segment	logOfferedLT	9	192	3.13	0.002	Food : Metallic Products	0.041	-0.36
Fac Locn	logOfferedLT	6	194	3.40	0.002	Nth Asia : UK/Europe	0.039	0.82
Manu Segment	logDaysUP	9	186	2.00	0.042	Food : Metallic Products	0.003	-0.58
Annual Sales	logDaysUP	6	181	2.87	0.011	none		
Response Depth	sqrtDOI	2	193	6.98	0.001	Bus Unit : Whole Co.	0.001	-2.1
Manu Segment	sqrtDOI	9	188	2.40	0.013	Food : Machinery	0.010	-4.22
”	”	”	”	”	”	Petroleum : Machinery	0.012	-4.27
”	”	”	”	”	”	Metallic Prod : Machinery	0.009	-4.06
Locn Type	”	2	196	4.77	0.009	Multi dom : Multi national	0.012	-1.43
Manu Segment	Cash-to-cash	9	182	2.61	0.007	Food : Machinery	0.001	-89.3
”	”	”	”	”	”	Wood : Machinery	0.038	-78.4
”	”	”	”	”	”	Petroleum : Machinery	0.024	-72.4
”	”	”	”	”	”	Metallic Prod : Machinery	0.005	-77.3
”	”	”	”	”	”	Electronics : Machinery	0.020	-81.6
Fac Locn	”	6	183	2.27	0.030	Cent Sth Amer : Nth America	0.042	-62.9
Locn Type	”	2	189	3.20	0.043	none		
”	Product Costs	2	192	3.30	0.039	Multi dom : Multi National	0.035	-0.37

Table 4.43: Summary Results of ANOVA Analysis on Business Descriptor Factors Showing Only The Significant Differences and Significant Individual Factor Element Differences Between Groups Found – Part A. (Note: ” = ditto)

Factor	Dependent Var	df_1	df_2	F	p	Factor Element Differences	p	Delta
Posn in Orgn	Supply Chain Goals	5	203	2.66	0.023	CEO : VP	0.038	0.80
Annual Sales	,,	6	194	2.36	0.032	none		
Response Depth	Supply Chain Cust Relnships	2	204	3.65	0.028	Division : Whole Co.	0.041	-0.41
Manu Segment	Optimisation of Points of Prodn	8	196	2.68	0.006	Textile : Machinery	0.022	1.11
Posn in Orgn	Planning/Sched Extensive	5	202	2.40	0.039	none		
Locn Type	,,	2	206	6.76	0.001	Single site : Multi nat	0.001	0.64
Fac Locn	P&S processes integrated	6	200	2.38	0.023	Nth Asia : Sth America	0.034	-2.50
Locn Type	,,	2	206	3.76	0.025	Single : Multi nat	0.020	0.50
,,	Integn incl Feed fwd & feedback	2	206	7.19	0.001	Single : Multi nat	0.001	0.25
,,	,,	,,	,,	,,	,,	Multi dom : Multi nat	0.038	0.35
Fac Locn	P&S Int with other SC proc	6	199	2.21	0.035	none		
Annual Sales $M	,,	6	192	2.93	0.009	<=50 : 1501 to 3000	0.005	1.05
Response Depth	P&S Int with suppliers	2	203	4.81	0.009	Division : Whole Co.	0.007	0.48
Manu Segment	,,	9	198	2.48	0.011	Food : Petroleum	0.015	0.87
Fac Locn	,,	6	200	2.59	0.014	Sth Asia : UK/Europe	0.019	1.12
Posn in Orgn	Effective Demand F/cast	5	202	2.45	0.035	Analyst : VP	0.026	1.25
Annual Sales $M	Transactions e-enabled	6	193	2.27	0.039	<=$50 : >$3000	0.024	-1.01
Response Depth	,,	2	203	3.19	0.043	none		

Table 4.44: Summary Results of ANOVA Analysis on Business Descriptor Factors Showing Only The Significant Differences and Significant Individual Factor Element Differences Between Groups Found – Part B.

Factor	Dependent Var	df_1	df_2	F	p	Factor Element Differences	p	Delta
Fac Locn	Role Networks Understood	6	199	2.23	0.033	Sth Asia : Nth Asia	0.048	1.31
Locn Type	Shared Vision High	2	205	3.20	0.043	Multi dom : Multi nat	0.040	0.36
Annual Sales	Common Mental Models	6	192	2.28	0.037	none		
Fac Locn	Personal Mastery High	6	199	2.15	0.040	Sth Asia : UK/Europe	0.047	0.92
Locn Type	„	2	205	3.66	0.27	Multi dom : Multi nat	0.021	0.35
„	Right People on the Bus	2	205	3.07	0.049	none		
Manu Segment	Political Astuteness	9	197	2.60	0.007	Food : Petroleum	0.001	0.91
”	”	”	”	”	”	Food : Other	0.024	0.72
Locn Type	„	2	205	5.60	0.004	Multi dom : Multi nat	0.003	0.44

Table 4.45: Summary Results of ANOVA Analysis on Business Descriptor Factors Showing Only The Significant Differences and Significant Individual Factor Element Differences Between Groups Found – Part C.

Factor	Freq p≤0.05	Freq p≤0.001	Factor Elements	Factor Elem Freq (p≤0.05)	Factor Elem Freq (p≤0.001)
Manufacturing Segment	14	2	Food & Beverage	7	2
			Textile	1	
			Wood & Paper	1	
			Petroleum	4	1
			Metallic Products	4	
			Machinery	9	1
			Electronics	1	
			Other	1	
Location Type	9	2	Single Site	3	2
			Multi-Domestic	6	
			Multi-National	9	2
Facility Location	6	0	Nth Asia	3	
			Sth Asia	3	
			Nth America	1	
			Sth America	2	
			UK/Europe	3	
Response Depth	3	1	Business Unit	1	1
			Division	2	
			Whole Co.	3	1
Position in Organisation	2	0	Analyst	1	
			VP	2	
			CEO	1	
Annual Sales US$M (bands)	2	0	<= 50	2	
			1501~3000	1	
			> 3000	1	
Total	36	5		72	10

Table 4.46: Summary Table of Above ANOVA Analysis (Tables 4.43 to 4.45) on Business Descriptor Factors Showing Frequency of Significant Differences and Frequency of Factor Element Differences at $p \leq 0.05$ and $p \leq 0.001$.

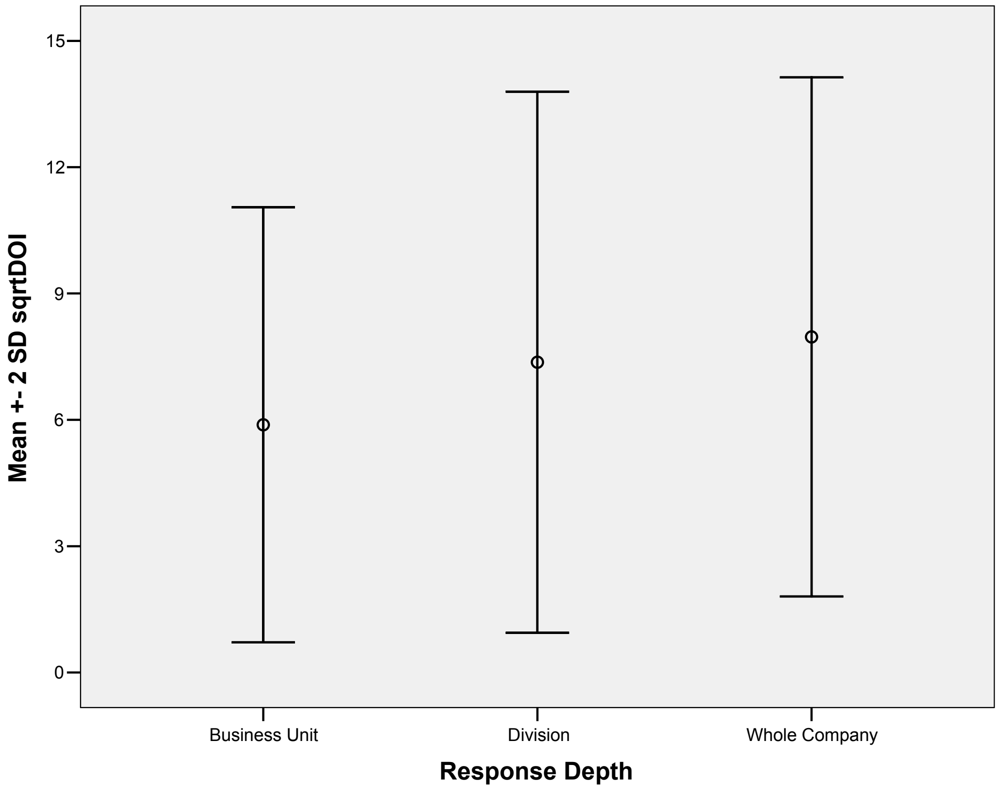


Figure 4.27: Error Chart of Response Depth and square-root Days of Inventory Found by ANOVA Analysis to Have Significantly Different Means (Business Unit Vs Whole Company) at $p \leq 0.001$

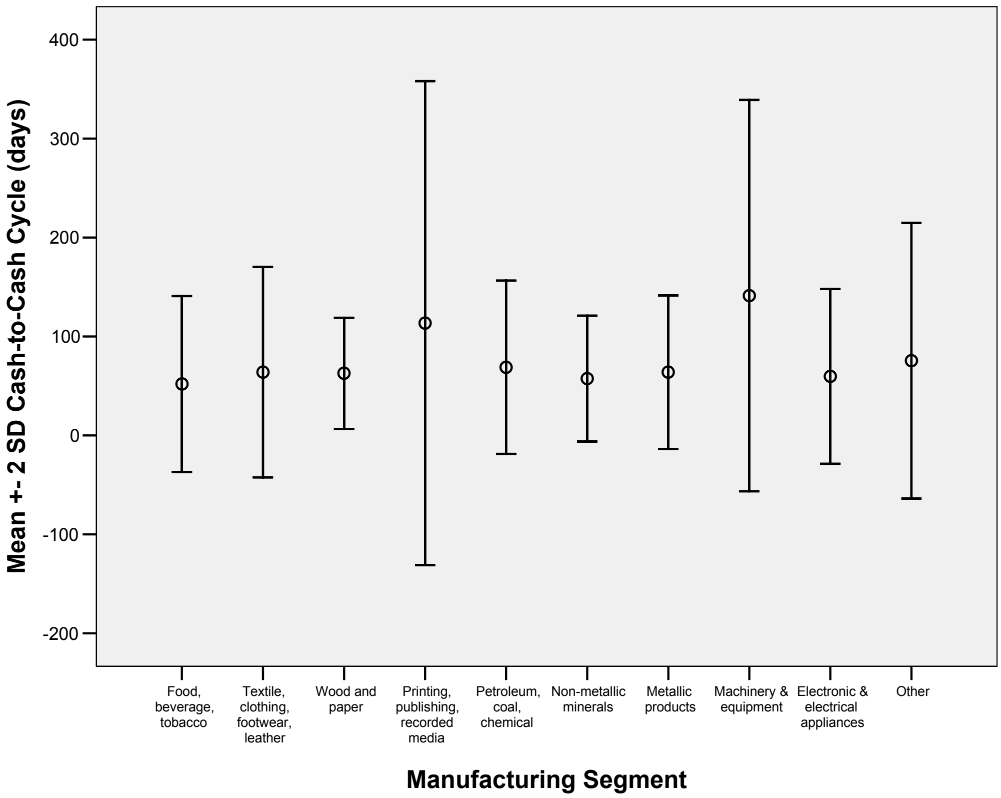


Figure 4.28: Error Chart of Manufacturing Segment and Cash-to-Cash Cycle Time Found by ANOVA Analysis to Have Significantly Different Means (Food Vs Machinery) at $p \leq 0.001$

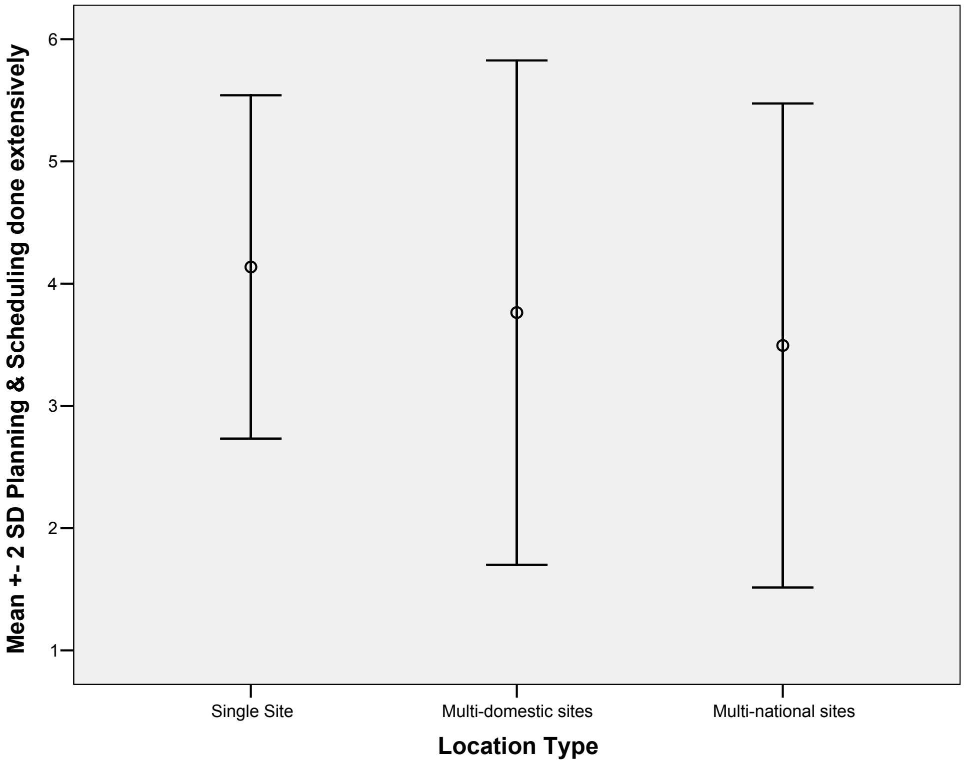


Figure 4.29: Error Chart of Location Type and Level of Planning and Scheduling Found by ANOVA Analysis to Have Significantly Different Means (Single Site Vs Multi-National Site) at $p \leq 0.001$

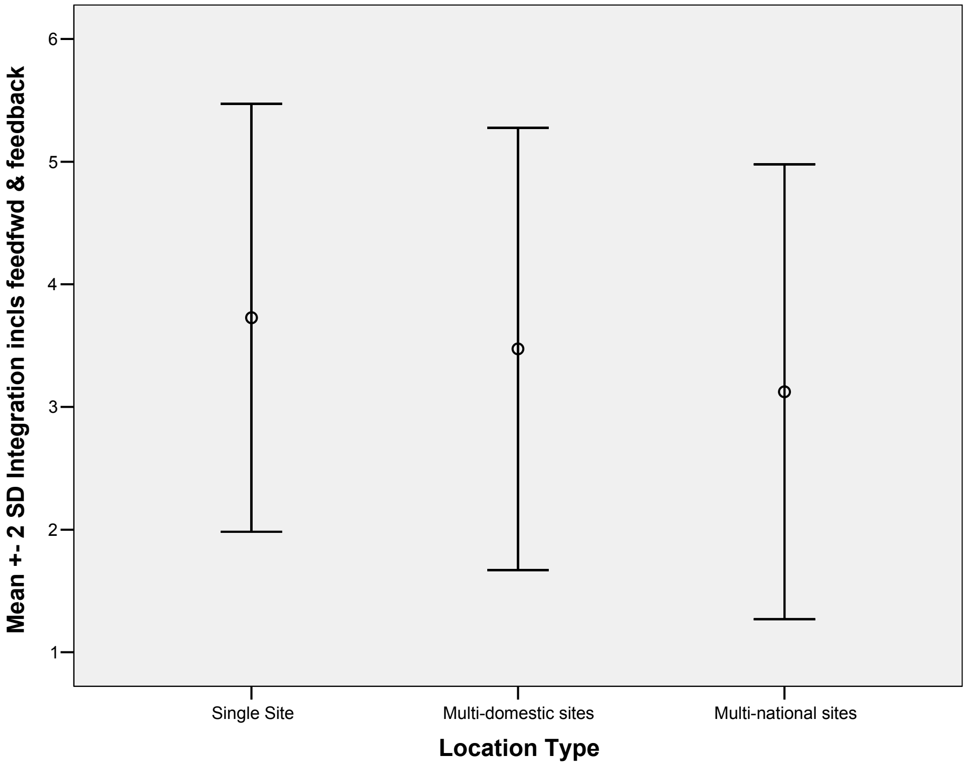


Figure 4.30: Error Chart of Location Type and Integration Includes Feed-Forward and Feedback Found by ANOVA Analysis to Have Significantly Different Means (Single Site Vs Multi-National Site) at $p \leq 0.001$

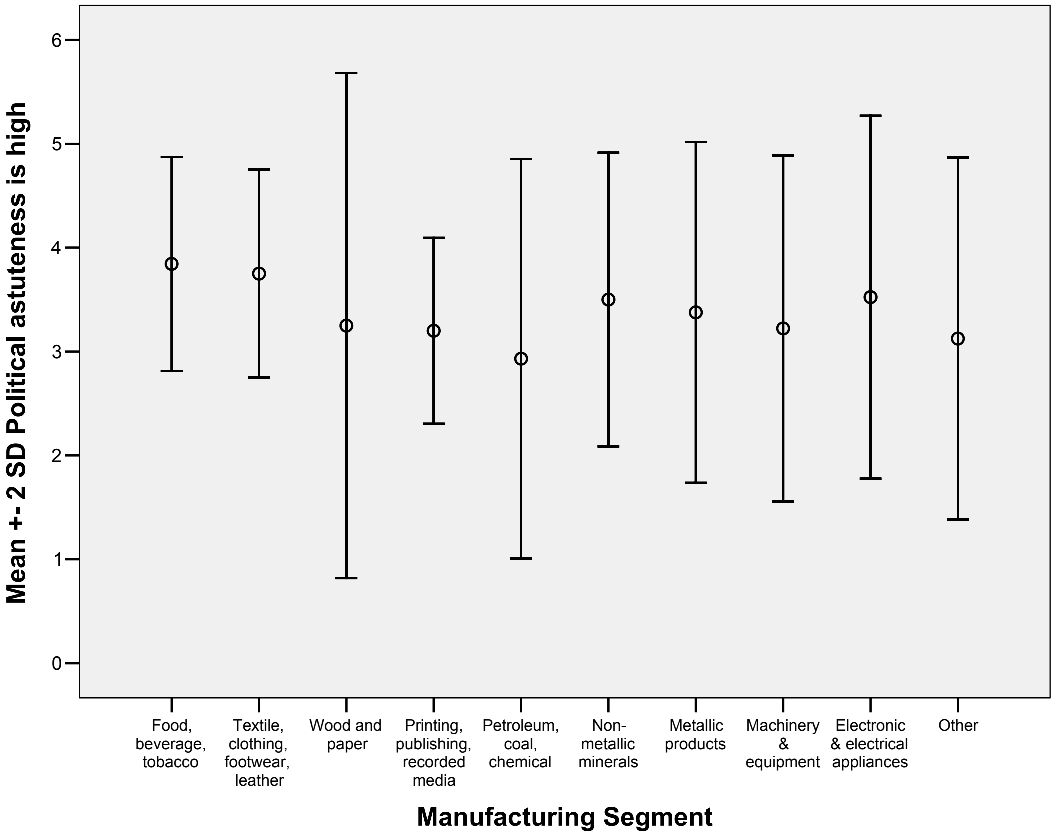


Figure 4.31: Error Chart of Manufacturing Segment and Political Astuteness Found by ANOVA Analysis to Have Significantly Different Means (Food Vs Petroleum) at $p \leq 0.001$

4.2.7 Factor Analysis

A factor analysis was conducted on both the manifest dependent variables and manifest independent variables in order at assess if any sensible data reduction was possible. The results of the factor analysis conducted are shown at Tables 4.47 to 4.50 below.

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.595
Bartlett's Test of Sphericity	Approx. Chi-Square	525.636
	df	45
	Sig.	.000

Table 4.47: KMO and Bartlett's Test Results for Dependent Variable Factor Analysis

Rotated Component Matrix(a)

Dependent Variables	Component				
	1	2	3	4	5
refsqrtDP			.903		
refsqrtPERFECT			.897		
logmfgLT				.674	
logOfferLT				.874	
logdaysUP		.855			
logdaysDOWN		.914			
sqrtDOI	.881				
Cash-to-Cash Cycle (days)	.917				
Product Costs/Unit Quartile					.780
% Return-on-Capital Margin					-.672

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a Rotation converged in 5 iterations.

Table 4.48: Rotated Component Matrix for Factor Analysis on Dependent Variables

4.2.8 Discussion of Results – Factor Analysis

For the manifest dependent variables and considering the factor analysis descriptives shown in Table 4.47, the Kaiser-Meyer-Olkin Measure of Sampling Adequacy value is 0.6 (recommended threshold is 0.6 (Pallant, 2005, pp182)), the Bartlett's Test of Sphericity is significant (sig. = 0.000), thus it is concluded that factor analysis is appropriate considering those measures.

The 5 factors shown in Table 4.48 all have Eigen values ≥ 0.974 and explain 78% of the total variance. The 5 factors were chosen, after observation of the results of 4, 5 and 6 factor extractions, to represent the most sensible set of factors. Additionally, and as can be seen from Table 4.48, the dependent variables loaded very strongly on the 5 factors recorded.

The 5 factors shown were therefore assigned the following groupings: Factor 1 - Cash Cycle Time, Factor 2 – Flexibility (to market demand changes), Factor 3 – Delivery Performance, Factor 4 – Lead-Time and Factor 5 – Profitability.

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.874
Bartlett's Test of Sphericity	Approx. Chi-Square	2512.444
	df	496
	Sig.	.000

Table 4.49: KMO and Bartlett's Test Results for Independent Variable Factor Analysis

Rotated Component Matrix(a)

Independent Variables	Component							
	1	2	3	4	5	6	7	8
SC Operating Principle Used					.54			
SC Focus (more strategic than operational)								.79
SC Goals (more cust aligned than int aligned)					.70			
SC Orgl Approach (more tot chain than silo)								
SC Cust Relnships (more coopt than advers)					.54			
SC Supp Relnships (more coopt than advers)							.61	
SC Strategy (is well defined & clear)								
SC Prod Flow (happens by design)								
Orgn more cust/supp facing than int facing					.67			
Opt of PoPs is practiced								
Planning & Scheduling done extensively				.73				
Level of integration of P&S processes is Hi				.57				
Integration incls feedfwd & feedback				.66				
Linkage is automated								
P&S integrated with other SC processes						.56		
P&S integrated with customers						.74		
P&S integrated with suppliers							.63	
Sharing of sched with cust done electronically		.59						
Sharing of sched with supp done electronically							.66	
Effective demand forecasting is done				.52				
e-Logistics is active & key SC strategy		.60						
Convergence of Internet & Dec Supp has begun		.79						
Transaction activities with cust/supp e-enabled		.75						
Role networks well understood	.70							
Shared vision is high	.66							
Common mental models clear & aligned	.65							
Personal mastery is high			.57					
Have right people 'on the bus'			.75					
Level of training is adequate	.66							
Team learning is high			.66					
Senior sponsorship is active			.65					
Political astuteness is high			.54					

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a Rotation converged in 33 iterations.

Table 4.50: Rotated Component Matrix for Factor Analysis on Independent Variables

For the independent variables and again considering firstly the factor analysis descriptives shown in Table 4.49, the Kaiser-Meyer-Olkin Measure of Sampling Adequacy value is 0.87 and the Bartlett's Test of Sphericity is significant (sig. = 0.000), thus it is concluded that factor analysis is appropriate for the independent variables also.

The independent variables loaded well and on the 8 factors as shown in Table 4.50. All factors shown in the table have Eigen values ≥ 1.0 and explain 61% of the total variance. The factors can sensibly be assigned as follows: Factor 1 – People Systems, Factor 2 – e-Commerce, Factor 3 – People Quality, Factor 4 – Intra-Co. Integration, Factor 5 – Customer Facing, Factor 6 Inter-Co. Integration, Factor 7 – Supplier Facing and Factor 8 – Supply Chain Focus.

The factor scores for both dependent variates and independent variates were saved and used in the SEM models below to test theoretical frameworks 1, 2 and 3 (such frameworks are explained in Section 2.4).

4.2.9 **Structural Equation Modelling (SEM)**

"Structural equation modelling is a multivariate technique combining aspects of multiple regression and factor analysis to estimate a series of interrelated dependence relationships simultaneously." (Hair et al, 1998, pp. 583) Structural equation modelling was chosen for this data analysis because (i) it can estimate such multiple dependence relationships (including interrelated ones) and, (ii) it can accommodate unobserved variables and give reasons for measurement error in determining the relationship estimates.

4.2.10 **Discussion of Results – Structural Equation Modelling**

The SEM models presented below represent the theoretical frameworks described above in Chapter 2. For the theoretical framework 1, both manifest variable model runs and factor score (obtained from factor analysis explained above) model runs (using the same model structure) were conducted. This was undertaken because it was noticed that when conducting the factor score runs, a number of important individual manifest variable relationships were missed (i.e. not uniquely identified in the factor score runs). Manifest variable runs were *not* conducted for the theoretical frameworks 2 and 3, as the resultant models were very complicated. Factor score runs were therefore used to confirm theoretical frameworks 2 and 3.

Figures 4.32 to 4.34 below show example results of structural equation model runs for theoretical framework 1 using the manifest variables. A feature of AMOS 5.0 called 'Specification Search' (explained at Chapter 3 - Methodology above) was used to calculate the estimates shown in the diagrams. The diagrams are actual AMOS 5.0 model runs and were copied and pasted from AMOS 5.0 into this document. For the example SEM runs shown here, the manifest Parts II, III and IV independent variables were regressed against the dependent variables shown in the figures.

A *complete set* of SEM model runs for theoretical framework 1 for all manifest dependent and all manifest independent variables is displayed at Appendix 2.

All of the *factor score* confirmatory runs for theoretical frameworks 2 and 3 are shown below.

Where the SEM models were not overly complex (<20 pathways), best-fit-model indices calculated by AMOS 5.0 Specification Search feature, were used to select the models shown. In most cases this was the $BCC_0 = 0$ (Browne-Cudeck criterion (Arbuckle and Wothke, 1999, pp. 404)) estimate of the best-fit model. In each case, only model paths found to be significant at $p \leq 0.05$ are presented for the model runs using the Specification Search feature. For the more complex models (≥ 20 <30 pathways), the AMOS 5.0 'maximum-likelihood' calculation of estimates method was used.

SEM Diagram Notes: Values next to single headed arrows on the charts are regression weights, near double headed arrows are covariances, near the dependent variable are intercepts and near the input variables are means and variances.

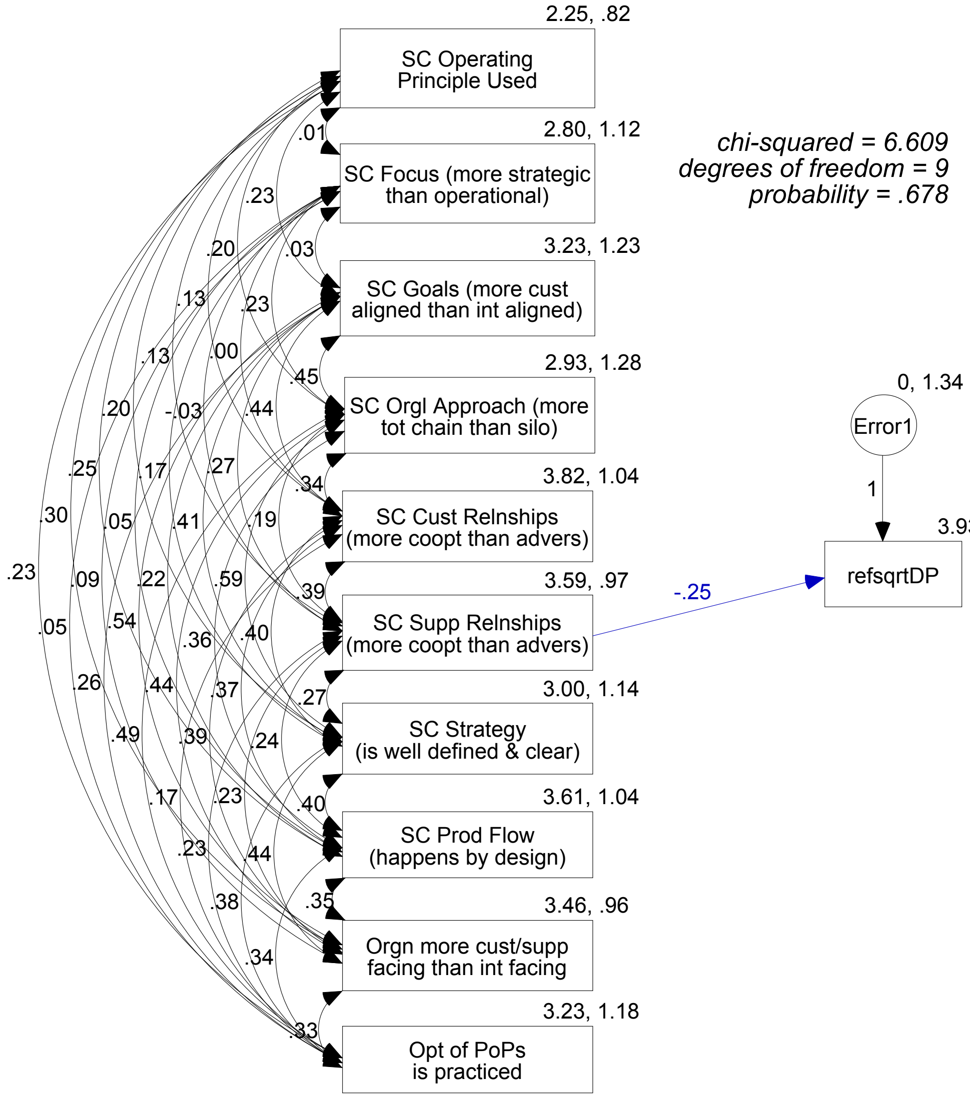


Figure 4.32: Example of 10 Pathway SEM Specification Search on Manifest Part II Independent Variables and reflect-square-root Delivery Performance to Confirm Theoretical Framework 1 (Note: only significant regression paths (p≤0.05) are shown)

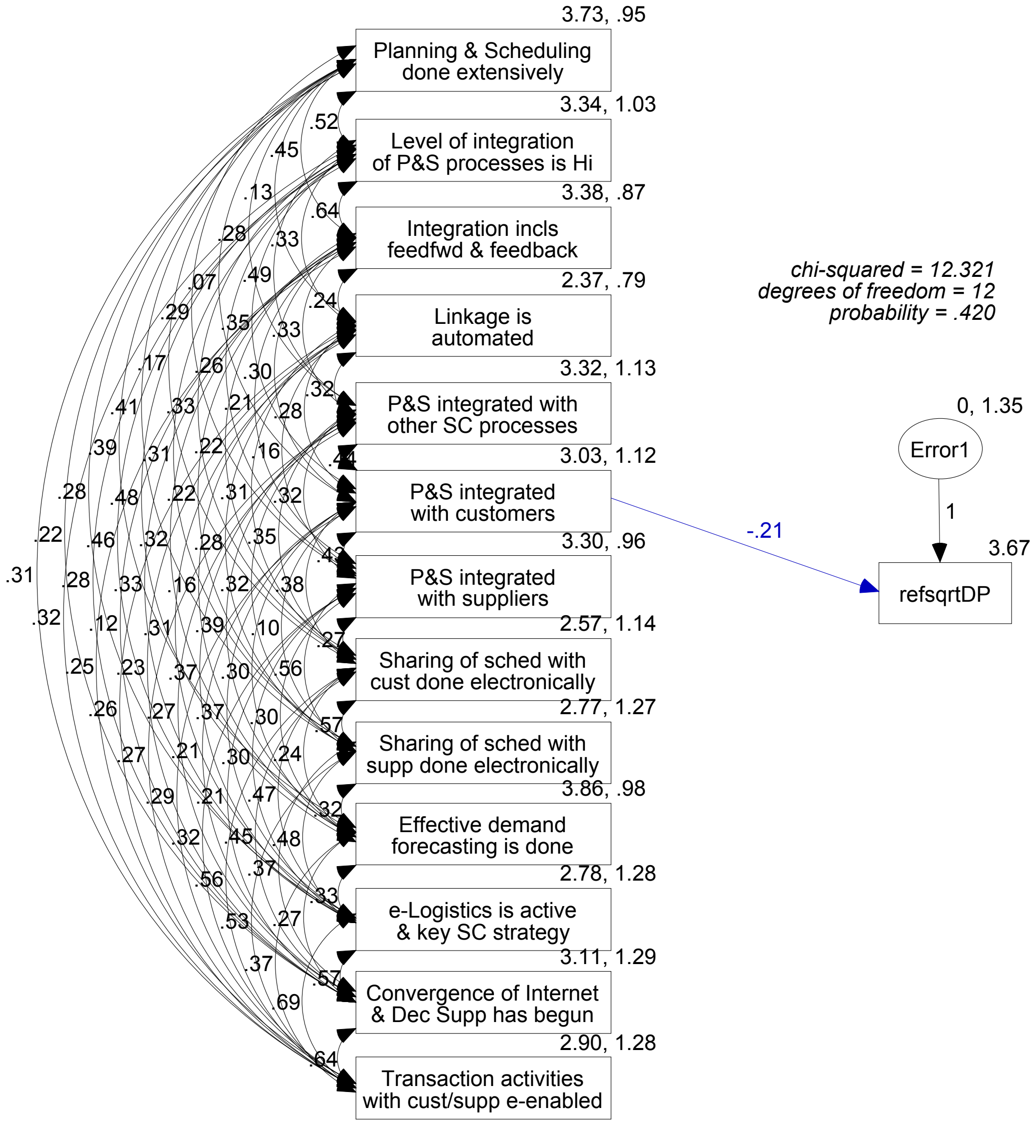


Figure 4.33: Example of 13 Pathway SEM Specification Search on Manifest Part III Independent Variables and reflect-square-root Delivery Performance to Confirm Theoretical Framework 1 (Note: only significant regression paths (p≤0.05) are shown)

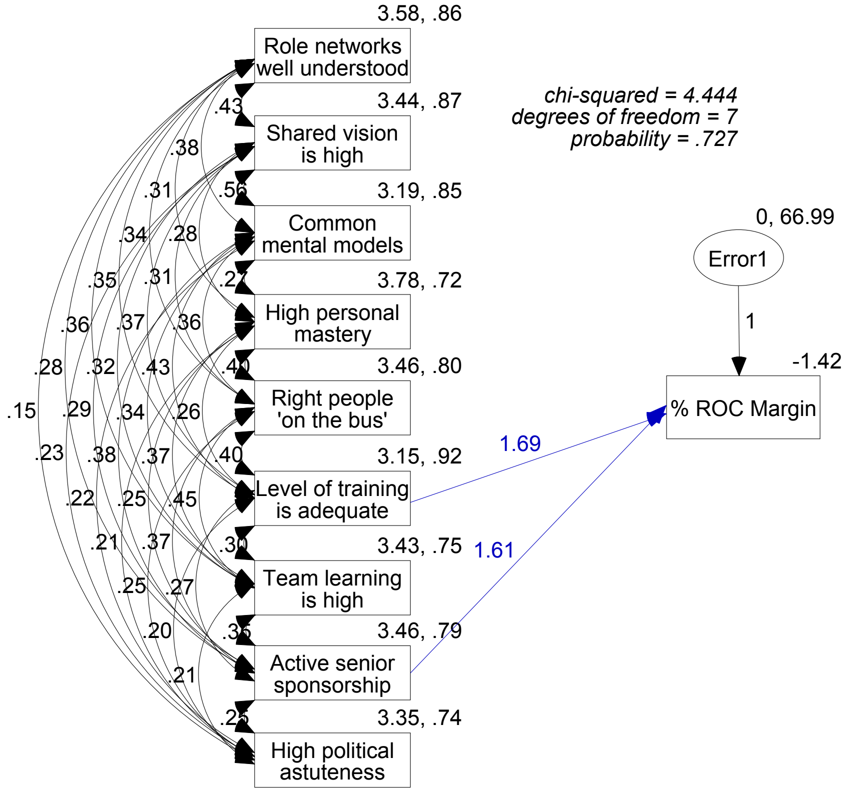


Figure 4.34: Example of 9 Pathway SEM Specification Search on Manifest Part IV Independent Variables and % Return on Capital Margin to Confirm Theoretical Framework 1 (Note: only significant regression paths (p≤0.05) are shown)

The summary results of all manifest variable SEM runs (i.e. all independent and dependent variables) to confirm theoretical framework 1 and showing the significant regression paths found (p≤0.05) are recorded in Tables 4.51 to 4.56.

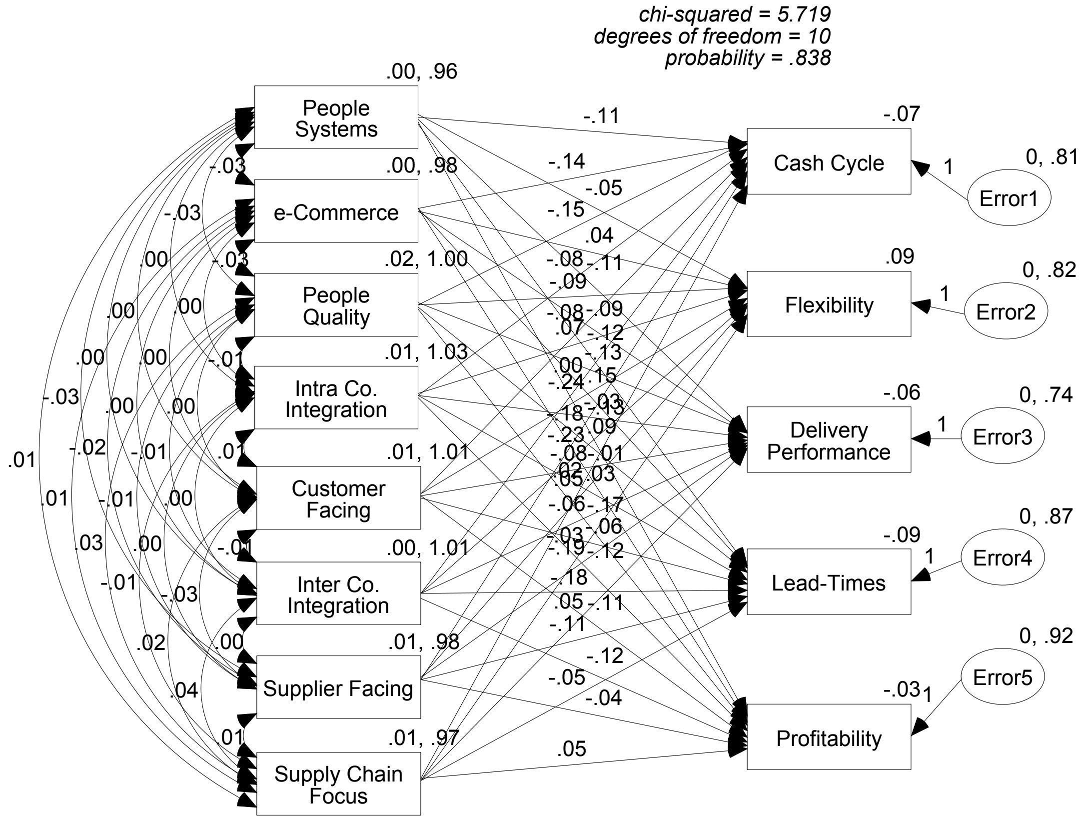


Figure 4.35: Result of Factor Score SEM Run for 5 Dependent Variate Factors and 8 Independent Variate Factors (i.e. 40 pathways) to Confirm Theoretical Framework 1 Using Maximum- Likelihood Calculation of Estimates Method (Specification Search not used here as model too large, $2^{40} = 1.1 * 10^{12}$ iterations)

The significant paths calculated by AMOS 5.0 for the Figure 4.35 model are shown at Table 4.57 below.

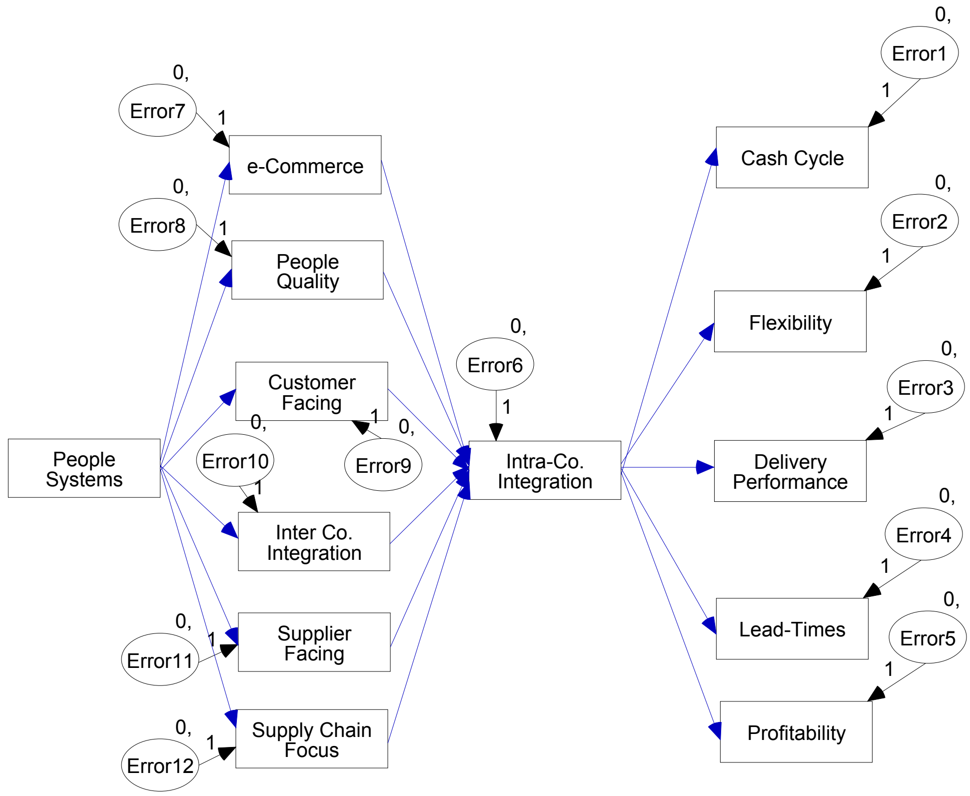


Figure 4.36a: 17 Pathway SEM Factor Score Based Model Structure Used to Confirm Theoretical Framework 2

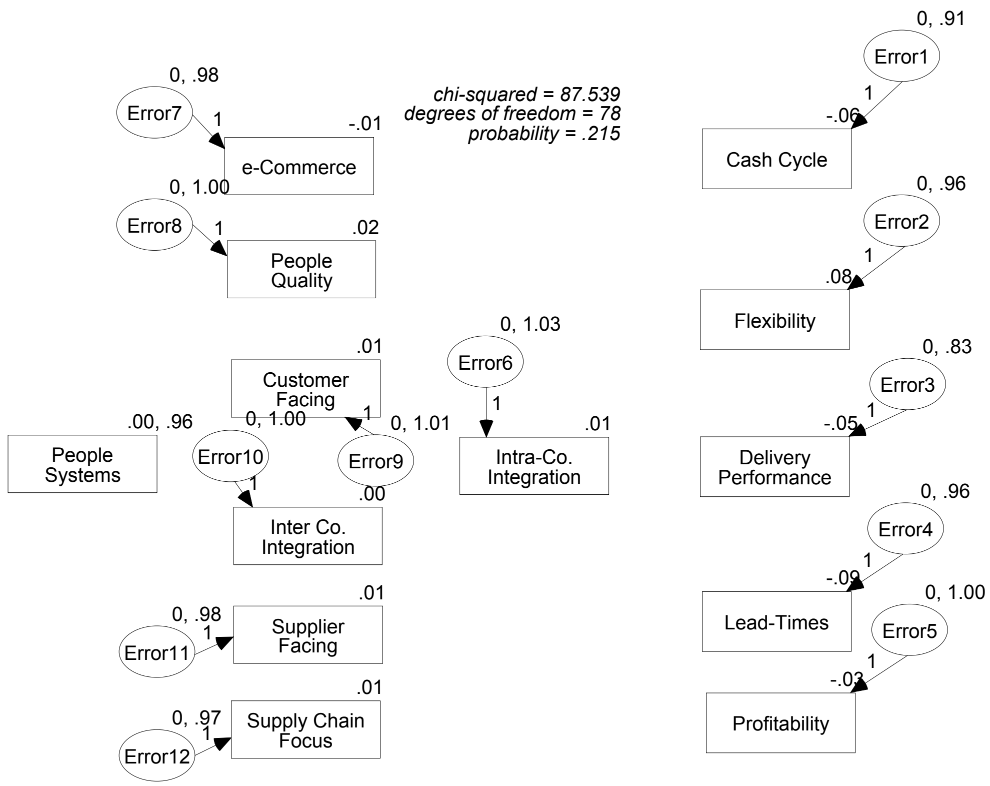


Figure 4.36b: Result of Running Model Shown Above at Figure 4.36a. AMOS 5.0 Specification Search Feature Used (no significant paths found).

For the model run shown in Figure 4.36b, *none* of the regression paths showed to be significant for the 17 paths tested. The data does not support this model structure.

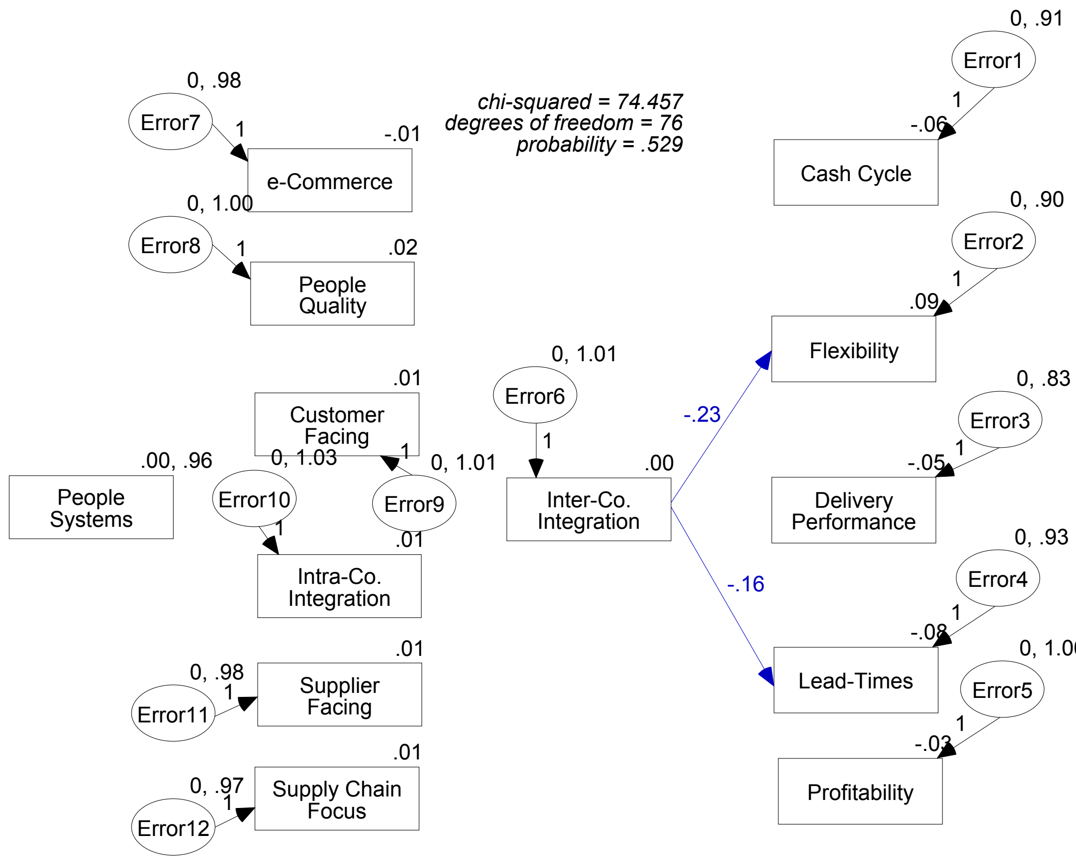


Figure 4.37: Model Run Results for Modified SEM Factor Scores Based Model Used to Confirm Theoretical Framework 2 (Inter-Co. Integration and Intra-Co. Integration Variates were Swapped Position)

After swapping the positions of Inter-Co. Integration and Intra-Co. Integration and rerunning the model, only the paths previously identified in Table 4.57 showed to be significant i.e. the paths 'Inter-Company Integration' → 'Flexibility' and 'Inter-Company Integration' → 'Lead-Times'. Again, this modified model structure is not very well supported by the data.

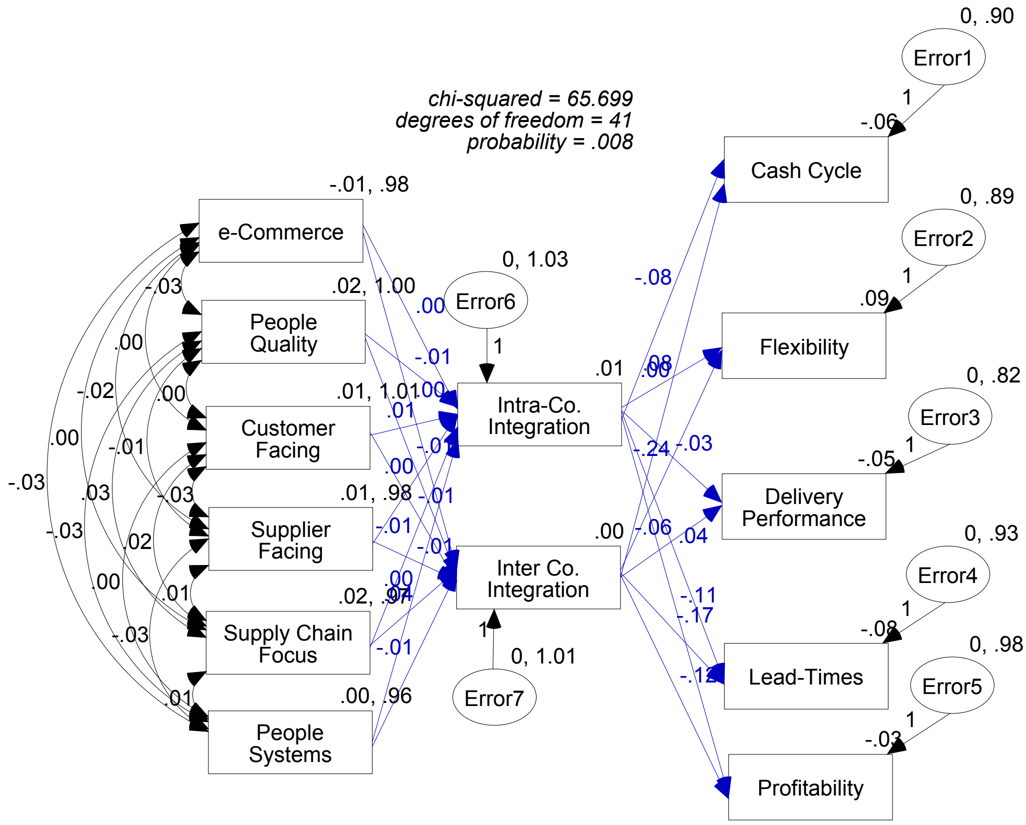


Figure 4.38: SEM Factor Scores Based Model Used to Confirm Theoretical Framework 3 (Specification Search not used as model too large, 2^{22} = 4.19 million iterations. Instead, the Maximum-Likelihood Calculation of Estimates method was used.)

For the model show at Figure 4.38, only 2 paths regressed as significant, being the same 2 as per Figure 4.37. Again, this model structure is not a good fit to the data.

The summary results shown at Tables 4.51 to 4.56 below were calculated using the manifest dependent and manifest independent variables. Additionally for these results, the AMOS 5.0 Specification Search feature was used to identify the best-fit model for each model run. The model structures used to obtain the Table 4.51 to 4.56 results are those shown at Appendix 2. (Note: smc = squared multiple correlation and is an estimate of the Dependent Variables' variance explained. For example, taking the first record in Table 4.51, 5.6% of the Cash-to-Cash Cycle variable's variance is explained by its predictors in the model, the most significant of which, for the Part II Independent Variables, is having a Clear Supply Chain Strategy. Regression Wt is an estimate of the regression weight, so taking the same record and for these results, as the score for having a Clear Supply Chain Strategy goes up by 1 then the Cash-to-Cash cycle time goes down by 7.944 days.)

Independent Variable	Dependent Variable	Regression Wt	P	smc	Supports H_n
Clear SC Strategy	Cash-to-Cash	-7.944	0.037	5.6%	Yes
Clear SC Strategy	Flex (Dem up) [2]	-0.109	0.023	6.1%	Yes
Clear SC Strategy	Mfg Lead-Time[2]	-0.095	0.047	6.5%	Yes
Customer Aligned	ROC Margin	1.226	0.030	11.3%	Yes
Customer Rel'ships	Flex (Dem dn) [2]	-0.109	0.009	8.0%	Yes
Customer Rel'ships	Flex (Dem up) [2]	-0.099	0.048	6.1%	Yes
Customer Rel'ships	Mfg Lead-Time[2]	-0.109	0.024	6.5%	Yes
Customer Rel'ships	Offered L/T[2]	-0.098	0.008	4.3%	Yes
Optimise PoPs	Flex (Dem dn) [2]	-0.105	0.007	8%	Yes
Optimise PoPs	Product Costs	-0.159	0.008	3.5%	Yes
Outward Facing	Perf Ord Fulfilmt[1]	-0.290	0.028	5.6%	Yes
Planned Product Flow	Flex (Dem up) [2]	0.101	0.044	6.1%	No
SC Operating Princ	Days-of-Invent[3]	-0.523	0.032	2.3%	Yes
Supplier Rel'ships	Delivery Perf[1]	-0.247	0.003	4.2%	Yes
Supplier Rel'ships	ROC Margin	1.598	0.010	11.3%	Yes

Table 4.51: Part II Manifest Independent Variables Regression Result Against Each Manifest Dependent Variable *Sorted by Independent Variable*

Independent Variable	Dependent Variable	Regression Wt	P	smc	Supports H_n
Clear SC Strategy	Cash-to-Cash	-7.944	0.037	5.6%	Yes
SC Operating Princ	Days-of-Invent[3]	-0.523	0.032	2.3%	Yes
Supplier Rel'ships	Delivery Perf[1]	-0.247	0.003	4.2%	Yes
Outward Facing	Perf Ord Fulfilmt[1]	-0.290	0.028	5.6%	Yes
Customer Rel'ships	Flex (Dem dn) [2]	-0.109	0.009	8.0%	Yes
Optimise PoPs	Flex (Dem dn) [2]	-0.105	0.007	8%	Yes
Clear SC Strategy	Flex (Dem up) [2]	-0.109	0.023	6.1%	Yes
Customer Rel'ships	Flex (Dem up) [2]	-0.099	0.048	6.1%	Yes
Planned Product Flow	Flex (Dem up) [2]	0.101	0.044	6.1%	No
Clear SC Strategy	Mfg Lead-Time[2]	-0.095	0.047	6.5%	Yes
Customer Rel'ships	Mfg Lead-Time[2]	-0.109	0.024	6.5%	Yes
Customer Rel'ships	Offered L/T[2]	-0.098	0.008	4.3%	Yes
Optimise PoPs	Product Costs	-0.159	0.008	3.5%	Yes
Customer Aligned	ROC Margin	1.226	0.030	11.3%	Yes
Supplier Rel'ships	ROC Margin	1.598	0.010	11.3%	Yes

Table 4.52: Part II Manifest Independent Variables Regression Result Against Each Manifest Dependent Variable *Sorted by Dependent Variable*

Independent Variable	Dependent Variable	Regression Wt	P	smc	Supports H_n
Effective Dem F/C	Offered L/T[2]	-0.091	0.036	6.8%	Yes
eSched ←→ Cust	Cash-to-Cash	-9.084	0.012	8.6%	Yes
eSched ←→ Supp	Perf Ord Fulfilmt[1]	-0.245	0.019	8.4%	Yes
eSched ←→ Supp	Product Costs	0.137	0.031	5.7%	No
eTransactions with Custs and Suppliers	Days-of-Invent[3]	-0.516	0.009	7.3%	Yes
eTransactions with Custs and Suppliers	Product Costs	-0.131	0.039	5.7%	Yes
Extensive P & S	Offered L/T[2]	0.105	0.019	6.8%	No
Feed fwd:Feedback	Product Costs	-0.153	0.033	5.7%	Yes
Integrated P & S	Mfg Lead-Time[2]	-0.148	0.011	10.7%	Yes
Integrated P & S	Offered L/T[2]	-0.089	0.051	6.8%	Yes
Integrated P & S	ROC Margin	2.643	<0.001	9.9%	Yes
P&S Int with Cust	Delivery Perf[1]	-0.208	0.007	3.5%	Yes
P&S Int with Cust	Perf Ord Fulfilmt[1]	-0.368	<0.001	8.4%	Yes
P&S Int with Cust	Flex (Dem dn) [2]	-0.167	<0.001	12.2%	Yes
P&S Int with Cust	Flex (Dem up) [2]	-0.155	<0.001	6.1%	Yes
P&S Int with Supp	Cash-to-Cash	-10.422	0.008	8.6%	Yes
P&S Int with Supp	Days-of-Invent[3]	-0.468	0.040	7.3%	Yes
P&S Int with Supp	Mfg Lead-Time[2]	-0.107	0.034	10.7%	Yes
Tools Convergence	Offered L/T[2]	0.067	0.048	6.8%	No

Table 4.53: Part III Manifest Independent Variables Regression Result Against Each Manifest Dependent Variable *Sorted by Independent Variable*

Independent Variable	Dependent Variable	Regression Wt	P	smc	Supports H_n
eSched ←→ Cust	Cash-to-Cash	-9.084	0.012	8.6%	Yes
P&S Int with Supp	Cash-to-Cash	-10.422	0.008	8.6%	Yes
eTransactions with Custs and Suppliers	Days-of-Invent[3]	-0.516	0.009	7.3%	Yes
P&S Int with Supp	Days-of-Invent[3]	-0.468	0.040	7.3%	Yes
P&S Int with Cust	Delivery Perf[1]	-0.208	0.007	3.5%	Yes
eSched ←→ Supp	Perf Ord Fulfilmt[1]	-0.245	0.019	8.4%	Yes
P&S Int with Cust	Perf Ord Fulfilmt[1]	-0.368	<0.001	8.4%	Yes
P&S Int with Cust	Flex (Dem dn) [2]	-0.167	<0.001	12.2%	Yes
P&S Int with Cust	Flex (Dem up) [2]	-0.155	<0.001	6.1%	Yes
Integrated P & S	Mfg Lead-Time[2]	-0.148	0.011	10.7%	Yes
P&S Int with Supp	Mfg Lead-Time[2]	-0.107	0.034	10.7%	Yes
Effective Dem F/C	Offered L/T[2]	-0.091	0.036	6.8%	Yes
Extensive P & S	Offered L/T[2]	0.105	0.019	6.8%	No
Integrated P & S	Offered L/T[2]	-0.089	0.051	6.8%	Yes
Tools Convergence	Offered L/T[2]	0.067	0.048	6.8%	No
eSched ←→ Supp	Product Costs	0.137	0.031	5.7%	No
eTransactions with Custs and Suppliers	Product Costs	-0.131	0.039	5.7%	Yes
Feed fwd:Feedback	Product Costs	-0.153	0.033	5.7%	Yes
Integrated P & S	ROC Margin	2.643	<0.001	9.9%	Yes

Table 4.54: Part III Manifest Independent Variables Regression Result Against Each Manifest Dependent Variable *Sorted by Dependent Variable*

Independent Variable	Dependent Variable	Regression Wt	P	smc	Supports H_n
'Right' People	Cash-to-Cash	-14.54	<0.001	5.8%	Yes
'Right' People	Days-of-Invent[3]	-0.64	0.009	3.3%	Yes
'Right' People	Delivery Perf[1]	-0.18	0.056	1.8%	Yes
'Right' People	Perf Ord Fulfilmt[1]	-0.38	0.005	3.9%	Yes
Clear Role N/W's	Product Costs	-0.171	0.016	3.0%	Yes
Com Mental Model	Flex (Dem dn) [2]	-0.15	0.001	5.2%	Yes
Level of Training	ROC Margin	1.691	0.009	8.4%	Yes
Political Astuteness	Flex (Dem up) [2]	-0.13	0.018	2.8%	Yes
Senior Sponsorship	Mfg Lead-Time[2]	-0.12	0.026	2.4%	Yes
Senior Sponsorship	ROC Margin	1.614	0.021	8.4%	Yes

Table 4.55: Part IV Manifest Independent Variables Regression Result Against Each Manifest Dependent Variable *Sorted by Independent Variable*

Independent Variable	Dependent Variable	Regression Wt	P	smc	Supports H_n
'Right' People	Cash-to-Cash	-14.54	<0.001	5.8%	Yes
'Right' People	Days-of-Invent[3]	-0.64	0.009	3.3%	Yes
'Right' People	Delivery Perf[1]	-0.18	0.056	1.8%	Yes
'Right' People	Perf Ord Fulfilmt[1]	-0.38	0.005	3.9%	Yes
Com Mental Model	Flex (Dem dn) [2]	-0.15	0.001	5.2%	Yes
Political Astuteness	Flex (Dem up) [2]	-0.13	0.018	2.8%	Yes
Senior Sponsorship	Mfg Lead-Time[2]	-0.12	0.026	2.4%	Yes
Clear Role N/W's	Product Costs	-0.171	0.016	3.0%	Yes
Level of Training	ROC Margin	1.691	0.009	8.4%	Yes
Senior Sponsorship	ROC Margin	1.614	0.021	8.4%	Yes

Table 4.56: Part IV Manifest Independent Variables Regression Result Against Each Manifest Dependent Variable *Sorted by Dependent Variable*

Independent Variate	Dependent Variate	p	smc
People Quality	Profitability	0.035	8.4%
Customer Facing	Flexibility	0.001	14.1%
Inter-Company Integration	Flexibility	0.002	14.1%
Inter-Company Integration	Lead-Times	0.024	9.8%
People Quality	Cash Cycle	0.048	10.1%
Supplier Facing	Cash Cycle	0.020	10.1%
Supplier Facing	Delivery Performance	0.008	9.8%

Table 4.57: Summary Results of SEM *Factor Score* Based Model Run Shown at Figure 4.35 (Note: The results represented in this table were not calculated via the Specification Search feature as the model is too complex (too many pathways), rather, the AMOS 5.0 maximum-likelihood calculation of estimates method was used.)

4.3 Conclusions for Data Analysis

4.3.1 From the analysis of the descriptive statistics, it was shown firstly that a number of the distributions of the reported dependent variable results were quite skewed, especially Delivery Performance, Lead-Times (manufacturing and offered), Flexibility (to demand increases/decreases) and Days-of-Inventory. This required variable transformations in order to achieve better normality. Secondly, 6 of the independent variable results show quite distinct bi-modal patterns (Supply Chain Goals, Supply Chain Organisational Approach, Supply Chain Strategy, e-Logistics, Convergence of Internet and Decision Support Tools and e-Enabled Transaction Activities) leading to the conclusion that supply chain approaches on these dimensions are not uniform across the companies surveyed. Thirdly, because the redundant type questions used to test the validity of some of the measures did indeed confirm their repeatability eg Customer/Supplier Relationships and Customer/Supplier Facing, Sharing of Schedules with Customers/Suppliers Electronically and e-Logistics, it can be concluded that these results add to the content validity of these variables. Fourthly, because the supply chain focus of the majority of the companies involved in the survey (50%) is more operational than strategic, then it can be concluded (and particularly if the results of this sample are indicative of manufacturing organisation more generally) that there are still many companies that look to their supply chain as something operational rather than strategic. Lastly, and importantly for the SEM conclusions below, strong support for cooperative customer and supplier relationships was found.

4.3.2 From the series of ANOVA analyses conducted, it was found firstly that the Food and Beverage manufacturing segment showed significantly better results than other segments considered on the measures of Cash-to-Cash Cycle Times and Political Astuteness of their supply chain logistics personnel. There are two possible conclusions that can be drawn from this result, (i) The food/beverage segment is competitively intense and thus participants in this segment must be good in order to survive, and (ii) The Food/Beverage segment has been doing this for longer. That is, they have more experience in the field of supply chain management having started with the Efficient Consumer Response (ECR) group in 1992. Secondly, levels of planning and scheduling including feed-forward and feedback process integration, are higher on single site type operations than they are on multi-national site type operations and Days-of-Inventory are lower (better) for business unit reported results than for whole company reported results. This leads to the conclusion that there are a number of factors (e.g. management span, organisational complexity, supply chain network complexity, competition for resources and focus of those resources) operating at a multi-national/whole company level that determine lower results on these activities verses the results achieved by single site/business unit level type operations.

4.3.3 From the Factor Analysis conducted, it can be concluded that the 10 manifest dependent variables included in the study, can be sensibly reduced to 5 factor variates. Additionally, the 32 manifest independent variables can be sensibly reduced to 8 factor variates. Importantly however, when using the factor scores from the factor analysis in running SEM type regressions, a number of the individual significant pathways, identified when using the manifest variables, were lost.

4.3.4 From the numerous Structural Equation Models tested, the main conclusions are as follows:

4.3.4.1 From the SEM runs used to confirm theoretical framework 1 and using the manifest variables, it can be concluded that in order to achieve higher performance levels on the business outcomes sought (i.e. the study's dependent variables) then it is important to have:

- A clear supply chain strategy.
- Agile supply chain operating principles.
- Strong customer/supplier relationships (an outward facing attitude).
- Optimisation of points-of-production.
- The electronic sharing of schedules with customers and suppliers.
- e-Enabled transactions with customers and suppliers.
- Integrated planning and scheduling systems.
- Planning and scheduling systems integrated with customers and suppliers. This was a particular repeating finding being significant along 7 SEM

pathways (as shown at Table 4.51 above).

- Planning and scheduling process integration includes feed-forward and feedback.
- Effective demand forecasting.
- Clear role networks.
- The ‘right people on the bus’ i.e. people with the right skills and capabilities match with the job required to be undertaken.
- Supply chain personnel sharing common mental models about what they are trying to achieve and how they will go about it.
- An adequate level of training
- Active senior sponsorship.
- Political astuteness of supply chain personnel.

There were 4 significant relationships identified that do not support the research hypotheses. This leads to the conclusion that the independent variables involved in these relationships can diminish performance on the business outcome measures (i.e. the associated dependent variable). Additionally, another conclusion is that supply chain practitioners need to carefully consider the impact of these variables on their particular supply chain. The 4 significant relationships concerned are:

- Higher levels of planned product flow were found to be associated with greater time to respond to customer demand increases. A possible reason for this relationship is that companies with more complex supply chains and complex product flows take the time to plan them more carefully and that it is the nature of such chains therefore that makes response flexibility much more difficult.
- The sharing of schedules electronically with suppliers was found to be associated with higher per unit product costs. Two possible reason for this relationship are suggested: (a) companies with high underlying product costs may be using such practices in order to reduce their costs whereas lower product cost companies may not be so inclined, and (b) the cost to set up the electronic transaction process and staff structure to support it may be adding to the product cost structure.

- The convergence of the Internet and decision support tools was found to be associated with increased offered lead-time days. A possible reason for this relationship is that the development of such technological solutions are still in their infancy and so it may take some years before the tools are developed to the point they are easy to implement and use and thus of useful assistance to supply chain practitioners.

- Extensive Planning and scheduling was found to be associated also with increased offered lead-time days. A possible reason for this relationship could be similar to the planned product flow relationship above. That is, organisations with more complex (or long vertically integrated) supply chains and product flows need to undertake such extensive planning in order to attempt to manage their supply chains properly and it is the underlying nature of such complex (and or long) chains that results in higher (longer) offered lead-times.

4.3.4.2 From the SEM runs used to confirm theoretical framework 1 using the factor scores, it can be concluded that in order to achieve higher performance on the business outcome measures considered (i.e. the 5 dependent variates), that it is important to have:

- An outward facing orientation for the organisation. That is a strong focus/receptiveness/consideration of/relationships with, customers and suppliers.
- An adjunct to outward facing orientation is the need for strong inter-company process integration.
- High levels of people quality (measured in terms of skills/capabilities fit with job, personal mastery, team learning attitude, political astuteness and active sponsorship).

4.3.4.3 From the SEM runs used to confirm theoretical frameworks 2 and 3 and using the factor scores, it can be concluded that these frameworks are not supported by the data of this study. That indeed theoretical framework 1 is the more appropriate model to explain the underlying structure of relationships found with this work.

5 Chapter 5 – Simulations

5.1 Introduction

One of the challenges facing all organisations and particularly those wrestling in the modern day competitive world having to deal with the organisational cultural changes necessary to realise a truly collaborative supply chain, is how to conceive and implement performance improvement ideas that will actually work i.e. that will actually deliver the sought after outcomes and that the result will be sustainable (Richmond, 2001, pp. 1). As discussed at section 2.0 above, manufacturing organisations have adopted an array of improvement methodologies over the past 20 years, some of which have been very successful, some moderately successful and some have made either the target or inter-related results worse.

On many occasions ("75% of reengineering efforts do not produce targeted performance improvement." (Richmond, 2001, pp3)), the improvement projects themselves (e.g. reengineering projects, ERP projects) over-run their budget and timetable and consequently not only fail to deliver the intended business benefits they claimed they would, but damage the organisation directly via heavy and unintended demands on human resources and cash (Richmond, 2001, pp. 3). As noted in section 2.2.6, Hall, Rosenthal and Wade (1993, as in Waller, 1999, pp. 187) claim that reengineering is not universally successful and explain a number of failure instances in a survey of 100 reengineering efforts they conducted.

What could be the possible root causes of such misadventures? Richmond (2001, pp. 6) argues that the cause is to do with a mismatch between human cognitive ability and complex modern day socio-cultural systems. In short, the development of the human biological system has not kept up with technological and organisational advancements. Richmond's point is that our given cognitive capacities and process make it difficult for humans to accurately form mental models of complex situations let alone reliably simulate them mentally. Human neurobiology has evolved over many centuries with a prime goal being that of survival. As such our mental models about situations contain a lot of detail about *immediate* things, in space and time (Richmond, 2001, pp. 7). Such "localness" in our thinking is reflected even today with many of the silos that exist in most modern day organisations e.g. Marketing, Manufacturing, Finance, IT in businesses, or as departments within faculties in educational institutions. Humans, it seems, need to be able to simplify complex 'things' in order to make sense of them. Such simplification though, can lead to short sightedness of impacts and actions that happen outside the simplified immediate space. I.e.:

Please see print copy for Figure 5.1

Figure 5.1: Immediate Space and Time Focus Limits Validity of Mental Models of Wider Systems (Richmond, 2001, pp. 8)

Such thinking in Richmond's view utilises meta-assumptions that do not reflect reality in a number of key aspects. For example, meta-assumptions that assume that input factors (causes) operate independently and that causality runs only one way, or that there are no process 'lags', or that relationships are only ever linear (Richmond, 2001, pp. 11). Richmond calls for a better conceptual framework and tools that will facilitate the development and use of more valid models and more reliable simulations. Richmond promotes Systems Dynamics as a potential solution to the dilemma. Such an approach is used below in the development of a simulation model that captures the essence of the data analysis result for this research.

5.2 Scope and Intent

The purpose of the simulation part of this thesis is to capture in a systems dynamics type representation, the key conclusions and relationships found via the above data analysis. Supply chain practitioners can then use the model as a test bed for their supply chain improvement ideas.

The intent of this simulation modelling therefore is to capture and exhibit the underlying supply chain 'DNA' that has been uncovered by this research in order that others may improve the robustness of their development ideas and initiatives. In short, to help them develop more complete mental models of the system operating within their supply chain(s).

The scope of the simulation part is limited to the variables covered in the research and to the recorded results and identified relationships of those variables.

5.3 Simulation Infrastructure and Architecture

"ithink" software was chosen as the tool to undertake this simulation. ithink uses a modelling language that is primarily made up of stocks, flows and converters. A stock (considered as a 'noun') is essentially an accumulator of physical 'things' (such as finished goods inventory levels) and non-physical states-of-being (such as morale, motivation or satisfaction levels). A flow (considered as a 'verb') is essentially a flow controller and controls the flow rate of the physical or non-physical parameter into and out of stocks. A converter (considered as an adverb or modifier) contains values used to modify a flow.

Deterministic simulation (as explained in Chapter 3) was chosen for this research because (a) randomness was not a prime consideration of this work and (b) the construction time and complexity required of a stochastic model were beyond the time constraints of the researcher.

Expressing the following simple systems dynamics model (Figure 5.2) into the 'ithink' language would result in a model diagram as shown at Figure 5.3 below.

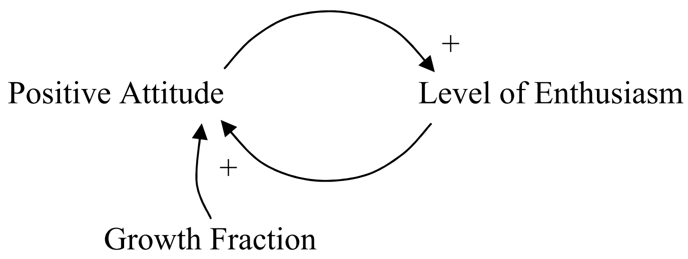
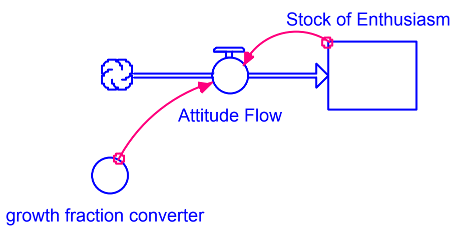


Figure 5.2: Simple Systems Dynamics Reinforcing Loop Model



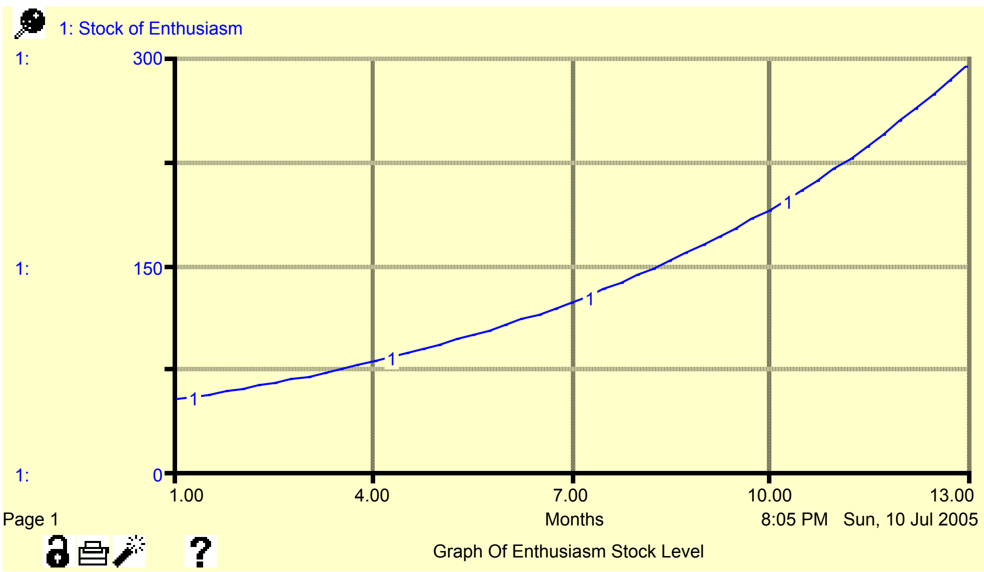


Figure 5.3: 'ithink' Representation of Model Shown in Figure 5.2 With Resultant Exponential Growth Rate of Enthusiasm

The data analysis results of this research represent a ‘reference behaviour pattern’ (within the validity and reliability conditions as discussed in Chapter 3 above). Because of the availability of such reference data, the model was constructed using the actual regression results of the study’s data analysis. That is, the actual individual relationship regression weights calculated in the data analysis were coded into the model equations for each of the significant ($p \leq 0.05$) relationships determined. All such relationships can be seen visually at Figure 5.4 below. Additionally, the starting level for each stock and each converter in the model was set to the mean level determined from the data analysis. Further, in order for the model to be dampened by the squared multiple correlation results, these values were also coded into the model equations. So a typical flow equation used in the model is of the form:

*Dependent Variable Improvement/Deterioration Flow Rate = Sum of (Amount of Change to Independent Variable * Regression Weight * Squared Multiple Correlation) for all independent variables acting on that Dependent Variable.*

For those variables that were transformed for the data analysis, their regression weights were transformed back such that they could be used for the original state of the variables. For example, taking Delivery Performance and the significant relationship found between it and Supplier Relationships, the regression weight for this couple was –0.247. So for every 1-unit *increase* in the independent variable Supplier Relationships, reflect-square-root Delivery Performance goes *down* by 0.247. Taking the mean (untransformed) Delivery Performance result from the data of 90.34% gives a reflect-square-root result of:

reflect-square-root (90.34) = square root (101 - 90.34) = 3.265

Reducing this by 0.247, (assuming that the Supplier Relationship score goes up by 1) then: *3.265 – 0.247 = 3.018*. Back transforming this figure gives:
$101 - (3.018)^2 = 91.89$, which means that as the score for Supplier Relationships goes *up* by 1 unit then Delivery Performance (in this example) goes *up* by: *(91.89 – 90.34) = 1.55.*

When executing the model, the amount of change to the independent variables is set by the operator of the model using the slider controls on the control panel shown at Figure 5.5. In this way, the operator of the model can increase or decrease the value of any or all of the independent variables whilst the model is running and can observe the effect of such changes using the software's graph pad feature (Figures 5.6 to 5.9). In order to restrict the extent of the change to be within the range of responses found in the survey results, only +2 to –2 change range is available to the operator.

5.4 Relevance to 'Real World'

The relevance of the model is that it represents in structure and statistics, the capture of the key findings of this research. That is, the model is a manifestation of the key variable relationships and the values calculated around those relationships and is presented in a way that the operator can test the effect of varying the driver variables (singly or in unison) and can gauge the impact of such changes on the outcome variables to an extent as calculated by the data analysis.

Of course there are limitations to the use of such a model. Firstly, the supply chain 'DNA' represented by this model (and as reinforced by levels of the squared multiple correlations calculated) considers only a portion of all of the driver variables that can and do act on the outcome measures considered. Secondly, an operator of the model must appreciate that other factors will come into play when such business measures reach very high or very low levels (for example sustained and high return-on-capital-margin results would make such an industry very attractive to new entrants, whose actions in turn may well reduce return-on-capital-margin performance). Thirdly, the model is valid within the constraints of a cross-sectional analysis as mentioned above. Fourthly, the relationships are statistical and not causal. Designed experiments would be required to confirm causality. Fifthly, improved results in actuality are achieved not only if the improvement efforts are relevant, but that they must be adequately resourced and sustained for a considerable period of time also. Lastly, because data capture around business improvement programs and specifically the time taken for such programs to have an impact were not part of this work, the timescale used for the simulations shown here was set by the researcher based upon 38 years of direct manufacturing industry and business improvement knowledge. Users of the simulation model therefore need to be aware of this fact and must take care to set the timescale in the 'ithink' software to reflect the expected improvement cycle lead-time for their circumstances.

5.5 Developed Model

The model developed for the simulation is shown at Figure 5.4. The model uses a flow controller referred to as a bi-flow. This controller will add to a stock if the resultant flow is positive (i.e. flows to the right in the diagram) and subtract from a stock if the resultant flow is negative (i.e. flows to the left in the diagram). The slide controls on the "Control Panel for Supply Chain Simulator" shown below at Figure 5.5 can thus be set to increase (positive) or decrease (negative) the independent variable values within the range exhibited by these variables in the data. Each of the stocks in the model was initialised to the mean value for that variable as determined from the survey results. The links drawn on the model represent the significant relationships found from the data analysis. As can be seen, the independent variables around the outside of the model are those with a greater number of relationships, whereas those on the inside of the model have mostly single point relationships.

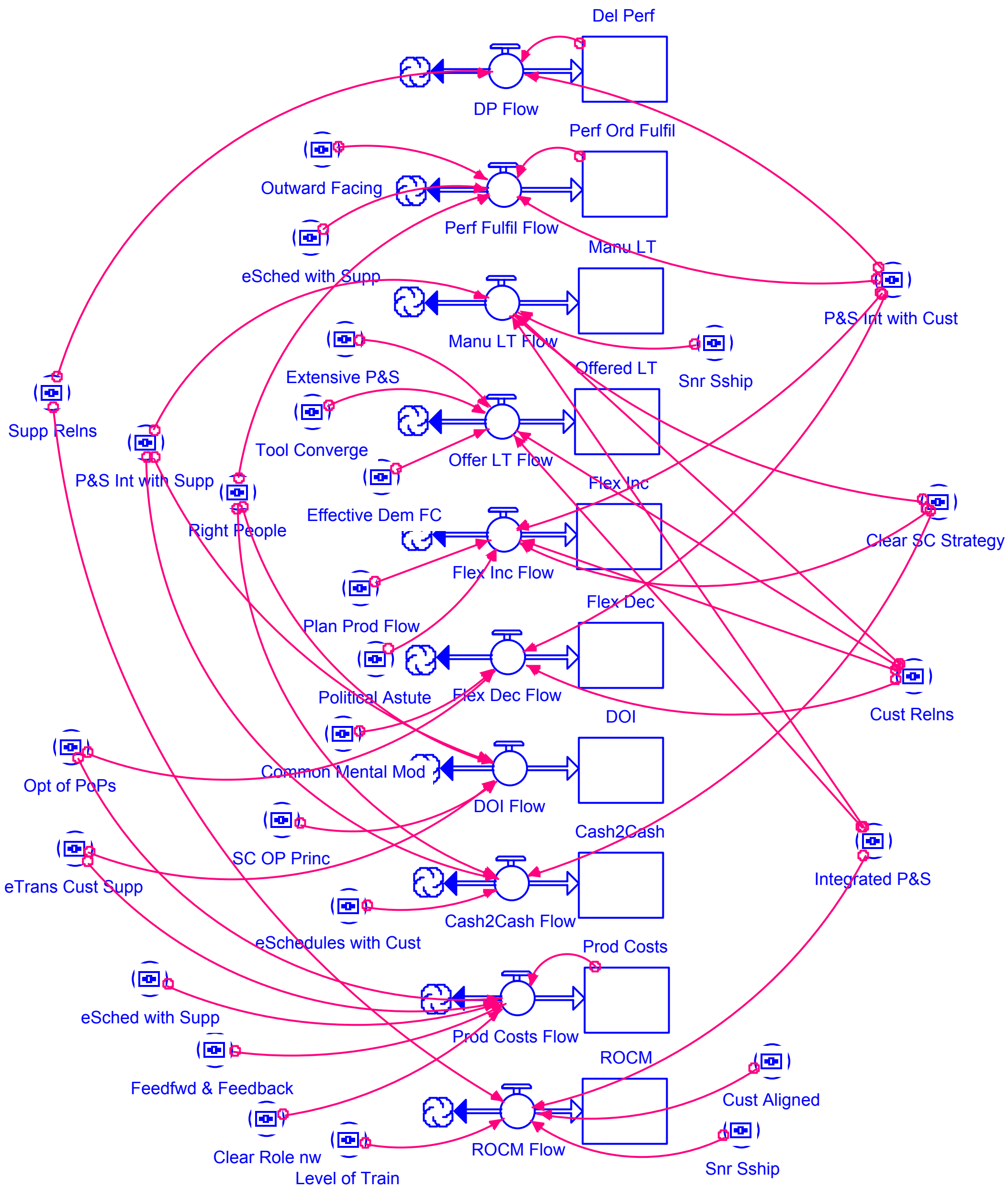


Figure 5.4: ithink Simulation Model of Research Relationship Findings

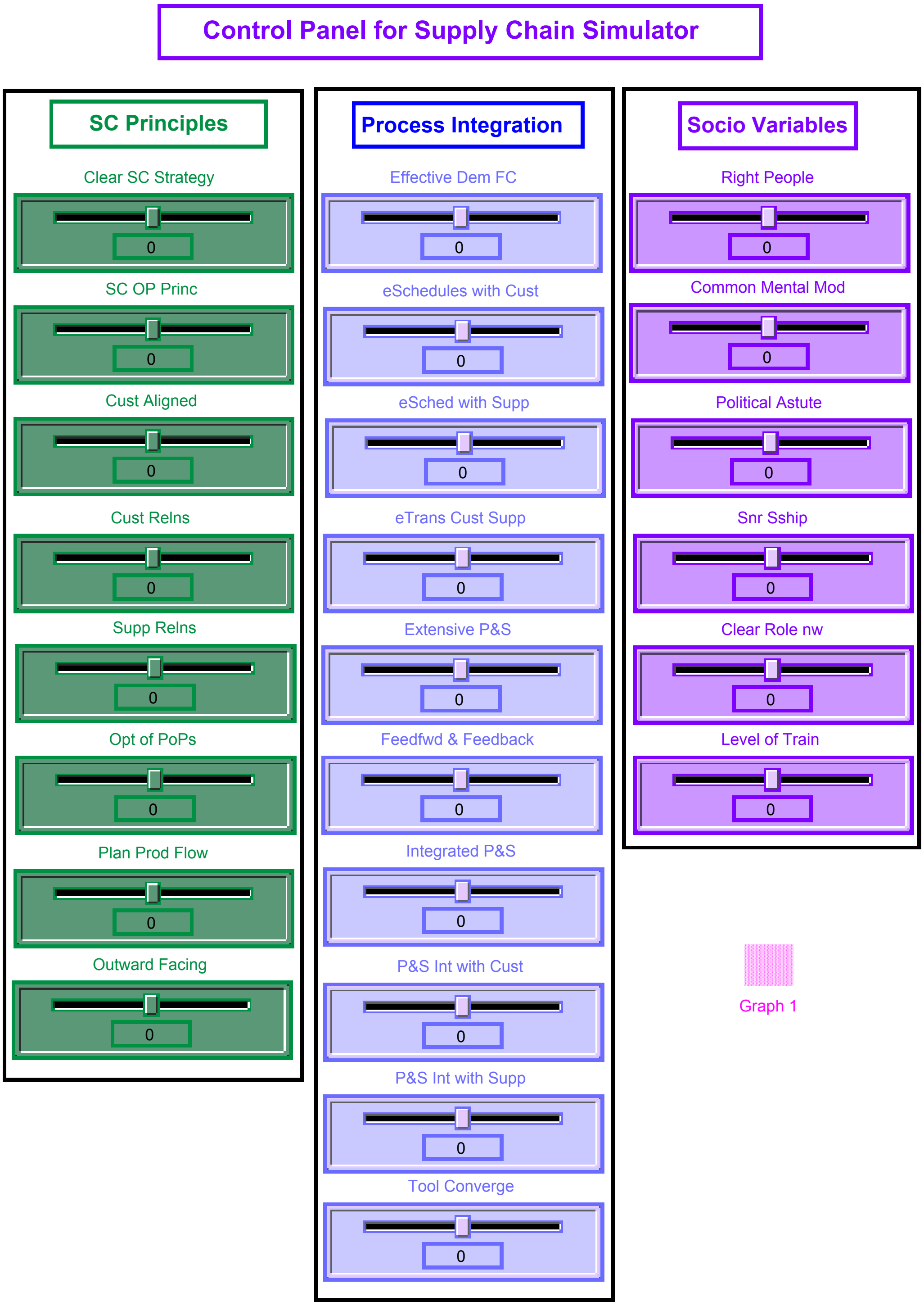


Figure 5.5: Simulation Model Control Panel (Showing Slider Control for Each Part II (SC Principles), Part III (Process Integration) and Part IV (Socio) Independent Variable Exhibiting a Significant Relationship with a Dependent Variable (move to right to increase value (0 to +2 units) and move to left decrease value (0 to -2 units))).

5.6 Results of Model Runs

Presented below are the results of several runs of the model using different independent variable settings. Figure 5.6 shows the impact of increasing the values of Customer Alignment, Supplier Relationships, Integrated Planning and Scheduling, Level of Training (of logistics practitioners) and Senior Sponsorship only. As can be seen, Return-on-Capital Margin progressively increases over the period of the run. Also, as none of the before mentioned independent variables were found to be significantly related to Product Costs, the "Prod Costs" line remains flat.

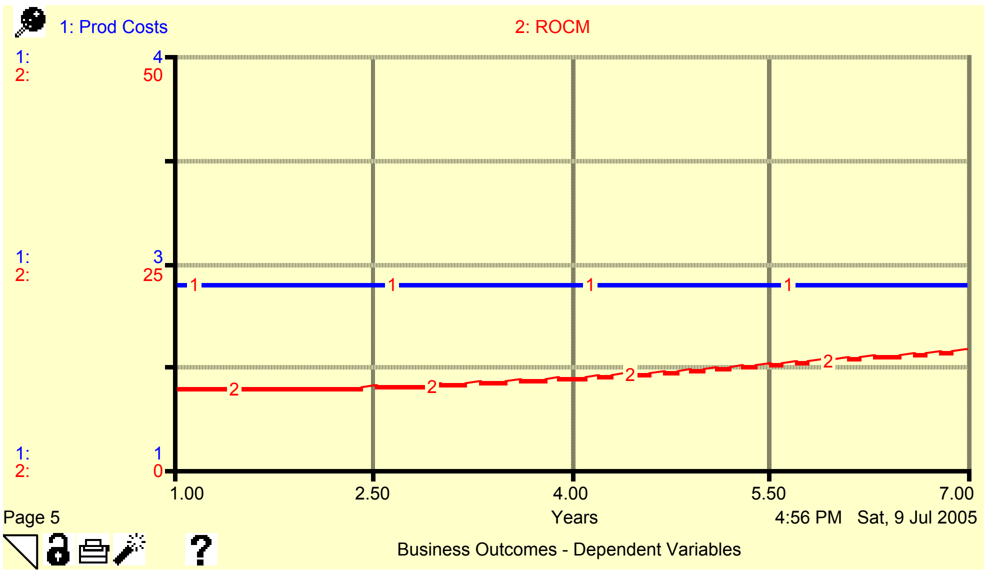


Figure 5.6: Result of Increasing Independent Variables Having a Positive Impact on Return-on Capital-Margin

Figure 5.7 shows the impact of increasing and then decreasing Optimisation of Points of Production, e-Transactions Conducted with Customers and Suppliers, Planning and Scheduling Process Integration Includes Feed-forward and Feedback and Clear Role Networks. It can be seen that Product Costs/Unit first falls and then rises when the independent variables are moved from positive impact to negative impact. Again, as none of these independent variables were found to be related to Return-on-Capital Margin, its line on the chart remains flat.

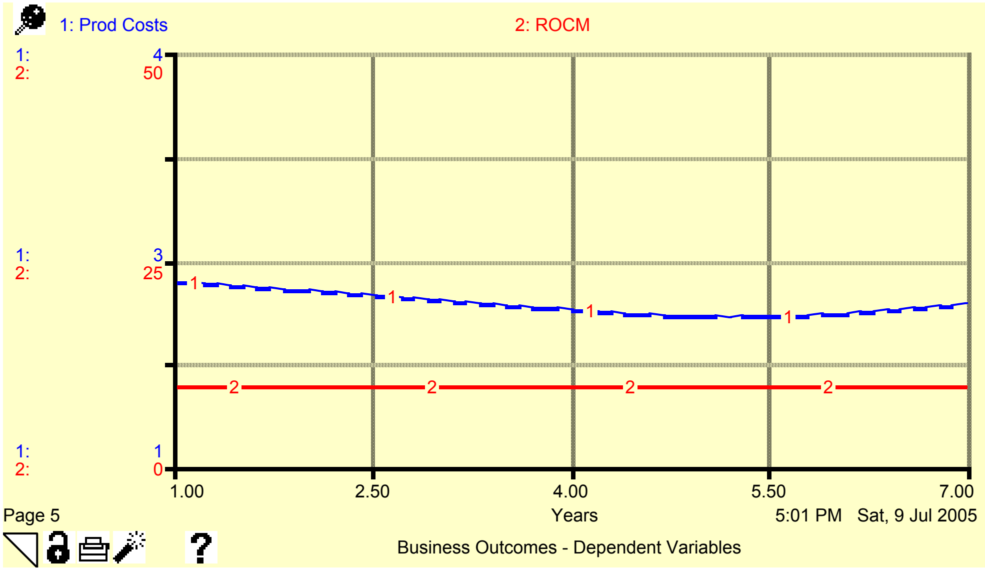


Figure 5.7: Result of Increasing and Then Decreasing the Independent Variables Positively Impacting Product Costs

Figure 5.8 shows the impact on Perfect Order Fulfilment of increasing and then decreasing Outward Facing, Planning and Scheduling Integrated with Customers, Schedules Shared with Suppliers Electronically and having the Right People. As Planning and Scheduling Integrated with Customers is also related to Delivery Performance, a smaller change is also evident on that variable.

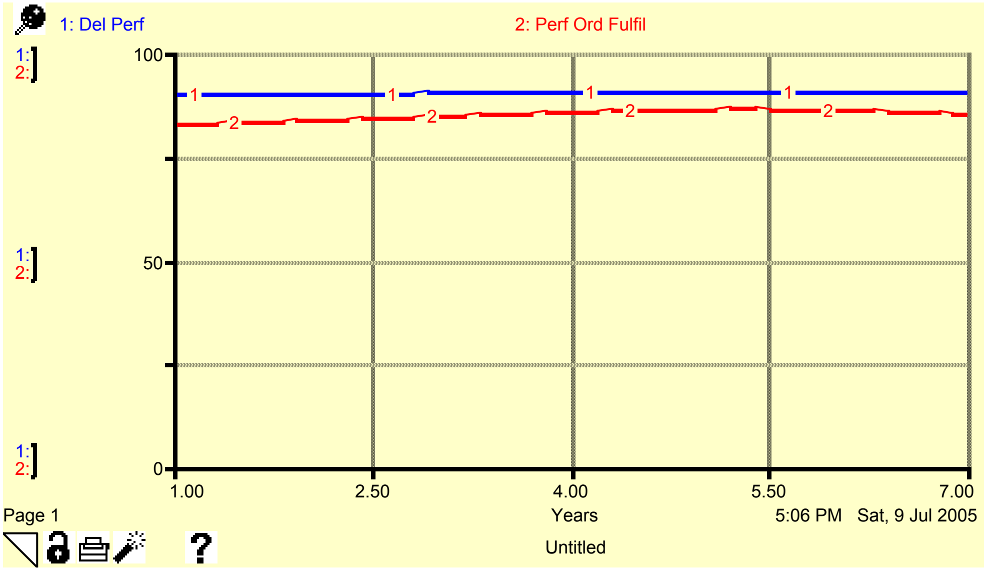


Figure 5.8: Result of Increasing and Then Decreasing the Independent Variables Positively Impacting Perfect Order Fulfilment

Figure 5.9 shows the impact of first increasing and then returning the amount of change to zero of Clear SC Strategy, Schedules Shared Electronically with Customers, Planning and Scheduling Integrated with Suppliers and having the Right People on Cash-to-Cash Cycle time. As can be seen, the business outcome measure first improves and then levels out at the new lower plane. Because 2 of those variables (Planning and Scheduling Integrated with Suppliers and having the Right People) also impact Days of Inventory, its line also reduces but to a lesser extent.

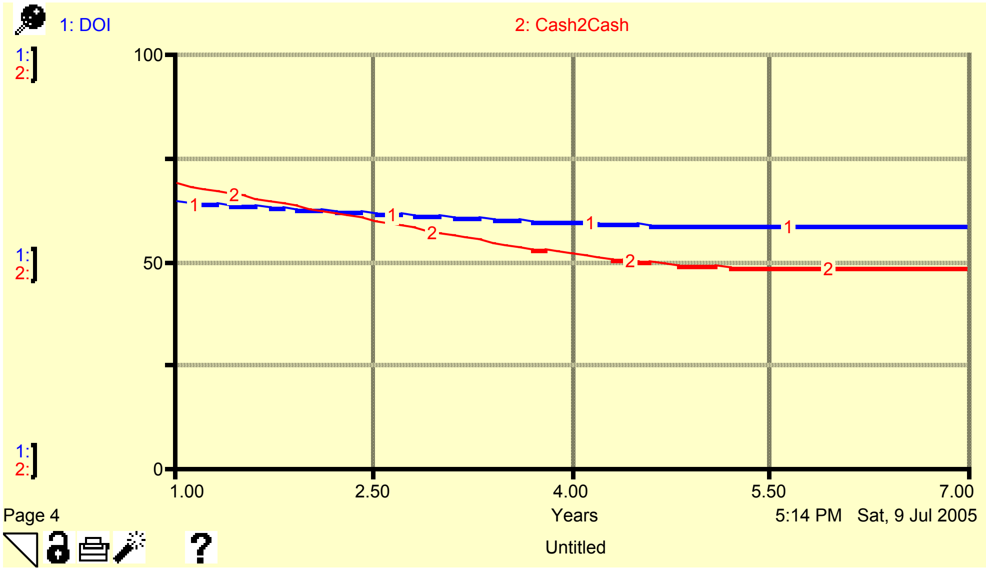


Figure 5.9: Result of Increasing and Then Returning to Zero the Independent Variables Positively Impacting Cash-to-Cash Cycle Times

5.7 Conclusion

The model was tested on several different scenarios and on each occasion behaved in a manner consistent with the results of the data analysis. It is concluded therefore that the model replicates the relationship structure and relationship strengths as identified in the data analysis results. In this form supply chain practitioners can use it to test against both their mental models and improvement ideas. For example, which levers will give them the most improvement on the dimension they are looking to improve and more importantly, if they pull a lever by a certain extent, what are the likely effects on other inter-related variables in the model. The advantage of simulation is that the effects can be seen dynamically, that is, the practitioner is not looking at a single snapshot result.

In addition, educators could make use of such a model in Operations Management type programmes where they are attempting to demonstrate both the factors involved in a supply chain management context and their inter-relatedness.

Lastly, it is felt that the model provides a good basis for researchers to further develop and enhance from the results of further applied research and/or from causality confirmation experiments. In this way, the model demonstrated here can be grown to include other associated supply chain and ultimately other key business processes.

6 Chapter 6 – Conclusions and Implications

6.1 Introduction

The previous chapters of this thesis have described the work undertaken in the study to reach this point. That is, an introduction to the research has been described, results of a detailed literature review presented including the research questions, the main research hypotheses, and the key theoretical frameworks, the specifics of the methodology were discussed, results of the data analysis presented and a simulation model based on the key research findings has been demonstrated. This chapter therefore attempts to reach relevant conclusion from all of the work undertaken thus far.

6.2 Conclusions About Each Hypothesis

Based upon the three hypotheses tested in the study, it is concluded as follows:

The first hypothesis stated:

H_1: That the *integration* of supply chain logistics *processes* does significantly and positively impact supply chain and business performance.

It is concluded from the results of the data analysis that this hypothesis was conditionally supported. That is, for the 'Part III' study variables (supply chain logistics process integration variables), using a manifest-variable structural equation model of the type shown at Figure 4.33 above, out of 130 total possible paths, 16 of them were found to be significant ($p \leq 0.05$) and in support of H_1. All 16 significant paths were process integration related independent variables. An additional 3 significant paths were found to not support H_1. 2 of these were integration related independent variables and 1 was to do with convergence of Internet and decision support tools. It must be added also that whilst the 16 paths in support of the hypothesis were found to be statistically significant, the amount of dependent variable variance explained in each case was fairly low at 5.7% to 12.2%.

The second hypothesis stated:

H_2: That the *application* of supply chain management *principles* does significantly and positively impact supply chain and business performance.

It is concluded that this hypothesis was also conditionally supported. That is, for the 'Part II' study variables (supply chain principles type variables), using a manifest-variable structural equation model of the type shown at Figure 4.32 above, out of a possible 100 model paths, 15 were determined to be significant and 14 of these were in support of H_2. The single pathway not in support was that of planned product flow and flexibility to respond to a demand increase. Again it must be added that whilst the 14 paths in support of the hypothesis were found to be statistically significant, the amount of dependent variable variance explained in each case was fairly low at 2.3% to 11.3%.

The third hypothesis stated:

H_3: That the *application* of *human 'social' principles/approaches* does significantly and positively impact supply chain and business performance.

It is concluded that this hypothesis was also conditionally supported. That is, for the 'Part IV' study variables (logistic personnel socio variables), using a manifest-variable structural equation model of the type shown at Figure 4.34 above, out of a possible 90 model paths, 9 were determined to be significant and all of them were in support of H_3. Again, whilst the 9 paths in support of the hypothesis were found to be statistically significant, the amount of dependent variable variance explained in each case was low at 1.8% to 8.4%.

The result of the SEM model run using the factor scores (model shown at Figure 4.35) supports the above conclusions. That is, out of the 40 possible pathways in this model, 7 of them were identified as significant ($p \leq 0.05$). Of the 7 significant paths found, 2 support H_1, 3 support H_2, and 2 support H_3. The amount of dependent variable variance explained in each case was 8.4% to 14.1%. It could be argued that the results of the factor score model run is a more representative model of the data as the effects of inter-correlations (multicollinearity) were minimised.

6.3 Conclusions About the Theoretical Frameworks

From the data analysis results of this study, reasonable support was demonstrated for theoretical framework 1 (Figure 2.29). This indicates that the independent variables act directly and independently upon the business outcome variables considered. SEM model runs using the manifest variables and the factor score variates confirmed this outcome.

From the SEM results using factor scores, theoretical frameworks 2 and 3 were not supported by the data. Therefore it is be concluded that the socio environment described for the logistics practitioners in this study and the particular supply chain principles utilised *do not* directly impact the levels of intra and inter company integration of logistics processes. Rather, it appears that these factors more so impact directly on the business outcome factors used.

6.4 Conclusions About the Research Problem

The stated research question from Chapter 1 is:

"How much and in what ways does the integration of supply chain logistics processes in manufacturing organisations impact upon business performance?"

Using the results of the hypothesis testing as discussed in the section immediately above, it is concluded that the integration of such supply chain logistics processes does significantly and positively impact business performance outcomes as defined and used in this study. It is further concluded in relation to the secondary research questions stated at section 2.5 above, that the application of modern supply chain management principles and higher levels of people quality and active senior sponsorship of supply chain logistical personnel, does also assist the business performance outcomes so mentioned. The simulation model developed for Chapter 5 takes these key study findings and captures them in a way that can be dynamically demonstrated.

Three important caveats to the above conclusions however must be made. The first is that due to the low levels of variance explained for the dependent variables, the supply chain factors considered in this study represent *only a fraction* of all of the factors impacting upon such business outcomes as described. The other factors involved in the total business performance ‘system’ are those noted as the *out of scope* subject areas listed in section 1.7.1. Such factors as organisational strategic intent, the basis of competition, overall core competencies, underlying competitive advantages, barriers to entry, strength of brand, patent protection, price and margin management, operational excellence and corporate values are considered as key additional determinates of organisational performance (Porter, 1990, pp. 49~53). These factors can be summarised in as shown in Figure 6.1 below. This research covered parts of the Business Strategy, Customer Value, People and Operating Excellence business success determinates shown.

Please see print copy for Figure 6.1

Figure 6.1: Determinates of Business Success (Researcher, 2005)

Roth and Miller (1992, pp. 73~74) reinforce this 'total system' concept whereby they describe a firm's economic performance outcomes as a function of both *manufacturing success* (appropriate manufacturing strategy and actual implementation of that strategy) and *managerial success* (management's ability to exploit developed manufacturing capabilities and necessary functional capabilities and strengths). Detailed considerations of managerial success as defined by Roth and Miller were not part of this research.

The second caveat is that the assistance to business performance outcomes identified in the study is not general. That is, not every independent variable significantly impacted every dependent variable. The specific significant path relationships shown in Tables 4.51 to 4.57 therefore need to be stressed and observed.

The third caveat is that the research question conclusions need to be considered in light of the generalisability limitations of the research as explained in section 3.3.8.

6.5 Conclusions About the Simulation Model Developed

The simulation model developed as part of this work was tested on several different scenarios related to the survey results. On each occasion the model behaved in a manner consistent with the results of the data analysis. Because of this and because the model was built using the study's actual data analysis parameters and set up to represent the starting condition as defined by the survey results, it is concluded that the model replicates the relationship structure and relationship strengths as identified in the study. As such, it is concluded that the data analysis results as captured in the simulation model developed, extends the body of knowledge around this subject. The implications of this are discussed below.

6.6 Implications for Theory

As mentioned in Chapters 1 and 5, part of the justification of this research was the desirability of uncovering key parts of the underlying supply chain 'DNA' that are relevant to the scope of this work. It is considered that this has been achieved. That is, the *structure* of the relationships and the *strengths* of the relationships that exist between the study's chosen independent and dependent variables have been identified, quantified and simulated in the work presented at Chapters 4 and 5 above. It was confirmed for example that theoretical framework-1 was the structural model most supported by the data.

This knowledge can be used to grow the shared understanding base of the supply chain management discipline. Through improved mental models of how such supply chain 'DNA' works, operating businesses can use the new knowledge relating to the strength and structure of the identified relationships to improve their focus, identify gaps in their supply chain performance, identify improvement ideas/projects and ultimately lift their supply chain capabilities. It can also now be used as a guide for further research. That is, it can be built upon via further research and can be used to better understand supply chain concepts in neighbouring domains.

For these reasons it is concluded that the specific above described outcomes of the data gathering, data analysis, discussion of findings and simulations undertaken with this study, do make a distinct contribution to the body of knowledge of this subject.

6.7 Implications for Private Sector Managers

Private sector managers can use this work to test the dependability and reasonableness of both the mental models they hold around supply chain concepts and any improvement ideas they may have. For example, such managers can use the study's results to assess potential performance improvements if they were to enact the supply chain levers (independent/cause variables) available to them. Importantly, if they use the simulation model developed as part of this work and calibrate it for their particular business, they can adjust an independent variable by a certain amount and will be able to assess the likely effects on other inter-related variables in the model. As such, private sector managers can use the work to reinforce the importance of 'getting right' the significant pathways identified and the effects of doing that.

Private sector managers will also be able to use the simulation model's results to make resource trade-off decisions in circumstances where resource constraints exist.

Finally, private sector managers will be able to use the simulation model and its outputs to influence key decision makers or those resisting change within their organisations (Shapiro, 2001, pp. 24).

6.8 Implications for Public Sector Managers

The implications for public sector managers are similar in concept to those in the private sector. That is, for public sector managers who are responsible for the delivery of a *service*, then the underlying supply chain principles for the reliable on-time, short-cycle cost-effective delivery of that service are considered to be similar to that of a manufacturer delivering a physical product. The particular relationship structure and relationship strengths may differ, however the supply chain management concept especially the outward facing aspects (focus on others in the chain and not just internally) are considered relevant to the public sector as well.

In particular, for public sector educators the SEM structure and the simulation model can be used to explain and demonstrate to their students a research based explanation of key supply chain considerations in managing business performance. Educators can also make use of the simulation model to conduct class demonstrations or tutorials (or student team competitions) such that students can learn from 'hands-on' experience via operating the model and testing the effects of applying different supply chain strategies.

6.9 Limitations

In addition to the caveats discussed above (section 6.4), the limitations of this work are stated as follows:

6.9.1 The generalisability of the data analysis results and the conclusions are subject to the sample frame considerations discussed at section 3.3.8.

6.9.2 The relevance of the findings is limited to the field of this study. That is, the relevance does not cover those elements nominated as out of scope in section 1.7.1.

6.9.3 From the early assessment of survey responses (i.e. before the follow-up clarification activities were undertaken) it was obvious to the researcher that a number of the respondents (10%~15%) struggled to reply to some of the survey questions even though definitions of the sought after information was provided. The main reason for this is considered to be that in these cases, the practitioners surveyed *did not know* the answers. That is, such information was either not made available to them on a regular basis or they didn't see the need for it, or they didn't understand its significance to them. This was especially the case for 'return on capital margin', 'product costs' and 'cash-to-cash cycle time'. The limitation this observation raises concerns the competency of survey participants and thus the reliability of the supplied answers. An alternative idea to overcome this limitation (as discussed below) is that of a series of 'research audits' undertaken over a range of organisations (say 40 to 50) in order to improve the veracity of research data.

6.9.4 Industry practitioners and/or academics wishing to make use of the simulation model developed as part of this work will need to carefully estimate improvement cycle lead-times for each of the changeable parameters and make sure such lead-times are reflected in the model's time-scale settings.

6.10 Recommendations for Further Research

Further research is recommended in the following areas:

6.10.1 Taking the findings of this study as a base, it is recommended that further elements (both influencer and outcome elements) be investigated such that the early 'DNA' supply chain business model developed here can be expanded. Importantly, the model needs to develop sufficient scope and relevance such that the explained variances in the dependent variables are ≥ 50%.

6.10.2 The number of questions asked in this study had to be curtailed in order to increase the likelihood that targets would complete it. Therefore not all of the potential variables for the ‘Part II, III and IV’ sets of questions could be included. Additionally, for the social dimension questions, it may be that more appropriate operationalisation of the social concepts can be achieved than was the case for this study. Therefore it is recommended that further work be undertaken on each of these ‘Parts’ separately in order to better define the independent variable set and to undertake analyses to confirm and expand the understandings reached with this work

6.10.3 Limited analysis was undertaken in this work, to understand why some industries and some companies within some industries are much more advanced with respect to their supply chain thinking and the application of supply chain principles than others. Indeed, a sighter to this effect is apparent in the dichotomous results evident in the independent variable descriptive statistics results presented in Chapter 4. It is recommended therefore that this observation be followed up. That is an investigation undertaken to understand why some companies lead the field and others don’t seem to bother.

6.10.4 It is recommended that a simulation model be constructed that actually demonstrates different process integration paradigms. In order for such a model to not become too large and complex, it is recommended that the scope of the model be restricted to the core set of order generation to fulfilment processes as overviewed at Figures 2.17 and 2.23. Such a model should have a transparent structure and thus be capable of clearly demonstrating to practitioners how the integration works, including the specific connections and what is passed along each connection.

6.10.5 It is considered that a more robust quantification/definition of business process integration levels would be beneficial to both practitioners and researchers. For example as expressed very well by van Donk and van der Vaart (2005, pp. 97): “On the one hand, there is some evidence that linking internal processes to external suppliers and customers is a prerequisite for success and a consensus among researchers exists concerning the strategic importance of integration (Stevens,1989). On the other hand, textbooks (Saunders, 1997; Lysons, 2000; Bloomberg et al., 2002) seem to use terms like integrated supply management and integration too easily and with little precision."

Shapiro (2001, pp. 552) presents a method of categorising the reach and range of organisational IT infrastructure that could be used as a model. It is recommended therefore, that in order to minimise the likelihood of obtaining perceptions rather than more relevant and appropriate scores when attempting to measure such levels of integration, that research work be undertaken to further develop of the level of process integration measurement scales.

6.10.6 Finally it is recommended that an alternate applied research methodology be developed in order to overcome (i) resistance that many business people have towards undertaking the completion of industry surveys, (ii) access to the 'right' (i.e. competent) people and (iii) greater veracity around the collected data. An idea that is offered for advancement is that of a 'Structured Research Audit'. The basic concept is to utilise a safety audit/quality audit type processes within a set of companies (40~50 in number) in order to collect information on the practices used, the results achieved and status of key dependent and independent variable elements. Such a process would follow a well-defined structure in order for the approach to be repeatable in each company/business unit audited. Rewards (such as Government tax rebates or education grants for each sponsored audit entertained by a company) would need to be a key feature of the process. As well, very strict guidelines around confidentiality of information would need to be included as would time and frequency guidelines necessary to minimise audited company disruption.

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Appendices

Appendix 1

Descriptive Statistics Results for Dependent and Independent Survey Question Variables by Manufacturing Segment

Notes on below tables:

i. The dependent variables ‘% Delivery Performance’ through to ‘% Return on Capital Margin’ are continuous variables and their units are described in the heading of each column. ‘Product Costs/unit’ units are quartiles with quartile 1 the lowest cost/unit and quartile 4 the highest cost/unit.
ii. The independent variable ‘Operating Principle’ is scaled as follows: 1 = production-push, 2 = Kanban-pull, 3 = Agile, 4 = Other.
iii. The remaining independent variables i.e. ‘Supply Chain Focus’ through to ‘Political Astuteness is High’ are scaled using the Likert scale where 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree.
iv. Data in the tables can be used by industry practitioners to benchmark the results of their company’s performance against the survey results for their manufacturing segment and/or the other segments shown.

Manufacturing Segment

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Food, beverage, tobacco	34	16.2	16.3	16.3
	Textile, clothing, footwear, leather	4	1.9	1.9	18.2
	Wood and paper	12	5.7	5.7	23.9
	Printing, publishing, recorded media	5	2.4	2.4	26.3
	Petroleum, coal, chemical	29	13.8	13.9	40.2
	Non-metallic minerals	2	1.0	1.0	41.1
	Metallic products	61	29.0	29.2	70.3
	Machinery & equipment	9	4.3	4.3	74.6
	Electronic & electrical appliances	21	10.0	10.0	84.7
	Other	32	15.2	15.3	100.0
	Total	209	99.5	100.0	
Missing	System	1	.5		
Total		210	100.0		

Table A1.1: Frequency Statistics for Manufacturing Segments

Report

Manufacturing Segment		% Delivery Performance	% Perfect Order Fulfilment	Mfg Lead-Time (days)	Offered Lead-Time (days)
Food, beverage, tobacco	Mean	92.5	84.3	13.2	6.5
	Std. Deviation	6.7	14.9	20.0	8.4
Textile, clothing, footwear, leather	Mean	90.3	87.8	37.3	31.5
	Std. Deviation	9.5	12.2	36.0	31.7
Wood and paper	Mean	95.1	80.3	8.9	9.2
	Std. Deviation	4.2	12.8	11.2	13.3
Printing, publishing, recorded media	Mean	93.3	92.0	23.1	12.8
	Std. Deviation	4.4	4.6	27.0	7.6
Petroleum, coal, chemical	Mean	91.0	83.1	12.1	7.3
	Std. Deviation	5.7	14.0	23.5	11.1
Non-metallic minerals	Mean	95.5	91.5	5.5	9.0
	Std. Deviation	.7	4.9	2.1	7.1
Metallic products	Mean	88.3	81.2	20.1	12.0
	Std. Deviation	8.8	12.9	18.2	12.2
Machinery & equipment	Mean	85.0	66.7	48.6	27.8
	Std. Deviation	10.2	32.6	46.3	29.5
Electronic & electrical appliances	Mean	90.4	84.1	23.7	11.9
	Std. Deviation	6.2	13.1	39.4	11.5
Other	Mean	91.0	86.6	29.6	13.1
	Std. Deviation	13.2	17.4	47.0	21.7
Total	Mean	90.4	82.9	20.3	11.5
	Std. Deviation	8.7	15.7	30.0	15.4

Table A1.2: Mean and SD Statistics for Manufacturing Segment Results on Q7~10

Report

Manufacturing Segment		Days to Respond to 20% Demand Increase	Days to Respond to 20% Demand Decrease	Days of Inventory
Food, beverage, tobacco	Mean	26.7	18.3	63.4
	Std. Deviation	56.3	21.4	80.5
Textile, clothing, footwear, leather	Mean	38.8	16.3	74.3
	Std. Deviation	36.1	18.0	32.4
Wood and paper	Mean	64.2	29.8	51.1
	Std. Deviation	99.9	37.2	24.7
Printing, publishing, recorded media	Mean	29.0	21.4	113.2
	Std. Deviation	26.6	25.1	92.0
Petroleum, coal, chemical	Mean	100.1	56.2	52.3
	Std. Deviation	208.2	89.5	36.9
Non-metallic minerals	Mean	61.0	47.5	60.5
	Std. Deviation	83.4	60.1	48.8
Metallic products	Mean	115.3	30.3	54.1
	Std. Deviation	244.6	32.1	34.0
Machinery & equipment	Mean	58.0	38.6	136.7
	Std. Deviation	44.7	43.1	89.0
Electronic & electrical appliances	Mean	26.3	18.9	59.3
	Std. Deviation	24.1	19.4	45.5
Other	Mean	52.4	31.2	71.1
	Std. Deviation	74.6	32.9	58.4
Total	Mean	70.2	30.9	63.9
	Std. Deviation	161.6	44.2	56.2

Table A1.3: Mean and SD Statistics for Manufacturing Segment Results on Q11~13

Report

Manufacturing Segment		Cash-to-Cash Cycle (days)	Product Costs/Unit Quartile	% Return-on-Capital Margin
Food, beverage, tobacco	Mean	52.0	2.3	7.6
	Std. Deviation	44.4	1.0	5.6
Textile, clothing, footwear, leather	Mean	64.0	2.8	6.8
	Std. Deviation	53.2	.5	9.2
Wood and paper	Mean	62.8	2.1	9.7
	Std. Deviation	28.1	.6	8.6
Printing, publishing, recorded media	Mean	113.5	2.3	8.8
	Std. Deviation	122.3	1.0	4.4
Petroleum, coal, chemical	Mean	68.9	2.3	10.4
	Std. Deviation	43.8	1.0	9.2
Non-metallic minerals	Mean	57.5	3.0	2.3
	Std. Deviation	31.8	1.4	9.5
Metallic products	Mean	64.0	2.2	8.7
	Std. Deviation	38.8	.9	7.6
Machinery & equipment	Mean	141.3	2.6	9.2
	Std. Deviation	98.9	.5	6.8
Electronic & electrical appliances	Mean	59.7	2.8	12.6
	Std. Deviation	44.1	1.0	11.7
Other	Mean	75.6	2.4	11.5
	Std. Deviation	69.7	1.0	10.8
Total	Mean	68.2	2.3	9.5
	Std. Deviation	54.0	.9	8.6

Table A1.4: Mean and SD Statistics for Manufacturing Segment Results on Q14~16

Report

Manufacturing Segment		SC Operating Principle Used	SC Focus (more strategic than operational)	SC Goals (more cust aligned than int aligned)	SC Orgl Approach (more tot chain than silo)
Food, beverage, tobacco	Mean	2.3	2.9	3.1	3.1
	Std. Deviation	.9	1.0	1.2	1.1
Textile, clothing, footwear, leather	Mean	1.8	2.3	3.5	3.3
	Std. Deviation	1.0	1.3	1.0	1.0
Wood and paper	Mean	2.8	2.6	3.3	3.2
	Std. Deviation	1.0	1.2	1.0	1.2
Printing, publishing, recorded media	Mean	1.8	1.6	3.2	2.6
	Std. Deviation	1.1	.5	1.3	1.8
Petroleum, coal, chemical	Mean	2.1	3.0	3.1	3.0
	Std. Deviation	1.0	1.1	1.1	1.1
Non-metallic minerals	Mean	2.5	2.5	3.5	2.0
	Std. Deviation	.7	.7	.7	.0
Metallic products	Mean	2.3	2.8	3.2	2.9
	Std. Deviation	.8	1.0	1.1	1.2
Machinery & equipment	Mean	1.9	3.1	4.0	3.1
	Std. Deviation	.8	1.5	1.0	1.2
Electronic & electrical appliances	Mean	2.6	2.7	3.3	2.9
	Std. Deviation	.7	1.2	1.3	1.0
Other	Mean	2.1	2.8	3.3	2.8
	Std. Deviation	1.0	1.1	1.1	1.2
Total	Mean	2.2	2.8	3.2	2.9
	Std. Deviation	.9	1.1	1.1	1.1

Table A1.5: Mean and SD Statistics for Manufacturing Segment Results on Q17~20

Report

Manufacturing Segment		SC Cust Relnships (more coopt than advers)	SC Supp Relnships (more coopt than advers)	SC Strategy (is well defined & clear)	SC Prod Flow (happens by design)
Food, beverage, tobacco	Mean	4.0	3.9	3.2	3.6
	Std. Deviation	1.0	.9	1.2	1.0
Textile, clothing, footwear, leather	Mean	3.5	3.8	3.0	3.8
	Std. Deviation	1.0	.5	1.4	1.3
Wood and paper	Mean	3.9	3.8	3.0	3.8
	Std. Deviation	1.0	1.0	1.3	1.0
Printing, publishing, recorded media	Mean	3.8	3.6	2.6	3.6
	Std. Deviation	1.3	1.1	1.8	1.5
Petroleum, coal, chemical	Mean	3.8	3.4	2.8	3.7
	Std. Deviation	1.1	1.0	1.0	.8
Non-metallic minerals	Mean	4.0	4.0	3.0	2.0
	Std. Deviation	.0	.	.	.
Metallic products	Mean	3.9	3.6	2.9	3.6
	Std. Deviation	1.1	.9	1.0	1.1
Machinery & equipment	Mean	3.7	3.1	2.9	3.6
	Std. Deviation	.9	1.2	1.3	1.0
Electronic & electrical appliances	Mean	3.7	3.5	3.3	3.6
	Std. Deviation	1.0	1.3	.9	1.1
Other	Mean	3.7	3.5	3.1	3.4
	Std. Deviation	.9	.9	1.1	1.0
Total	Mean	3.8	3.6	3.0	3.6
	Std. Deviation	1.0	1.0	1.1	1.0

Table A1.6: Mean and SD Statistics for Manufacturing Segment Results on Q21~24

Report

Manufacturing Segment		Orgn more cust/supp facing than int facing	Opt of PoPs is practiced
Food, beverage, tobacco	Mean	3.2	3.2
	Std. Deviation	1.1	1.1
Textile, clothing, footwear, leather	Mean	3.8	4.0
	Std. Deviation	.5	.0
Wood and paper	Mean	3.7	3.8
	Std. Deviation	1.0	1.1
Printing, publishing, recorded media	Mean	3.4	2.6
	Std. Deviation	1.1	1.3
Petroleum, coal, chemical	Mean	3.2	3.0
	Std. Deviation	.9	1.0
Non-metallic minerals	Mean	3.0	2.0
	Std. Deviation	.	.
Metallic products	Mean	3.6	3.6
	Std. Deviation	1.0	1.1
Machinery & equipment	Mean	3.8	2.9
	Std. Deviation	1.1	.9
Electronic & electrical appliances	Mean	3.7	3.1
	Std. Deviation	.8	1.0
Other	Mean	3.4	2.8
	Std. Deviation	1.0	1.1
Total	Mean	3.5	3.2
	Std. Deviation	1.0	1.1

Table A1.7: Mean and SD Statistics for Manufacturing Segment Results on Q25~26

Report

Manufacturing Segment		Planning & Scheduling done extensively	Level of integration of P&S processes is Hi	Integration incls feedfwd & feedback	Linkage is automated
Food, beverage, tobacco	Mean	3.9	3.5	3.7	2.5
	Std. Deviation	1.0	1.0	.9	1.1
Textile, clothing, footwear, leather	Mean	3.5	3.3	3.5	3.0
	Std. Deviation	1.0	1.5	1.0	.8
Wood and paper	Mean	3.8	3.9	3.5	2.5
	Std. Deviation	1.3	.8	1.2	.8
Printing, publishing, recorded media	Mean	3.2	2.6	3.0	2.4
	Std. Deviation	1.3	.9	1.0	1.1
Petroleum, coal, chemical	Mean	3.5	3.2	3.4	2.2
	Std. Deviation	1.1	1.0	1.0	.8
Non-metallic minerals	Mean	2.5	3.0	2.5	2.5
	Std. Deviation	.7	1.4	.7	.7
Metallic products	Mean	3.9	3.3	3.3	2.3
	Std. Deviation	.8	1.0	.9	.8
Machinery & equipment	Mean	3.3	3.1	3.3	2.3
	Std. Deviation	.9	1.1	.9	1.0
Electronic & electrical appliances	Mean	3.8	3.4	3.3	2.4
	Std. Deviation	1.0	1.0	.9	.8
Other	Mean	3.7	3.3	3.3	2.4
	Std. Deviation	1.0	1.0	.9	1.0
Total	Mean	3.7	3.3	3.4	2.4
	Std. Deviation	1.0	1.0	.9	.9

Table A1.8: Mean and SD Statistics for Manufacturing Segment Results on Q27~30

Report

Manufacturing Segment		P&S integrated with other SC processes	P&S integrated with customers	P&S integrated with suppliers	Sharing of sched with cust done electronically	Sharing of sched with supp done electronically
Food, beverage, tobacco	Mean	3.5	3.2	3.7	2.5	3.0
	Std. Dev.	.9	1.0	.8	1.1	1.2
Textile, clothing, footwear, leather	Mean	3.3	3.3	3.8	3.0	3.3
	Std. Dev.	1.5	1.0	.5	1.2	1.0
Wood and paper	Mean	3.8	3.2	3.3	2.8	2.5
	Std. Dev.	1.0	1.3	1.0	1.1	1.2
Printing, publishing, recorded media	Mean	2.8	2.4	2.4	2.4	1.8
	Std. Dev.	1.6	1.5	.5	1.5	.4
Petroleum, coal, chemical	Mean	3.2	2.9	2.8	2.4	2.5
	Std. Dev.	1.1	1.1	1.0	1.0	1.0
Non-metallic minerals	Mean	3.0	3.0	3.0	2.0	2.0
	Std. Dev.	1.4	.0	.0	.0	.0
Metallic products	Mean	3.2	3.0	3.2	2.5	2.7
	Std. Dev.	1.0	.9	.9	1.0	1.0
Machinery & equipment	Mean	3.0	3.2	3.1	2.4	2.3
	Std. Dev.	1.2	1.1	1.4	1.2	1.1
Electronic & electrical appliances	Mean	3.4	2.9	3.7	3.0	3.2
	Std. Dev.	1.0	1.2	1.0	1.0	1.2
Other	Mean	3.3	3.1	3.3	2.7	3.0
	Std. Dev.	1.1	1.1	1.0	1.3	1.2
Total	Mean	3.3	3.0	3.3	2.6	2.8
	Std. Dev.	1.1	1.1	1.0	1.1	1.1

Table A1.9: Mean and SD Statistics for Manufacturing Segment Results on Q31~35

Report

Manufacturing Segment		Effective demand forecasting is done	e-Logistics is active & key SC strategy	Convergence of Internet & Dec Supp has begun	Transaction activities with cust/supp e-enabled
Food, beverage, tobacco	Mean	4.3	2.7	2.9	2.8
	Std. Deviation	.8	1.2	1.2	1.1
Textile, clothing, footware, leather	Mean	3.8	3.3	3.0	3.3
	Std. Deviation	1.3	1.0	1.2	.5
Wood and paper	Mean	3.9	2.9	3.2	3.4
	Std. Deviation	1.2	1.2	1.3	1.5
Printing, publishing, recorded media	Mean	3.4	2.2	2.8	3.2
	Std. Deviation	1.5	1.3	1.6	1.3
Petroleum, coal, chemical	Mean	3.8	2.5	3.0	2.7
	Std. Deviation	1.0	1.1	1.1	1.1
Non-metallic minerals	Mean	3.0	1.0	2.0	1.0
	Std. Deviation	1.4	.0	.0	.0
Metallic products	Mean	4.0	2.9	3.2	2.9
	Std. Deviation	1.0	1.1	.9	1.0
Machinery & equipment	Mean	3.6	3.0	3.3	2.8
	Std. Deviation	1.2	1.2	1.1	1.3
Electronic & electrical appliances	Mean	3.5	2.9	3.3	3.0
	Std. Deviation	1.1	1.2	1.3	1.2
Other	Mean	3.8	2.8	3.2	2.9
	Std. Deviation	.9	1.2	1.2	1.1
Total	Mean	3.9	2.8	3.1	2.9
	Std. Deviation	1.0	1.1	1.1	1.1

Table A1.10: Mean and SD Statistics for Manufacturing Segment Results on Q36~39

Report

Manufacturing Segment		Role networks well understood	Shared vision is high	Common mental models clear & aligned	Personal mastery is high
Food, beverage, tobacco	Mean	3.7	3.6	3.5	4.0
	Std. Deviation	.9	.9	1.0	.8
Textile, clothing, footwear, leather	Mean	3.0	3.3	3.3	3.5
	Std. Deviation	1.2	1.5	1.5	1.0
Wood and paper	Mean	4.0	3.8	3.5	3.5
	Std. Deviation	.7	.7	.8	1.2
Printing, publishing, recorded media	Mean	3.8	3.6	4.0	3.8
	Std. Deviation	1.1	1.1	.7	.8
Petroleum, coal, chemical	Mean	3.6	3.2	3.1	3.6
	Std. Deviation	1.1	.9	.9	.9
Non-metallic minerals	Mean	3.5	3.0	3.0	3.0
	Std. Deviation	.7	.0	.0	.0
Metallic products	Mean	3.6	3.5	3.1	3.9
	Std. Deviation	.8	.9	.9	.7
Machinery & equipment	Mean	3.2	3.3	2.9	3.9
	Std. Deviation	1.0	1.2	1.1	.8
Electronic & electrical appliances	Mean	3.4	3.3	3.3	3.7
	Std. Deviation	1.1	1.1	1.0	1.1
Other	Mean	3.4	3.4	2.9	3.7
	Std. Deviation	.9	.9	.9	.8
Total	Mean	3.6	3.4	3.2	3.8
	Std. Deviation	.9	.9	.9	.9

Table A1.11: Mean and SD Statistics for Manufacturing Segment Results on Q40~43

Report

Manufacturing Segment		Have right people 'on the bus'	Level of training is adequate	Team learning is high	Senior sponsor ship is active	Political astuteness is high
Food, beverage, tobacco	Mean	3.5	3.4	3.6	3.6	3.8
	Std. Dev.	1.0	.9	.9	1.0	.5
Textile, clothing, footwear, leather	Mean	3.5	3.5	3.5	3.3	3.8
	Std. Dev.	1.0	1.0	1.0	1.5	.5
Wood and paper	Mean	3.5	3.1	3.5	3.3	3.3
	Std. Dev.	1.2	1.0	.8	1.2	1.2
Printing, publishing, recorded media	Mean	3.8	3.6	4.0	3.8	3.2
	Std. Dev.	.8	1.1	1.0	.8	.4
Petroleum, coal, chemical	Mean	3.2	3.1	3.3	3.3	2.9
	Std. Dev.	.9	1.1	.9	1.0	1.0
Non-metallic minerals	Mean	3.0	3.5	2.5	2.5	3.5
	Std. Dev.	.0	.7	.7	.7	.7
Metallic products	Mean	3.5	3.1	3.4	3.3	3.4
	Std. Dev.	.8	.9	.9	.8	.8
Machinery & equipment	Mean	3.2	2.9	3.6	3.7	3.2
	Std. Dev.	1.1	1.2	.7	.7	.8
Electronic & electrical appliances	Mean	3.6	3.2	3.5	3.7	3.5
	Std. Dev.	.9	.9	.7	.6	.9
Other	Mean	3.5	3.2	3.3	3.6	3.1
	Std. Dev.	.8	1.0	.9	.8	.9
Total	Mean	3.5	3.2	3.4	3.5	3.4
	Std. Dev.	.9	1.0	.9	.9	.9

Table A1.12: Mean and SD Statistics for Manufacturing Segment Results on Q44~48

Appendix 2

Results of Each Structural Equation Model Specification Search

Note: Significant linkages only (p≤ 0.05) are shown between the independent and dependent variables.

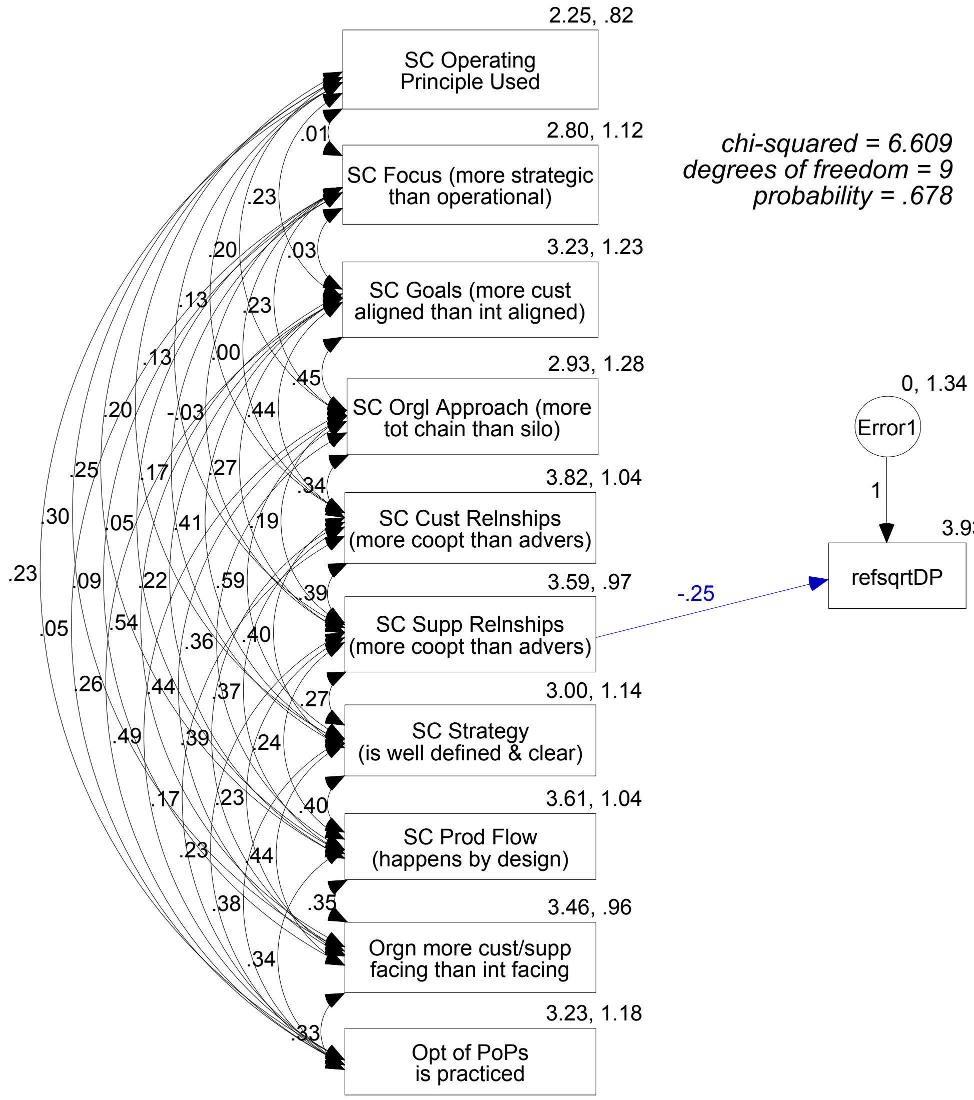

Figure A2.1: Result of SEM Specification Search on Manifest Part II Independent Variables and reflect-square-root Delivery Performance.

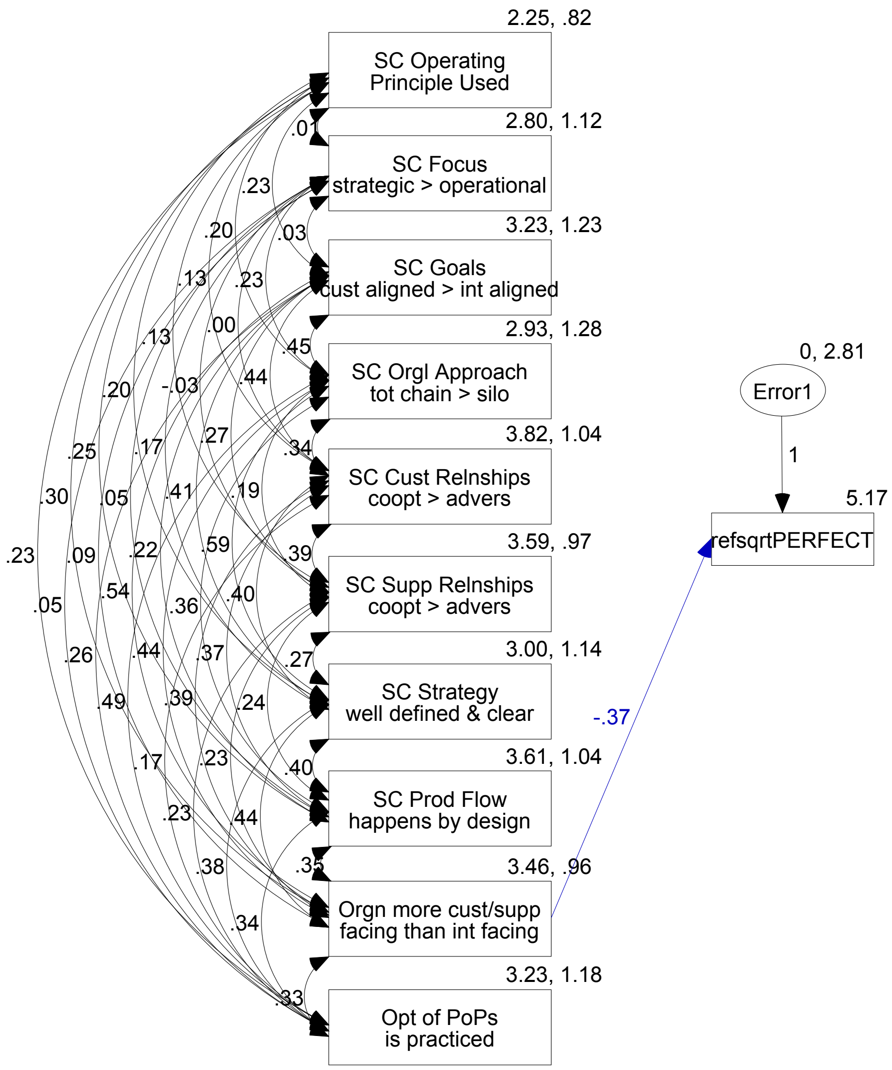

Figure A2.2: Result of SEM Specification Search on Manifest Part II Independent Variables and reflect-square-root Perfect Order Fulfilment.

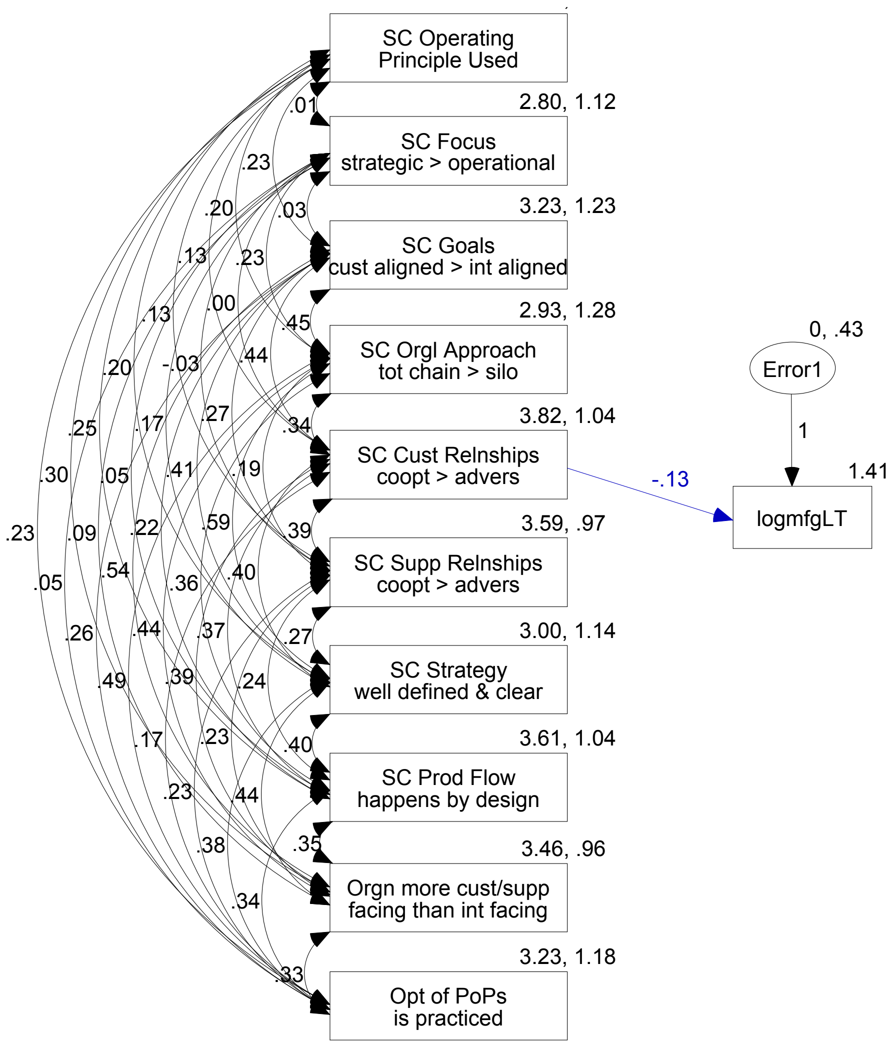

Figure A2.3: Result of SEM Specification Search on Manifest Part II Independent Variables and log Manufacturing Lead-Time.

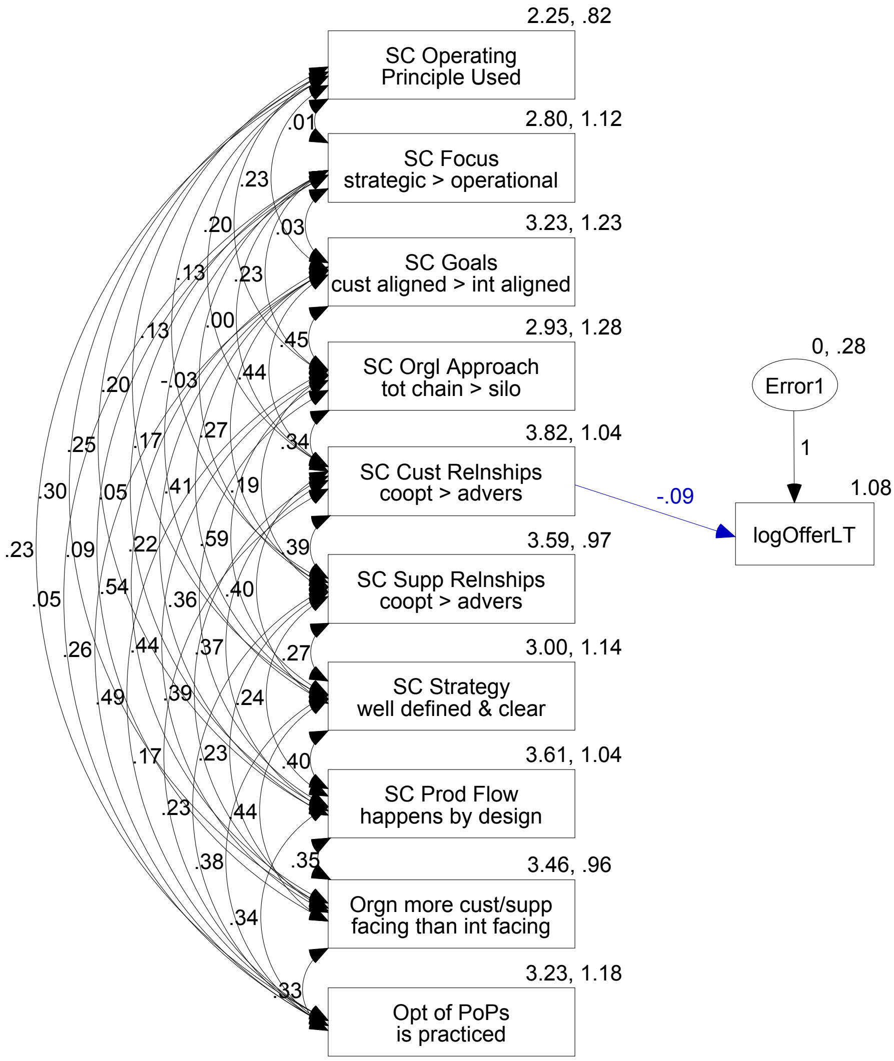

Figure A2.4: Result of SEM Specification Search on Manifest Part II Independent Variables and log Offered Lead-Time.

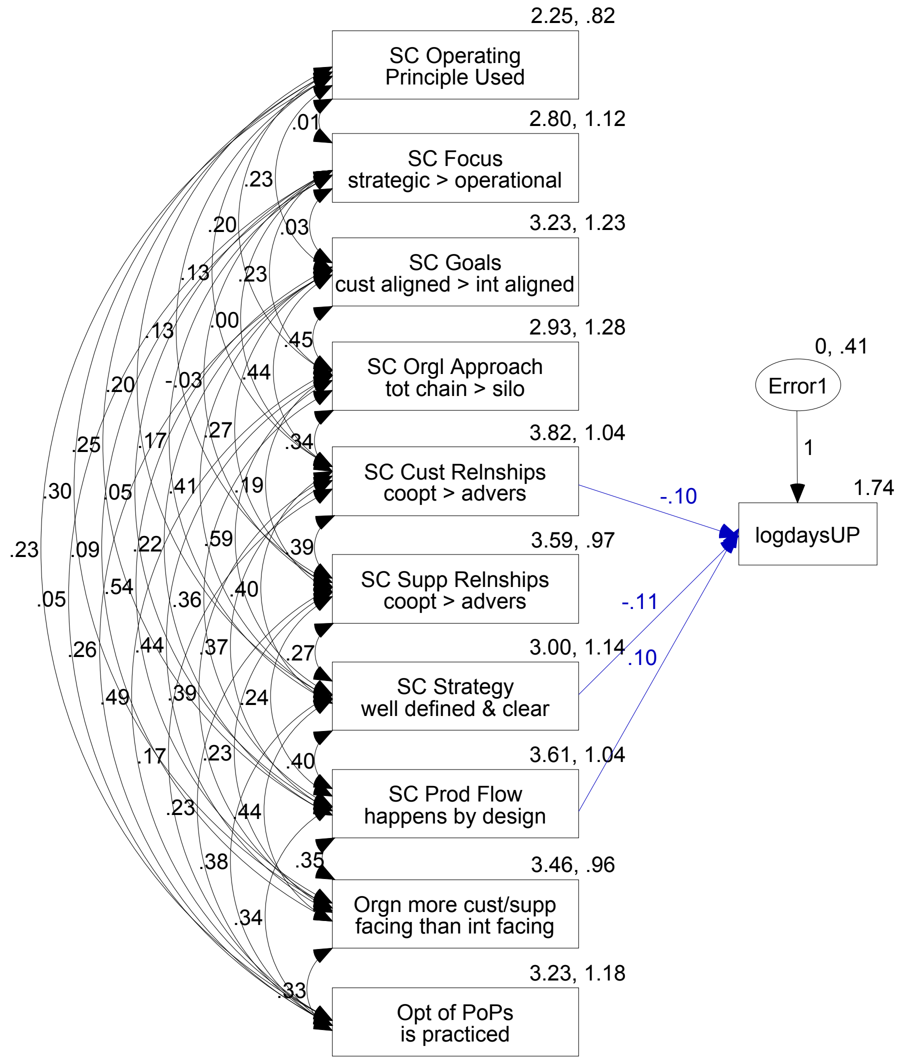

Figure A2.5: Result of SEM Specification Search on Manifest Part II Independent Variables and log Time to Respond to a 20% Demand Increase.

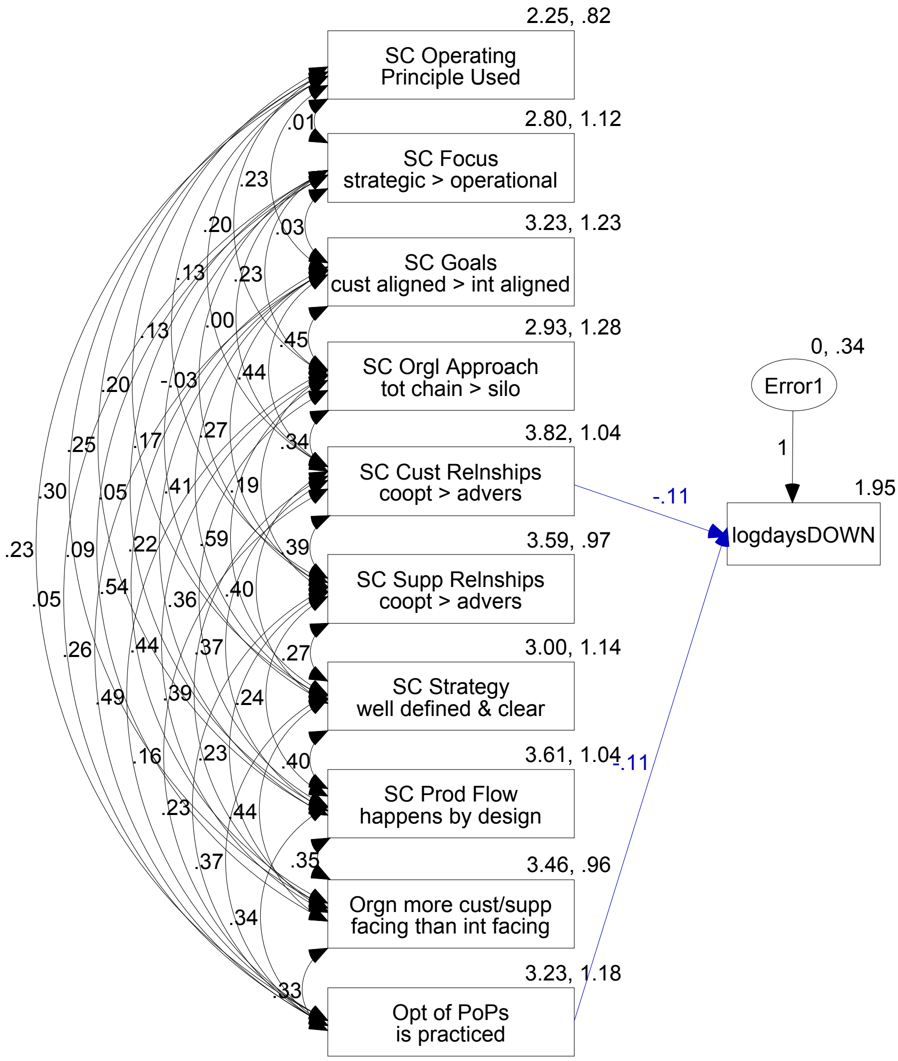

Figure A2.6: Result of SEM Specification Search on Manifest Part II Independent Variables and log Time to Respond to a 20% Demand Decrease.

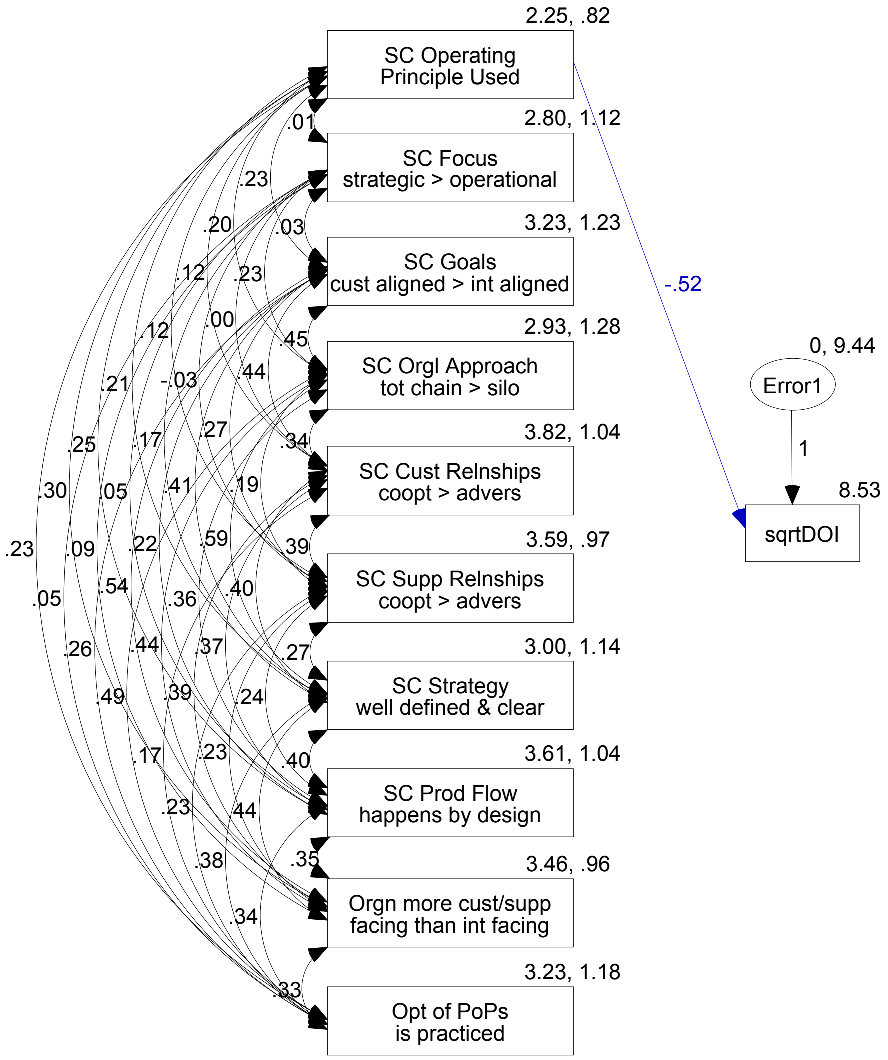

Figure A2.7: Result of SEM Specification Search on Manifest Part II Independent Variables and square-root Days of Inventory.

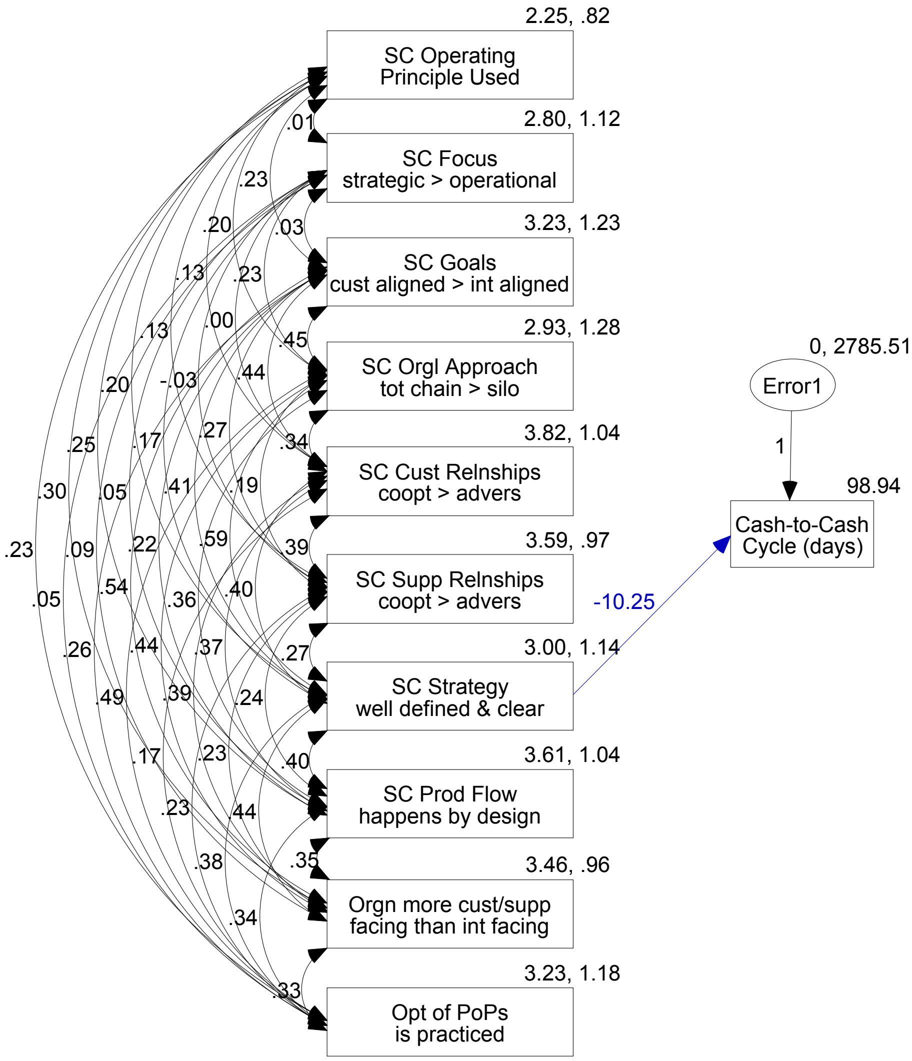

Figure A2.8: Result of SEM Specification Search on Manifest Part II Independent Variables and Cash-to-Cash Cycle Time.

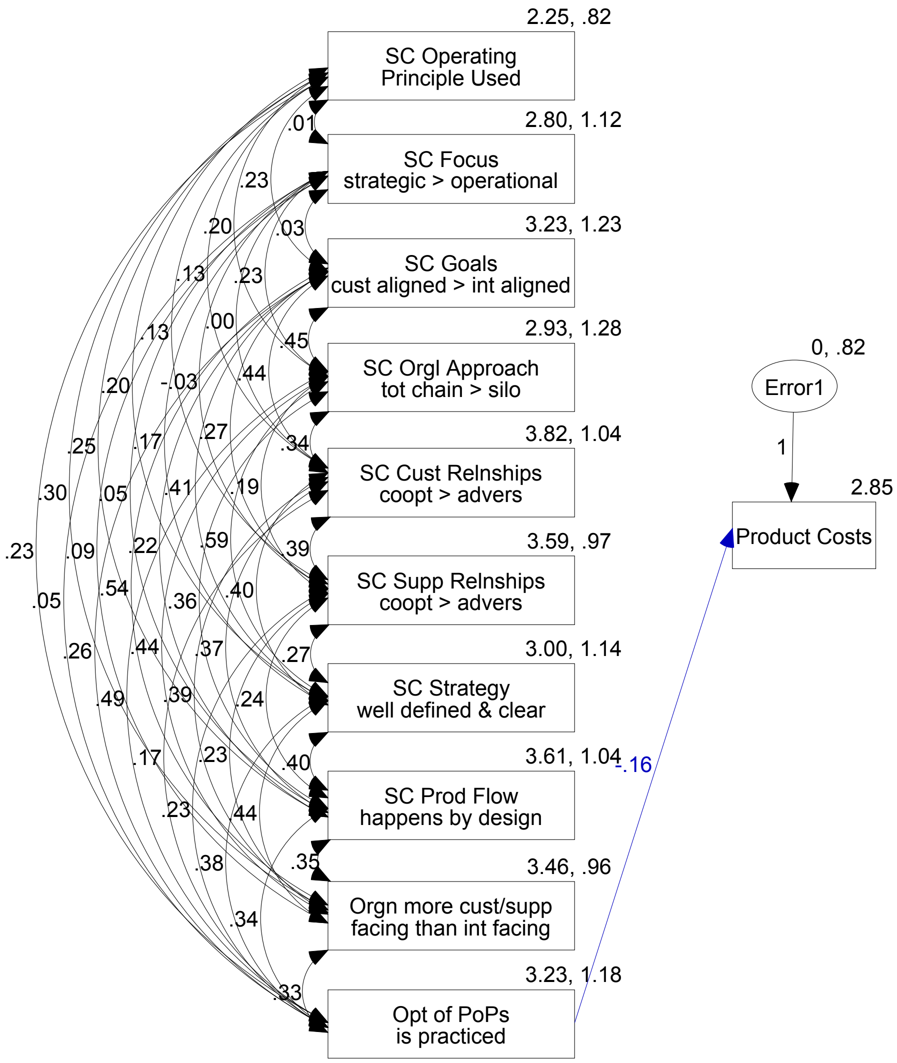

Figure A2.9: Result of SEM Specification Search on Manifest Part II Independent Variables and Product Costs/Unit Quartile.

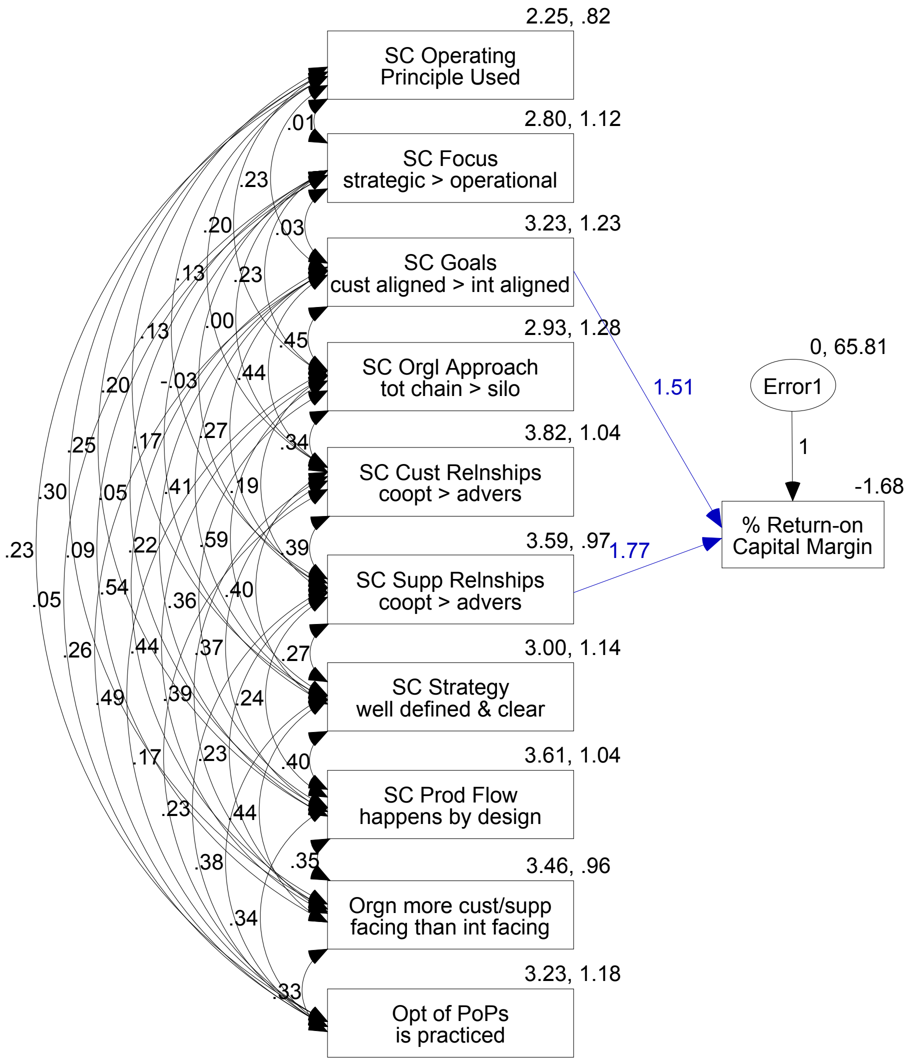

Figure A2.10: Result of SEM Specification Search on Manifest Part II Independent Variables and % Return on Capital Margin.

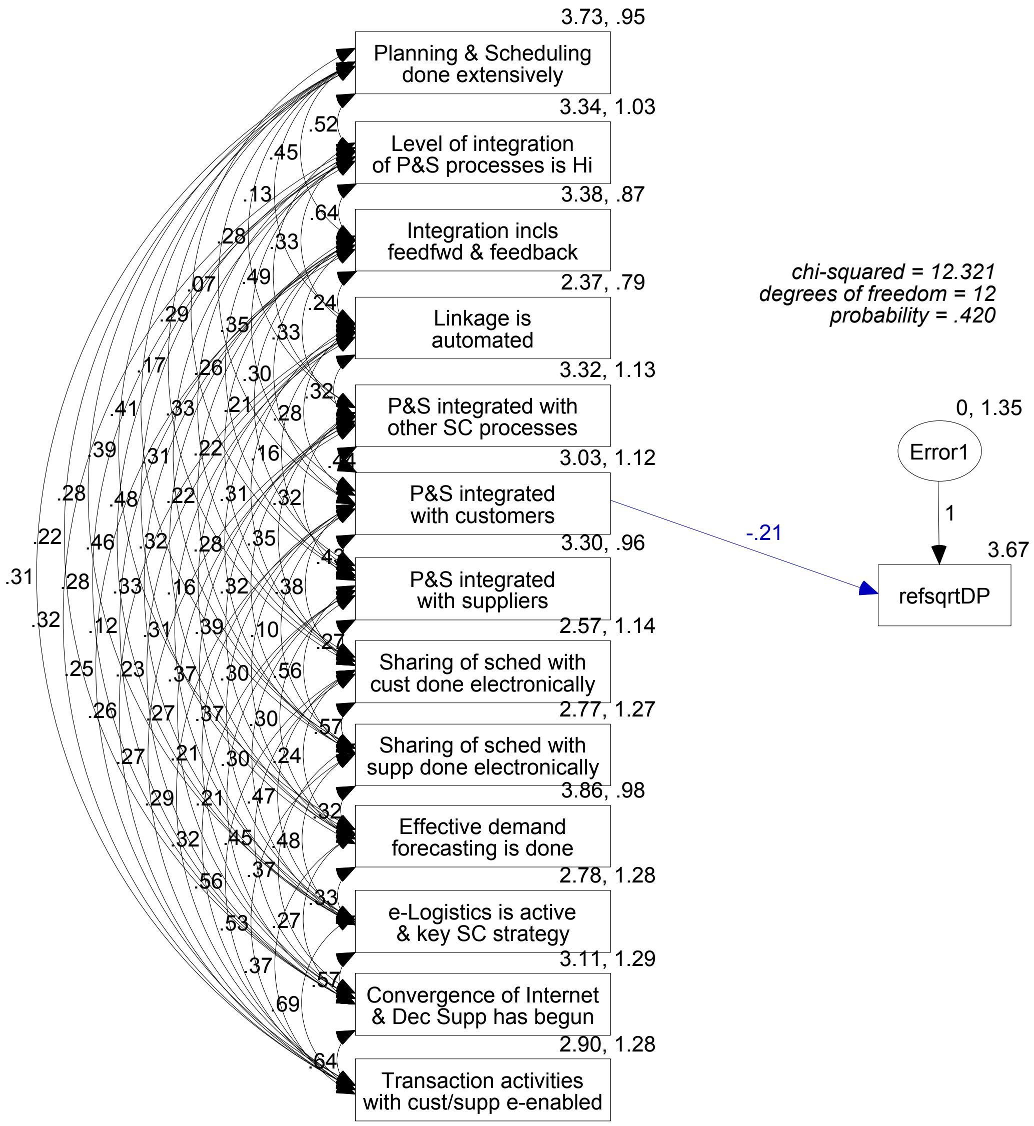

Figure A2.11: Result of SEM Specification Search on Manifest Part III Independent Variables and reflect-square-root Delivery Performance.

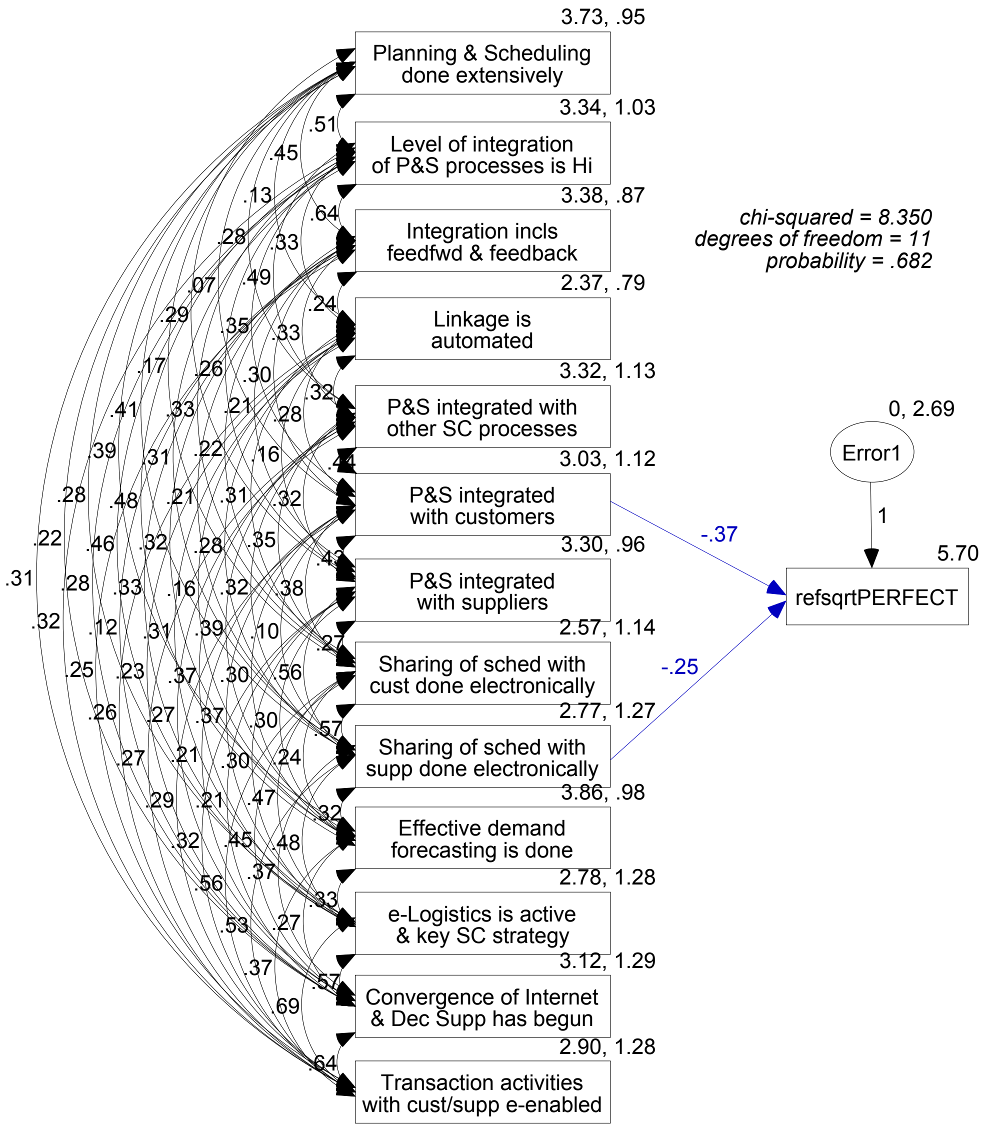

Figure A2.12: Result of SEM Specification Search on Manifest Part III Independent Variables and reflect-square-root Perfect Order Fulfilment.

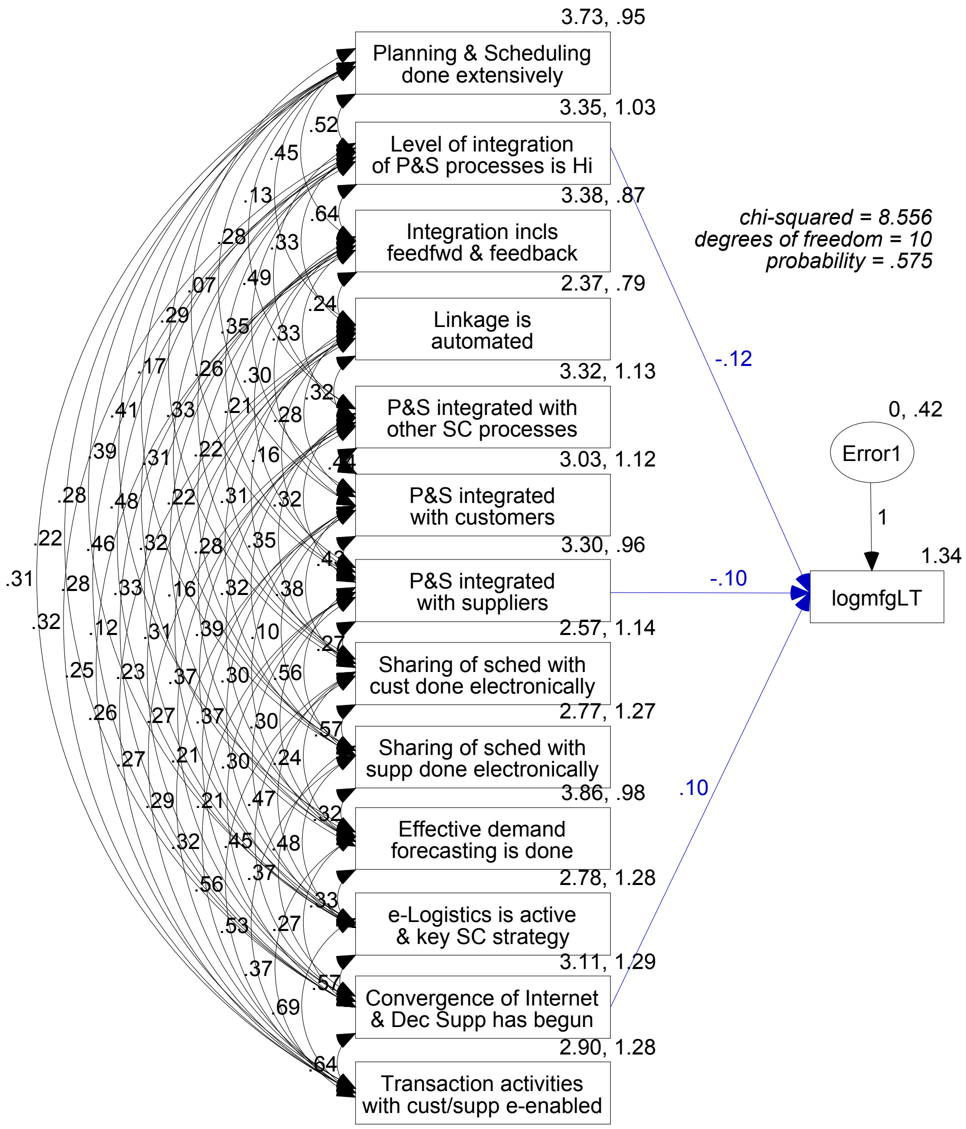

Figure A2.13: Result of SEM Specification Search on Manifest Part III Independent Variables and log Manufacturing Lead-Time.

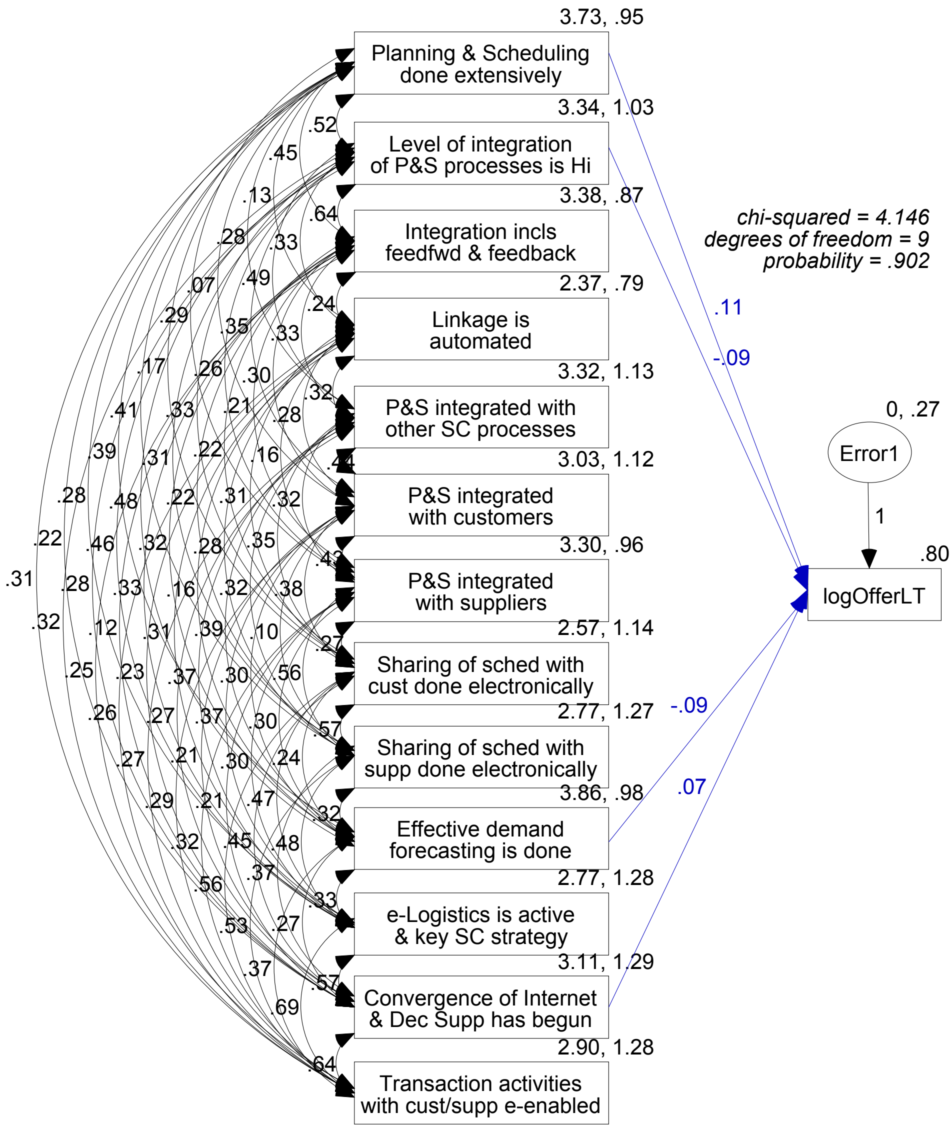

Figure A2.14: Result of SEM Specification Search on Manifest Part III Independent Variables and log Offered Lead-Time.

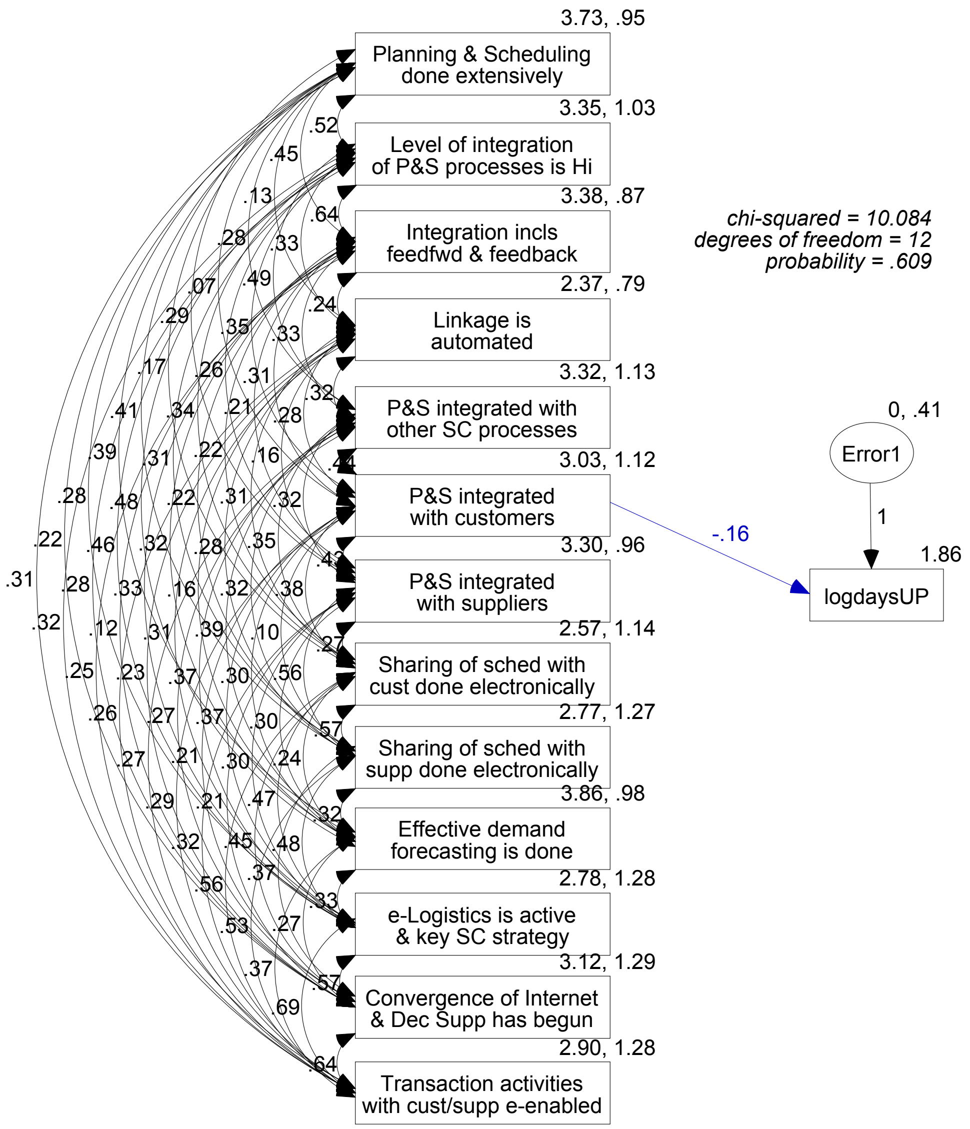

Figure A2.15: Result of SEM Specification Search on Manifest Part III Independent Variables and log Time to Respond to a 20% Demand Increase.

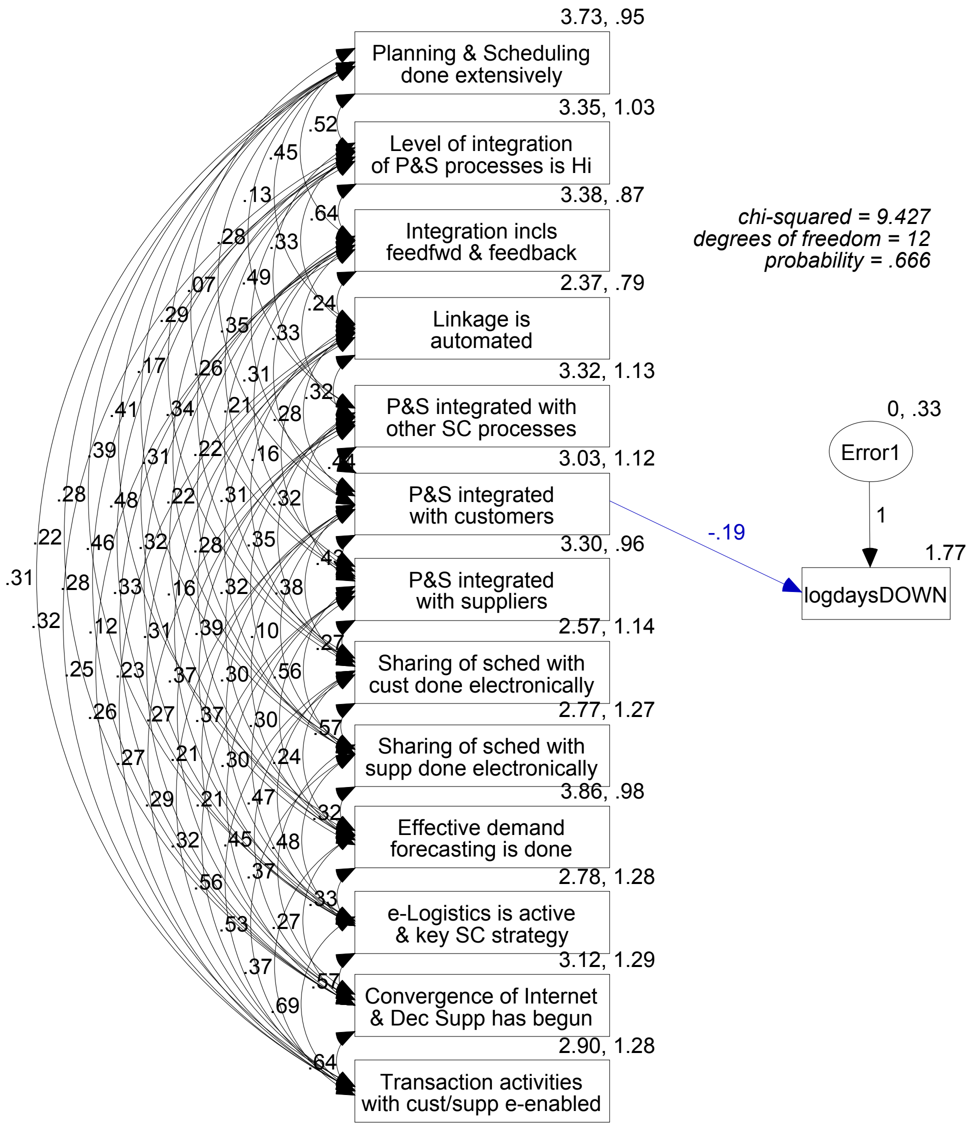

Figure A2.16: Result of SEM Specification Search on Manifest Part III Independent Variables and log Time to Respond to a 20% Demand Decrease.

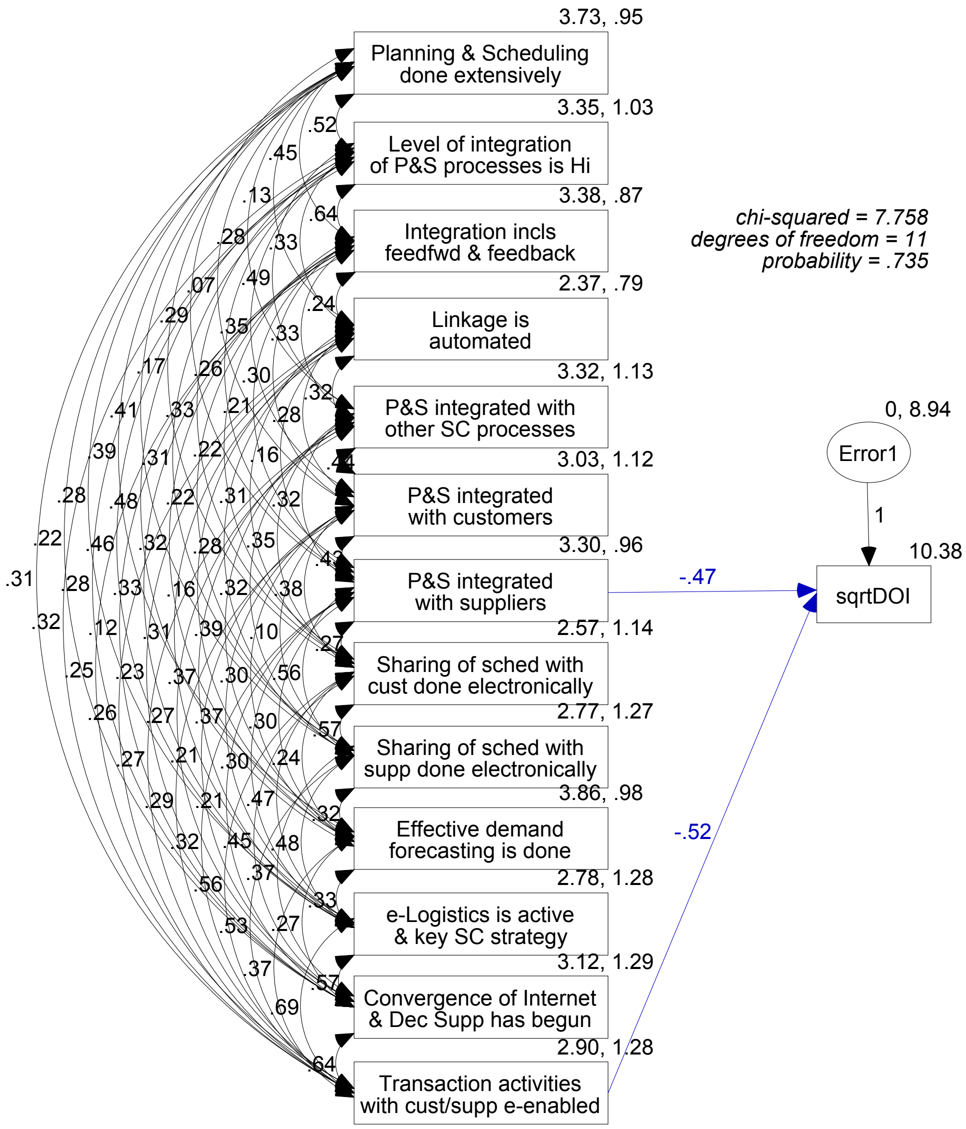

Figure A2.17: Result of SEM Specification Search on Manifest Part III Independent Variables and square-root Days of Inventory.

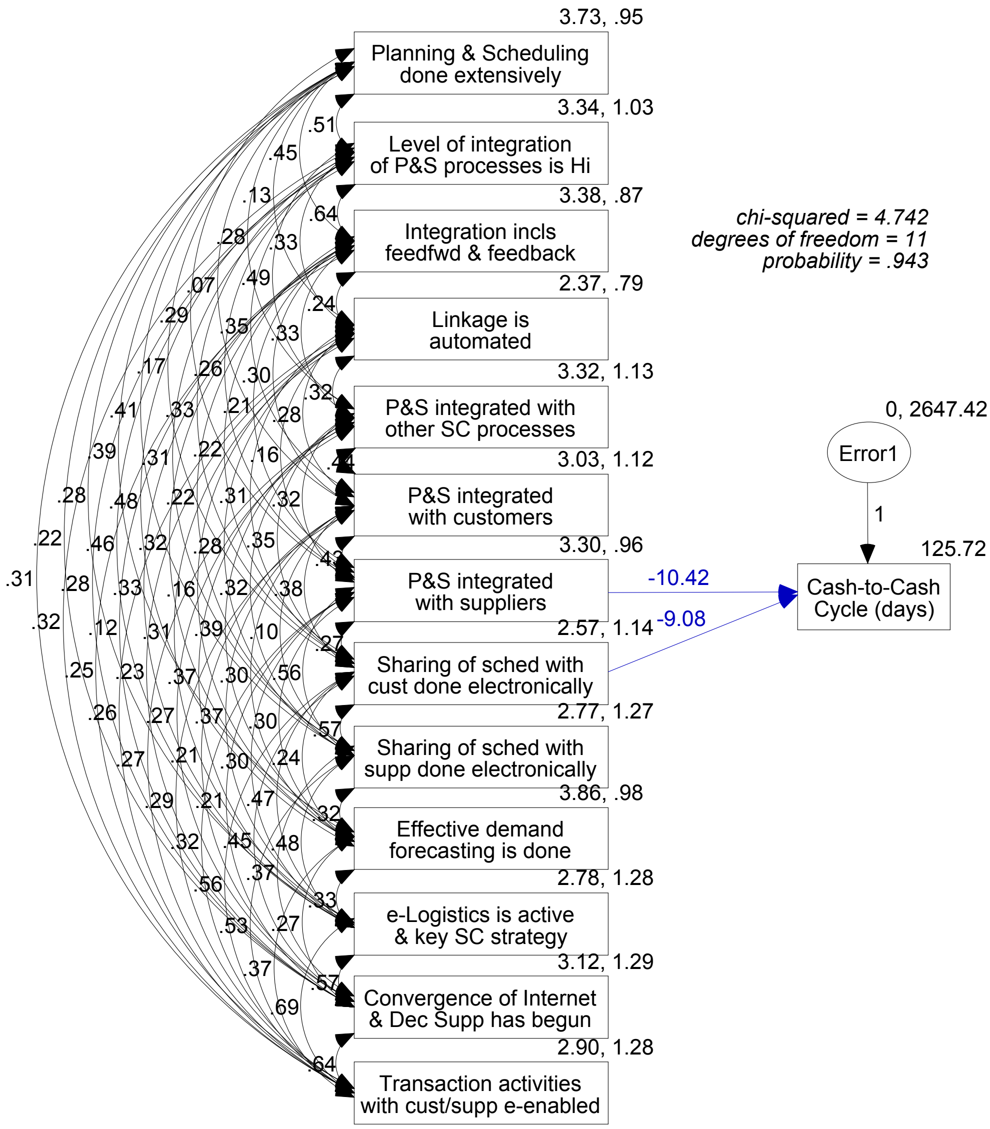

Figure A2.18: Result of SEM Specification Search on Manifest Part III Independent Variables and Cash-to-Cash Cycle Time.

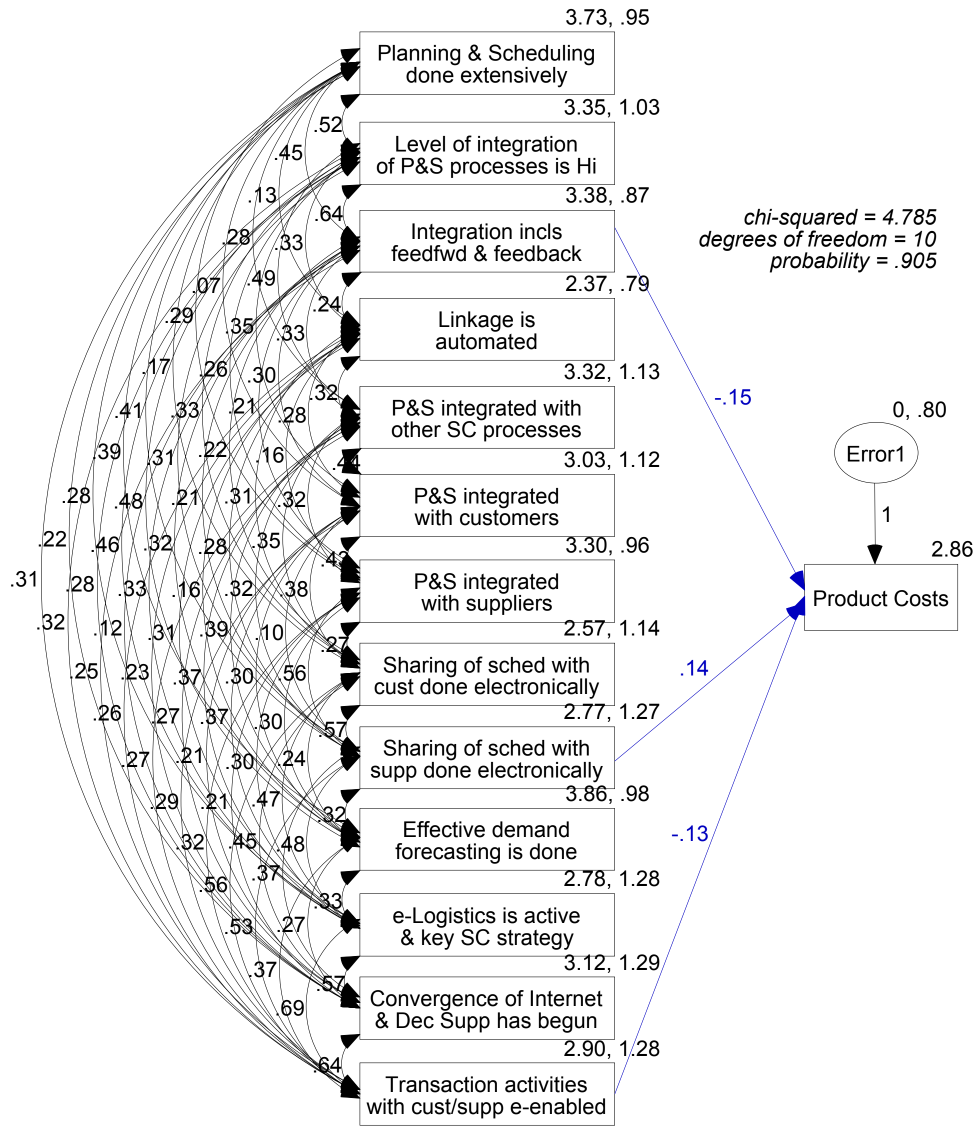

Figure A2.19: Result of SEM Specification Search on Manifest Part III Independent Variables and Product Costs/Unit Quartile.

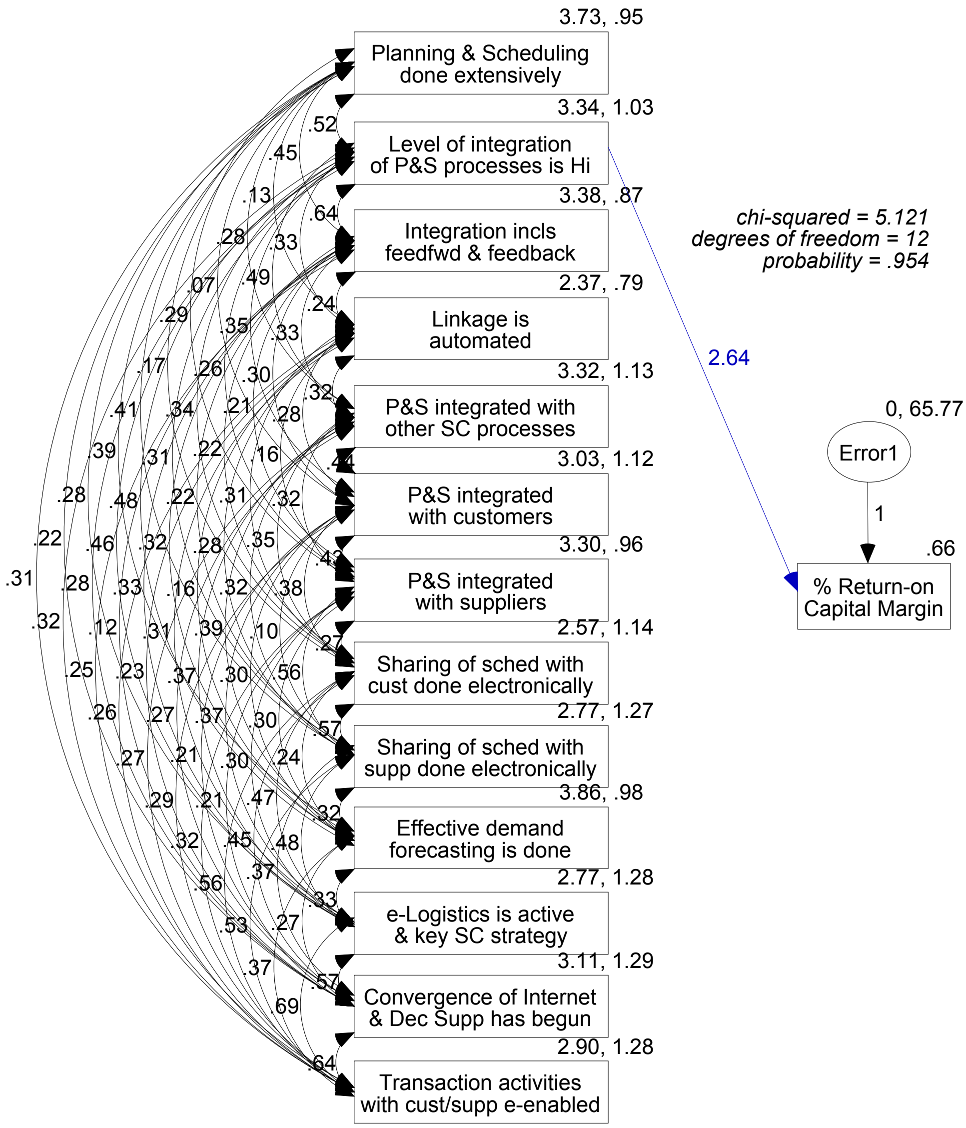

Figure A2.20: Result of SEM Specification Search on Manifest Part III Independent Variables and % Return on Capital Margin.

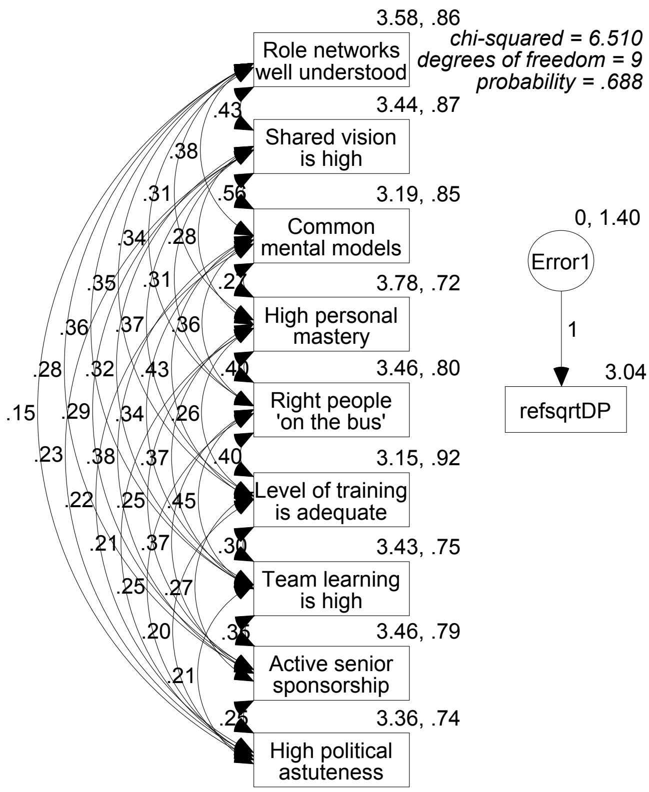

Figure A2.21: Result of SEM Specification Search on Manifest Part IV Independent Variables and reflect-square-root Delivery Performance.

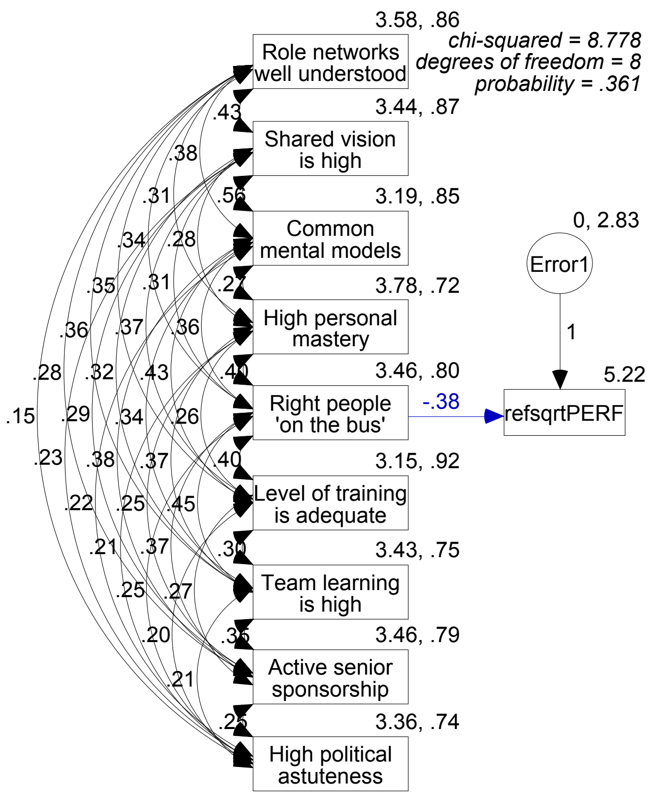

Figure A2.22: Result of SEM Specification Search on Manifest Part IV Independent Variables and reflect-square-root Perfect Order Fulfilment.

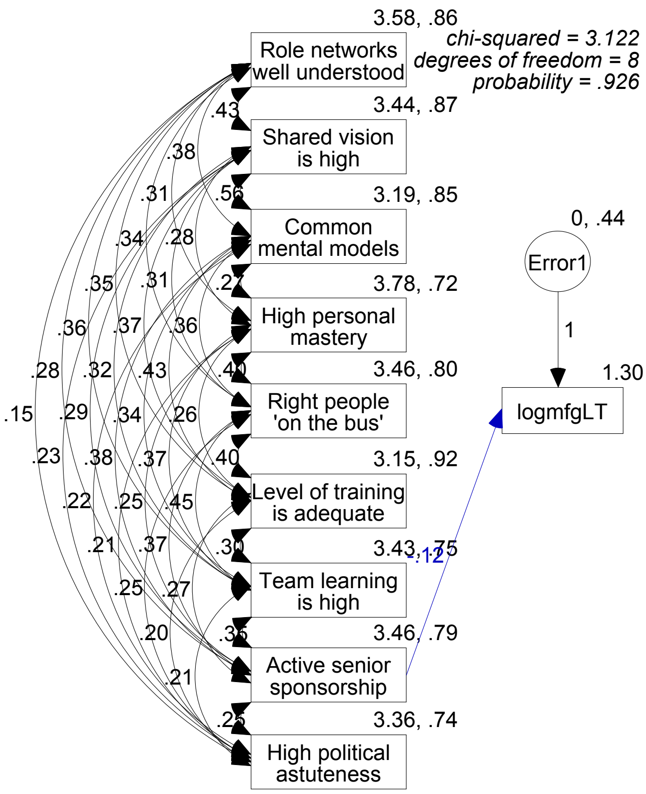

Figure A2.23: Result of SEM Specification Search on Manifest Part IV Independent Variables and log Manufacturing Lead-Time.

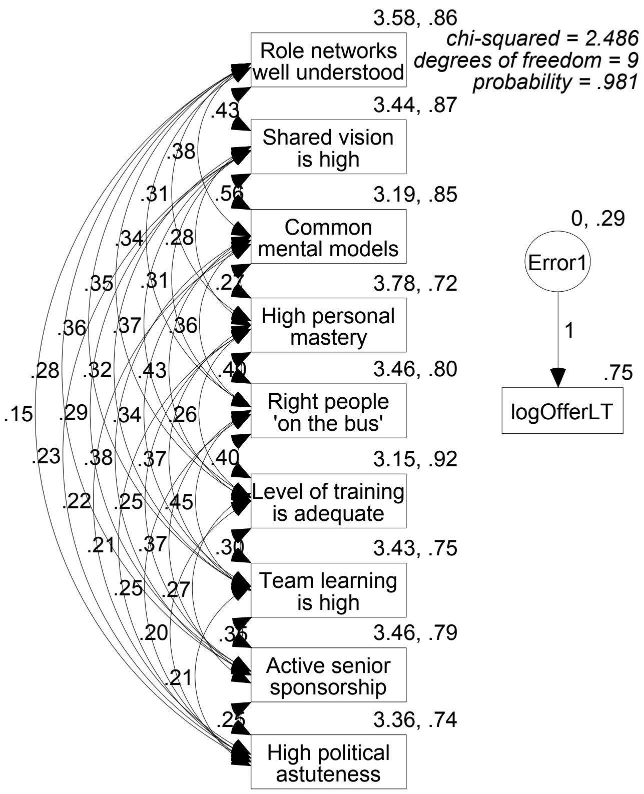

Figure A2.24: Result of SEM Specification Search on Manifest Part IV Independent Variables and log Offered Lead-Time.

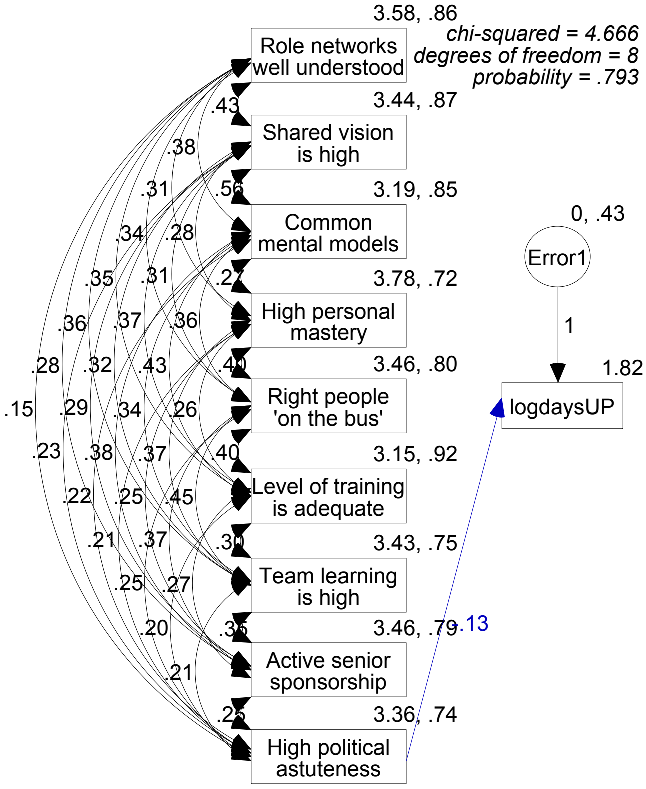

Figure A2.25: Result of SEM Specification Search on Manifest Part IV Independent Vars and log Time to Response to a 20% Demand Increase.

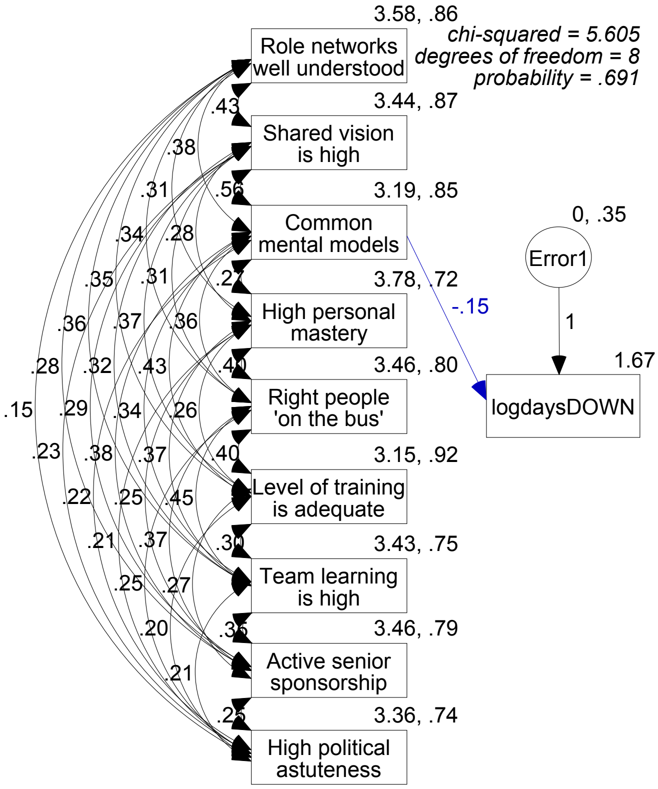

Figure A2.26: Result of SEM Specification Search on Manifest Part IV Independent Vars and log Time to Response to a 20% Demand Increase.

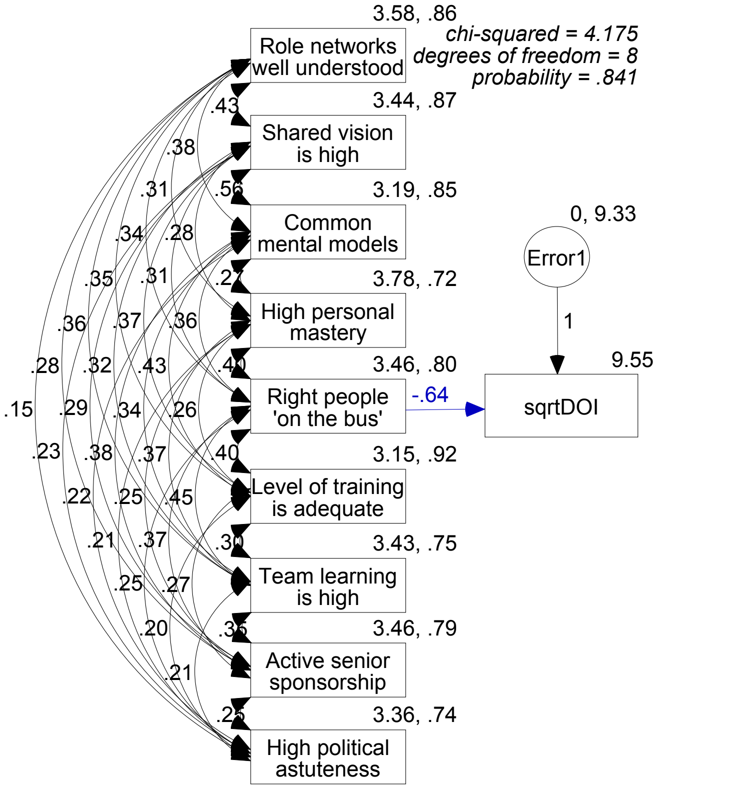

Figure A2.27: Result of SEM Specification Search on Manifest Part IV Independent Variables and square-root Days of Inventory.

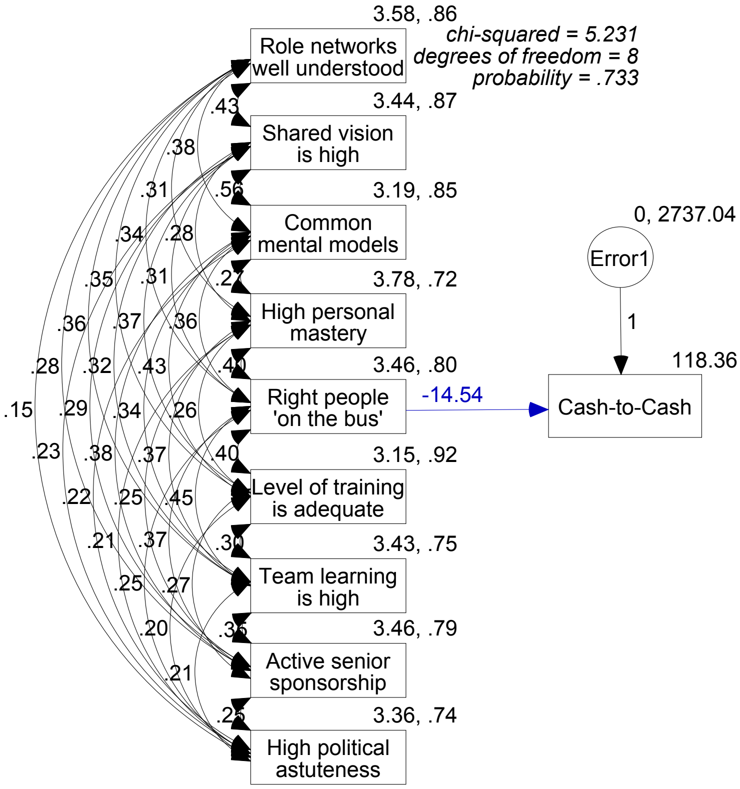

Figure A2.28: Result of SEM Specification Search on Manifest Part IV Independent Variables and Cash-to-Cash Cycle Time.

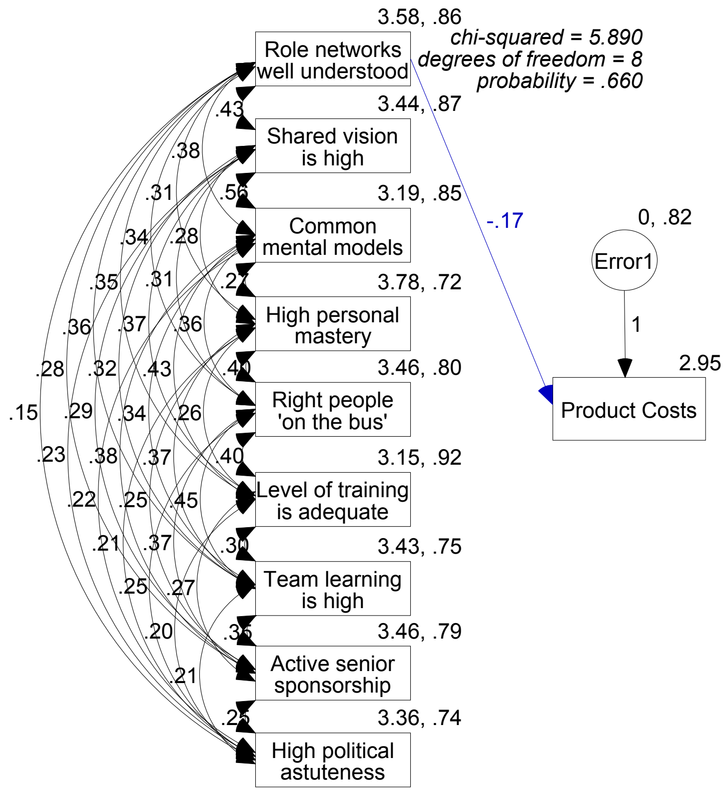

Figure A2.29: Result of SEM Specification Search on Manifest Part IV Independent Variables and Product Costs/Unit Quartiles.

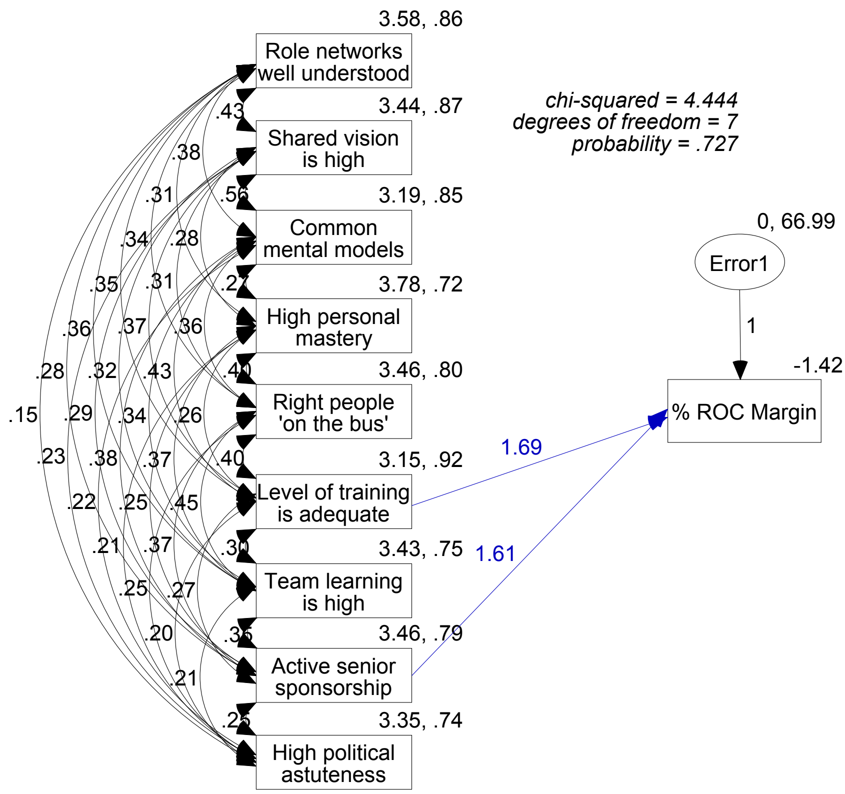

Figure A2.30: Result of SEM Specification Search on Manifest Part IV Independent Variables and % Return on Capital Margin.

Appendix 3

Survey Questionnaire

University of Wollongong

PhD Research – Industry Survey

Questionnaire on the Integration of Supply Chain Logistics[1] Processes

([1] 'Logistics' here refers to procurement, supply chain planning and scheduling, order and product flow management, transport, warehousing and distribution)

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CRICOS Provider No: 00102E

Instructions

This survey consists of four parts. Coverage of each part is as follows:

Part I - General questions to do with your organisation and its current performance.
Part II - Your organisation's overall approach to the management of its supply chain.
Part III - Specific questions to do with the integration of supply chain logistics processes in your organisation, and
Part IV - Social/cultural issues concerning supply chain managers and practitioners.

You are asked to answer each question by ticking the box ☑ most appropriate for your organisation. In some questions you are asked to enter a numerical value.

It is estimated that it will take you about 15 minutes to complete this survey.

Please enter your name and email address here if you wish to receive a copy of the aggregated results of this survey:
Name: ______________________________
Email: ______________________________

Part I – The Business

1. Throughout this survey, will you be answering on behalf of your *whole Company*, the *Division* you work in, or the *Business Unit* you work in? (For the remainder of the survey therefore, whenever you see "your organisation" please apply the same definition as you select here.):

   ☐ My whole Company
   ☐ My Division of the Company
   ☐ My Business Unit

2. Your *position* in your organisation is:

   ☐ CEO
   ☐ President
   ☐ Vice President
   ☐ Manager
   ☐ Analyst
   ☐ Other

3. Your organisation belongs to which *manufacturing segment*:

- ☐ Food, beverage and tobacco manufacturing
- ☐ Textile, clothing, footwear and leather manufacturing
- ☐ Wood and paper product manufacturing
- ☐ Printing, publishing and recorded media
- ☐ Petroleum, coal, chemical and associated product manufacturing
- ☐ Non-metallic mineral product manufacturing
- ☐ Metallic product manufacturing
- ☐ Machinery and equipment manufacturing
- ☐ Electronics and electrical appliance product manufacturing
- ☐ Other manufacturing

4. Your organisation's manufacturing facilities are *located* mostly in:

- ☐ Africa
- ☐ Central/South America
- ☐ Mid East
- ☐ North America
- ☐ North Asia
- ☐ Oceania
- ☐ South Asia
- ☐ Soviet
- ☐ Sub-continent
- ☐ UK/Europe
- ☐ Globally located

5. Your Organisation's *manufacturing facilities* are:

- ☐ Single site
- ☐ Multi-domestic sites
- ☐ Multi-national sites

6. Your organisation's *annual $sales* are:

US$M	

7. Given that % delivery performance of customer orders is = (number of orders delivered on-time/number of orders due)*100 (eg. 55 orders due in time window 'n' with 51 actually delivered in time window 'n', gives a delivery performance of 51/55*100 = 93%), what has been your organisation's *delivery performance* over the past 3 years:

	%

8. Given that perfect order fulfilment is defined as the percentage of orders where all items are delivered on-time to the customer request date, in the correct quantity, with the correct documentation and in perfect condition over all orders due, what has been your organisation's *perfect order fulfilment* performance over the past 3 years:

	%

9. Defining manufacturing lead-time as the average time it takes from launch of raw materials (i.e. raw materials are first 'launched' from a stockpile into production) to the time that finished products are ready for despatch, what is your organisation's *manufacturing lead-time* for its mainstream products:

	days

10. Quite often, offered lead-time to the market (time period between order placement and promised delivery of the order) is considerably shorter than an organisation's manufacturing lead-time. What is your organisation's *offered lead-time* for its mainstream products:

	days

11. The time required for your organisation's supply chain to respond to a 20% sustained *increase in demand* would be (from the time the demand changes to the time the full increased level of demand can be met):

	days

12. The time required for your organisation's supply chain to respond to a 20% sustained *decrease in demand* would be:

	days

13. Defining 'days of inventory' as = (annual average $value of your organisation's trading stock)/((annual $cost of sales {e.g. material, labour, energy, supplies-used-in-production-period} + depreciation – selling and admin expenses)/365), your organisation's *days of inventory* over the previous 3 years were:

	days

14. Defining cash-to-cash cycle time as = (days of inventory + debtor {receivables} days – creditor {payables} days), your organisation's *cash-to-cash cycle* is:

	days

15. Dividing the product cost performance for organisations in your industry into four quartiles from lower quartile to upper quartile, your organisation's *average product costs per unit* compared to your industry are:

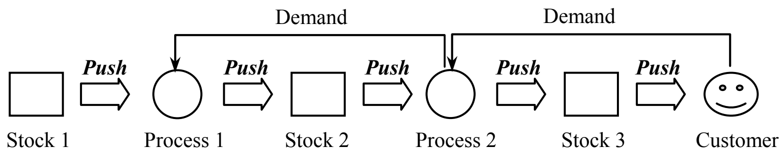
☐ Lower ¼ ☐ Second ¼ ☐ Third ¼ ☐ Upper ¼

16. Over the business cycle your organisation makes a *return-on-capital-margin* (ROC margin = ((net operating profit after tax/total capital employed)*100) − % Cost of Capital) of (please show sign (-) if negative):

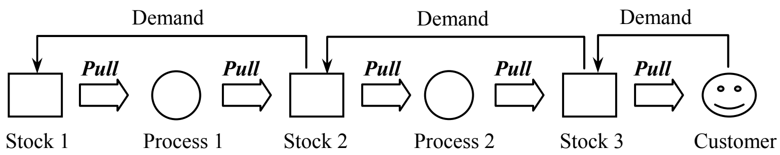
	%

Part II – Supply Chain Principles Employed

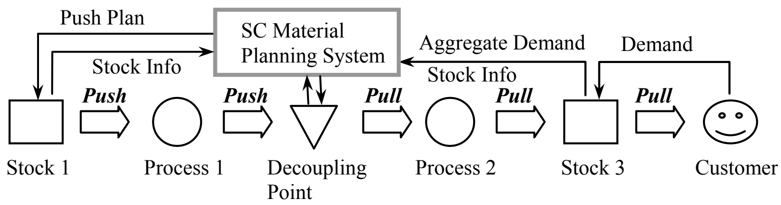
17. Which of the following diagrams, best describes the *operating principle* used by your organisation's supply chain:

☐ 

Production Push

☐ 

Kanban Pull

☐ 

Agile

☐ Other ______________________________

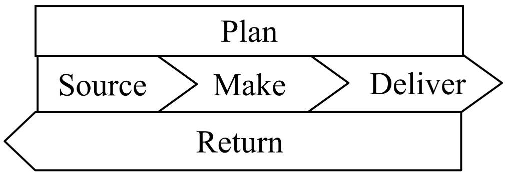
	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
18. Your organisation's supply chain *focus* is more strategic than it is operational.	☐	☐	☐	☐	☐
19. Your organisation's supply chain *goals* are more internally aligned than customer aligned.	☐	☐	☐	☐	☐
20. Your organisation's supply chain *organisational approach* is more functional silos based than it is total chain aligned.	☐	☐	☐	☐	☐
21. Your organisation's supply chain *relationships with customers* are more adversarial than cooperative	☐	☐	☐	☐	☐

		Strongly disagree	Disagree	Neutral	Agree	Strongly agree
22.	Your organisation's supply chain *relationships with suppliers* are more adversarial than cooperative	☐	☐	☐	☐	☐
23.	Your organisation's overall Supply Chain Management (SCM) *strategy* is well defined, clear and widely understood within your organisation.	☐	☐	☐	☐	☐
24.	Your organisation's concept of *product flow* management is that flow is something that happens by default. All units are simply loaded to maximum capacity.	☐	☐	☐	☐	☐
25.	Your organisation is more internally facing than it is customer and/or supplier facing.	☐	☐	☐	☐	☐
26.	For your organisation, the *Optimisation* of Points-of-Production (PoPs), routes, flow rates and throughput levels is not practiced.	☐	☐	☐	☐	☐

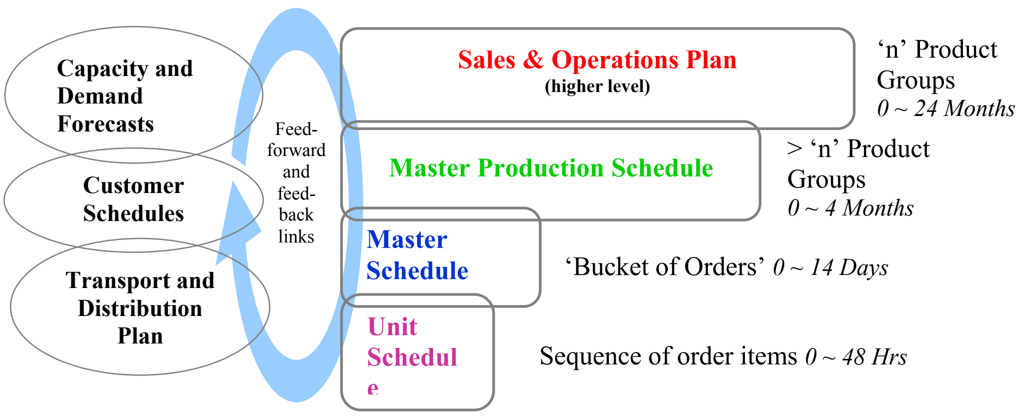
Part III – Levels of Integration of Supply Chain Logistics Processes

The following brief background information is provided for this part.

At a high level, the Supply Chain Council's SCOR (Supply Chain Operations Reference) model consists simply of:



Taking the "Plan" part of the SCOR model and extending it to include more detailed planning and scheduling processes, can result in a model as shown below:



Such processes can be integrated with feed-forward and feedback linkages as shown above.

		Strongly disagree	Disagree	Neutral	Agree	Strongly agree
27.	Your organisation carries out such *planning and scheduling* activities extensively.	☐	☐	☐	☐	☐
28.	The *level of integration* of each process with its neighbouring planning and scheduling process(es) within your organisation is high.	☐	☐	☐	☐	☐
29.	Such integration includes both *feed-forward and feedback* linkages between the processes.	☐	☐	☐	☐	☐

		Strongly disagree	Disagree	Neutral	Agree	Strongly agree
30.	Where feed-forward or feedback does occur between the above processes, the *nature of the linkage* is completely automated.	☐	☐	☐	☐	☐
31.	The integration of your organisation's supply chain processes extends beyond the planning and scheduling ones, eg your planning and scheduling processes are integrated with your *other supply chain processes* (such as order enquiry, order entry, order management, customer relationship management, invoicing, manufacturing execution processes).	☐	☐	☐	☐	☐
32.	Your company's planning and scheduling processes are *integrated* with customers.	☐	☐	☐	☐	☐
33.	Your company's planning and scheduling processes are *integrated* with suppliers.	☐	☐	☐	☐	☐
34.	In your organisation, the practice of *sharing of schedules* with customers is achieved electronically.	☐	☐	☐	☐	☐
35.	In your organisation, the practice of *sharing of schedules* with suppliers is achieved electronically.	☐	☐	☐	☐	☐
36.	In your organisation, no effective *demand forecasting* is conducted.	☐	☐	☐	☐	☐
37.	For your organisation, *e-Logistics*† is an active and key supply chain strategy. (†Visibility of crucial supply chain logistics information is provided electronically to partners along the supply chain e.g. available-to-promise, due-date-quoting, order status, kanban status, end user consumption rates, inventory details)	☐	☐	☐	☐	☐
38.	For your organisation, the *convergence* of the internet and decision support tools is not yet begun.	☐	☐	☐	☐	☐
39.	Transactional activities (such as order placement, order amendment, invoices and payments) between your organisation and its customers and suppliers are *extensively e-enabled*.	☐	☐	☐	☐	☐

Part IV – Socio Considerations for Supply Chain Logistics Personnel (i.e. Planning & Scheduling, Customer Service, Procurement and Transport Personnel)

		Strongly disagree	Disagree	Neutral	Agree	Strongly agree
40.	For your organisation, the logistics personnel's *Role Networks* (focal roles, role clarity, key interfaces, role responsibilities, role accountabilities) are not well understood, not defined.	☐	☐	☐	☐	☐
41.	For the logistics community in your organisation, their level of *shared vision* around integrated supply chain processes is low.	☐	☐	☐	☐	☐
42.	For the logistics personnel in your organisation, their *common mental model* about integrated supply chain processes is very clear and aligned.	☐	☐	☐	☐	☐
43.	For the logistics personnel in your organisation, the level of *personal mastery* (commitment, diligence, professionalism, take their job seriously, customer focussed, performance orientated, continuously improving, up-skilling and learning) they exhibit around their jobs is high.	☐	☐	☐	☐	☐
44.	The logistics personnel in your organisation have the *right people* 'on the bus' (skills/capabilities match with job).	☐	☐	☐	☐	☐
45.	For the expectations set for them, the *training level of your organisation's logistics personnel is* sub-standard, inadequate.	☐	☐	☐	☐	☐
46.	For the logistics personnel in your organisation, their level of *team learning* (working openly, collaboratively and energetically as a team, inclusive of others, share information, share best practices, remember and apply what works and what doesn't work, adopt and adapt the ideas of others) is high.	☐	☐	☐	☐	☐
47.	In your organisation, the level of *senior sponsorship* for your logistics personnel is active and energetic.	☐	☐	☐	☐	☐
48.	In your organisation, your logistics personnel's *political astuteness* (awareness of organisational politics, key power brokers, key influencers) is high.	☐	☐	☐	☐	☐

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