A Study of Leagility and Supply Chain Design

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DECLARATION

I certify that except where due acknowledgement has been made, the work is that of the author alone; the work has not been submitted previously, in whole or in part, to qualify for any other academic award; the content of the thesis/project is the result of work which has been carried out since the official commencement date of the approved research program; any editorial work, paid or unpaid, carried out by a third party is acknowledged; and, ethics procedures and guidelines have been followed.

Masih Fadaki

16 July 2015

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DEDICATION

To my beloved ones:

Atie, Mam, Mr. Shirazi, Mehraban, and Mehregan.

Masih Fadaki

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

In the context of a dynamic and hyper-competitive business environment, appropriate design of supply chains helps organisations to align resources for improved flow of products and services and satisfy customers' diverse needs. Researchers have proposed several supply chain designs which are mutually exclusive such as efficient versus responsive, and lean versus agile. Quantitative testing of these designs revealed that many firms' supply chain designs do not match with what was conceptually expected.

In this research, a new approach to supply chain leagility is investigated, proposing all supply chains are leagile with different magnitudes of leanness and agility. In this regard, a new index, 'deviation from leagility' (DFL), is introduced, and employed in this study to optimise supply chain design. DFL is the absolute distance of supply chain design from a balanced supply chain. Balanced supply chain is a position where the magnitude of leanness and agility is equal. A comprehensive model of uncertainty including demand, supply, and internal uncertainty is engaged to investigate the impact of uncertainty as a key design driver of supply chains.

The partial least squares (PLS) was employed to analyse data collected from Australian firms. The results indicate that higher performance is achievable when the deviation from a balanced supply chain in which both aspects of leanness and agility are equally embedded, is minimised. Results also reveal that DFL is directly and positively influenced by the level of uncertainty; while it is indirectly impacted by the level of competition intensity and customers' expectation.

Analysis of market segment revealed that irrespective of the segment a firm is operating in or for, uncertainty is a significant determinant of designing a supply chain. However, there is higher magnitude of agility for companies active in the up-market segment of an industry compared to the down-market segment.

KEYWORDS

Agile Supply Chain, Efficient Supply Chain, Leagile Supply Chain, Lean Supply Chain, Responsive Supply Chain, Supply Chain Design

CHAPTER 1: INTRODUCTION

1.1 Introduction

Supply chain management has emerged as one of the main strategies for organisations to attain a competitive edge. Effective management of supply chains is a challenging and convoluted task, since current product varieties are increasing in number, the life cycles of products are becoming shorter, more companies are adopting outsourcing strategy, businesses are globalised, and advances in information technology are tremendous (Lee 2002; Vinodh & Aravindraj 2013). Furthermore, the design of the supply chain has an enormous influence on the value and cost of the product throughout its lifetime.

An effective supply chain strategy ensures that a company will attain its competitive advantages by utilising the supply chain capabilities including cost efficiency, response speed, and flexibility. It also determines how different business functions such as manufacturing, procurement, marketing, and logistics perform together to support the preferred competitive strategy (Handfiels & Nichols 2002; Wagner, Grosse-Ruyken & Erhun 2012). Regarding the growing impact of supply chain design, the battlefield shifts from rivalry between organisations to competition between supply chains in the 21st century. Other researchers emphasised that an effective supply chain design could be considered as a key source of competitive advantage ((Schnetzler, Sennheiser & Weidemann 2004; Qi, Boyer & Zhao 2011).

Felicitous design of supply chain helps the organisation to consolidate all the resources to improve the flow of the product over the value stream to meet customers' diverse needs (Robert 2004). Since supply chains are dynamic in nature, both planning and implementation systems should be constantly fine-tuned by supply chain executives to address the emerging industry dynamics. Several studies have proposed different supply chain designs which are mutually exclusive or even collectively exhaustive such as efficient versus responsive (Fisher 1997), efficient, responsive, risk-hedging, and agile (Lee 2002), and market of one versus mass market (Reeve & Srinivasan 2005). The common fact about the proposed mutually exclusive strategies is that most studies only looked at the conceptual stage (Naylor, Naim & Berry 1999; Lee 2002; Wong et al. 2006) or used a case study approach for only a limited number of companies (Fisher

1997; Aitken, Childerhouse & Towill 2003). Ho, Chi and Tai (2005) emphasised that opportunities for building a theory and verification should employ empirical research which is essential for advancing supply chain management studies.

Empirical studies of the proposed mutually exclusive strategies by other researchers (Li & O'Brien 2001; Selldin & Olhager 2007; Lo & Power 2010) has revealed that supply chain strategies might be neither collectively exhaustive nor mutually exclusive. In other words, even though one strategy could be considered as a dominant strategy, executives would adopt the other aspect of supply chain design at the same time to tackle the increasing hyper-competition forces.

Furthermore, the proposition of hybrid strategies to design a supply chain (Christopher & Towill 2001; Samuel, Mohit & Shi 2002; Hopp & Spearman 2004; Minnich & Maier 2006; Lo & Power 2010) such as leagile supply chain models (Naylor, Naim & Berry 1999; Mason-Jones, Naylor & Towill 2000) is further evidence substantiating that a movement from unilateral designs of supply chain to hybrid models has occurred.

There is evidence to support the contention that in today's volatile environment, adopting a purely lean or a purely agile supply chain is not effective. For example, Qi, Boyer and Zhao (2011) studied the impact of competitive strategy (cost leadership vs differentiation) and supply chain strategy (lean vs agile supply chain) on business performance and one of their main conclusion was:

> "The choice of supply chain strategy is not a simple 'either-or' choice. The lean and agile strategies often work in a complementary manner. For example, cost leaders not only increase the use of lean supply chain strategy, but also increasingly emphasize agile supply chain strategy in a volatile environment. The implication is that a cost leader needs to develop both lean and agile capabilities in its supply chain to stay competitive" (p. 13).

It is obvious that recent studies have supported the fact that differentiation between the lean and agile supply chain designs is not an effective approach given the current volatile environment. Qi, Boyer and Zhao (2009) also identified a 'lean/agile' supply chain strategy which outperforms the traditional mutually exclusive strategies. They implied that most companies are not clustered in the pure strategy zones and concluded that it is possible to adopt a strategy which emphasises either developing a lean or an agile supply chain strategy. However, a combination of the two strategies, leagile, seems to outperform either strategy individually. It is undeniable that the combined strategy would likely require more challenging management.

The above-mentioned studies could indicate the need for an index to facilitate the appraisal of supply chain design to provide a better understanding of practical leagile designs. To address the efficiency (leanness) and responsiveness (agility) at the same time, the index should measure the characteristics of supply chain design in one scale. In this research, an index titled as Deviation From Leagility (DFL) is introduced and the relationships between the index and supply chain key design driver (uncertainty), external forces (competition intensity and level of customers' expectation), and firm performance will be studied.

1.2 **Research Problem**

In this section the research problem is explained to identify the knowledge gap and provide a justification for the research framework.

1.2.1 Deviation From Leagility (DFL) Index

The significance of introducing this index emanates from these facts:

(i) As stated earlier, when proposed conceptual mutually exclusive designs including lean versus agile were quantitatively tested by recent researchers, it has been revealed that supply chain design of numerous companies does not match with what was conceptually expected. For instance, it is highlighted by Selldin and Olhager (2007) that the relationship between the product type and the supply chain design is not significant, and consequently the Fisher (1997) model is not quantitatively supported. The interesting point in their research is that supply chain designs of most companies are scattered around the midpoint which is a balanced supply chain (equal weights of leanness and agility). The other issue which needs more thought is when Selldin and Olhager (2007) clustered the companies based on Fisher's model, in their study they removed all companies which were on the borderline located between two strategies.

In order to address these issues, along with engaging the key design driver of supply chain (uncertainty), the external forces to a company and its supply chain are also required to be employed in a thorough investigation. In past decades, it might be feasible that a company would focus only on cost reduction (increasing leanness), or improvement in agility (responsiveness). However, in today's hyper-competitive environment where the expectation of customers has sharply increased, companies are forced to adopt hybrid strategies to remain competitive. This trend was noted in the study by Selldin and Olhager (2007); they demonstrated that most companies are adopting hybrid strategies. Therefore, there is a need for an index to evaluate a hybrid strategy properly whereby the above-mentioned issues could be addressed.

In the majority of studies (Naylor, Naim & Berry 1999; Christopher & Towill 2001; Samuel, Mohit & Shi 2002; Tim & Melvyn 2004; Wong et al. 2006; Selldin & Olhager 2007; Lo & Power 2010; Omera, Christopher & Alessandro 2012), leanness and agility are measured on two scales. It means that leanness is measured by a separate scale and agility is measured through different variables. However, in a hybrid strategy, business executives are not employing leanness and agility separately. In other words, the aforementioned studies have tried to adjust the leanness and agility levels in a way that highest cost reduction and responsiveness would be achieved concurrently. Therefore, an appropriate index should be introduced to evaluate the leagile strategy through measuring both leanness and agility in one scale.

As a result, in order to effectively investigate a supply chain hybrid strategy, this study introduces an index to the supply chain body of knowledge, known as 'Deviation From Leagility' (DFL). If supply chain design is modelled on a spectrum in terms of current status of leanness and agility, two extremes would be a purely lean (efficient) supply chain and a purely agile (responsive) supply chain (Figure 1-1). The midpoint of this scale represents a balanced leagile supply chain in which both aspects of leanness and agility have an equal weighting (50%-50%).

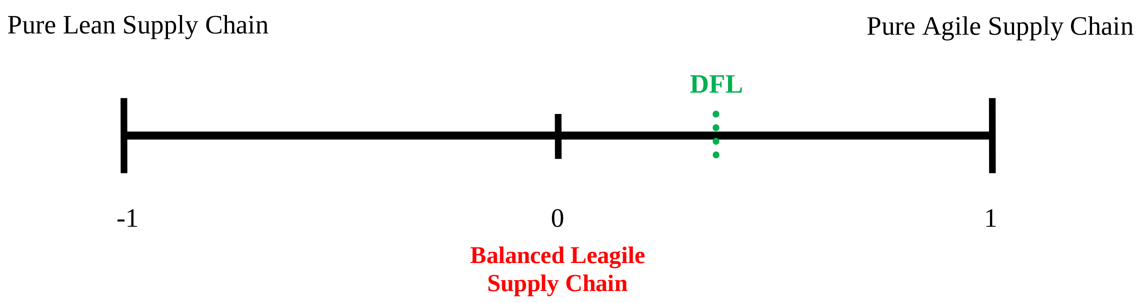

Figure 1-1: Deviation From Leagility Index (DFL)

(ii) Investigation into the position of DFL of companies' supply chain could clarify whether today's design of supply chains is still mutually exclusive or hybrid. The studies which have put forward the idea of mutually exclusive supply chain designs are mostly related to previous decades (Fisher 1997; Naylor, Naim & Berry 1999; Lee 2002; Wong et al. 2006). As cited by other researchers (Lo & Power 2010; Omera, Christopher & Alessandro 2012) the external forces including competition forces and growing expectation of customers would put pressure on executives to consider both leanness and agility simultaneously. Assessing the position of DFL will provide useful information regarding the current status of supply chain designs.

(iii) Study of DFL over different segments of market could provide more details with reference to the supply chain design. As explained by Kotler and Keller (2006), companies stretch their marketing to capture different segments including up-market and down-market. Up-market is defined as the segment of the market in which products are designed for high-income consumers. In other words, price tag of products in up-market segment is higher than down market. It is expected that companies operating in an up-market segment put more effort into quality and agility than cost and leanness. In contrast, cost and efficiency are expected to be the main criteria for developing supply chain strategies in the down-market segment. As a result, comparison of leagility over up-market and down-market segments could provide a useful guideline for supply chain executives to fine-tune the leagility level as close to the optimum design which is recommended for the segment they are operating.

1.2.2 Uncertainties and DFL

Increased uncertainty is one of the main influencing factors on today's supply chain environment (Paulraj & Chen 2007; Ulf & Ulrich 2011). The majority of researchers agree that uncertainty is a key driving force behind the effective building of supply chain relationships (Bluedorn et al. 1994; Haunschild 1994; Williamson 2010). Ulf and Ulrich (2011) highlighted that high level of uncertainty along the supply chain would impact on the design of supply chain to become highly complex and dynamic. Several studies have investigated limited aspects of supply chain uncertainty (Fisher 1997; Lee 2002; Szu-Yuan, Meng-Hsiang & Wen-Jin 2009). Comparatively, there is limited research which provides a broader view of supply chain uncertainty (for example: Ho, Chi & Tai 2005; Lo & Power 2010).

Many firms have enhanced their supply chain agility to tackle the environmental uncertainties with maximum efficiency. However, increasing supply chain agility is costly (Swafford, Ghosh & Murthy 2006). Accordingly, as emphasised by Pujawan (2004), a company should wisely evaluate how much agility they actually require. Numerous comprehensive studies have delineated the relationships between leanness-agility level, uncertainty, and performance (e.g., Gerwin 1993; Olhager 1993; Pagell & Krause 1999; Vokurka & O'Leary-Kelly 2000; Chang et al. 2003; Pagell & Krause 2004; Sawhney 2006). However, only a few studies have provided a guideline to formulate the supply chain strategy in terms of leanness-agility optimisation. In this regard, Sánchez and Pérez (2005) emphasised there have been very limited studies on supply chain flexibility and there are even fewer concerning the relationship between uncertainty, supply chain flexibility, and firm performance. In this context, some researchers including Sánchez and Pérez (2005) have used the terms 'flexibility' and 'leanness-agility level' interchangeably. However, supply chain flexibility has diverse connotations in different literature.

Although the majority of researchers proposed that uncertainty is a crucial driving force to develop an effective supply chain design, most studies are still in the early stages of conceptual development. For example, Fisher (1997) study introduced demand uncertainty as the main driver to select a proper supply chain strategy, while

Naylor, Naim and Berry (1999) introduced the concept of leagility. Studies following Fisher's (1997) model that was developed further by Wong et al. (2006), were case studies focusing on the manufacturing sector, such as Aitken, Childerhouse and Towill (2003). Nevertheless, as argued by Flynn et al. (1990), experimental research provides opportunities for theory development and verification, which is crucial for the expansion of supply chain management research.

In this research, various aspects of uncertainty which influence supply chain design are investigated. As indicated in previous studies, uncertainties which could affect a supply chain model have been categorised in three major types:

(i) Demand Uncertainty (e.g., Fisher 1997; Minnich & Maier 2006; Selldin & Olhager 2007; Omera, Christopher & Alessandro 2012)

The aforementioned studies focused only on the demand aspect of uncertainty. The product type to be either functional or innovative was defined based on the level of demand uncertainty. The necessity of a match between supply chain strategy and product type was highlighted. The main finding indicated that lean supply chain is suitable for functional products (low level of demand uncertainty), while agile supply chain is recommended for innovative products.

(ii) Supply Uncertainty (e.g., Lee 2002; Lo & Power 2010)

They emphasised that uncertainty along a supply chain does not restricted to only demand uncertainty. They provided several examples indicating that optimising supply chain design would require special attention to supply uncertainty besides demand uncertainty.

(iii) Internal Uncertainty (e.g., Minnich & Maier 2006; Paulraj & Chen 2007)

Since a company consists of head (customer/marketing/demand), body (process/production/collaboration), and tail (suppliers/procurement/supply), a comprehensive model of uncertainty must include demand, supply, and internal uncertainty.

The current research assesses the overall uncertainty by measuring each construct (demand, supply, and internal uncertainties) and then the relationship between the overall uncertainty and DFL is investigated. As part of the post analysis, the relationship between each construct (demand, supply, and internal uncertainty) and DFL is explored to provide more details in relation to the impact of each aspect of uncertainty on DFL. An analysis of the impact of uncertainty on DFL could provide a useful guideline for supply chain executives to fine-tune their supply chain strategy as per existing uncertainty level along the supply chain.

1.2.3 Competition and Supply Chain Design

Although uncertainty is the key driving force when designing a supply chain, other external factors put pressure on executives to reconsider strategies for supply chain so that a better competitive advantage is achieved. For instance, Ulf and Ulrich (2011) argued that when competitive pressure increases in the market, firms are required to make product life cycles shorter, enhance the variety of products, and to become accustomed to technological variations more swiftly than they did previously.

As explained earlier, a trend could be traced in the literature indicating that the leanness-agility level in most companies' supply chain is getting closer to the mid-point which is referred to as a 'balanced leagile' supply chain. One of the influencing factors could be competitive pressures on supply chain. According to Fisher's (1997) model, if a company produces a functional product, it requires to adopt a lean supply chain to minimise the cost. On the other hand, if a company produces an innovative product, it needs to adopt a responsive supply chain to increase the agility. However, in today's hyper-competitive environment, other than minimising the cost, a company is required to both increase the variety of products and also pay more attention to being responsive to customers' expectations which means improving the overall agility. Similarly, in the second Fisher's scenario, to improve its competitive position, a company is required to not only keep the responsive position but also minimise the cost by increasing efficiency. As a result, competitive pressures would considerably affect the design of supply chain.

To the extent of this author's knowledge, not studies have directly explored the impact of competitive forces on design of supply chain. This knowledge gap is addressed in this study by investigating the moderating effect of competition intensity on the relationship between uncertainty and DFL. The detailed explanation of competition intensity in the supply chain context is provided in the literature review in Chapter 2.

1.2.4 Growing Expectation of Customers and Supply Chain Design

As stated by Ulf and Ulrich (2011), complexity in supply, manufacturing, and distribution are increasing and consumers are becoming more demanding. It means that customers expect more customised products and a higher level of customer service than in the previous decades. In the report issued by Design Council (2004/2005), it is highlighted that where customers' expectations regarding contradictory goals such as product variety and lower cost are exponentially growing, more attention should be paid to design whereby companies can gain a competitive advantage in their supply chains.

As a result, design of supply chain without considering the level of customers' expectations in an industry will lead to a less desirable market position. This study tries to explore another knowledge gap - the impact of customers' expectations on supply chain design. Given uncertainty is the main influencing factor on supply chain design, the moderating effect of customers' expectations is examined in the relationship between uncertainty and DFL. The detailed explanation of customers' expectations in supply chain context is provided in Chapter 2.

1.2.5 DFL and Firm Performance

The ultimate goal of every design is to achieve the best performance and a better competitive position. In order to verify the effectiveness of a supply chain design, most studies investigated the impact of the proposed model on a firm's performance (e.g., Ho, Chi & Tai 2005; Ulf & Ulrich 2011). Further to introducing the new index (DFL) which is an enabler that clarifies the leagility status of a hybrid supply chain, the impact of DFL on firm performance is investigated. This could provide critical information for executives to fine-tune the design of supply chain to achieve maximum performance. The detailed explanation of how a design of supply chain impacts on business performance is provided in chapter 2: Literature Review.

1.3 **Research Questions**

Several different factors are required to design an effective supply chain and make it optimised to achieve maximum performance. Cost, quality, lead time and service level have been quoted as the main market qualifiers and depending on the market segment, a combination of them has been considered as market winners (Mason-Jones, Naylor & Towill 2000). However, depending on the segment in which a firm is operating and the level of internal and external factors, each of the aforementioned elements could be a market qualifier or a market winner. Organisations adopt different levels of leanness and agility to provide products which meet the market qualifier and market winner requirements. Moreover, these optimisations must be implemented throughout a firm's value chain including the supply chain (Amir 2011). In this regard, the concept of leagility has a major strategic significance to create an effective supply chain enabling companies to optimise cost and lead time. In the current research, a new approach to supply chain leagility is investigated to answer the following core research question:

> Given that all supply chains are leagile with different magnitudes of leanness and agility, what are the key design drivers of a leagile supply chain?

The above research question will be addressed by developing specific hypotheses in Chapter 3 on the research methodology. They will provide the necessary building blocks for developing the research model.

1.4 **Research Objectives**

With respect to different viewpoints stated in the earlier section regarding supply chain design, the current research as an exploratory study aims to address the following issues:

i) Develop Deviation From Leagility (DFL) index, identify location of the index, and investigate the impact of DFL on firm performance.

   Study the distribution of DFL addresses the dilemma whether supply chain designs are mutually exclusive or the preferred supply chain strategy follows a hybrid model. It could be achieved by analysing the position of DFL to examine whether its distribution indicates most companies tend to employ a more balanced leagile supply chain. Further comparison between leagility indexes of different market segments would be another objective of this research to provide an insight and understanding of leagility status. Finally, the impact of DFL on firm performance is investigated to identify the location of DFL which attains better performance.

ii) To examine the impact of supply chain uncertainty (demand, supply, and internal uncertainties) on DFL.

A comprehensive model of uncertainty as the crucial influencing factor on effective design of supply chain is investigated in the current study. Since each element of supply chain uncertainty (demand, supply, and internal) could impact on the adoption of a leagile supply chain with different weights of leanness and agility, further investigation on the relationship between each construct of supply chain uncertainty and DFL is one of the essential objectives of the current research.

iii) Investigate the moderating effect of external forces (competition intensity and customers' expectations) in the relationship between supply chain uncertainty and DFL.

In the literature it is evident that the design of supply chain has altered in recent decades. However, the sources of these changes have not been thoroughly investigated. Accordingly, this study looks at the impact of external forces including competition level and customers' expectations on the leagility aspect of supply chain. External forces will be examined as moderators of the relationship between supply chain uncertainty and leagility index. In this regard, further analysis will be carried out to investigate the moderating effect of external forces on the relationship between each element of supply chain uncertainty (demand, supply, and internal) and DFL.

iv) Investigate the impact of market segment on leagility balance of supply chain.

A segment of the market in which a firm is operating could impact on the design of supply chain. There are similarities in terms of external forces in each segment of the market. Therefore, it is expected that companies operating in the same market segment adopt similar design of supply chain. The impact of market segment on the leagility index will be investigated to justify this proposition.

1.5 **Significance of the Study**

It is highly desirable that a study provides a practical guideline for supply chain executives to make an improvement through implementation of research findings. The current available literature in terms of leanness-agility aspect of supply chain does not clearly propose whether the best practice would be to adopt a purely lean/agile model as per product characteristics, or a hybrid strategy needs to be fine-tuned in terms of leanness and agility to achieve the highest performance.

A study of DFL firstly provides critical information for executives and researchers to be practically enabled to decide whether employing one of the mutually exclusive designs or a hybrid supply chain strategy would provide a better performance. The second important aspect of this study is to investigate the influence of uncertainties on leagility degree of companies. The current research provides critical information with reference to the impact of overall uncertainty and its constructs (demand, supply, and internal uncertainty) on the leagility indicator (DFL). The third significance of this study is linked to an investigation of the influence of market characteristics in design of supply chain. Since the characteristics of up-market and down-market segments of an industry are not the same, a study of DFL over different market segments provides a guideline for tailoring the design of supply chain based on the market segment in which a firm is operating.

As the fourth major contribution of this study, a significant knowledge gap which is the influence of external factors (competition level and level of a customers' expectation) on leagility will be filled. As understanding the nature and magnitude of these forces is vital to fine-tune the design of supply chain, it is important to investigate how external forces influence the leagility balance of supply chains. The fifth and last significant feature of this study relates to the effect of leagility on firm performance.

This information enables supply chain executives to achieve the highest possible performance through adjusting the leanness-agility magnitudes in design of supply chain. As one of the outcomes of this study, the relationship between the leagility and firm performance will clarify. This insight would be a guideline for supply chain managers on how to maximise the firm performance by employing both lean and agile techniques at an optimal level. For example, if findings of this research indicate that firms with lower DFL (more balanced supply chain) attain higher performance, supply chain executives would be recommended to balance the current leanness/agility level by dedicating additional resources to the aspect which is less regarded.

1.6 **Expected Outcomes**

Reviewing the literature of supply chain design in terms of leagility and its trend supports the idea of a movement toward a leagile supply chain due to increasing pressures of competition intensity and growing expectations of customers. Accordingly, it is expected that an investigation into the designs of supply chains with respect to DFL index, indicates most companies adopt a leagile design with a more balanced leanness-agility level. This finding supports the preferred adoption of hybrid strategies (leagile supply chain) compared to mutually exclusive designs (purely lean or purely agile supply chain).

Although it is expected that DFL of companies would be closer to zero (balanced leagile supply chain), the direction is still important. It means that depending on the segment a firm is operating in, the weight of leanness or the weight of agility is higher in a leagile supply chain. It is also expected that a comparison of leagility index over market segments (up-market and down-market) demonstrates a significant difference between the leagility of different market segments. In other words, in a leagile supply chain operating in an up-market segment, the magnitude of agility is anticipated to be more than leanness and vice versa.

Furthermore, with a decline in the level of uncertainties along the supply chain, companies are expected to adopt a more balanced supply chain so that they can utilise more resources to improve the supply chain design in the absence of high uncertainty. Decreasing the value of DFL where uncertainty level is lower along the supply chain would be an indication of this trend.

In spite of expecting variations in DFL due to different levels of uncertainties, external forces including competition level and growing expectations of customers would influence the leagility degree of supply chain. It is expected both competition intensity and level of customers' expectations will play a moderator role in the relationship between uncertainty and DFL. In other words, in a more competitive environment or if customers' expectations are very high, it is expected that the impact of uncertainty on DFL would decline.

As up-market is defined as the segment of market in which products are designed for high-income consumers, it is expected that customers of this segment pay extra attention to the level of quality and service. Therefore, it is anticipated that companies operating here adopt a more agile supply chain which is represented by higher leagility index. The final outcome of this research will be related to a study of the relationship between DFL and firm performance. Those companies which adopted a supply chain design with less deviation from leagility are expected to demonstrate higher overall performance.

1.7 **Scope of Study**

The scope of the current study is limited to companies which are dealing with supply chain of manufacturing products in Australia in different industries. A brief description of the Australian manufacturing industry is presented in this section (*Year Book Australia* 2012). The manufacturing industry production is measured by different indices including industry gross value added (GVA). Figure 1-2 demonstrates the total production of Australian manufacturing industry between 1985 and 2010. The global financial crisis of 2008-09 caused a reduction of 6% in total production in the manufacturing sector with only a partial recovery in 2009–10.

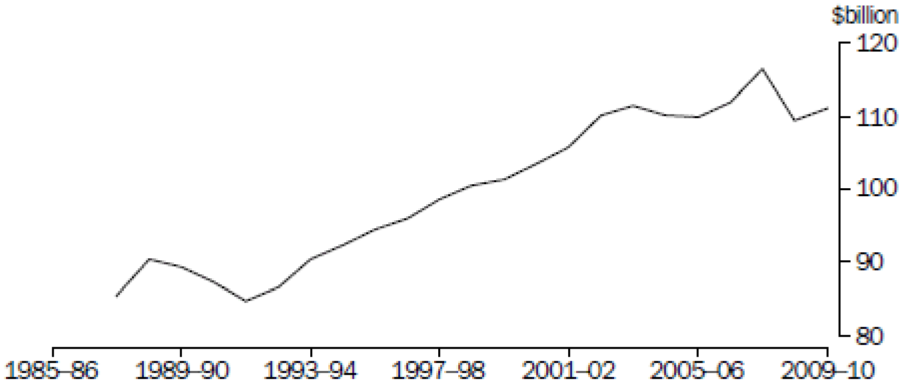

Figure 1-2: Total production of Australian Manufacturing Industry, as measured by industry GVA (in volume terms) Source: Year Book Australia (2012)

Table 1-1 shows the industry GVA for components of Australia's manufacturing industry.

Table 1-1: Industry GVA and GDP contribution for components of Australian Manufacturing Industry (2005-2010) Source: Year Book Australia (2012)

Sub-industries	Unit	2005–06	2006–07	2007–08	2008–09	2009–10	% change from 05–06 to 09–10
Food, beverage and tobacco products	$m	22,743	22 ,973	22,945	22,228	23,755	4.4
Textile, clothing and other manufacturing	$m	6,153	6,096	6,381	5,720	4,704	–23.5
Wood and paper products	$m	8,309	8,080	7,768	7,176	7,442	–10.4
Printing and recorded media	$m	5,484	5,536	5,676	4,683	4,486	–18.2
Petroleum, coal, chemical and rubber products	$m	20,979	20,608	21,113	18,995	19,660	–6.3
Non-metallic mineral products	$m	5,424	5,551	5,801	5,764	5,658	4.3
Metal products	$m	20,048	22,024	24,521	23,738	22,990	14.7
Machinery and equipment	$m	21,671	21,659	22,375	21,099	22,361	3.2
Total manufacturing	$m	109 ,798	111,869	116,306	109,403	111,057	1.1
Contribution to GDP	%	9.5	9.4	9.4	8.7	8.7	

The contribution of state and territory production (in current prices) for 2009–10 in Australian manufacturing industry is depicted in Figure 1-3 (*Year Book Australia* 2012). The maximum contribution to state production from manufacturing for Tasmania and South Australia was 11.7% and 11.6%, respectively. Victoria (11.2%) and New South Wales (9.6%) were the third and fourth states in terms of manufacturing's contribution to production.

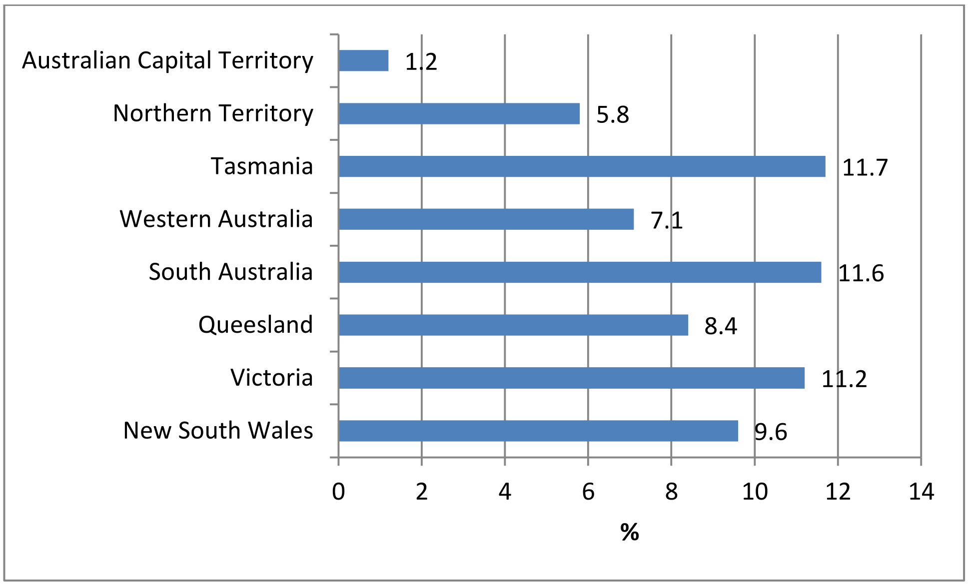

Figure 1-3: State and territory production as measured by total factor income Source: Year Book Australia (2012)

As presented in Table 1-2, the total wages and salaries paid in 2009–10 by manufacturing organisations was estimated to be $52 billion. The manufacturing industry generated $381 billion of sales and service income and $97 billion of industry value added (IVA).

The highest contribution to total manufacturing sales and service income was related to Food products with $74 billion sales (19%). The food industry was also the highest contributor to wages and salaries with $9 billion (18%), and the largest contributor to total manufacturing IVA ($17b or 17%). Primary metal and metal product manufacturing (16% of sales and service income and 7% of IVA), Machinery and equipment manufacturing (9% of sales and service income and 11% of IVA) and Transport equipment manufacturing (8% of sales and service income and 9% of IVA) were the major contributors after the Food industry.

Table 1-2: Australian manufacturing industry subdivisions and their contributions (2009–2010) Source: Year Book Australia (2012)

Subdivisions	Wages and salaries	Sales and service income	Industry value added
	$m	$m	$m
Food product manufacturing	9 183	74 128	16 832
Beverage and tobacco product manufacturing	1 942	17 770	6 609
Textile, leather, clothing and footwear manufacturing	1 595	9 162	2 839
Wood product manufacturing	2 224	12 692	4 211
Pulp, paper and converted paper product manufacturing	1 459	9 657	2 633
Printing (including the reproduction of recorded media)	2 246	9 183	4 034
Petroleum and coal product manufacturing	627	25 590	1 584
Basic chemical and chemical product manufacturing	3 625	30 482	8 393
Polymer product and rubber product manufacturing	2 764	16 078	5 390
Non-metallic mineral product manufacturing	2 689	17 197	5 411
Primary metal and metal product manufacturing	4 585	59 188	6 844
Fabricated metal product manufacturing	5 820	28 656	10 510
Transport equipment manufacturing	5 350	30 431	8 448
Machinery and equipment manufacturing	6 299	33 653	10 575
Furniture and other manufacturing	1 445	7 296	2 495
Total Manufacturing	**51 853**	**381 165**	**96 809**

1.8 **Summary**

Supply chain leanness and agility are two major aspects of supply chain design in all types of industries. As design of supply chain without engaging the main influencing factors could result in problems being experienced the value chain, this study aims to identify and employ both internal and external forces in a comprehensive model. To do this, an extensive literature review is required to confirm which internal forces impact on the supply chain design the most. It seems demand, supply, and internal uncertainty would be the key design drivers. With regard to the external forces, competition intensity and level of the individual customers' expectation seems to influence the supply chain design as well. Research questions and objectives have been developed to facilitate a scientific and systematic investigation into the key design drivers of a supply chain, in particular the leagility aspect. A review of the literature will be provided in the next section to assess these factors. The scope of the current study is limited to companies which are dealing with manufacturing products' supply chains in Australia in various industries.

CHAPTER 2: LITERATURE REVIEW

In this chapter the literature that is relevant to the concept of supply chain leagility and the influencing factors impacting on the supply chain design are explored. The first section provides information regarding any prior research that has been done on this topic. The research questions are stated and knowledge rationale is delineated. In section two of this chapter, the conceptual model and hypotheses are developed to address the problem statement. Finally, the concepts which have been employed in the conceptual model, are operationalised in order to develop a survey questionnaire.

In today's hyper-competitive environment, organisations are struggling to obtain the highest possible performance from their supply chains by utilising various diverse means. These include enhanced knowledge sharing, sophisticated planning methods, advanced replenishment and forecasting, and third-party logistics strategies. However, prior to dealing with any of the mentioned tools, supply chain of an organisation should be designed properly (Selldin & Olhager 2007).

Cohen and Fine (2000) and Fine (2003) stressed that design of a supply chain must be considered as a separate dimension in addition to the design of processes and products. By proposing the product-process matrix, Hayes and Wheelwright (1979b, 1979a, 1984) delineated the association between product characteristics and process type. The matrix provided a framework to explain the best match between product and process characteristics. This model was empirically examined by several researchers (e.g., Spencer & Cox 1995; Safizadeh et al. 1996; McDermott, Greis & Fischer 1997) and has become one of the most well-known concepts in the production strategy field.

Concurrent to optimisation of production strategies, organisations are striving to improve their supply chain operations as well. In other words, manufacturing organisations have realised the significance of engaging the best process and supply chain design to ensure the maximum fitness with their products' characteristics (Ahmad & Schroeder 2002; Selldin & Olhager 2007). Accordingly, every manufacturing firm requires systems and methods to design a suitable supply chain which provides the highest value to the organisation.

The core of this research is an analysis of the relationship between the supply chain uncertainty and deviation from leagility (DFL). An additional analysis will be carried out by investigating the potential moderators (competition level and customers' expectation level) and the influence of DFL on firm performance. Accordingly, background of these notions is summarised in this chapter.

2.1 **Uncertainty and Supply Chain Design**

The process of completing an order from point of sales to delivery of a product to the customer, order-fulfilment, involves the coordination of different supply chain members and actions, including sales obligations, production, and managing suppliers' relationships for procuring or distribution, which generally occur in multiple diverse business units. The outstanding issue of this complex network is the uncertainty that influences all elements of the chain (Davis 1993).

The issue of uncertainty will escalate for a finished product due to significantly more companies being involved in the processes of order-fulfilment. Jauch and Kraft (1986) stressed that one of the crucial factors to successfully manage a supply chain is to eradicate problems linked to uncertainty by precisely adjusting the order-fulfilment process.

It is necessary to differentiate between the forms and sources of uncertainty along the supply chain. As argued by Gaonkar and Viswanadharn (2007), there are three major forms of uncertainty in the supply chain: disruption, deviation, and disaster. These forms could occur due to natural disasters, manufacturing failures, terrorism, bankruptcy of suppliers, and strikes. It is obvious that not all sources of uncertainty are manageable within the organisation. Alternatively, there are some external forces which make the uncertainty fluctuate along the supply chain. As a result, a total risk management program is required to minimise the side effects of these volatile uncertainties. One widely accepted method in efficient risk management is to remove vulnerability by increasing resilience across the supply chain (Bogataj & Bogataj 2007). They emphasised that proper decision-making is the key factor to mitigate the supply chain risks.

From the standpoint of the convoluted nature of the interactions between organisations in the order fulfilment process, Davis (1993) clarified that demand, supply, and internal (manufacturing) uncertainty were the key sources that compromise supply chain executives ability to manage the order fulfilment process. A well-defined strategy is necessary to continually monitor and measure all aspects of uncertainties and their effect on the order-fulfilment process.

Starting with Davis (1993) several studies have attempted to investigate the different aspects of uncertainty along the supply chain. The most frequently cited elements of uncertainty which significantly impact on supply chain design are: (a) demand uncertainty, (b) supply uncertainty, and (c) internal/manufacturing/technology uncertainty (Ho, Chi & Tai 2005; Paulraj & Chen 2007; Ulf & Ulrich 2011).

2.1.1 Demand Uncertainty

Most researchers agree that the prevailing source of uncertainty in supply chains is demand fluctuations (Towill, Naim & Wikner 1992; Lee & Whang 1997; Mason-Jones & Towill 1998; Taylor 2000; Lee, Padmanabhan & Whang 2004). Demand uncertainty stems from the disparity between the information signals detected by supply chain participants and real consumer demand. The main source of disparity is the erroneous decision-making by supply chain members in response to demand information (Sterman 1989; Towill, Naim & Wikner 1992; Lee, Padmanabhan & Whang 2004). For instance, an order which is received by upstream members from a downstream one is frequently changed and adjusted because of changes in safety stock and ordering plans. As highlighted by Towill, Naim and Wikner (1992), demand fluctuation would be higher when lead-times are longer and number of decision-makers are greater along the chain.

There are other occasions which lead to higher demand fluctuations. For instance, Lee, Padmanabhan and Whang (2004) argued that when retailers are in doubt about the suppliers to be in short supply, they start to place extra orders. In other words, demand uncertainty is also influenced by increasing overreacting decisions coming from fear of instability all along the supply chain.

One of the well-known models discussing the demand uncertainty and supply chain design is Fisher’s (1997) paper proposing an effective supply chain ought to be designed with respect to the characteristics of the product. His theory regarding product-supply chain matrix has been evolved over several literature (Fisher et al. 1994; Fisher 1997; Fisher et al. 1997; Cachon & Fisher 2000) and the theory was supported by case studies of Campbell Soup and Sport Obermeyer. The thrust of Fisher’s theory is that products could be classified into two groups: functional or innovative. The classification criteria are product demand pattern and expectations of the market (Table 2-1). On the other hand, Fisher proposed that there are two individual methods of design of supply: lean (efficient) and agile (responsive) (Table 2-2). According to his framework, the best supply chain design for a functional product is an efficient one, whereas a responsive supply chain is suitable for an innovative product (Figure 2-1).

Table 2-1: Functional versus Innovative products **Source: Fisher (1997), p.108**

Aspects of Demand	**Functional** (Predictable Demand)	**Innovative** (Unpredictable Demand)
Product life cycle	more than 2 years	3 months to 1 year
Contribution margin	5% to 20%	20% to 60%
Product variety	low (10 to 20 variants per category)	high (often millions of variants per category)
Average margin of error in the forecast at the time production is committed	10%	40% to 100%
Average stockout rate	1% to 2%	10% to 40%
Average forced end-of season markdown as percentage of full price	0%	10% to 25%
Lead time required for made-to-order products	6 months to 1 year	1 day to 2 weeks

Table 2-2: Lean versus Agile supply chain Source: Fisher (1997), p.108

	Lean (Physically Efficient) Process	**Agile (Market-Responsive) Process**
Primary purpose	supply predictable demand efficiently at the lowest possible cost	respond quickly to unpredictable demand in order to minimize stockouts, forced markdowns, and obsolete inventory
Manufacturing focus	maintain high average utilisation rate	deploy excess buffer capacity
Inventory strategy	generate high turns and minimise inventory throughout the chain	deploy significant buffer stocks of parts or finished goods
Lead-time focus	shorten lead time as long as it does not increase cost	invest aggressively in ways to reduce lead time
Approach to choosing suppliers	select primarily for cost and quality	select primarily for speed, flexibility, and quality
Product-design strategy	maximise performance and minimise cost	use modular design in order to postpone product differentiation for as long as possible

	Functional Products	Innovative Products
Lean (Efficient) Supply Chain	Match	Mismatch
Agile (Responsive) Supply Chain	Mismatch	Match

Figure 2-1: Match between product type and supply chain design
Source: Fisher (1997), p. 109

It is obvious that in Fisher's model, demand uncertainty is the main criterion for categorising the product type and the product type is the key factor in selecting a supply chain design. Furthermore, the type of proposed supply chain designs could be considered as mutually exclusive or even collectively exhaustive designs (lean and agile). In other words, executives need to design a supply chain that is either lean (for functional products) or agile (for innovative products).

However, in practice there are several concerns which need to be addressed:

(i) Is demand uncertainty the only and sufficient element of uncertainties to determine the design of a supply chain?

In this study, the crucial elements of uncertainty along the supply chain are investigated and relevant literature is reviewed.

(ii) Is mutually exclusive categorisation of supply chain able to address the current complexities of environmental forces?

Reviewing the recent literature and introducing deviation from leagility (DFL) index will address this issue.

(iii) Fisher's model is based on a case study of two companies. If a larger sample size is analysed, will the model still be valid? Which environmental forces would possibly influence design of supply chain?

Reviewing recent literature revealed that for a larger sample size, the validity of the model is questionable (Selldin & Olhager 2007). In the current research major environmental forces will be reviewed to provide in-depth knowledge.

(iv) When demand is considered as either predictable or unpredictable, is there any practical way of testing whether the current demand is predictable or unpredictable?

There are numerous mathematical techniques to predict the future demand and monitor its trend including time series techniques. However, there is no well-accepted method to precisely differentiate between predictable and unpredictable demand.

From 1997 onwards numerous researchers have proposed different approaches to match supply chain design and product characteristics including Ramdas and Spekman (2000), Samuel, Mohit and Shi (2002), Childerhouse, Aitken and Towill (2002), and Lee (2002). However, the main concept referred to was Fisher's model. Alternative viewpoints on different types of supply chain designs were formed to stress that the combination of lean and agile notions could a viable option (e.g., Naylor, Naim & Berry 1999; Mason-Jones, Naylor & Towill 2000; Aitken, Christopher & Towill 2002). It is noteworthy that even though they tried to add some complementary details to Fisher's model, in nature, a lean supply chain has analogous specifications as efficient type (terminology of Fisher), and an agile supply chain is comparable to responsive design in Fisher's model.

In contrast to literature trying to develop Fisher's model, a range of recent studies tested this model and they could not find statistical evidence to support it. For example, Selldin and Olhager (2007) highlighted that the relationship between the product type and the supply chain design is not significant and therefore the Fisher (1997) model is not quantitatively supported (Figure 2-2).

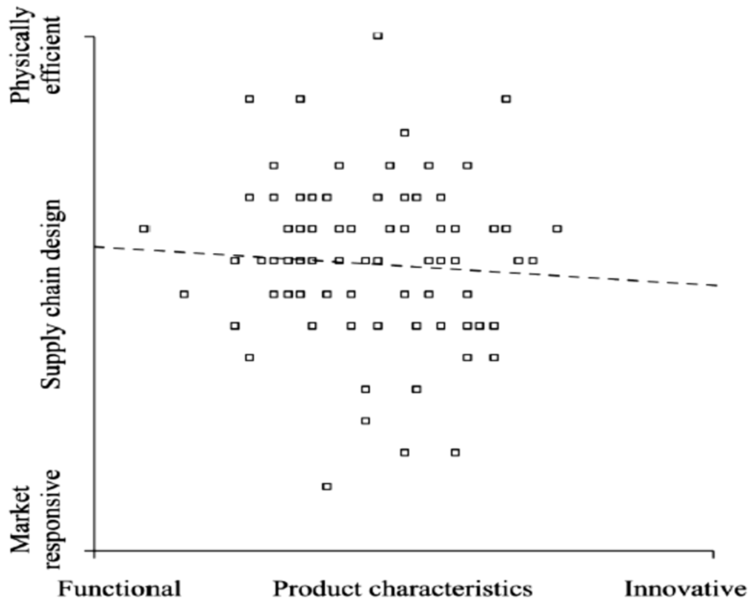

Figure 2-2: Scatter diagram of the product type versus supply chain Source: Selldin and Olhager (2007), p. 47)

As shown in Figure 2-2, the majority of supply chain designs are scattered around the midpoint. It could be a valid reason indicating that external factors have forced companies to adopt a hybrid strategy. Figure 2-3 demonstrates the distribution of supply chains as per Fisher's model. It is very important to note that Selldin and Olhager (2007) removed all companies located on the borderlines. Location of companies on this borderline is an accurate indication that both lean and agile strategies are employed at the same time in design of supply chain.

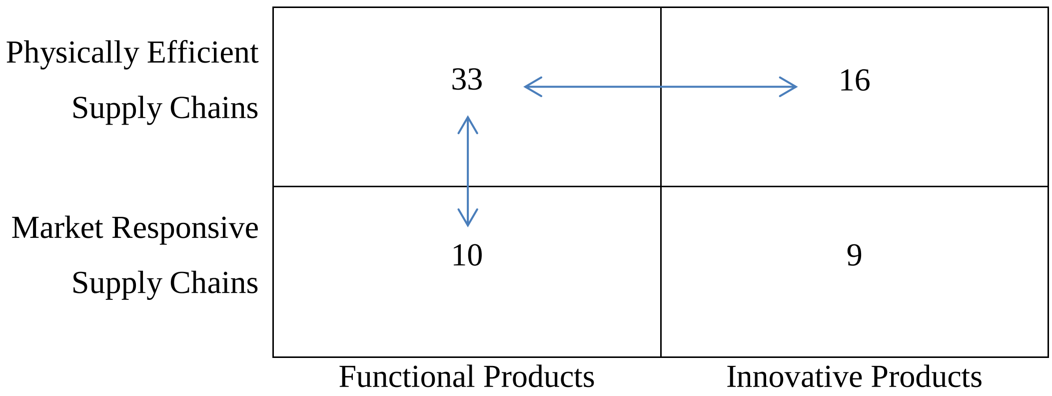

Figure 2-3: The distribution of companies based on supply chain design and product type Source: Selldin and Olhager (2007) , p. 47

A summary of the key literature which has directly and indirectly addressed the impact of demand uncertainty on leanness/agility aspect of supply chain design is provided in Table 2-3.

Table 2-3: A summary of key literature - Demand Uncertainty

Study	**Summary**
Fisher (1997)	Two mutually exclusive supply chain designs exist: Lean and Agile. For Functional products, Lean supply chain and for Innovative Products, Agile supply chain should be adopted. The main factor to differentiate Functional from Innovative Products is the level of demand uncertainty. The study employed only two case study companies.
Ramdas and Spekman (2000)	Advanced form of integration in which suppliers are integral to supply-and-demand planning are also a source of performance advantage within both functional and innovative chains, but innovative chains use these practices to a significantly greater extent. In this research, demand uncertainty is addressed by an investigation into demand plan of organisations.
Samuel, Mohit and Shi (2002)	In this research the answer to the question "Is product demand predictable or unpredictable?" was considered as the key factor to categorise the products as either functional or innovative.
Selldin and Olhager (2007)	Fisher's model was statistically tested for an adequate sample size and none of the propositions were supported.
Qi, Boyer and Zhao (2011)	These firms perform worse than those having a strategy focused on lean, agile, or lean/agile supply chain. The strategies are examined with respect to product characteristics and financial and operational performance. In this study, demand uncertainty is engaged to differentiate the product categories.

2.1.2 Supply Uncertainty

In addition to demand side of supply chain uncertainty, there are other crucial drivers for formulating an accurate supply chain strategy including supply side of value chain. As explained by Lee (2002), a company's supply side could be considered as 'stable' when both production and its underlying technology are in the maturity phase and the supply base is well-developed. Comparatively, a firm's supply side is referred to as 'evolving' when production and its underlying technology are still developing and the number of variations in the system is still high. In this circumstance, supply base has not reached to its best size and its capabilities are fairly restricted. Lee (2002) listed the disparities between a stable and evolving supply process (Table 2-4).

Table 2-4: Supply characteristics Source: Lee (2002), p. 107

Stable Supply Process	Evolving Supply Process
Less breakdowns	Vulnerable to breakdowns
Stable and higher yield	Variable and lower yields
Less quality problems	Potential quality problems
More supply sources	Limited supply sources
Reliable suppliers	Unreliable suppliers
Less process changes	More process changes
Less capacity constraints	Potential capacity constraints
Easier to changeover	Difficult to changeover
Flexible	Inflexible
Dependable lead time	Variable lead time

Manufacturing structure in a stable supply system is simpler and easier to manage. For instance, in the stable manufacturing processes, production is extremely automated, and goods and services are supplied through long-term agreements. On the other hand, higher uncertainty in an evolving supply system makes a manufacturing process more complex in a way that more adjustments are required. Evolving supply system emanates from a vast variety of issues including greater possibility of breakdowns. In this situation, the reliability of supply base is significantly less as the suppliers are still improving their processes and products.

Fisher (1997) implied that a more stable supply system is desirable for functional products, however, Lee (2002) clarified that this assumption could not be right for all kinds of functional products. For instance, there are several functional products such as utility products and electricity where the demand pattern for a specific region is stable. Nevertheless, the supplier of electricity actually uses a hydroelectric power which is highly dependent on the rate of rain in that region. Since the rainfall rate could fluctuate enormously, it could affect the supply of electricity. As a result, a stable demand pattern for a product does not guarantee a stable supply process.

Another example of the mentioned scenario is the influence of environmental forces such as weather on supply side of a product. For some agricultural products, there is a fairly stable demand. However, the supply side depends highly on environmental changes.

The opposite side of this scenario could be also happen for innovative products (Lee 2002). For these sorts of products the demand fluctuation is high. However, for others the supply pattern is partially stable. For instance, in the fashion industry, a product could have a short selling period, even though the demand predictability is fairly low. For this type of industry, highly automated manufacturing system, mature underlying technology, and the trustable supply process provide a stable supply base. In this regard, Lee (2002) provided examples of products with different demand and supply uncertainties (Figure 2-4).

Demand Uncertainty

Supply Uncertainty		**Low** (Functional Products)	**High** (Innovative Products)
	Low (Stable Process)	Grocery, basic apparel, food, oil and gas	Fashion apparel, computers, pop music
	High (Evolving Process)	Hydro-electric power; some food produce	Telecom, high-end computers, semiconductor

Figure 2-4: Products with different demand and supply uncertainties
Source: Lee (2002), p. 108

It is undeniable that supply chain strategies should be developed precisely to handle uncertainties to provide a better competitive position. As an extension to Fisher's (1997) model which stressed the influence of demand uncertainty in formulation of supply chain strategy, Lee (2002) emphasised that supply uncertainty is a crucial factor in developing a supply chain strategy. Fisher (1997) proposed two mutually exclusive supply chain strategies as efficient and responsive. However, Lee (2002) added two more strategies to Fisher's (1997) model as described in more detail below.

a. *Efficient Supply Chain*

The thrust of an efficient supply chain strategy is to provide the highest cost efficiencies along the supply chains. Many methods can achieve cost efficiencies including elimination of non-value-added activities, trying to achieve highest economy of scale/scope, maximising capacity utilisation in both manufacturing and distribution through deployments of optimisation techniques, and using information technology to integrate all activities so that efficiency and accuracy of activities across the supply chain are enhanced.

Supply Uncertainty	*Demand Uncertainty*	**Low** (Functional Products)	**High** (Innovative Products)
	Low (Stable Process)	Efficient supply chains	Responsive supply chains
	High (Evolving Process)	Risk-hedging supply chains	Agile supply chains

Figure 2-5: Formulation of supply chain strategy as per demand and supply uncertainties Source: Lee (2002), p. 109

b. *Risk-Hedging Supply Chain*

As depicted in Figure 2-5, companies must adopt a risk-hedging strategy when the demand uncertainty is low and the supply uncertainty is high. For such strategies to be achieved, resources are pooled and shared across the supply chain to mitigate and share the risk of supply disruption. Actually, the title of risk-hedging strategy emanates from the fact that in this strategy the most focus is on minimising the risks of supply through sharing and marshalling all resources.

The uncertainty which is a result of supply disruption would be higher when the number of supply sources or alternative resources is limited. In other words, the risk of supply disruption decreases when a company establishes supply contracts with a number of reliable suppliers.

One of the techniques which is used to hedge the risk of supply disruption is to enhance the level of safety stock for vital components. However, increasing the safety stock is costly. Many companies utilise a strategy that aims at sharing the safety stock with other supply chain members who may also need this crucial component. Exploiting this strategy will help the companies to both mitigate the risk of supply disruption and reduce the maintaining cost of safety stock. The strategies aiming at pooling of resources are prevalent in retailing, where various retailers or authorised sellers require sharing inventory. Since implementation of this strategy need the collaboration of various entities across the supply chain, effective employment of information technology is crucial to achieve the most cost-effective results.

c. *Responsive Supply Chain*

The underlying reason for developing a responsive supply chain is to be responsive to different needs of customers which are also changing. It means when expectations of customers are growing fast, a company must design a supply chain in a way that all various diverse requirements of customers would be satisfied.

In order to design a responsive supply chain, organisations exploit build-to-order and mass customisation techniques to meet the various needs of customers. In other words, by increasing the supply chain flexibility, a company can manage the customisation processes.

d. *Agile Supply Chain*

When both demand and supply uncertainties are high, a supply chain needs to be both responsive to customers’ needs and facilitate a process to mitigate the risk of supply disruption through marshalling and pooling of all resources. The supply chain strategy which is able to tackle both issues at the same time is referred to as agile supply chain.

This type of strategy aims to develop processes that combine the capabilities of risk-hedging and responsive supply chains. Lee (2002) employed the terminology of agile supply chain since this type of supply chain needs to minimise procurement risks at the back end of the company, while providing adequate responsiveness to the various, diverse, and volatile demands of customers at the front end.

Further development is required regarding the conceptual model of supply uncertainties which was proposed by Lee (2002):

(i) This model is still conceptual and it has not been tested quantitatively.

(ii) In a wide range of literature, responsiveness and agility are used interchangeably. However, Lee (2002) provided different definitions for responsive and agile supply chains.

(iii) This model is still classified as mutually exclusive models.

(iv) No external forces have been investigated in this model.

Lee's theory has opened a new door into the concept of supply chain management as employing only the demand uncertainty is not sufficient to formulate an effective supply chain strategy. Supply uncertainty should be also engaged as it is a crucial factor in the design of a supply chain.

Following Lee's proposition, several studies have followed his idea whereby both demand and supply uncertainties have been involved in the investigation of supply chain design (e.g. Rezapour, Allen & Mistree 2015). For example, Boonyathan and Power (2007) investigated the relationships between supply chain uncertainty, supply chain relationships and firms' performance. The interesting finding in their study was that supply uncertainty has been identified as a more significant determinant of performance than demand uncertainty. Therefore, supply uncertainty is not only the influencing factor of supply chain design; special attention should also be paid to supply uncertainty as it is more important than demand uncertainty.

In this regard, Szu-Yuan, Meng-Hsiang and Wen-Jin (2009) studied the relationship between environmental uncertainties and supply chain strategies. They concluded that better supply chain performance would be achieved where there is a match between environmental uncertainty level and supply chain strategies. In this study, environmental uncertainty is operationalised and measured by both demand and supply uncertainties.

A summary of the key studies that have directly and indirectly addressed the impact of supply uncertainty on the leanness/agility aspect of supply chain design is provided in Table 2-5.

Table 2-5: A summary of key literature - Supply Uncertainty

Study	Summary
Lee (2002)	This the first and the most important study which contradicts Fisher's proposition in terms of utilising only demand uncertainty for the formulation of supply chain strategy. He emphasised that to formulate an effective supply chain, employing demand uncertainty is not sufficient, and supply uncertainty should also be engaged.
Boonyathan and Power (2007)	In this study, the relationships between supply chain uncertainty, supply chain relationships and firm's performance were investigated in both product and service related organisations. The results indicate that supply uncertainty is a more significant determinant of performance than demand uncertainty in both product and service related organisations.
Szu-Yuan, Meng-Hsiang and Wen-Jin (2009)	Different supply chain strategies are appropriate for distinct environmental uncertainties. It is not enough to simply form an SC strategy for improving SCM performance without considering the alignment between supply chain strategies and environmental uncertainties. In this study, demand and supply uncertainty have been employed to estimate environmental uncertainty.
Rezapour, Allen and Mistree (2015)	In this study, supply-side uncertainty in a supply network with a multi-echelon supply process has been explored. In the supply network, the phenomenon of uncertainty propagation has been modelled and quantified. A trustable flow plan against the propagation of demand and supply side uncertainties is presented.

2.1.3 Internal Uncertainty

There are several terminologies for this type of uncertainty which have been frequently used in the literature. For instance, Paulraj and Chen (2007) referred to this type of uncertainty as 'technology uncertainty' and they argued that three main sources of uncertainty along the supply chain are market demand, supply, and technology. Some researchers have exploited the term 'manufacturing uncertainty' in this context (Ho, Chi & Tai 2005; Lo & Power 2010). Since in this research a comprehensive model of uncertainty is going to be studied, 'internal uncertainty' is selected to cover all sources of uncertainty within the organisation which could influence the supply chain design. Reviewing the literature revealed that the factors listed in Table 2-6 are the main causes of internal uncertainty and could influence either leanness or agility.

Table 2-6: Potential internal uncertainties affecting supply chain design

Literature	Parameter	Potential Impact
Minnich and Maier (2006)	Long component lead times	Decrease Responsiveness
Minnich and Maier (2006)	Erroneous components	Decrease Responsiveness
Kim et al. (2002) Minnich and Maier (2006) Lo and Power (2010)	Capacity constraints/restrictions	Decrease Responsiveness

While Manuj and Sahin (2011) studied the relationship between supply chain complexity and unexpected and/or undesirable outcomes, they identified internal uncertainty as an unexpected outcome of system complexity. Internal uncertainty emanates from company-specific parameters including labour dissatisfaction, equipment failures, and confused lines of responsibility. They also pointed out that internal uncertainty resulting from the inability to coordinate demand factors with manufacturing decisions is one of the main determinants which should be considered in design and architecture of supply chain.

As explained in this section, demand, supply, and internal uncertainties have been addressed in numerous studies as determining factors of supply chain design.

Review of the literature indicates that design of supply chain could be addressed from different angles. As the focus of the current research is on leanness/agility aspect of supply chain, the next section reviews the literature in which leagility of supply chain has been studied.

A summary of the key literature which has directly and indirectly addressed the impact of internal uncertainty on leanness/agility aspect of supply chain design is provided in Table 2-7.

Table 2-7: A summary of key literature - Internal Uncertainty

Study	**Summary**
Ho, Chi and Tai (2005)	This study employed a structural approach to measure supply-chain uncertainty. The findings created a validated uncertainty scale that can provide assistance in diagnosing supply-chain issues. The analysis indicated that not only demand and supply uncertainties are involved in supply chain overall uncertainty. In fact internal/manufacturing uncertainty should be employed in a comprehensive scale for measuring supply chain uncertainty.
Paulraj and Chen (2007)	This study adopts resource dependence theory to clarify the direct impact of supply chain uncertainties on strategic supply management. The rationale behind this research is related to the fact that environmental uncertainty plays a crucial role in the implementation of strategic supply management initiatives. They employed demand, supply, and internal (technological) uncertainties to measure the concept of environmental uncertainty.
Lo and Power (2010)	They emphasised that Fisher's model only represents one sort of supply chain uncertainty: demand uncertainty. Since the supply chain strategy should aim at coping with both downstream and upstream partners, it should engage several other sources of uncertainty taking place in a supply chain. They argued that Fisher's model did not capture supply uncertainty from the raw materials side, or internal/manufacturing uncertainty resulting from lead time fluctuations in the manufacturing process.

2.2 **Supply Chain Design and Strategies**

Study of supply chain from different viewpoints has led to several supply chain strategies being proposed by researchers. In the current study, the focus is on strategies to control or reduce the supply chain uncertainty. Davis (1993) might be the first researcher who suggested three strategies to tackle the supply chain uncertainty: (i) total quality control; (ii) new product design, and (iii) redesign of supply chain. As proposed by Gerwin (1993) and Geary, Disney and Towill (2006), the first two approaches are suitable for curtailing manufacturing/internal uncertainty, whereas the third strategy can tackle the supply and demand related uncertainty.

As the main focus of this study is on optimisation of supply chain design, an in-depth review has been done on the third strategy. A number of researchers including van der Vorst and Beulens (2002) and Bhatnagara and Sohal (2005) introduced some elements of the supply chain which should be incorporated into the redesign process. The main elements are indicated below:

- chain configuration: structure, facilities, members involved
- chain control: decision functions that manage execution of strategic aims and operational activities
- chain information systems
- chain organisation and governance: responsibilities and authorities

In terms of supply chain strategies which are developed to tackle or control the uncertainty, Simangunsong, Hendry and Stevenson (2012) classified the strategies as lean management, supply-chain integration, supply-chain flexibility and agility and risk mitigation. They referred to some literature including Geary (2002) and Lockamy III et al. (2008) to classify lean strategies under the ‘reducing uncertainty’ category; whereas based on other articles such as Prater, Biehl and Smith (2001), Sawhney (2006), and Gosling, Purvis and Naim (2010), agile supply chain strategy is classified under the ‘coping with uncertainty’ category. It is undeniable that companies try to both reduce and cope with uncertainties along the supply chain. Therefore, recent literature has focused on a combination of lean and agile techniques as a part of total supply chain strategies. In the next part, leagility as the hybrid model of supply chain strategy is reviewed.

Lean thinking and agile manufacturing are two popular notions which have been thoroughly discussed in manufacturing literature (Richards 1996; Yusuf & Adeleye 2002; Hallgren & Olhager 2009). Lean and agile supply chain paradigms have been derived from manufacturing to enhance both efficiency and effectiveness of supply processes. Some researchers believe that a company is required to implement a lean manufacturing system s that agility is achieved (Ward 1994; Booth 1996). Recent studies emphasise the fact that in today's business environment the best outcome would be achieved if both lean and agile techniques are employed. In this regard, Vinodh and Aravindraj (2013) stated that in the volatile business environment, manufacturing companies can last longer by serving the dynamic demands of modern customers. Lean thinking suggests zero inventory and agile philosophy necessitates a safety inventory to tackle volatile market forces. Such a combination can promote a leagile paradigm where both lean and agile techniques are employed.

The new changes in business environment are also addressed by other researchers including Chan and Kumar (2009) who emphasised the fact that lean and agile paradigms have attracted significant interest in the past few decades. Industries worldwide are upgrading their systems to these paradigms to improve their performance, as they have are efficient in the management of supply chains. However, the current market trend requires a more robust approach incorporating the salient features of both lean and agile paradigms. Inspired by these, the leagility paradigm has evolved whereby both lean and agile features have been encapsulated into a robust strategy.

Huang and Li (2010) noted that when agility emerged originally, leanness and agility were generally regarded as dissimilar or mutually exclusive concepts, and agility was quoted as a new paradigm to substitute for leanness. They also indicated that in the late 1990s, effective integration of leanness and agility led to the concept of "leagility", as recommended by some scholars (Noaker 1994; Huang & Li 2009).

Naylor, Naim and Berry (1999) proposed that even though the two notions of leanness and agility are significantly different, both should be implemented within properly designed and executed total supply chains. They stressed that supply chain strategy determines the need for agility and leanness, especially by involving market knowledge. Furthermore, regarding the alignment between strategy and current characteristics of products, they concluded that an agile system is the best match for a volatile demand, while predictable demand requires a lean system to achieve better market position.

In this regard, Davies (2009) emphasised that although both techniques could provide valuable results, companies need to precisely decide when and where they need to be exploited. In addition, agility and leanness could be combined effectively within one supply chain to achieve maximum customer satisfaction.

There is no well-accepted definition for agility and leanness. However, since these two concepts in the supply chain emanated from agile and lean manufacturing system, Naylor, Naim and Berry (1999) proposed a definition for these paradigms which is widely accepted by supply chain researchers:

> "Agility means using market knowledge and a virtual corporation to exploit profitable opportunities in a volatile market place" (p. 108).

> "Leanness means developing a value stream to eliminate all waste, including time, and to ensure a level schedule" (p. 108).

As highlighted by Omera, Christopher and Alessandro (2012), a highly competitive environment and growing expectations of customers put pressure on companies to be more customer-centric than product-centric. From a customer's point of view, it is irrelevant whether a company is using an agile, lean, or leagile system. The only concern of a customer is the total received value.

Johansson (1993) explained that if the main focus of supply chain design is to be customer-centric, then multiple factors and measures need to be considered. Nonetheless, all these factors may be combined to form Service, Quality, Cost and Lead-time as depicted in Figure 2-6. These four elements are shaping the total value of the product/service to the end-user.

$$\textbf{Value} = \frac{\textbf{Quality} \times \textbf{Service}}{\textbf{Cost} \times \textbf{Lead Time}}$$

Figure 2-6: Total value as per customer perception Source: Johansson (1993)

A customer evaluates a product by the total perceived value; however, the weight of importance given to each element is varies from industry to industry and even in different market segments within an industry. In other words, in a particular market segment, higher levels of service and quality could be more important than lower costs and shorter lead times and vice versa. Actually, the order winner of this year could be a market qualifier for the next year (Hill 1993). For instance, one year a company may win more orders by increasing the level of service, the following year the same entity is required to maintain or even increase the level of service to only be evaluated as a qualified organisation in the same market. This market pressure clarifies that companies need to adopt agile and lean techniques in manufacturing and supply chain systems to not only maintain the market position but also develop a better competitive advantage.

Samuel, Mohit and Shi (2002) stated that the advent of lean thinking in the supply chain management context was due to tackle several issues. Firstly, in a supply chain the flow of information is not on the spot. As a result, the members of supply chain at upstream are not thoroughly aware of the market fluctuations including trend of variations, the exact amount of requiring raw material, etc. This noticeable deviation in information from the front-end of an organisation would undermine the precision of decision-making in relation to the number of products being produced. This phenomena is referred to as ‘bullwhip effect’ in the supply chain context (Metters 2008). Secondly, an organisation does not develop collaborative strategies with its suppliers, known as supplier relationship management, would create several types of waste which is a source of weakness and worse competitive position. Thirdly, in some organisations, distribution is not considered to achieve cost reductions, to improve lead-times, and to enhance the availability of products. The mentioned roles have been changed to postpone product differentiation to decrease the stock-out and over-stocking rates by delaying the customisation process to the distribution process.

A lean supply chain is not going to be applied to an organisation in a short timeframe. Continuous improvement processes are required to constantly eliminate wastes from all elements of the supply chain (Samuel, Mohit & Shi 2002). This process needs to be supported by dropping set-up periods to let the company manufacture small quantities. In this way an organisation could gain cost efficiencies, flexibility, and pointing to external agility by fulfilling customer needs.

Employing lean supply chain could provide several benefits for the firm including greater profits, internal production productivity, and flexibility. However, this process is unable to support the external responsiveness to end-user needs (Christopher & Towill 2000). On the other hand, there are several techniques which help companies to achieve internal responsiveness such as time-based competition method, which is used to make the development and manufacturing time shorter. This method will increase responsiveness and profitability and also helps the system to deliver better customer service and make the cost of quality lower (Booth 1996).

Although a lean supply chain employs lean production and waste elimination techniques, different time compression techniques are widely utilised to maintain flexibility and responsiveness (Mason-Jones, Naylor & Towill 2000). Nonetheless, as per the nature of the business environment, there are rapid variations in the market. To keep their market position, most companies are involved in ‘multiple niche competition’. Accordingly, companies are manufacturing products with different quality, quantity, and level of service to compete in very diverse market niches. These environmental forces would put pressure on companies to increase responsiveness and adopt mass customisation strategies (Samuel, Mohit & Shi 2002).

Pressures from the market are not the only external forces to the supply chain to keep focus on mass customisation and improving responsiveness. Expectations of customers are rapidly changing and products’ life cycles are becoming shorter. Consequently, to remain competitive, in addition to maintaining leanness, companies realised that developing an interface with the market is vital in order to respond to market variations instantaneously. In practice, organisations are obliged to squeeze the period of developing a concept to creating the cash flow (Omera, Christopher & Alessandro 2012).

As argued by Christopher and Towill (2000), increasing market pressure and also growing expectations of customers would create a need for agile supply chain thereby companies would be able to remain competitive. The main focus of agility in the supply chain is the interface between an organisation and the market. An agile supply chain provides value for the organisation by responding to fast pace of changes and also constantly fragmenting global marketplaces through being growth focused, flexible and dynamic (Samuel, Mohit & Shi 2002). The main concentration of an agile supply chain is predominantly on handling the unpredictable market changes and minimising customer dissatisfaction. It helps to improve a prompter delivery process and enhance lead time flexibility. Since the thrust of an agile supply chain is to fulfil the customer-designed orders, it employs new equipment and systems, exploits information technologies and data transaction services, focuses on a company's issues and employees, integrates most processes and procedures, and increases innovations (Sharifi & Zhang 1999).

Following of introducing the lean (efficient) and agile (responsive) supply chain strategies (e.g., Fisher 1997; Lee 2002), a new concept of 'hybrid strategies' was developed by Samuel, Mohit and Shi (2002), which implies the same meaning as 'leagility' used by (Naylor, Naim & Berry 1999). One of the techniques used in the leagile supply chain is the postponement process which is about delaying product differentiation until the last stage of assembly to attain maximum mass customisation. For most component products, both lean and agile systems might be employed simultaneously. The interface between an organisation and market should be agile enough to fulfil customer needs by increasing adaptability and responsiveness. Samuel, Mohit and Shi (2002) provided characteristics of lean, agile, and hybrid chains as listed in Table 2-8.

Table 2-8: A comparison of lean, hybrid and agile supply chains
Source: Samuel, Mohit and Shi (2002)

Category	Lean supply chain	Hybrid supply chain	Agile supply chain
Purpose	Focuses on cost reduction, flexibility and incremental improvements for already available products Employs a continuous improvement process to focus on the elimination of waste or non-value added activities across the chain	Interfaces with the market to understand customer requirements, maintaining future adaptability Tries to achieve mass customisation by postponing product differentiation until final assembly and adding innovative components to the existing products	Understands customer requirements by interfacing with the market and being adaptable to future changes Aims to produce in any volume and deliver into a wide variety of market niches simultaneously Provides customised products at short lead times (responsiveness), by reducing the cost of variety
Approach to choosing suppliers	Supplier attributes involve low cost and high quality	Supplier attributes involve low cost and high quality, along with the capability for speed and flexibility, as and when required	Supplier attributes involve speed, flexibility, and quality
Inventory strategy	Generates high turns and minimizes inventory throughout the chain	Postpone product differentiation till as late as possible. Minimise functional components inventory	Deploys significant stocks of parts to tide over unpredictable market requirements
Lead time focus	Shorten lead-time as long as it does not increase cost	Is similar to the lean supply chain at component level (shorten lead-time but not at the expense of cost). At product level, to accommodate customer requirements, it follows that of an agile supply chain	Invest aggressively in ways to reduce lead times

Category	**Lean supply chain**	**Hybrid supply chain**	**Agile supply chain**
Manufacturing focus	Maintain high average utilisation rate	It is a combination of lean and agile, where the beginning part is similar to lean and the later part is similar to agile	Deploy excess buffer capacity to ensure that raw material/components are available to manufacture the product according to market requirements
Product design strategy	Maximise performance and minimise cost	Components follow the lean concept (cost minimisation), at the beginning. Modular design helps in product differentiation towards the latter stages	Use modular design in order to postpone product differentiation for as long as possible

Samuel, Mohit and Shi (2002) developed a conceptual model to investigate the alignment between product characteristics and desired supply chain designs. Their aim was to improve on the Fisher (1997) and Hau (2002) models (Figure 2-7).

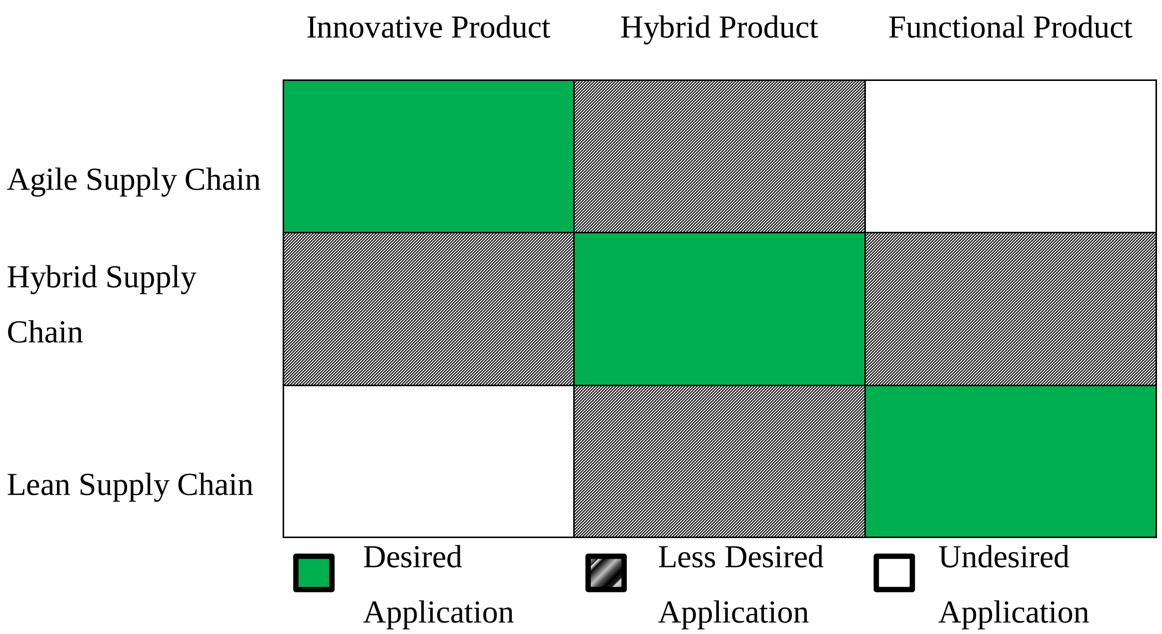

Figure 2-7: Match product with supply chain

Source: Samuel, Mohit and Shi (2002), p. 195

The definition provided by Samuel, Mohit and Shi (2002) for functional and innovative products was adopted from Fisher (1977) and Lee (2002), however, they developed the concept of hybrid product from the model proposed by Sharifi and Zhang (1999). They explained a hybrid product may be made up of either diverse blends of standard components, or a combination of innovative and functional components.

They provided an example from automotive manufacturing in which the core components including engine and electronics are produced or assembled in a process which remains the same for many phases. Accordingly, a lean process would be the best match for these processes. On the other hand, the final part of the assembly line should be able to complete the car as per customers' requirements which are constantly changing. Consequently, an agile system should be adopted to provide maximum value. As a result, a hybrid supply chain is the best selection for this sort of product. Through utilising a hybrid supply chain, a company can be successful in mass customisation, cost minimisation, and flexible to future changes.

There are many similarities between the hybrid supply chain proposed by Samuel, Mohit and Shi (2002) and leagile supply chain model offered by Naylor, Naim and Berry (1999). As explained by the latter, the paradigms of leanness and agility could be combined to provide an effective supply chain. They emphasised the strategic exploitation of a decoupling point, whereby the benefits of both notions – leanness and agility – can be reaped (Figure 2-8).

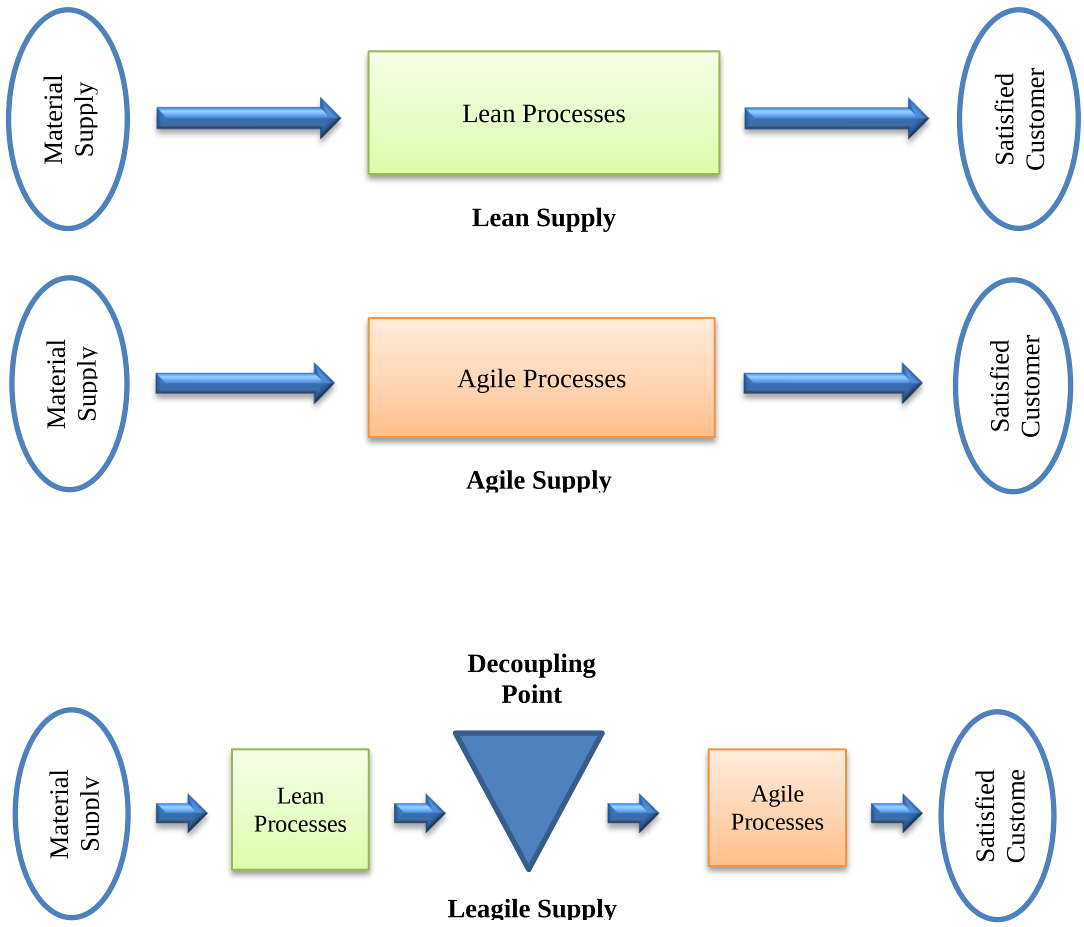

Figure 2-8: Block diagrams representing lean, agile, and leagile supply

Source: Naylor, Naim and Berry (1999), p. 116)

They stressed that if engineering of a leagile supply chain is to be economically feasible, an organisation enjoys significant cost reductions, while improving customers' satisfaction. In a leagile supply chain, the upstream of the decoupling point of a supply chain exploits lean technique in both supply and manufacturing, while the downstream of the decoupling point utilises leagile model to handle volatile and changing customers' expectations. Naylor, Naim and Berry (1999) defined leagile supply chain as leagile which is a combination of the lean and agile principles within a total supply chain strategy. They did this by positioning the decoupling point to best suit the needs for responding to a fluctuating demand downstream and at the same time, providing smooth scheduling upstream from the marketplace.

Naylor, Naim and Berry (1999) borrowed the definition of decoupling point from Hoekstra and Romme (1992):

> "The decoupling point is the point in the material flow streams to which the customer's order penetrates. It is here where order-driven and the forecast-driven activities meet. As a rule, the decoupling point coincides with an important stock point - in control terms a main stock point - from which the customer has to be supplied" (p. 108).

They also pointed out decoupling point splits:

> "part of the organisation [supply chain] oriented towards customer orders from the part of the organisation [supply chain] based on planning" (p. 108).

Changing customers' requirements and/or highest rate of product variety would justify holding a strategic stock at the decoupling point to achieve maximum customer satisfaction and plan production effectively. It is also crucial for a company to implement the agile or lean manufacturing systems based on the decoupling point position. The proper position of the decoupling point would also provide useful information to design the postponement process effectively.

The main goal of postponement is to enhance supply chain efficiency through shifting the process of product differentiation (at the decoupling point) to the later stages nearer to the end-user (Lee & Corey 1992). Proper design of postponement process and accurate positioning of the decoupling point would assist companies to minimise the stock-out and overstocking rates simultaneously. The mentioned minimisation process is vital for companies/retailers which have much stock.

Although there is no well-accepted theory of leagile supply chain design, several researchers admitted that even though lean and agile supply chain designs are repeatedly referred to as opposing paradigms, they share a communal aim, meeting customer demands at the least total cost (Goldsby, Griffis & Roath 2006; Xun et al. 2008; Hilletofth 2012). It is actually the characteristics of this demand and the basis of meeting customer demand that determine which approach receives more attention (Goldsby & Garcia-Dastugue 2003). Numerous researchers have proposed that the lean and agile notions can be integrated in a variety of conducts to craft so-called "leagile" supply chains (Stratton & Warburton 2003; Banihashemi 2011). Therefore, it is not certainly a question of selecting among lean and agile fashions, but rather the thoughtful engagement and integration of the correct aspects of these paradigms which has a maximum fit to the particular supply chain (Christopher, Peck & Towill 2006). All of the aforementioned research emphasised that in order to tackle today’s volatile and uncertain environment, integration of lean and agile paradigms is necessary. In the current research the scenario would be investigated from different angles since lean and agile paradigms might not exist as individual strategies in real business contexts. In other words, all supply chains could be considered as leagile in any case.

Even though flexibility and leagility are not identical notions in the context of supply chain, researchers including Ulf and Ulrich (2011) have employed the terms interchangeably. There are several different definitions for supply chain flexibility in the supply chain literature. Most of them have stemmed from the concept of flexibility in manufacturing that has been quoted extensively (Swafford, Ghosh & Murthy 2006). Alternatively, some researchers have referred to supply chain flexibility as a trade-off between leanness and agility (Leslie, Robert & Rhonda 2003; Mert 2011; Ulf & Ulrich 2011).

This approach to supply chain flexibility is supportive of the concept of modelling supply chain strategies in a spectrum in contrast to the studies that tried to classify supply chain strategies in mutually exclusive categories (lean versus agile, efficient versus responsive). As highlighted by Sánchez and Pérez (2005), there are very few studies on supply chain flexibility. Regarding the relationship between the mentioned approach to flexibility and uncertainty, Ulf and Ulrich (2011) argued that supply chain flexibility is extensively gaining attention as one major technique to tackle the growing uncertainty and competition in the marketplace. Both researchers and supply chain executives acknowledge that a competitive advantage could be achieved through better supply chain flexibility. As flexibility is costly, a match between flexibility and environmental uncertainty appears to be an applicable option.

Although in the current research the notion of supply chain flexibility is not considered as just a trade-off between leanness and agility, the literature which has employed this approach is supportive to the general idea of this study. A summary of the key literature which has addressed the leagility aspect of supply chain design is provided in Table 2-9.

Table 2-9: A summary of key literature - Supply Chain Design

Study	Summary
Fisher (1997)	Two mutually exclusive supply chain designs exist: Lean and Agile. For Functional products, Lean supply chain and for Innovative Products, Agile supply chain should be adopted.
Naylor, Naim and Berry (1999)	They proposed that even though two notions of leanness and agility are significantly different, both of them should be implemented within properly designed and executed total supply chains. They emphasised the necessity of leagility, however, they proposed that the lean and agile process should be employed in a series model for different stages of the supply chain. In other words, for the processes which are close to the supply side of the business, the lean concept should be applied; whereas, the processes which are close to the customer side of the business should employ an agile model.
Lee (2002)	He introduced supply uncertainty as the second supply chain uncertainty construct and it should be considered when a supply chain is designed. He emphasised that categorisation of supply chain design into lean and agile parts is not enough. He outlined four types of supply chain designs: Efficient, Risk-Hedging, Responsive, and Agile.
Samuel, Mohit and Shi (2002)	In this study, it has been concluded that Fisher's model fails to explain all types of supply chain designs which are available. They introduced hybrid supply chain design which is recommended for hybrid products. They concluded there are three product types: functional, hybrid, and innovative. The best supply chain match for each product type is lean, hybrid, and agile supply chain, respectively.
Selldin and Olhager (2007)	Fisher's model was statistically tested for an adequate sample size and none of the propositions were supported.
Lo and Power (2010)	This research empirically examined the interrelationships between product characteristics and supply chain strategy. They tested Fisher's (1997) model in which supply chain strategy is linked to product nature. The findings indicate that the relationship between product nature and supply chain strategy is not significant.

2.3 **External Forces**

An effective formulation of strategy for all levels of an organisation requires scrutinising both internal status and external/environmental forces (Hitt, Hoskisson & Ireland 2007). As explained earlier, most researchers agree that uncertainty is the key factor to be considered when devising an effective supply chain strategy (Fisher 1997; Fisher et al. 1997; Mason-Jones & Towill 1998; Lee 2002; Ho, Chi & Tai 2005; Selldin & Olhager 2007; Ulf & Ulrich 2011). However, it is not clear whether there are other external forces which could influence the relationship between uncertainty and supply chain design.

Running parallel to research on the impact of uncertainty on supply chain design, contingency-based studies on the effect of external environment as a crucial variable should be engaged when decisions on strategies and practices are made (Hofer 1975; Bourgeois 1980; Prescott 1986; Miller 1988; Swink & Way 1995). In a holistic investigation, both uncertainty and external forces should be engaged to provide an insight into modelling an effective supply chain design. For instance, when the competition is getting fierce in the market and the competitors start a price war, the level of uncertainty varies which is not necessarily a part of demand, supply, or internal uncertainties. In this situation, the company adopts a leaner supply chain strategy to achieve cost reduction and tackle external pressures.

With regard to the influence of competition on the supply chain design, Samuel, Mohit and Shi (2002) argued that the competition circumstances in terms of level of stability (stable with least change or highly turbulent) would affect selection of supply chain strategy. When competition circumstances are changing immensely, a company requires an agile supply chain to be responsive to market volatility. On the contrary, stable competition circumstances would provide an opportunity for companies to focus more on enhancing the leanness of the supply chain to achieve maximum efficiency. It is worth noting that Samuel, Mohit and Shi (2002) did not quantitatively examine the mentioned hypothesis. Competition has emerged as one of the influencing factors affecting the uncertainty and supply chain design, however, the number of studies in this era is sparse.

In a review paper presented by Simangunsong, Hendry and Stevenson (2012), the external uncertainty explained as the factors which are outside a company's direct areas of control, and include: environment, government regulations, competitor behaviours and macroeconomic issues, and disasters, for example, earthquakes or hurricanes. They emphasised that competition pressures are a major source of external forces on supply chain.

The second crucial external pressure on supply chain is growing expectations of customers. This factor is closely linked to the increasing variety of products. Since one of the main consequences of elevating the level of customers' expectations is that they demand more product variety, these two terms are sometimes used to mean the same thing in the supply chain context. Omera, Christopher and Alessandro (2012) indicated that as customers' expectations are growing rapidly, they request more products that are cheaper. Consequently, the role of design has garnered more attention by which organisations would be able to achieve a better competitive position.

Samuel, Mohit and Shi (2002) emphasised the role of customers' expectations in supply chain design by indicating that the only reliable method that organisations can capture the market share and profit is to satisfy customer's requirements. Furthermore, although design of supply chain is related to the product type, the level of customers' expectations is one of the crucial factors in developing the supply chain strategy.

On condition that customers' expectations/requirements remain fairly stable, through adoption of a lean supply chain, a company would be able to both satisfy customers' requirements and reduce the price. By contrast, when the rate of variation in customer requirements is swift, an organisation needs to adopt an agile supply chain to be able to respond to these changes promptly.

Samuel, Mohit and Shi (2002) also pointed out that the level of customers' expectations has an increasing trend in most industries. As a result, organisations need to increase the agility over a period of time. This is another evidence indicating that the study of supply chain design should be carried out in a holistic view in which all supply chain designs are considered as leagile with different weights of leanness and agility. Similar to competition level, there is no empirical research which would attempt to scrutinise the influence of customers' expectations on supply chain design, to the best of author's knowledge.

In this research, level of competition and customers' expectations will be studied as potential moderators in the relationship between the uncertainty and supply chain design. A summary of the key literature which has addressed the leagility aspect of supply chain design is provided in Table 2-10.

Table 2-10: A summary of key literature - External Forces

Study	**Summary**
Samuel, Mohit and Shi (2002)	They argued that the competition circumstance in terms of level of stability (stable with least change or highly turbulent) would affect selection of supply chain strategy. In addition, they emphasised that the level of customers' expectation has an increasing trend in most industries. As a result, organisations need to increase the agility over a period of time.
Ulf and Ulrich (2011)	They described today's supply chains as highly complex and dynamic. They characterised business environment by increasing uncertainties. It has been pointed out globalisation of customers, sourcing, manufacturing, and distribution is continuing and customers are becoming more demanding, expecting better customised products and better customer service than in the past. The high competitive pressure urges companies to shorten product life cycles, increase product variety, and to adapt to technological changes more quickly than they did in former times.
Omera, Christopher and Alessandro (2012)	They indicated that as customers' expectations are growing rapidly, they request more product variety at lower cost. Consequently, the role of supply chain design has gained more attention by which organisations need to achieve a better competitive position.

2.4 **Market Segment**

As cited by several researchers including McDonald (2012), three vital determinants of firm success are correct market definition, market segmentation and positioning. A market segment is a sub-set of a market which consists of people or companies with at least one characteristic enabling them to demand a comparably priced product and/or services. Competition is one of the main external forces which should be considered to develop a company's strategy including supply chain strategy (Hitt, Hoskisson & Ireland 2007). Competition is evaluated in the market segment in which a firm operates. Therefore, it is expected that design of supply chain will be influenced by the characteristics of a market segment.

Mason-Jones, Naylor and Towill (2000) proposed the theory of market qualifiers and market winners in supply chain management whereby the design of supply chain is influenced by market characteristics including price, quality, lead time, and service level. As the market segment is a sub-set of a market with at least one characteristic in common, if segmentation is carried out as per one of the supply chain design determinants, it seems there should be a relationship between the market segment and supply chain design. However, the question would be which segmentation method is appropriate to investigate the impact of a market segment on supply chain design.

It seems the best method of market segmentation would be a method whereby market qualifiers and market winners affecting the design of supply chain, are employed. There is a method of market segmentation which is not scientifically delineated, however, it is commonly accepted and used by customers and has been referred to by a couple of analyses (Shaw & Cresswell 2002; Kotler & Keller 2006; McDonald 2012). The market is split into two segments: up-market and down-market. Price would be the market winner for the down-market segment and service level and quality would be market winners for the up-market segment.

A summary of the key literature which has addressed the market segmentation in the context of supply chain design is provided in Table 2-11.

Table 2-11: A summary of key literature - Market Segment

Study	**Summary**
Mason-Jones, Naylor and Towill (2000)	They proposed the theory of market qualifiers and market winners in supply chain management whereby the design of supply chain is influenced by market characteristics including price, quality, lead time, and service level.
Hitt, Hoskisson and Ireland (2007)	They indicated that competition is one of the main external forces which should be considered to develop a company's strategy including supply chain strategy. As competition is evaluated in the market segment in which a firm is operating, it is expected that design of supply chain would be impacted by the characteristics of a market segment.
McDonald (2012)	He indicated that three vital determinants of firm success are correct market definition, market segmentation and positioning. A market segment is a sub-set of a market which consists of people or companies with at least one

Study	Summary
	characteristic that make them to demand comparably priced product and/or services. As price range and service level are determinants of product type and supply chain design, if the market becomes segmented based on these attributes, it is expected that this segment could be one of the supply chain design's influencing factors.

2.5 **Performance**

The best way to evaluate the successful implementation of supply chain strategy is to measure performance. Literature shows that researchers have exploited either supply chain performance or the overall firm performance to compare the degree of alignments between the internal/external uncertainty and supply chain strategy.

For instance, Chan (2003) put forward a framework for measuring supply chain performance through quantitative variables such as cost and resource exploitation and also qualitative variables such as flexibility, trust, quality, innovativeness, and visibility. In this regard, by exploiting the framework provided by Kaplan and Norton (1996), Brewer and Speh (2000) proposed a model based on balanced scorecard (BSC) to evaluate supply chain performance. In this regard, Chan and Qi (2003) proposed a process-based model to apply the performance measurements in the supply chain context. They exploited the variables of supply chain performance, dependent variable, from the model presented by Brewer and Speh (2000).

There are a couple of issues in measuring the performance. For example, Gunasekaran, Patel and Tirtiroglu (2001), Gunasekaran, Patel and McGaughey (2004), and Gunasekaran and Kobu (2007) highlighted the following potential problems in performance measurement:

- Incompleteness and inconsistencies in performance measurement and metrics.
- Failing to represent a set of financial and non-financial measures in a balanced framework, some concentrating on financials, others concentrating on operational measures.
- Having a large number of metrics, making it difficult to identify the critical few among trivial many.
- Failing to connect the strategy and the measurement.

- Having a biased focus on financial metrics.
- Being too much inward looking.

In addition, as pointed out by Arzu Akyuz and Erman Erkan (2010), KPI prioritisation and dependence of measuring supply chain performance could bias the result. In other words, depending on the nature of a firm, different KPIs including partnership, virtualisation, e-commerce efficiency, collaboration, agility, flexibility, information productivity and business excellence metrics could be utilised to measure the supply chain performance. Therefore, measuring the supply chain performance could be significantly biased and requires employing too many control variables.

Since improvement in supply chain performance would directly impact on firm performance, most studies in the last decade have evaluated the success of supply chain strategy by measuring firm performance (Leslie, Robert & Rhonda 2003; Qi, Boyer & Zhao 2011; Ulf & Ulrich 2011; Wagner, Grosse-Ruyken & Erhun 2012). In this study, firm performance is considered a measure to evaluate the proposing research model. A summary of the key literature which has addressed firm performance in the context of supply chain design is provided in Table 2-12.

Table 2-12: A summary of key literature - Firm Performance

Study	**Summary**
Selldin and Olhager (2007)	In the first section of this study, Fisher's model was tested statistically. The second section investigated whether the higher firm performance is achievable where there is a match between supply chain design and product type. In this study, firm performance was evaluated by comparing performance variables in a company and its competitors.
Qi, Boyer and Zhao (2011)	In this study, the impact of competitive strategy and supply chain strategy on business performance was investigated. Rather than measuring business performance through a direct evaluation of financial metrics, a comparative approach in which performance of company was measured through a comparison of performance variables with competitors was utilised.
Wagner, Grosse-Ruyken and Erhun (2012)	They studied the relationship between supply chain fit and financial performance of the firm. In their study, they adopted the relative approach to measure firm performance.

2.6 **Summary**

A timeline of the key articles which greatly contributed in the leagility aspect of supply chain is provided in Table 2-13.

Table 2-13: A timeline of key articles

Year	Author(s)	Summary
1996	Richards	Lean thinking and agile manufacturing are two popular notions which have been thoroughly discussed in manufacturing literature
1997	Fisher	Two mutually exclusive supply chain designs exist: Lean and Agile. For Functional products, Lean supply chain and for Innovative Products, Agile supply chain should be adopted. Demand uncertainty was regarded as the main driver to differentiate the type of product.
1999	Naylor, Naim and Berry	A concept of decoupling point was provided whereby a new approach to supply chain leagility was presented.
2002	Lee	He introduced supply uncertainty as the second supply chain uncertainty construct and it should be considered when a supply chain is designed. He emphasised that categorisation of supply chain design into lean and agile parts is not enough. He outlined four types of supply chain designs: Efficient, Risk-Hedging, Responsive, and Agile.
2002	Samuel, Mohit, and Shi	In this study, it has been concluded that Fisher's model fails to explain all types of supply chain designs which are available. They introduced hybrid supply chain design which is recommended for hybrid products. They concluded there are three product types: functional, hybrid, and innovative. The best supply chain match for each product type is lean, hybrid, and agile supply chain, respectively.
2005	Ho, Chi and Tai	This study employed a structural approach to measure supply-chain uncertainty. The findings created a validated uncertainty scale that can provide assistance in diagnosing supply-chain issues. The analysis indicated that not only demand and supply uncertainties are involved in supply chain overall uncertainty.

Year	Author(s)	Summary
		In fact internal/manufacturing uncertainty should be employed in a comprehensive scale for measuring supply chain uncertainty.
2007	Selldin and Olhager	Fisher's model has been tested for a large number of samples. Fisher's model was not statistically supported.
2010	Lo and Power	This research empirically examined the interrelationships between product characteristics and supply chain strategy. They tested Fisher's (1997) model in which supply chain strategy is linked to product nature. The findings indicate that the relationship between product nature and supply chain strategy is not significant.

The concepts of hybrid supply chains and leagility are widely discussed in the literature. However, there are several issues which need more consideration:

- To the extent of this author's knowledge, the proposed models (hybrid strategy and leagile supply chain designed based on decoupling point) have not been empirically substantiated. As depicted in Figure 2-7, hybrid supply chain could be exploited for all sorts of scenarios. Furthermore, the existence of companies which are adopting a purely agile or a purely lean supply chain is not statistically. As a result, one may conclude that in practice, design of all supply chains is hybrid/leagile where agility and leanness vary. Therefore, from practical perspective, it seems logical as not to split supply chains to be either lean or agile.

- Using the decoupling point in a leagile supply chain could help the companies to achieve the benefits of combining lean and agile systems simultaneously. However, the question is how many companies are using this technique. On the other hand, in practice, all companies are trying to minimise their costs through an elimination of waste, and increasing agility to improve customer satisfaction. As a result, the leagility concept is currently employed in organisations even if they are not aware of the scientific terminology. It is therefore necessary to evaluate the supply chain over one spectrum holistically, assuming that all supply chains are leagile with different magnitudes of leanness and agility.

- Several researchers emphasised that in order to tackle today's volatile and uncertain business environment, integration of lean and agile paradigms is necessary. In the current research the scenario will be investigated from different perspectives as lean and agile paradigms might not exist as individual strategies in reality. In other words, all supply chains could be considered as leagile with different magnitudes of leanness and agility.
- None of the current literature has looked at the status of supply chain leagility. Understanding the situation of leagility and its impact on the performance of businesses could provide a guideline for executives to tailor the supply chain design to achieve the maximum performance. Therefore, in the current study, the position of a firm's leagility and the implications of different leagility values on firm performance will be investigated.
- Uncertainty has been referred to as the key driver in supply chain design. However, less comprehensive model of uncertainty has been utilised to examine the leagility aspect of supply chain in the majority of studies. In addition, researchers have heretofore measured leanness and agility in two separate scales. However, as per the main assumption of this study, leagility is evaluated by one measuring scale. Therefore, it would be rational to both investigate the impact of comprehensive model of uncertainty and each individual construct (demand, supply, and internal uncertainty) on DFL.
- As explained earlier, a couple of researchers emphasised that environmental forces would impact on supply chain design. However, the effect of competition intensity and customers' expectation has not been clearly addressed to date. In this study, both external forces will be investigated as potential moderators to the relationship between uncertainty and leagility in supply chain design.
- Investigating into the impact of uncertainty on leagility over different market segments and also studying of the status of leagility in different market segments are still untouched fields. As a complementary study, the effect of uncertainty on DFL will be probed over market segments.

Extensive review of literature in lean/agile aspect of supply chain design indicated that it is not quite clear whether adopting a purely lean/agile supply chain could create the highest performance, or supply chain executives are required to develop a leagile supply chain to maximise a firm's throughput. It is also not transparent how magnitudes of leanness and agility should be adjusted if a leagile design is approached.

Regarding either solution explained above, uncertainty has been cited as a key driver of supply chain design. Although the current literature has addressed different aspect of uncertainty, no study offers a comprehensive model of uncertainty including demand, supply, and internal uncertainties.

As in a rigorous research model, the main influencing factors should be included, and thus relying on just uncertainty as the main influencing factor of supply chain design does not seem to provide a deep insight into the context. There are a couple of factors which have been the main driving forces causing the changes in business models. For example, growing expectations of customers and hyper-competition have put significant pressure on companies to improve the quality and service level and decrease costs and lead time at the same time. These factors could moderate the impact of uncertainty on supply chain design. However, no study has addressed this matter.

It is also undeniable that developing a formula to fit all market segments does not seem to be an appropriate approach. However, studying of design of supply chain over different market segments is still untouched.

In conclusion, from strategic perspective, a lack of rigorous leagility model is obvious, which should be able to not only explain the existing supply chain designs but also it needs to address the current inconsistent results and findings regarding the adoption of lean/agile supply chain. The other identified gap pertains to the limited available knowledge to explain the impact of overall uncertainty on leagility status of a supply chain and the potential moderating factors which may moderate this relationship.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 **Research Design**

With respect to the research methods for business, Sekaran (2003) implied that after defining the parameters of a problem and designing the theoretical framework, the next step is to develop the data collection and analysis methods to find a solution. The major purpose of research design is to delineate how to discover answers to questions and this shapes the blueprint for the gathering, measurement and analysis of collected data. Furthermore, the plan and framework of investigation serve to resolve research problems. Sekaran (2003) stipulated that a comprehensive research design has to encompass these factors (Figure 3-1):

Figure 3-1: Basic aspects of research design **Source: Sekaran (2003), pp. 117-140**

3.1.1 Study Characteristics

As discussed by Sekaran (2003), the essence and aim of the study relate to the stage of development to which the knowledge progresses our understanding of the research topic. A research analysis trying to explore novel fields is considered to be an "exploratory study". On condition that a research attempts to distinguish certain specifications of a phenomenon, it could be referred to as a "descriptive study". On the other hand, a research investigating the relationship between variables is considered to be "hypotheses testing or explanatory".

The current thesis is a mixed research comprising both exploratory and explanatory sections. From the exploratory perspective, a new approach to supply chain leagility is investigated by studying deviation from the leagility index and comparing the index over different market segments. The other exploratory aspect is related to introduce moderators of the relationship between supply chain uncertainty and DFL. From the explanatory viewpoint, the relationship of a comprehensive model of supply chain uncertainty and leagility is investigated.

The primary data will be gathered by administering a questionnaire to measure the constructs and variables of the model. A questionnaire is developed on the basis of a 7-point Likert scale to provide more detailed information on supply chain characteristics. The first section is devoted to gathering demographic information of respondents and related industries. Deviation from leagility is measured in the second section of the questionnaire through questions extracted from many studies that investigated leagility. However, the questions measuring leanness and agility are merged together to provide one scale that evaluates the leagility index. The third section is dedicated to measuring supply chain uncertainty via evaluating the uncertainty main constructs (demand, supply, and internal). External pressures including competition and customers' expectations level are measured in the fourth section. The final section of the questionnaire is dedicated to measuring the firm's performance. Since companies' financial information is rarely accessible, firm performance will be measured conceptually by investigating the current financial status and growth rate of companies.

3.1.2 Taxonomy of Investigation

The taxonomy of investigation is directly related to the research questions (Sekaran 2003). Furthermore, this taxonomy determines the researcher’s extent of interference in a scientific study. There are two classes of investigation: correlation and causal. Provided that the research questions attempt to create a definite cause and effect association, then causal research would be the taxonomy of investigation. Generally, in most causal investigations, a small number of parameters are identified to establish the relationships. In contrast, in much business research, there are numerous parameters that could affect one another and the researcher might be required to identify the essential factors associated with the problem. With respect to the research model aiming at investigating the relationship between supply chain uncertainty and the new concept of leagility, the category of investigation could be considered as *causal*.

3.1.3 Unit of Analysis

Unit of analysis is the central recognisable entity investigated in a study and for which data are gathered in the format of variables (Sekaran 2003). In other words, it is an individual part in a population of a scientific research. The variation of the unit of analysis is vast from study to study depending on the aims and research questions. In the business context, unit of analysis could be an organisation, an individual, a group of people, or a division or even a country. With respect to the scope of study, Australian companies will be scrutinised here in terms of supply chain leagility. Therefore, the unit of analysis is identified as *Supply Chain of Organisations*.

3.1.4 Time Horizon

Cross-sectional research is designed in a way that data are collected to answer a research problem. Alternatively, in longitudinal studies, data are gathered at disparate time intervals (Sekaran 2003). Since the questionnaire of evaluating the constructs and variables of this model is administered only once, then the time horizon can be referred to as *cross-sectional*.

3.1.5 Study Settings

Study setting could be categorised by referring to the type of investigation and the degree of researcher interference (Sekaran 2003). Study settings have been differently categorised by researchers, however, some well-established classifications are: field study, field experiment, and lab experiment.

In field studies the researcher observes and asks questions or requests the target respondents to provide information through answering to questionnaire, however, he or she does not alter anything in the current setting of the unit of measurement. In a field experiment, researcher makes changes to a number of explanatory variables to investigate how these factors influence the response variable. In the lab experiment the causes and effects of a relationship are investigated. In this type of study the researcher has a high level of control and can even create an artificial work environment.

With respect to the research design of this study, the questionnaire is administered without any researcher manipulation or adjustments to the current organisations' settings. Therefore, the study setting of this thesis can be considered as *field study*.

3.1.6 The Degree of Researcher's Interference

Sekaran (2003) stipulated that the degree of the researcher's intervention with the current flow of work at the unit of analysis is directly associated with the type of investigation undertaken. In this thesis the researcher administers the questionnaire without any interference to the flow of the work or in other words, without manipulation. Consequently, the extent of researcher interference is *minimal*.

3.2 **Conceptual Framework**

A conceptual framework would shape a research study by providing a visual representation of theoretical model including concepts, constructs, and variables of interest. To design a conceptual model, a thorough review of the literature has been carried out in the literature review section. Critical review of literature and organising the findings to confirm theories provides a baseline for developing the conceptual framework.

3.2.1 Theory Underpinning the Study

In recent decades, supply chain management as a multidisciplinary field has garnered immense interest from both academia and industry. Several journal articles concerning the supply chain constitute valid evidence for this topic (Sarkis, Zhu & Lai 2011). Current and emergent organisational theories should be investigated to resolve the supply chain issues. On the other hand, insights from supply chain management studies contribute to the advancement and understanding of existing and emerging organisational theories (Ketchen & Hult 2007b).

As highlighted by Ketchen and Hult (2007a), introduction and application of organisational theory in supply chain management and operations literature is still new. Providing a comprehensive definition for the organisational theory is not easily feasible since there are multiple disciplines and fields which are contributing to organisational theory within management and business studies, including economics, engineering, sociology, psychology, and political science (Pfeffer 1997). Sarkis, Zhu and Lai (2011) proposed a definition for organisational theory as:

> “a management insight that can help explain or describe organizational behaviours, designs, or structures” (p. 2).

Regarding the fact that extension of supply chain is beyond organisations to suppliers’ supplier and customers’ customer, theories should be supportive to how companies are linked. As indicated by Ketchen and Hult (2007a), the exploitation of organisational theory particularly in the supply chain management field is becoming more established. In Appendix 1, organisational the theories in the supply chain management field are summarised: Transaction cost Economics, Agency theory, Resource dependence theory (RDT), Institutional theory, Game theory, Network theory, Social network theory (SNT), Social capital theory, Strategic choice, Resource-based view/knowledge based view (RBV), Stakeholder theory, Information theory (information asymmetry and signalling theory), Complexity theory, and Feedback theory.

In the current study, three theories –Strategic choice, Institutional theory, and Complexity theory – have been exploited as the overarching methodologies to delineate the new concept of leagility in today's hyper-competitive environment. With this in mind, in order to design an effective strategy to achieve maximum performance, a designer is required to consider both internal and external conditions and forces (Hitt, Hoskisson & Ireland 2007). Therefore, a combination of strategic choice theory and institutional theory needs to be employed to provide a more effective model.

The main focus of strategic choice theory is that success and failure of an organisation mostly relies on executives' decisions (Child 1972). Strategic renewal and repositioning are the main concerns of this theory. A basic assumption of strategic choice theory is that organisations would be able to vigorously shape and form their own environment.

In traditional models of strategic choice theory, the primary driver for strategic decisions was the organisation. This approach compels organisations to exploit a generic strategy such as differentiation or cost leadership which would deploy to all elements in it such as the supply chain. Alternatively, in the recent 'best value' models, the primary driver for strategic decisions is the chain with its own specific requirements (Ketchen & Hult 2007a). This approach provides more value to the organisation through fine-tuning strategies for each element including supply chains. The outcome of this approach is strategic supply chain management.

With respect to strategic choice theory, the current study tries to provide critical information regarding the supply chain leagility index to help executives design the supply chain effectively. Strategic choice emphasises that managers' decisions are the main influencing factor in a company's success. This research will create a model for supply chain executives to design an effective supply chain that helps the firm perform at its best.

In contrast to strategic choice theory, institutional theory puts an emphasis on the influence of environmental pressures on an organisation's performance and activities (DiMaggio & Powell 1983). Most of the literature investigating supply chain design, has focused on uncertainty along the supply chain. Studies in scrutinising the impact of external pressures on design of supply chain are rare. In this research, by using the institutional theory as the underpinning structure, competition and customers' expectations are investigated as the crucial external pressures on supply chain.

In addition to strategic choice (focusing of managers' decisions) and Institutional theory (stressing on external pressures), today's complex environment needs complementary theories to contribute. In this regard, complexity theory proposes that when organisations face more difficulties they are forced to design suitable strategies and improve their productivity. In this complex environment, it is crucial for organisations to increase sensitivity and responsiveness to their environments (Crozier & Thoenig 1976). The current research emphasises that in today's complex environment, design of supply chain based on only product type (Fisher 1997; Selldin & Olhager 2007) or level of uncertainty (Fisher 1997; Lee 2002; Lo & Power 2010) is not sufficient and executives need to consider all over-arching factors (internal and external) to achieve the best results. In other words, focusing on only lean supply chain even for functional products, does not provide the highest value for the firm and as per complexity theory, all organisations are required to develop a degree of responsiveness to meet growing expectations of customers.

3.2.2 Ontology and Epistemology

Understanding the association between the investigator's view of reality (ontology) and the meaning the investigator ascribed to knowledge and its creation (epistemology) is crucial in being able to delineate the rationale for the research design and methodology (Darlaston-Jones 2007). Once the clear relationship between the investigator's epistemology and research methods is realised, the entire study made much more sense. As per epistemology fundamentals, it is explained below on how the four difference sources of knowledge are addressed in the current research.

I) Intuitive

Intuitive knowledge is formed from a number of sources including belief, faith, intuition, etc. It emanates from feelings rather than hard, cold facts. In general, it comes up when an initial idea for research is shaped. During the author's extensive experience in supply chain management over a number of countries and industries, no single case has been observed that a supply chain executive design a pure lean or a pure agile supply chain separately. Reviewing the relevant literature showed that the prevalent concept of mutually exclusive designs is not a preferred approach in business environment. Consequently, the idea of the current research has formed to amend the current school of thoughts and clarify that all supply chains are leagile with different magnitude of leanness and agility.

II) Authoritative

Authoritative knowledge is established on information received from existing sources including people, books, articles, etc. The validity of authoritative knowledge comes from the strength of these sources.

As per literature review chapter, a great number of literature has been reviewed to identify and precisely locate the knowledge gap. The knowledge provided by this review clearly showed that mutually exclusive designs such as pure lean and pure agile supply chain have been well-accepted over decades. However, quantities analysis of the proposed models over large number of samples clarified that they are fully supported from statistical perspective. In addition, a comprehensive model of uncertainty is required to provide a clear understanding of the impact of uncertainty on design of a supply chain. Furthermore, the current knowledge regarding the influence of external factors on design of a supply chain is scarce.

III) Logical

Logical knowledge is provided by reasoning from "point A" (current theories or what is generally accepted) to "point B" (the new knowledge). In the current study, the combination of intuitive and authoritative forms the rationale behind the research model. The investigator’s intuitive knowledge indicates that no forms of mutually exclusive pure lean or pure agile supply chains exist in the business world. On the other hand, the current literature presents inconsistent results and finding. Therefore, a logical knowledge is shaped to uncover the elements of existing supply chain designs in the leagility context.

IV) Empirical

Empirical knowledge is formed by findings and factual description which on are determined through observation and/or experimentation. In the current study, the proposed research model is tested by the data collected from Australian firms. The outcome of analysis provides the empirical knowledge in terms of leanness and agility aspects of supply chains.

3.2.3 Theoretical Model and Hypothesis Development

In the theoretical framework, the described knowledge gap and theories are joined together to create the research model (Figure 3-2) and develop hypotheses. A new approach to leagility is presented through the notion of deviation from leagility (DFL). In this approach, all supply chain designs are considered to be leagile with different magnitudes of leanness and agility.

I) Uncertainty and Leagility

Following a general investigation of the new approach of leagility and in line with strategic choice theory, the key driver of decision-making for supply chain design (supply chain uncertainty), is investigated. Review of literature demonstrated that different aspects of supply chain uncertainty could influence both design and strategy. As depicted in Figure 3-2, a comprehensive model of supply chain uncertainty is considered to investigate the impact of uncertainties on the leagility aspect of supply chain. The following hypothesis is examined to investigate this relationship:

H_1: Low level of Uncertainty would let the companies to adopt more balanced supply chains (less DFL)

In order to provide a better understanding of the relationship between supply chain uncertainties and leagility, the main constructs of uncertainty (demand, supply, and internal) are scrutinised through the hypotheses below (Figure 3-3):

H_{1-1}: Low level of Demand Uncertainty would let the companies adopt more balanced supply chains (less DFL)

$H_{1\text{-}2}$: Low level of Supply Uncertainty would let the companies adopt more balanced supply chains (less DFL)

$H_{1\text{-}3}$: Low level of Internal Uncertainty would let the companies adopt more balanced supply chains (less DFL)

II) Market Segment and Supply Chain Design

Another knowledge gap which will be addressed in this study is the market segment of the industry in which a company is operating. For instance, as stated earlier some researchers proposed a lean supply chain should be adopted for functional products. The question is whether this proposition can be generalised to all market segments. For instance, in the apparel industry, Giordano is selling to down-market targeted price sensitive customers. Although Giordano needs to achieve some level of agility to fulfil the customers' expectations, the focus of supply chain design should be on leanness. Alternatively, The Guess as a premium brand that provides better quality and a higher service level to the customers. At the same time, Guess is required to adopt lean thinking to maintain its competitive position in the same market segment. Therefore, supply chain design could be impacted by the characteristics of the market segment in which a firm operates. In this regard, the research model should be examined in different market segments to ensure whether the supply chain design is affected by market segment.

In order to investigate the effect of market segment, firstly the model should be tested for each market segment. Hence, the following hypotheses have been developed:

$H_{1\text{-}4}$: Low level of Uncertainty would let the companies operating in the down-market segment adopt more balanced supply chains (less DFL)

$H_{1\text{-}5}$: Low level of Uncertainty would let the companies operating in the up-market segment adopt more balanced supply chains (less DFL)

The second stage would be comparing the research model estimates for up-market and down-market segments through multi-group analysis. The following hypotheses investigate whether the difference between the models' estimates regarding two market segments is significant:

$H_{1\text{-}6}$: The impact of Uncertainty on DFL is greater for the up-market segment compared to down-market segment.

$H_{1\text{-}7}$: The impact of DFL on Performance is greater for the down-market segment compared to up-market segment.

III) Leagility and Firm Performance

The outcome of every effective design will be reflected in the firm's performance. Accordingly, the relationship between DFL and firm performance is examined by testing the following hypothesis so that model effectiveness is better understood:

H_2: A more balanced supply chains leads to better firm performance.

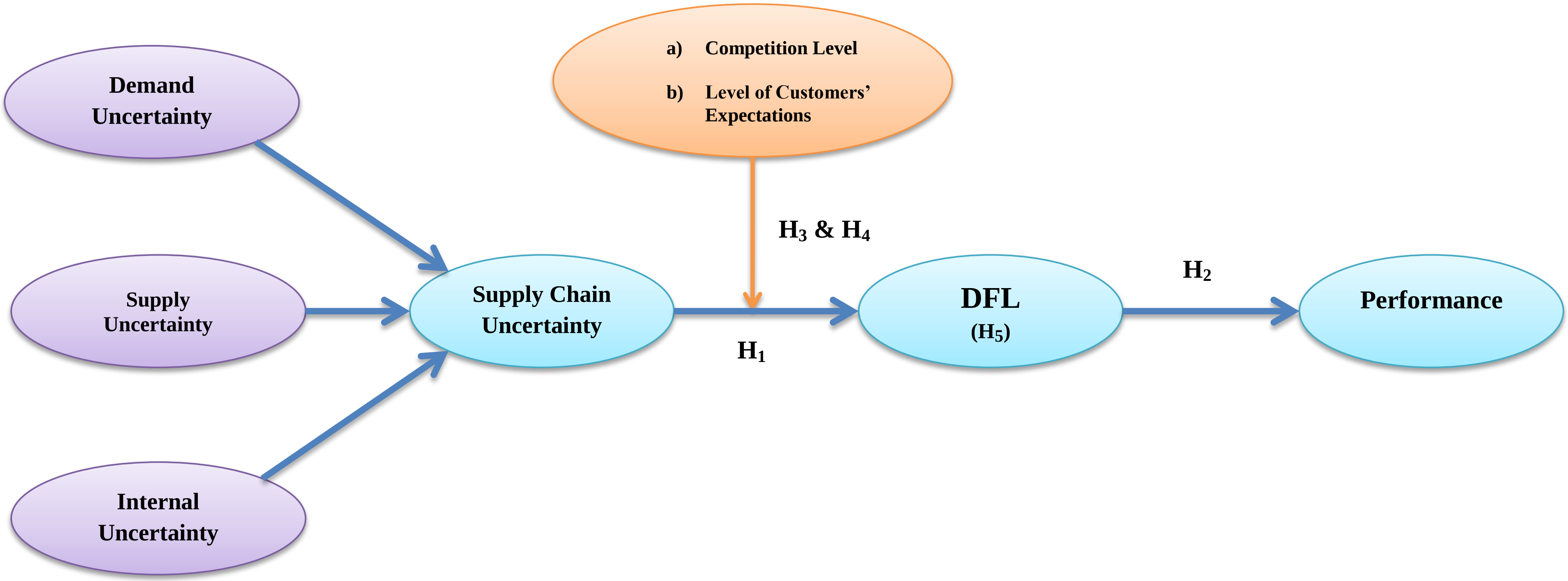

Figure 3-2: Main research model

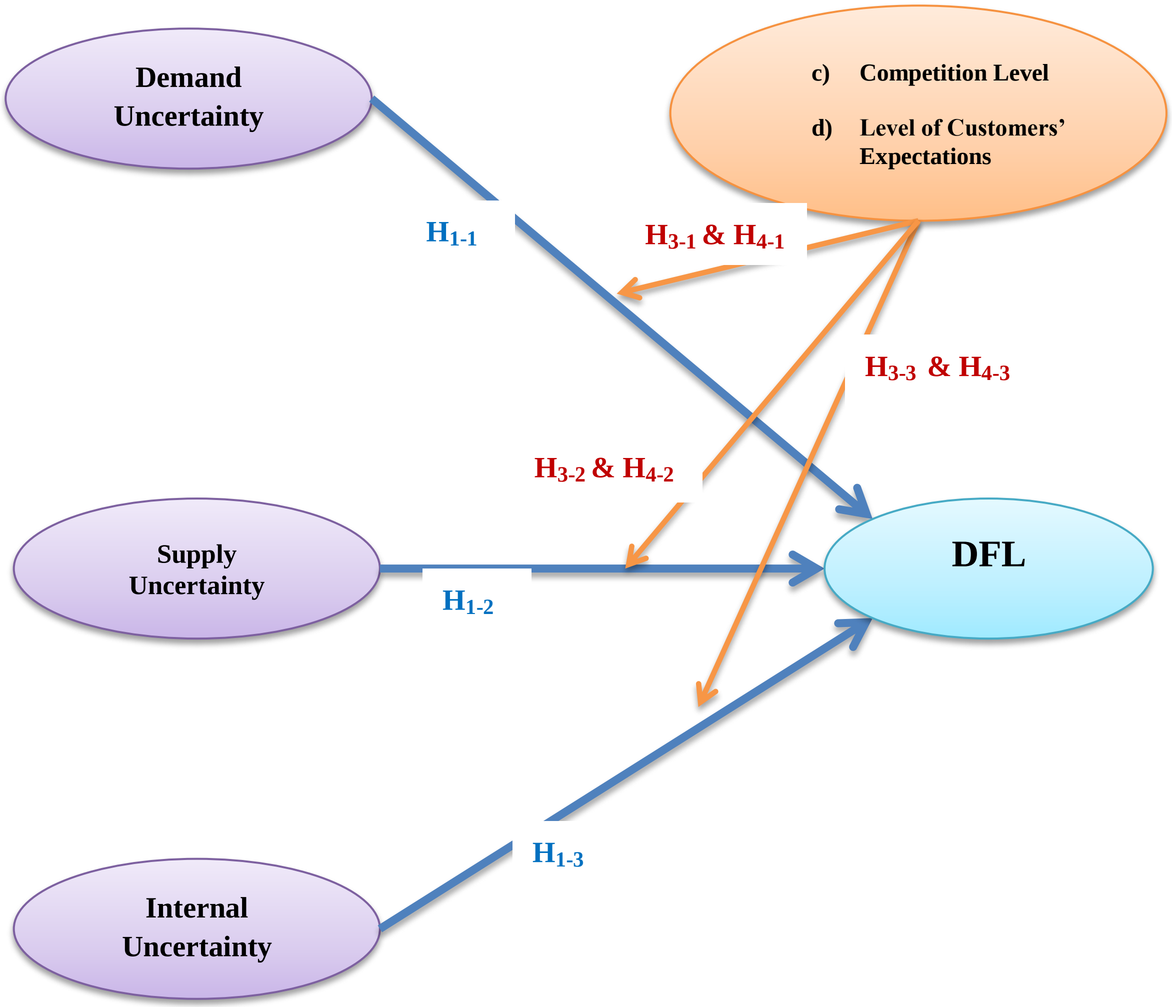

Figure 3-3: Complementary research model

IV) Moderating variable: Competition Intensity

According to institutional theory and involving external pressures in developing a strategy, and with regard to increasing environmental forces on firms and supply chains, the moderator effects of two external forces are investigated with reference to the relationship between supply chain uncertainty and DFL. When the competition is getting fierce, it is expected that companies adjust the magnitudes of leanness and agility to maintain or improve their competitive position:

H_3: The relationship between Uncertainty and DFL is moderated by the level of Competition.

Since each construct of supply chain uncertainty is crucial to effective design of supply chain, and in order to provide a better understanding of the moderating influence of external forces on the relationship between uncertainty elements and DFL, these subsequent detailed hypotheses are investigated (Figure 3-3):

H_{3-1}: The relationship between Demand Uncertainty and DFL is moderated by the level of Competition.

H_{3-2}: The relationship between Supply Uncertainty and DFL is moderated by the level of Competition.

H_{3-3}: The relationship between Internal Uncertainty and DFL is moderated by the level of Competition.

V) Moderating variable: Customers' expectation

Similarly, on condition that customers' expectation is high in an industry/segment, more balanced supply chain is required to meet multifaceted customer's demand. In this regard, the following hypotheses have been developed to investigate the moderating influence of customers' expectation on supply chain design (Figure 3-3):

H_4: The relationship between Uncertainty and DFL is moderated by the level of customers' expectations.

H_{4-1}: The relationship between Demand Uncertainty and DFL is moderated by the level of customers' expectations.

H_{4-2}: The relationship between Supply Uncertainty and DFL is moderated by the level of customers' expectations.

H_{4-3}: The relationship between Internal Uncertainty and DFL is moderated by the level of customers' expectations.

VI) Leagile vs Pure Lean/Agile Design

As delineated in the literature review, the companies need to adopt both lean and agile strategies to maximise their performance. Therefore, it is expected that most companies adopt leagile supply chains rather purely lean or agile supply chain design. In this regard, the following hypothesis is developed to check the distribution of leagility of observed firms.

H_5: Organisations adopt hybrid supply chain rather than a purely lean or a purely agile supply chain.

VII) Leagility and Market Segment

On condition that the market segment is identified as a determinant for the design of supply chains, it is crucial to understand the balance between leanness and agility in each market segment. In other words, it should be tested whether the similarity of characteristics in each market segment accounts for the magnitude of leanness/agility employed in design of supply chain. The hypothesis developed below tries to test the balance of leanness/agility in both market segments:

H_6: There is a higher agility magnitude (higher LI) for companies active in up-market segment of an industry compared to down-market segment.

VIII) Uncertainty and Market Segment

If both uncertainty and market segment are determinants of supply chain design, it would be wise to check whether a relationship exist between uncertainty and the market segment. In the up-market segment where service level and quality are the main market winners, more uncertainty is expected. Therefore, the following hypothesis is developed to address the potential relationship between uncertainty and the market segment:

H_7: There is a higher level of uncertainty for companies active in the up-market segment of an industry compared to the down-market segment.

3.2.4 Operationalisation of Variables

The process of expressing abstract concepts/constructs into measurable and observable variables is referred to as Operationalisation (Sekaran 2003). Prior to developing a questionnaire, a comprehensive conceptual model needs to be developed to help the researcher identify the measurable variables. In the current research, operationalisation should be carried out on all constructs and concepts which have been included in the research model including Deviation from Leagility (DFL), Demand Uncertainty, Supply Uncertainty, Internal Uncertainty, Level of Competition, Level of Customers' Expectations, and Firm Performance.

I) Deviation from Leagility

Deviation from leagility (DFL) is calculated from the leagility index as shown below where 4 is the mid-point of the 7-point Likert scale:

DFL= | LI - 4 |

Therefore, in order to estimate DFL, leagility index is evaluated using a survey questionnaire. Leagility status has not been measured in to date in any scale. It means that researchers (Fisher 1997; Levy 1997; Katayama & Bennett 1999; Christopher & Towill 2000; Selldin & Olhager 2007; Qi, Boyer & Zhao 2011) have measured leanness (efficiency) and agility (responsiveness) of supply chain using two separate measurement models. However, given the main assumption of this study that all supply chains are agile with different magnitudes of leanness and agility, one scale has been employed to measure leagility index.

The questions have been developed by uniting leanness and agility measurement tools utilised in the aforementioned literature. Six questions are utilised to measure the leagility index in this study (Table 3-1).

Table 3-1: Questions to measure Deviation from Leagility

Code	**Questions**	**Extremes**
DFL1	Our overall supply chain is designed to	A: minimise the cost B: provide the quickest response to customers' requirements
DFL2	Our main manufacturing focus is on	A: maintaining a high average utilisation rate B: deploying excess buffer capacity
DFL3	Our inventory strategy is developed to	A: generate high turns and minimise inventory throughout the chain B: deploy significant buffer stocks of parts or finished goods
DFL4	Our approach to choosing suppliers is to	A: select for cost and quality B: select for speed, flexibility, and quality
DFL5	Which cost source dominates your company's supply chain?	A: physical costs B: marketability costs
DFL6	Our supply chain helps the company to win the competition through	A: minimising the cost B: improving the service level and lead time

In order to measure both aspects of leagility in one scale, a comparative method has been adopted whereby A represents the characteristics of a purely lean supply chain and B represents the characteristics of a purely agile supply chain. Respondents are required to rank the leagility position of the supply chain with reference to the following 7-point Likert scale.

❍ 100% A (1)
❍ 84% A --- 16% B (2)
❍ 67% A --- %33 B (3)
❍ 50% A --- 50% B (4)
❍ 33% A --- 67% B (5)
❍ 16% A --- 84% B (6)
❍ 100% B (7)

If 1 is selected, it means the supply chain is purely lean whereas 7 represents a purely agile supply chain. It is quite obvious that 4 stands for a balanced leagile supply chain in which both aspects of leanness and agility are embedded equally.

II) Demand Uncertainty

Very little or no research has employed a comprehensive model of uncertainty to study supply chain design. Most studies (Fisher 1997; Chen & Paulraj 2004; Selldin & Olhager 2007; Qi, Boyer & Zhao 2011; Guo-Ciang 2013; Vivek et al. 2013) emphasised demand uncertainty as the major element of supply chain uncertainty. The following five questions are devised to measure demand uncertainty. Five questions based on the 7-point Likert scale range from: strongly disagree (1) indicating low demand uncertainty; to strongly agree (7) indicating a high level of demand uncertainty is used in the measurement tool (Table 3-2).

Table 3-2: Questions to measure Demand Uncertainty

Code	**Questions**
DU1	Our master production schedule has a high degree of variation in demand over time
DU2	Our demand fluctuates drastically from week to week
DU3	Customer requirements for products change dramatically
DU4	The volume and/or composition of demand is difficult to predict
DU5	We keep weeks of inventory of the critical material to meet changing demands

III) Supply Uncertainty

Another important aspect of uncertainty is supply uncertainty which is related to uncertainty involved in procurement of goods and services. Several researchers (Chen & Paulraj 2004; Qi, Boyer & Zhao 2011; Vivek et al. 2013) stressed the impact of supply uncertainty on supply chain design. However, Lee (2002) provided more details regarding different aspects of supply uncertainty over supply chain. Five questions based on 7-point Likert scale from strongly disagree (1) indicating low supply uncertainty to strongly agree (7) indicating high level of supply uncertainty are employed for this measurement tool (Table 3-3).

Table 3-3: Questions to measure Supply Uncertainty

Code	Questions
SU1	The suppliers consistently meet our requirements
SU2	The suppliers produce materials of a consistent quality
SU3	It has been very easy to procure raw materials for our major product
SU4	The price of raw materials and component parts has NOT changed frequently
SU5	We have several alternative sources in acquiring raw materials

IV) Internal Uncertainty

Only a few studies have investigated the effects of internal or manufacturing uncertainty on supply chain design (Chen & Paulraj 2004; Minnich & Maier 2006; Qi, Boyer & Zhao 2011; Guo-Ciang 2013; Vivek et al. 2013). Since a range of diverse factors impacts on the uncertainty in a business, operationalisation of the internal uncertainty construct is more problematic. An extensive literature review has been carried out and six questions based on a 7-point Likert scale from strongly disagree (1) indicating low internal uncertainty to strongly agree (7) indicating high level of internal uncertainty are employed for this measurement tool (Table 3-4). As explained in the literature review chapter, internal uncertainty emanates from a range of elements including technological, manufacturing/process, and resource-related uncertainties. Therefore, the questions have been carefully selected so that all main components of internal uncertainty are addressed: IU1 and IU3 have been included to measure the level of technological uncertainty; IU2 and IU4 address the manufacturing/process uncertainty; and IU5 and IU6 are selected to evaluate the level of resource-related uncertainties.

Table 3-4: Questions to measure Internal Uncertainty

Code	Questions
IU1	If we do not keep up with changes in technology, it will be difficult to remain competitive
IU2	The number of components in manufacturing is substantial
IU3	The production technology changes frequently
IU4	The number of erroneous components in manufacturing is considerable
IU5	The capacity constraints/restrictions in production are considerable
IU6	The manufacturing lead time for several components is long

V) Level of Competition Intensity

As one of the major external forces, level of competition is referred to as completion intensity in several studies (Tsaur & Wang 2011; Chan et al. 2012; Mahapatra, Das & Narasimhan 2012). Six questions based on a 7-point Likert scale from strongly disagree (1) indicating low competition intensity to strongly agree (7) indicating high level of competition intensity are employed for this measurement tool (Table 3-5).

Table 3-5: Questions to measure Competition Intensity

Code	Questions
CI1	Competition in our market is cut-throat
CI2	There are many “promotion wars” in our market
CI3	Anything that one competitor can offer in our market, others can match readily
CI4	Firms will be spending more of each sales dollar on marketing due to increased competition
CI5	Firms in our industry will be aggressively fighting to hold onto their share of the market
CI6	The number of competitors is high

VI) Level of Customers' Expectations

Another external force on companies which potentially affects the design of supply chain is the level of customers' expectations (Zeithaml, Berry & Parasuraman 1993; Buckingham & Coffman 2000). The first question is designed based on the categorisation of customers' expectations shown in the literature (Woodruff, Cadotte & Jenkins 1983; Higgs, Polonsky & Hollick 2005; Oliver 2010). The definition of each option is provided to clarify the concept. The remaining three questions are employed as per the 7-point Likert scale from strongly disagree (1) indicating low level of customers' expectation to strongly agree (7) indicating high level of customers' expectation (Table 3-6).

Table 3-6: Questions to measure Customers' expectation

Code	**Questions**
CE1	What is the level of customers' expectations concerning your product? ❍ Minimum functions (customer expects only the minimum functions from the product) (1) ❍ Minimum functions to acceptable expectations (2) ❍ Acceptable expectations (customer expects the product to serve in an adequate manner) (3) ❍ Experience-based norms (most times, customer experience of the product is good but sometimes it is only adequate) (4) ❍ Normative expectations (customers spends considerable money on the product and expects excellent quality) (5) ❍ Normative to ideal expectations (6) ❍ Ideal expectations (customer expects the product to be the best in all facets) (7)
CE2	Level of customers' expectations has increased over the past five years
CE3	Apart from accuracy and availability, customers expect your advice
CE4	Customers are demanding more varieties, customisation and features for the products

VII) Firm Performance

Measurement of firm performance is critical to appraise the overall effectiveness of supply chain design. As access to the firms' financial information is extremely difficult to achieve in Australia, the comparative method is utilised whereby the performance of a firm is measured by comparing the main performance factors that competitors employ (Beamon 1999; Gunasekaran, Patel & Tirtiroglu 2001; Vickery et al. 2003; Selldin & Olhager 2007; Qi, Boyer & Zhao 2011). As a result of the extensive literature review, five questions based on the 7-point Likert scale from much worse (1) indicating low firm performance to much better (7) indicating high firm performance are employed for this measurement tool (Table 3-7).

Table 3-7: Questions to measure Firm Performance

Code	Questions
P1	How well does the company perform relative to its competitors in terms of cost?
P2	How well does the company perform relative to its competitors in terms of flexibility?
P3	How well does the company perform relative to its competitors in terms of delivery speed?
P4	How well does the company perform relative to its competitors in terms of profitability?
P5	How well does the company perform relative to its competitors in terms of growth in market share?

The type of Likert scale which is used for the above questions are as follows:

- Much Worse (1)
- Worse (2)
- Somewhat Worse (3)
- About the Same (4)
- Somewhat Better (5)
- Better (6)
- Much Better (7)

VIII) Market Segment

Three crucial determinants of firm success are correct market definition, market segmentation and positioning (McDonald 2012). A market segment is a sub-set of a market which consists of people or companies with at least one characteristic that makes them demand a comparably priced product and/or services. As the market segment in which a firm is operating influences all aspects of a company, it is expected that design of supply chain could be influenced as well.

With reference to the theory of market qualifiers and market winners in supply chain management as proposed by Mason-Jones, Naylor and Towill (2000), design of supply chain is affected by market characteristics including price, quality, lead time, and service level. As market segment is a sub-set of a market with at least one characteristic in common, it seems there should be a relationship between the market segment and supply chain design. However, the question would be which segmentation method is most appropriate to investigate the impact of market segment on supply chain design.

It seems the best method of market segmentation would be a method whereby market qualifiers and market winners affecting the design of supply chain, are employed. While there is a method of market segmentation which is not scientifically delineated, it is commonly accepted and used by customers and has been referred to by two analyses (Shaw & Cresswell 2002; Kotler & Keller 2006; McDonald 2012). The market is split into two segments: up-market and down-market. Price would be the market winner for the down-market segment and service level and quality would be market winners for the up-market segment. Five questions based on the 7-point Likert scale from strongly disagree (1) indicating the firm is operating in down-market segment to strongly agree (7) indicating the firm is operating in up-market segment, have been included in the questionnaire (Table 3-8).

Table 3-8: Questions to measure Market Segment

Code	Questions
MS1	The majority of our customers are from a high-income category
MS2	Our customers’ main criteria for selecting our product is quality rather than cost
MS3	Our competitors are intensively investing in cost reduction
MS4	In the market, our product is recognised as high quality and expensive
MS5	The demand for our product increases when the average incomes of consumers increase

Since the direction of MS3 is contrary to the questions, the responses for this question would be inverted prior to analysis.

3.2.5 Survey Questionnaire

The survey questionnaire is developed based on the operationalisation outcome (Appendix 2: Survey Questionnaire). It consists of four main sections as explain in more detail below.

I) Participant information

The first section is dedicated to participant information. At the beginning of this section, the titles of research and contact information of investigators are provided. It is also stated that this study is a part of a PhD thesis undertaken by me at RMIT University.

In the second part, research outline, the aim of the study, research questions, and theoretical and practical contribution of the study are delineated. The third part, participation procedure, is included to provide a guideline for participants on how to complete the questionnaire. In addition, the estimated time of completion, number of questions, and characterises of the measuring scale (7-point Likert scale) are explained.

In the next section, risks and benefits, it has been stated that no direct risk or benefit is involved in this survey. As per University policy and procedure, confidentiality and anonymity status has been communicated to each participant whereby anonymity and confidentiality of responses are protected, within the limits of the law. The last part is dedicated to participants' rights as follows:

- The right to withdraw from participation at any time
- The right to request that any recording cease
- The right to have any unprocessed data withdrawn and destroyed, provided it can be reliably identified, and provided that so doing does not increase the risk for the participant.
- The right to have any questions answered at any time.

As a part of RMIT University's ethics process, a link is provided to participants whereby any potential complaint could be forwarded to the University.

II) Panel Selection

It is crucial to ensure only eligible and qualified experts can respond to the questionnaire. In this regard, screening questions have been developed to remove the potential respondents who are not fully qualified. The survey flow in which the qualified experts have been selected for this study is presented in Appendix 3: Survey Flow.

As per the following screening question, the respondents are required to have been employed for a minimum of three years. Otherwise, the designed survey flow will stop the respondents from continuing.

PS2 Do you have more than three years working experience?
- ❍ Yes (1)
- ❍ No (2)

The survey includes two additional screening questions to ensure only eligible respondents are able to complete the questionnaire. The questions are listed below:

PS1 Do you work in manufacturing industry?
- ❍ Yes (1)
- ❍ No (2)

PS3 Do you deal with the management (demand/supply/distribution) of manufacturing products?
- ❍ Yes (1)
- ❍ No (2)

As per the survey flow, the respondents should answer ‘Yes’ to at least one of the above questions so that they can undertake the survey.

III) Demographic Data

In this section, characteristics of the participants which are referred to as demographics are collected. When a survey is designed, it is a requirement to assess who responded to the survey and how to itemise overall survey response data into meaningful clusters of respondents. In addition, categorisation of companies into small, medium, and large is feasible through an investigation of number of employees and annual revenue. A list of demographic questions is presented in Appendix 2: Survey Questionnaire.

IV) Main Questions

Table 3-9 summarises the references used here to operationalise the concepts and constructs. A list of questions is provided in Appendix 2: Survey Questionnaire.

Table 3-9: Operationalisation of Constructs

Construct	Questions	Reference
Demand Uncertainty	DU1 … DU5	Guo-Ciang (2013) Vivek et al. (2013) Qi, Boyer and Zhao (2011) Selldin and Olhager (2007) Chen and Paulraj (2004) Fisher (1997)
Supply Uncertainty	SU1 … SU5	Vivek et al. (2013) Qi, Boyer and Zhao (2011) Chen and Paulraj (2004) Lee (2002)
Internal Uncertainty	TU1 … TU6	Guo-Ciang (2013) Vivek et al. (2013) Qi, Boyer and Zhao (2011) Minnich and Maier (2006) Chen and Paulraj (2004)
Leanness and Agility Level	LA1 … LA6	Gligor, Esmark and Holcomb (2015) Qi, Boyer and Zhao (2011) Selldin and Olhager (2007) Yusuf et al. (2004) van Hoek, Harrison and Christopher (2001) Christopher and Towill (2000) Mason-Jones, Naylor and Towill (2000) Katayama and Bennett (1999) Levy (1997) Fisher (1997)

Construct	Questions	Reference
Competition Intensity	CI1 … CI6	Simangunsong, Hendry and Stevenson (2012) Chan et al. (2012) Mahapatra, Das and Narasimhan (2012) Tsaur and Wang (2011) Ambler, Styles and Xiucun (1999) Jaworski and Kohli (1993) Lusch and Laczniak (1987)
Level of Customers' Expectations	CE1 … CE4	Buckingham and Coffman (2000) Zeithaml, Berry and Parasuraman (1993)
Firm Performance	FP1 … FP5	Qi, Boyer and Zhao (2011) Selldin and Olhager (2007) Vickery et al. (2003) Gunasekaran, Patel and Tirtiroglu (2001) Beamon (1999)
Market Segment	MS1 … MS5	McDonald (2012) Kotler and Keller (2006) Shaw and Cresswell (2002)

3.3 **Quality Criteria**

To ensure the analysis estimates are stable, valid, and reliable, the quality criteria should be assessed. In PLS analysis, quality criteria include reliability, validity, and communality. Construct validity is generally considered to be the extent to which an operationalisation measures the concept it is supposed to measure (Cook & Campbell 1986). Convergent validity and discriminant validity are subclasses or subtypes of construct validity. These are explained in more detail below.

3.3.1 Convergent Validity

Theoretically, two measures of constructs in a research model are expected to be related. Convergent validity refers to the degree to which they are actually related. In other words, the measurement variables of every potential construct must be loaded with significant t-values. To assess convergent validity in PLS-based analysis, factor loadings for each variable of related construct is explored.

The relationship between the variable and construct is considered to be valid if the factor loading is more than an acceptable limit. The minimum factor loading has been noted as 0.6 in some papers (Bagozzi & Youjae 1988), whereas others have considered 0.7 as a threshold for validity of a relationship (Chin 1998). In the current research, items with factor loadings of 0.7 or more are considered as valid.

3.3.2 Discriminant Validity

Discriminant validity applies to dissimilar constructs/concepts which are theoretically separated. In order to establish discriminant validity, supporting evidence should be provided to prove variables that are not supposed to be related are in reality not related. In other words, different measurements designed to measure different constructs should not highly correlate to each other. In PLS path modelling, discriminant validity is assessed as satisfactory when the square roots of the AVE values are higher than correlation coefficients between the variables (Fornell & Larcker 1981). The other aspect of discriminant validity refers to models with second order constructs. The second order constructs of a measurement model should not be highly correlated. Hair (2006) stated that as a part of discriminant validity, correlation among constructs should be less than 0.9.

3.3.3 Reliability

In order to assess the internal consistency of the measurement items, average variance extracted (AVE), composite reliability, and Cronbach's Alpha should be assessed. The minimum value for the composite reliability and Cronbach's Alpha is considered to be 0.7 while the value of AVE above 0.5 is deemed to be satisfactory (Fornell & Larcker 1981).

3.3.4 Communality

The communality for a construct is measured by taking the sum of the squared loadings of its related variables. There is a similarity between the concept of communality and R^2 values for regression models. The interpretation of communality for a given construct is the proportion of variation in that construct explained by the loaded variables. Comparatively, in multiple regression, R^2 is interpreted as the percentage of variation in the dependent variable explained by the independent variables. Fornell and Larcker (1981) suggested a cut-off point of 0.5 as the minimum value for communality.

3.4 **Research Plan**

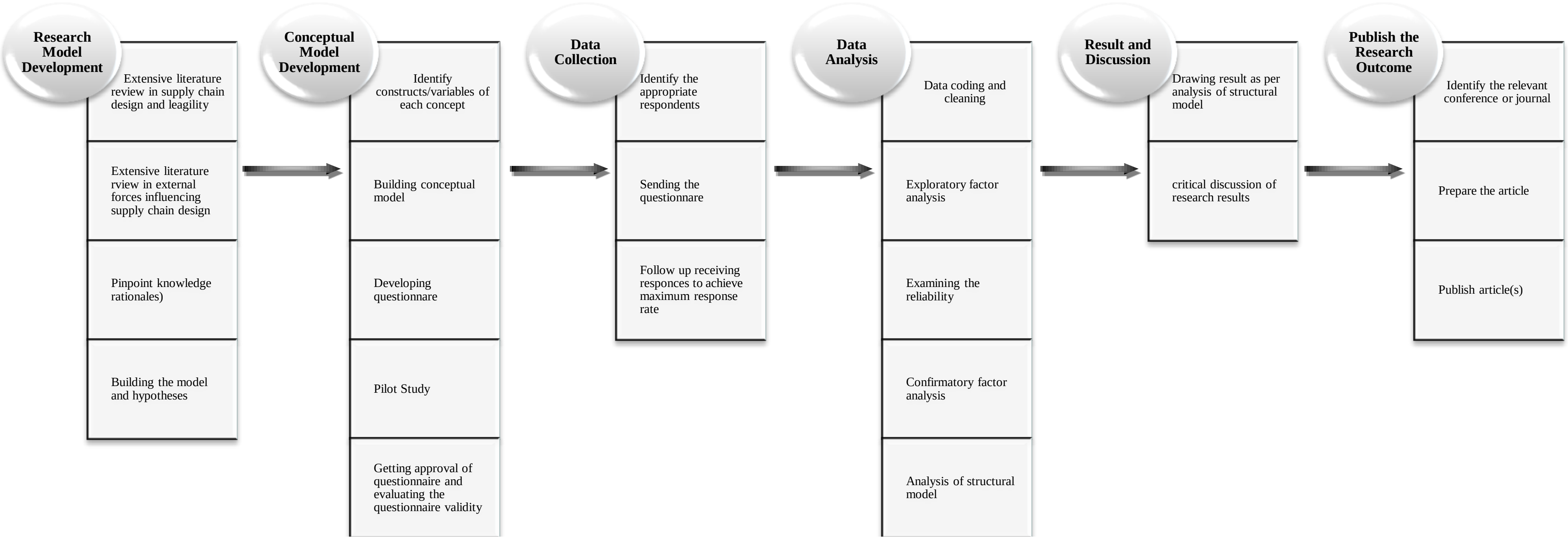

Figure 3-4: Research plan of the study

3.5 **Data Collection and Analysis**

Data collection methods are an integral part of research design. Interviewing, administering questionnaires, and observing people and phenomena are the three main data collection methods in survey research. Questionnaires have the advantage of obtaining data more efficiently in terms of time, energy, and cost (Sekaran 2003). Administering questionnaires to large numbers of people simultaneously is less expensive and less time-consuming than interviews. A survey methodology is utilised to collect data relating to the research questions and hypotheses described in the previous section.

3.5.1 Ethics Approval

As a part of RMIT University's policy and procedure, all research conducted by RMIT College of Business staff or students involving humans as subjects must have written approval from the Business College Human Ethics Advisory Network (BCHEAN). Survey questionnaire and all required documents were submitted to BCHEAN and ethics approval was granted on 13th December 2012 (Appendix 4: Ethics Approval Notice).

3.5.2 Sources of Data Collection

Data has been collected from different sources as described below.

I) Source 1:

Since the response rate is limited in Australia, it has been decided to engage companies which provide assistance in data collection. Not all companies active in the research industry make data collection available for business research. Therefore, the companies listed in the Appendix 5: Data Collection Service Providers Active in Research Industry have been contacted to investigate which company is suitable to provide assistance in data collection for this thesis. A list of data collection service providers active in the research industry is presented in Appendix 5: Data Collection Service Providers Active in Research Industry.

All companies have been contacted and data collection requirements have been communicated to relevant staff. After extensive investigation of proposals provided by service providers, it was concluded that Nine Rewards Pty Ltd would be the best option for this study. Furthermore an agreement was established with Nine Rewards Pty Ltd on 19^{th} February 2013 to collect 150 samples from Australian companies dealing with demand/supply/distribution of goods and services. The target respondents have been the operations managers, supply chain managers, and manufacturing managers – they have all been involved in companies' supply chains. RMIT University has provided funding ($2505) and the rest of the data collection cost has been paid for by this author.

An online platform has been developed in Qualtrics and the following items have been developed:

- The final version of the questionnaire has been uploaded and reviewed to obtain complete accuracy.
- As per RMIT University's ethics policy, the cover letter has been developed and uploaded to the database.
- Screening questions have been developed to make sure respondents fit the current study in terms of job title and length of employment.
- The quota to terminate the questionnaire has been developed.
- As per Nine Rewards' instruction, a process flow has been developed and implemented to redirect the questionnaire when a specified event was triggered including termination, screening, etc.

The questionnaire was forwarded to 750 potential respondents. 306 executives have participated in the survey after the launch of the online questionnaire. The screening process stopped at 129 participants to complete the questionnaire due to either mismatch of job title or lack of sufficient length of employment. Eventually, Nine Rewards provided 177 completed questionnaires and the process was finalised at the end of March 2013. Two samples have been identified as unusable since the respondents answered 7 to all questions. As a result, 175 completed questionnaires have been considered to be valid for the study.

II) Source 2:

The second source which has been used for this study is Linkedin, the most prominent social networking in the business area. Subscription has been carried to all relevant groups in LinkedIn including Logistics Association of Australia, Australian CEOs, Australian Chief Executive Officers, Australian Business Network, Australian Procurement Professionals, CIPS Australasia, Procurement & Supply Australia, Procurement Professionals Australia, Procurement, Logistics and Manufacturing Operations Australia, SCLAA (Supply Chain & Logistics Association Of Australia), Supply Chain & Logistics Australia, Supply Chain Network Australia & New Zealand, and Supply Chain Professionals Australia.

During February and March 2013, 11 executives participated in the survey. 10 samples are usable and 1 participant has been disqualified due to mismatch of job title.

III) Source 3:

A connection has been established to a senior category manager of the University of Melbourne Strategic Procurement. He authorised contacting the University of Melbourne's suppliers for data collection. The author provided the survey link and the hard copy of the survey to suppliers who are involved in manufacturing/distribution fields in Australia. In total, 146 executives active in demand/supply/distribution of goods/services participated in the survey and 114 usable samples were collected. The survey was terminated on 26 April 2013.

3.5.3 Response Rate

In total 299 samples were collected from three sources (Table 3-10).

Table 3-10: Data collection and response rate

Sampling	Source	Sent	Received	Usable	Response Rate
1st Distribution	Nine Rewards	750	306	175	23.3%
2nd Distribution	Linkedin, Australian University Suppliers, etc.	1292	157	124	9.6%
Total	All	2042	463	***299***	14.6%

As Nine Rewards targeted the potential respondents based on the information of subscribed candidates and a reward is provided in return for completing the questionnaires, the response rate is higher (23.3%) compared to the direct approaching of executives which resulted in a response rate of 9.6%. In total the response rate of the survey is 14.6%.

3.5.4 Data Processing

Samples were exported from the Qualtrics platform in csv format and can be imported into Microsoft Excel. The remaining samples were imported into Microsoft Excel. All samples were coded properly whereby the source of data collection could be differentiated. Then all samples were merged into one spreadsheet. Data were cleaned, reviewed, and labelled. There are some questions with reversed order of Likert Scale. Therefore, the data were recoded and recalculated for some questions. Data was converted into a suitable format to be imported into the statistical software for analysis.

3.5.5 Data Analysis

SPSS Statistics 17, the statistical software package, is employed to accomplish several tests to provide basic information regarding demographic data, descriptive statistics, normality assumption, non-response bias, and reliability of the measurement tool.

Structural equation modelling is selected as the method of analysis. However, it should be determined whether covariance-based or variance-based SEM is more appropriate for this study. If covariance-based SEM is selected, AMOS would be utilised as the statistical software package. On the other hand, if variance-based SEM is selected as the method of analysis, Smart PLS would be utilised as Partial least squares Path Modelling software.

Method of analysis - whether covariance-based or variance-based SEM - is selected based on normality distribution of data and sample size. On condition that significant departure from normality assumption is identified and sample size would be small, variance-based SEM such as Partial least squares (PLS) is more appropriate.

3.6 **Summary**

In order to develop a research design which is capable of addressing the research question, the first step would be to understand the research characteristics. The current research has a mixed methodology comprising both exploratory and explanatory strategies. With respect to the research model investigating the relationship between supply chain uncertainty and leagility, the type of investigation is considered to be causal. As Australian companies are going to be scrutinised in terms of supply chain leagility, the unit of analysis is identified as organisation. Since the questionnaire of evaluating the constructs and variables of this model is administered only once, the time horizon can be referred to as cross-sectional. In the current study, the researcher administers the questionnaire without any interference or manipulation. Consequently, the extent of researcher interference is minimal.

To ensure the analysis estimates are stable, valid, and reliable, the quality criteria are addressed by testing the reliability, validity, and communality of estimates. Construct validity, which is considered generally as the extent to which an operationalisation measures the concept it is supposed to measure, will be evaluated by testing convergent and discriminant validity. Reliability will be evaluated utilising the Cronbach Alpha which is a perfectly adequate index of inter-item consistency. Communality for a given construct which is the proportion of variation in that construct explained by the loaded variables, will be measured to check how the engaged variables are able to explain the incorporated constructs.

In the theoretical framework, the described knowledge gap and theories are joined together to create the research model and hypotheses. All concepts which have been involved in the research model have been operationalised to construct the measurement model. A new approach to leagility is presented in the current research through the concept of deviation from leagility (DFL).

As a part of RMIT University's policy and procedure, the survey questionnaire and all required documents were submitted to BCHEAN and ethics approval was granted on 13th December 2012. The scope of the current study is limited to companies dealing with supply chains of manufacturing industry products in Australia and involving different industries. The survey questionnaire was sent to 2042 potential respondents. In total, 299 completed questionnaires from three sources with a response rate of 14.6% were collected.

CHAPTER 4: BASIC DATA ANALYSIS AND TEST

This chapter presents the basic analysis including (a) demographic analysis which provides an insight into the respondent information and the companies which have been involved in this study (b) descriptive analysis which provides an overview of the variables of the research model (c) normality assumption which is a critical test for the selection of appropriate method of analysis (d) non-response bias test which is a crucial test when data are collected in more than one time (e) reliability analysis which is an indication of the stability and consistency with which the instrument measures the concept.

4.1 **Demographic Data Analysis**

One of the most popular methods to measure the dynamics and dimensions of populations is demographic analysis. Demographic analysis has initially been developed to investigate human populations, however, it is stretched to a vast variety of fields in which researchers desire to realise how populations of respondent can affect the study.

In the context of science, demographic analysis statistics are generally considered a concrete standard for estimating the precision of the census information collected for research purposes.

4.1.1 Screening Questions

It is very crucial to ensure only eligible and qualified experts have the opportunity to respond to questionnaire. In this regard, screening questions have been developed to remove the potential respondents who are not fully qualified to undertake the survey. The survey flow in which the qualified experts have been selected for this study is presented in Appendix 3: Survey Flow.

The respondents are required to have minimum three years working experience. Otherwise, the designed survey flow will stop the respondents to continue. As highlighted in Table 4-1, all respondents have more than three years work experience.

Table 4-1: Screening question. Minimum three year work experience

Minimum three year work experience	Frequency	Percent
Yes	299	100.0

The survey has also included two additional screening questions to ensure only the eligible respondents were able to complete the questionnaire. The questions are listed as below:

PS1: Do you work in manufacturing industry?

PS3: Do you deal with the management (demand/supply/distribution) of manufacturing products?

As per survey flow, the respondents should answer ‘Yes’ to at least one of the above questions to be qualified to undertake the survey.

As shown in Table 4-2, 85.6% of the respondents are working in the manufacturing industry.

Table 4-2: Screening question. Working in manufacturing industry

Working in manufacturing industry	Frequency	Percent
Yes	256	85.6
No	43	14.4
Total	299	100.0

The frequency analysis of the responses to the screening question asking whether the respondent is dealing with management (demand/supply/distribution) of manufacturing products indicates that 81.3% of respondent are involving in supply chain of manufacturing products (Table 4-3).

Table 4-3: Screening question. Deal with the management (demand/supply/distribution) of manufacturing products

Deal with the management (demand/supply/distribution) of manufacturing products	Frequency	Percent
Yes	243	81.3
No	56	18.7
Total	299	100.0

As stated earlier, to be eligible to participate in the current survey, respondents are required to either work in manufacturing industry, or they have to be involved in management (demand/supply/distribution) of manufacturing products.

It is undeniable that the most reliable respondents are the experts who are working in manufacturing industry and they are also dealing with the management (demand/supply/distribution) of manufacturing products. In other words, the highest quality of responses are expected when the participants response ‘Yes’ to both PS1 and PS3 screening questions.

In this regard, the respondents categorised into two groups. The first group includes the respondents who have replied positive to both screening questions. The second group includes the respondents replied positive to one of the screening questions. The frequency analysis of both groups is shown in the Table 4-4.

Table 4-4: Screening questions. The most reliable respondents

PS11_PS3_Recode

The most reliable respondents	Frequency	Percent
1.00	200	66.9
2.00	99	33.1
Total	299	100.0

Frequency analysis indicates that majority (66.9%) of respondents, category 1, are highly eligible to participate in the current survey.

4.1.2 Characteristics of Respondents

This section provides an insight into the characteristics of the respondents in terms of respondents' position in the organisation, education level, overall work experience, and work experience in supply chain (Table 4-5)

Table 4-5: Demographic Analysis. Characteristics of Respondents

Respondents' Position	Frq.	%	Education Level	Frq.	%	Work Experience	Frq.	%	Work Experience in SCM	Frq.	%
Managing Director	30	10.0	Diploma, certificate, and below	156	52.2	<5 Years	38	12.7	<5 Years	106	35.5
Supply Chain / Logistics Manager	42	14.0	Bachelor	87	29.1	5-9 Years	57	19.1	5-9 Years	89	29.8
Operations Manager	64	21.4	Master	54	18.1	10-20 Years	86	28.8	10-20 Years	76	25.4
Procurement/Purchasing Manager	42	14.0	PhD & Above	2	.7	>20 Years	118	39.5	>20 Years	28	9.4
Warehouse/Store/Inventory Manager	32	10.7	Total	299	100	Total	299	100.0	Total	299	100
Retail Managers	22	7.4									
Production/Manufacturing Manager	34	11.4									
Distribution Manager	16	5.4									
Other	17	5.7									
Total	299	100									

The best survey outcome could be achieved when the most qualified and reliable experts get participated in the study. As the current research focuses on supply chain strategy, the middle and senior level managers are in a better position to complete the questionnaire. In this regard, frequency analysis has been carried out on the position of respondents in the organisation to ensure qualified experts have participated in the survey. As demonstrated in Table 4-5, 94.3% of the respondents are working in managerial level. In other words, majority of respondents are highly qualified to express their ideas regarding supply chain strategy.

As depicted in Table 4-5, the education level of more than 50% of respondents is bachelor and certificate. It shows a considerable opportunity of improvement exists in Australian firms if scientific methods of supply chain management are utilised.

Investigation into the work experience of respondents is crucial as this study tries to provide an effective model of supply chain to achieve highest possible performance. Although a screening question has been embedded to ensure all respondents have more than three years work experience, it is highly desirable that participants have more than five years work experience. As shown in Table 4-5, majority of participants (87.3%) have more than five years work experience. In addition, 39.46% of respondents have more than twenty years work experience. It is a decent indication of utilising qualified participants in the current study.

As explained earlier, having three years of work experience has been considered as the minimum level to be qualified to participate in the current survey. Furthermore, majority of respondents (87.3%) have more than five years work experience. It is highly desirable that participants have being involved in management of supply chain over their work experience. Therefore, all participants have been required to provide information regarding work experience in supply chain/logistics/procurement/purchasing/operation management. Table 4-5 provides information regarding the work experience of the participants in supply chain/logistics/procurement/purchasing/operation management. Frequency analysis indicates that 64.5% of the respondents have more than five years work experience in supply chain/logistics/procurement/purchasing/operation management. It is a decent indication of having qualified respondents on board.

4.1.3 Characteristics of Companies

This section provides an overview of the companies which have been involved in the current study.

I) Industry

The outcome of a research would be more valuable and the level of generalisation to population would be improved when sampling is undertaken from more sectors of a population. In this regard, participants were required to provide information regarding the industry in which they are currently working.

Frequency analysis of the information provided by the participants regarding the industry indicates an acceptable range of industries are studied in the current research. Furthermore, the distribution of industries which have been studied is reasonable (Table 4-6). In excess of 10 industries have been explored in the existing research and the fragmentation of sectors is suitable as the highest contribution has been related to Metal Industry with 16% of respondents' contribution.

Table 4-6: Demographic analysis. Industry

Industry	Frequency	Percent
Food, beverage and tobacco products	26	8.7
Wood and paper products	26	8.7
Metal products	50	16.7
Textile, clothing and other manufacturing	22	7.4
Printing and recorded media	28	9.4
Non-metallic mineral products	18	6.0
Petroleum, coal, chemical and rubber products	40	13.4
Machinery, and equipment	37	12.4
Retail	9	3.0
Other	43	14.4
Total	299	100.0

II) Years Since Establishment of Company

All businesses are changing as time passes. A company goes through a number of stages of the business life cycle. A company goes through stages of development including seeding, start-up, and growth as the same as the life cycle for the human being.

In establishment phase and afterwards, the level of fluctuation in terms of strategic changes would be reduced. Therefore, study of supply chain in strategic level would provide a better outcome when a company is not in the initial stages of business life cycle. In this regard, as an important characteristic of a business, the age of companies in which the respondents are currently working, has been measured.

Table 4-7: Demographic analysis. Years since establishment of company

Years since establishment of company	Frequency	Percent
<5 Years	20	6.7
5-10 Years	24	8.0
>10 Years	255	85.3
Total	299	100.0

Table 4-7 shows that 93.3% of companies have been established for more than five years. Furthermore, 85.28% of companies have been set up for more than ten years. The analysis indicates that majority of companies have been established for long enough to pass the initial stages of business life cycle.

III) Number of Employees

Number of employees is an indicator of company size. In this regard, number of employees has been measured and shown in Table 4-8.

Table 4-8: Demographic analysis. Number of employees

Number of Employees	Frequency	Percent
1-19	79	26.4
20-49	51	17.1
50-199	66	22.1
200-249	14	4.7
250-499	15	5.0
500-1000	26	8.7
>1000	48	16.1
Total	299	100.0

IV) Annual Revenue (Latest)

Another method to measure the company size is to consider the annual revenue. In this regard, annual revenue of companies has been collected and shown in Table 4-9.

Table 4-9: Demographic analysis. Annual revenue (latest)

Annual revenue (latest)	Frequency	Percent
<$2 M	61	20.4
$2 M - $10 M	73	24.4
>$10 M - $50 M	65	21.7
>$50 M - $100 M	28	9.4
>$100 M - $250 M	5	1.7
>$250 M	67	22.4
Total	299	100.0

V) Company Size as per No of Employees

There are several methods to categorise companies into small, medium, and large size. In Australia, Australian Bureau of Statistics has provided a definition for company size in a report titled as Australian Bureau of Statistics (2001).

“For the purposes of this publication a small business is defined as a business employing less than 20 people. Categories of small businesses include:

- non-employing businesses - sole proprietorships and partnerships without employees;
- micro businesses - businesses employing less than 5 people, including non-employing businesses;
- other small businesses - businesses employing 5 or more people, but less than 20 people;

Small businesses tend to have the following management or organisational characteristics:

- independent ownership and operations;
- close control by owners/managers who also contribute most, if not all the operating capital; and
- principal decision-making by the owners/managers.

In this publication, statistics are also presented for the following categories:

- medium businesses - businesses employing 20 or more people, but less than 200 people; and
- large businesses - businesses employing 200 or more people."

The size of companies in which the participants are working, has been categorised as per instruction stated above. The outcome of frequency analysis is summarised in Table 4-10.

Table 4-10: Demographic analysis. Company size as per number of employees

Company size as per number of employees	Frequency	Percent
Small	79	26.4
Medium	117	39.1
Large	103	34.4
Total	299	100.0

As per outcome of the frequency analysis, a smooth distribution of company size (Small 26.42%, Medium 39.13%, and Large 34.45%) exists in the current study. Therefore, there is no major concern in terms of generalizability of the results to the population as different company sizes exist in the research samples.

VI) Company Size as per Revenue

The second method of categorising the companies in terms of size is proposed by Australian Taxation Office (Connolly, Norman & West 2012) in which the annual revenue of the company is taken into consideration. Companies are considered as a) Small, when annual revenue is less than $2M; b) Medium, when annual revenue is between $2M and $250; and Large, when annual revenue is more than $250M. It is necessary to mention that this method of categorisation is not popular as the first method. Table 4-11 shows the distribution of company size as per revenue which have participated in the current study.

Table 4-11: Demographic analysis. Company size as per revenue

Company size as per revenue	Frequency	Percent
Small	61	20.4
Medium	171	57.2
Large	67	22.4
Total	299	100.0

4.2 **Descriptive Data Analysis**

In order to describe the basic structures of the data in a research, researchers are generally using descriptive statistics. They provide primary outlines regarding the measures and the sample. Once graphics analysis incorporates with the demographic statistics, they could provide the basis of data quantitative analysis.

4.2.1 Demand Uncertainty

One of the constructs of uncertainty along a supply chain is demand uncertainty. To evaluate demand uncertainty, five variables have been identified whereby five questions have been included to the survey. Table 4-12 shows descriptive statistics for demand uncertainty.

Table 4-12: Descriptive statistics of Demand Uncertainty

Descriptives	DU1	DU2	DU3	DU4	DU5
Mean	4.72	5.09	5.18	5.06	4.58
Median	5	5	5	5	5
Std. Deviation	1.427	1.258	1.203	1.342	1.598
Skewness	-0.542	-0.43	-0.543	-0.513	-0.523
Kurtosis	-0.289	-0.652	-0.024	-0.61	-0.562

The mean of all variables of demand uncertainty is above the midpoint, 4. It indicates in today's business environment, the overall demand uncertainty is high for all company and supply chain types.

Minimum demand uncertainty of 1 and maximum 7 show companies with the entire range of demand uncertainty exist in the current study.

Skewness and Kurtosis of all demand uncertainty variables are within the range of -2 to +2. Therefore, departure from normality is not expected. However, statistical analysis should be carried out to ensure the normality assumption is not violated.

4.2.2 Supply Uncertainty

One of the constructs of uncertainty along a supply chain is supply uncertainty. To evaluate supply uncertainty, five variables have been identified whereby five questions have been included to the survey. Table 4-13 shows descriptive statistics for supply uncertainty.

Table 4-13: Descriptive statistics of Supply Uncertainty

Descriptives	SU1	SU2	SU3	SU4	SU5
Mean	3.21	3.18	4.25	5.01	4.45
Median	3	3	4	5	4
Std. Deviation	1.242	1.245	1.046	1.084	0.997
Skewness	0.472	0.511	0.085	-0.348	0.115
Kurtosis	-0.452	-0.364	-0.151	0.021	-0.534

The mean of S3, S4, and S5 variables of supply uncertainty is above the midpoint, 4. It indicates for these variables, the overall supply uncertainty is high for all company and supply chain types. However, the mean of S1 and S2 is under the midpoint indicating that judging about demand uncertainty requires detailed statistical analysis.

Minimum supply uncertainty of 1 and maximum 7 show companies with the entire range of supply uncertainty exist in the current study.

Skewness and Kurtosis of all supply uncertainty variables are within the range of -2 to +2. Therefore, departure from normality is not expected. However, statistical analysis should be carried out to ensure the normality assumption is not violated.

4.2.3 Internal Uncertainty

One of the constructs of uncertainty along a supply chain is internal uncertainty. To evaluate internal uncertainty, six variables have been identified whereby six questions have been included to the survey. Table 4-14 shows descriptive statistics for internal uncertainty.

Table 4-14: Descriptive statistics of Internal Uncertainty

Descriptives	IU1	IU2	IU3	IU4	IU5	IU6
Mean	4.96	4.69	5.2	5.13	5.2	5
Median	5	5	5	5	5	5
Std. Deviation	1.357	1.362	1.17	1.329	1.33	1.32
Skewness	-0.501	-0.629	-0.599	-0.549	-0.832	-0.694
Kurtosis	-0.111	0.254	0.033	-0.483	0.285	0.353

The mean of all variables of internal uncertainty is above the midpoint, 4. It indicates in today's business environment, the overall internal uncertainty is high for all company and supply chain types.

Minimum internal uncertainty of 1 and maximum 7 show companies with the entire range of internal uncertainty exist in the current study.

Skewness and Kurtosis of all internal uncertainty variables are within the range of -2 to +2. Therefore, departure from normality is not expected. However, statistical analysis should be carried out to ensure the normality assumption is not violated.

4.2.4 Leagility Index

As explained in research methodology, to evaluate supply chain strategy, the author has developed a new index named as Deviation from Leagility (DFL). DFL is calculated from Leagility index. To evaluate leagility index, six variables have been identified whereby six questions have been included to the survey.

Table 4-15: Descriptive statistics of Leagility Index

Descriptives	LI1	LI2	LI3	LI4	LI5	LI6
Mean	3.57	3.76	3.46	3.56	3.31	3.38
Median	4	4	4	4	4	4
Std. Deviation	1.999	1.862	2.121	1.933	1.719	1.948
Skewness	0.131	0.187	0.196	0.166	0.12	0.263
Kurtosis	-1.322	-0.977	-1.389	-1.255	-1.131	-1.16

Table 4-15 shows descriptive statistics for leagility index. The mean of all leagility index variables is less than the midpoint, 4. Although all market segments with different uncertainty levels have been participated in the current study, it seems that the magnitude of leanness is more than agility in supply chain of majority of companies. It shows hyper-competition forced the companies to invest heavily on cost reduction and make their processes leaner.

Minimum internal uncertainty of 1 and maximum 7 show companies with the entire range of leagility index exist in the current study.

Skewness and Kurtosis of all leagility index variables are within the range of -2 to +2. Therefore, departure from normality is not expected. However, statistical analysis should be carried out to ensure the normality assumption is not violated.

4.2.5 Performance

To measure the effectiveness of supply chain strategies, overall performance of the company has been comparatively measured.

Table 4-16: Descriptive statistics of Performance

Descriptives	P1	P2	P3	P4	P5
Mean	3.66	3.36	3.47	3.62	2.31
Median	4	3	4	4	2
Std. Deviation	1.061	1.119	1.103	1.139	1.352
Skewness	0.13	0.062	0.109	0.053	0.382
Kurtosis	-0.342	-0.553	-0.26	-0.498	-0.059

To evaluate overall performance of the company, five variables have been identified whereby five questions have been included to the survey. As shown in Table 4-16, the average score of performance is less than midpoint, 4. It indicates opportunities of improvement including optimisation of supply chain design exist in many companies.

Skewness and Kurtosis of all performance variables are within the range of -2 to +2. Therefore, departure from normality is not expected. However, statistical analysis should be carried out to ensure the normality assumption is not violated.

4.2.6 Customers' expectation

External factors including customers' expectation are key drivers requiring special attention when supply chain strategy is developed. To evaluate customers' expectation, four variables have been identified whereby four questions have been included to the survey. Table 4-17 shows descriptive statistics for customers' expectation.

Table 4-17: Descriptive statistics of Customers' expectation

Descriptives	CE1	CE2	CE3	CE4
Mean	4.43	4.4	4.32	4.53
Median	5	5	4	5
Std. Deviation	1.948	1.237	1.952	1.916
Skewness	-0.339	-0.547	-0.255	-0.337
Kurtosis	-1.034	-0.521	-1.038	-1.017

The mean of all variables of customers' expectation is above the midpoint, 4. It indicates in today's business environment, the overall customers' expectation is high for all company and supply chain types.

Minimum customers' expectation of 1 and maximum 7 show companies with the entire range of customers' expectation exist in the current study.

Skewness and Kurtosis of all customers' expectation variables are within the range of -2 to +2. Therefore, departure from normality is not expected. However, statistical analysis should be carried out to ensure the normality assumption is not violated.

4.2.7 Competition Intensity

Another crucial external factor which requires special attention when supply chain strategy is developed, is competition intensity. To evaluate competition intensity, six variables have been identified whereby six questions have been included to the survey. Table 4-18 shows descriptive statistics for competition intensity.

Table 4-18: Descriptive statistics of Competition Intensity

Descriptives	CI1	CI2	CI3	CI4	CI5	CI6
Mean	4.4	4.37	4.36	4.44	3.43	3.61
Median	5	5	5	5	3	4
Std. Deviation	1.985	1.962	1.979	1.926	1.731	1.766
Skewness	-0.303	-0.245	-0.295	-0.307	0.077	-0.093
Kurtosis	-1.096	-1.046	-1.019	-0.995	-1.252	-1.288

The mean of CI1, CI2, CI3, and CI4 variables of competition intensity is above the midpoint, 4. It indicates for these variables, the overall competition intensity is high for all types of companies. However, the mean of CI5 and CI6 is under the midpoint indicating that judging about competition intensity requires detailed statistical analysis.

Minimum competition intensity of 1 and maximum 7 show the entire range of competition intensity exist in the current study. Skewness and Kurtosis of all competition intensity variables are within the range of -2 to +2. Therefore, departure from normality is not expected. However, statistical analysis should be carried out to ensure the normality assumption is not violated.

4.2.8 Market Segment

As explained in research methodology chapter, complementary analysis would be undertaken to compare the research model per market segments. Therefore, segment of market the companies are operating is measured. To evaluate market segment, five variables have been identified whereby five questions have been included to the survey. Table 4-19 shows descriptive statistics for market segment.

Table 4-19: Descriptive statistics of Market Segment

Descriptives	MS1	MS2	MS3	MS4	MS5
Mean	3.62	3.96	3.22	3.98	3.94
Median	4	4	3	4	4
Std. Deviation	1.665	1.746	1.481	1.762	1.667
Skewness	0.107	-0.05	0.395	-0.142	-0.083
Kurtosis	-0.929	-1.094	-0.512	-0.995	-1.002

The mean of all variables of market segment is less than midpoint, 4. It indicates the majority of companies participated in this study are operating in low cost market than premium market.

Minimum market segment of 1 and maximum 7 show companies operating in the entire range of market exist in the current study.

Skewness and Kurtosis of all market segment variables are within the range of -2 to +2. Therefore, departure from normality is not expected. However, statistical analysis should be carried out to ensure the normality assumption is not violated.

4.3 **Normality**

In statistical analysis, the commonly used distribution is the normal distribution. In fact, one of the crucial assumptions to run the most parametric statistical analysis is the sample distributes normally.

Parametric statistical tests generally consider the test sample is taken from a population which is normally distributed. It is the reason for taking the assumption that parametric tests are more reliable than the same non-parametric test. In addition, parametric tests are able to identify variances with smaller sample sizes, or identify smaller variations with the similar sample size.

Naturally, numerous variables are distributing normally. However, it is always recommended to test the sample distribution through either statistical tests and or statistical plots. In the current study, two statistical tests have been used for testing normality:

Kolmogorov-Smirnov test

Kolmogorov-Smirnov test is one of the empirical distribution function (EDF) type test. In EDF tests generally the biggest vertical distance between the normal cumulative distribution function (CDF) and the sample cumulative frequency distribution is calculated.

Shapiro-Wilk test

Shapiro-Wilk test is one of the regression-type tests. In this test, the correlation of sample order statistics with a normal distribution is calculated. Shapiro-Wilk is one of the most precise normality tests whereby insignificant departures from normality could be identified. The Shapiro-Wilk works significantly more efficient for smaller sample size. It is recommended to use Shapiro-Wilk test on samples up to 5,000 observations.

4.3.1 Demand Uncertainty

Table 4-20 presents the result of Kolmogorov-Smirnov and Shapiro-Wilk normality tests on demand uncertainty variables. P-value of all variables for both tests is less than 0.05 indicating significant departure from normality.

Table 4-20: Test of Normality - Demand Uncertainty

	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
DU1	.208	299	.000	.924	299	.000
DU2	.211	299	.000	.909	299	.000
DU3	.197	299	.000	.912	299	.000
DU4	.213	299	.000	.906	299	.000
DU5	.205	299	.000	.922	299	.000

4.3.2 Supply Uncertainty

Table 4-21 presents the result of Kolmogorov-Smirnov and Shapiro-Wilk normality tests on supply uncertainty variables. P-value of all variables for both tests is less than 0.05 indicating significant departure from normality.

Table 4-21: Test of Normality - Supply Uncertainty

	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
SU1	.220	299	.000	.912	299	.000
SU2	.189	299	.000	.909	299	.000
SU3	.197	299	.000	.922	299	.000
SU4	.197	299	.000	.917	299	.000
SU5	.198	299	.000	.908	299	.000

4.3.3 Internal Uncertainty

Table 4-22 presents the result of Kolmogorov-Smirnov and Shapiro-Wilk normality tests on internal uncertainty variables. P-value of all variables for both tests is less than 0.05 indicating significant departure from normality.

Table 4-22: Test of Normality - Internal Uncertainty

	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
IU1	.160	299	.000	.923	299	.000
IU2	.177	299	.000	.918	299	.000
IU3	.208	299	.000	.904	299	.000
IU4	.204	299	.000	.906	299	.000
IU5	.230	299	.000	.880	299	.000
IU6	.181	299	.000	.914	299	.000

4.3.4 Leagility Index

Table 4-23 presents the result of Kolmogorov-Smirnov and Shapiro-Wilk normality tests on leagility index variables. P-value of all variables for both tests is less than 0.05 indicating significant departure from normality.

Table 4-23: Test of Normality - Leagility Index

	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
LI1	.185	299	.000	.898	299	.000
LI2	.133	299	.000	.932	299	.000
LI3	.192	299	.000	.871	299	.000
LI4	.211	299	.000	.898	299	.000
LI5	.189	299	.000	.907	299	.000
LI6	.196	299	.000	.896	299	.000

4.3.5 Performance

Table 4-24 presents the result of Kolmogorov-Smirnov and Shapiro-Wilk normality tests on performance variables. P-value of all variables for both tests is less than 0.05 indicating significant departure from normality.

Table 4-24: Test of Normality - Performance

	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
P1	.189	299	.000	.918	299	.000
P2	.191	299	.000	.922	299	.000
P3	.188	299	.000	.923	299	.000
P4	.199	299	.000	.922	299	.000
P5	.152	299	.000	.935	299	.000

4.3.6 Customers' expectation

Table 4-25 presents the result of Kolmogorov-Smirnov and Shapiro-Wilk normality tests on customers' expectation variables. P-value of all variables for both tests is less than 0.05 indicating significant departure from normality.

Table 4-25: Test of Normality - Customers' expectation

	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
CE1	.147	299	.000	.913	299	.000
CE2	.202	299	.000	.880	299	.000
CE3	.132	299	.000	.918	299	.000
CE4	.162	299	.000	.913	299	.000

4.3.7 Competition Intensity

Table 4-26 presents the result of Kolmogorov-Smirnov and Shapiro-Wilk normality tests on competition intensity variables. P-value of all variables for both tests is less than 0.05 indicating significant departure from normality.

Table 4-26: Test of Normality - Competition Intensity

	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
CI1	.154	299	.000	.910	299	.000
CI2	.131	299	.000	.916	299	.000
CI3	.131	299	.000	.911	299	.000
CI4	.156	299	.000	.917	299	.000
CI5	.140	299	.000	.903	299	.000
CI6	.136	299	.000	.896	299	.000

4.3.8 Market Segment

Table 4-27 presents the result of Kolmogorov-Smirnov and Shapiro-Wilk normality tests on market segment variables. P-value of all variables for both tests is less than 0.05 indicating significant departure from normality.

Table 4-27: Test of Normality - Market Segment

	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
MS1	.125	299	.000	.939	299	.000
MS2	.155	299	.000	.935	299	.000
MS3	.178	299	.000	.931	299	.000
MS4	.154	299	.000	.937	299	.000
MS5	.146	299	.000	.939	299	.000

4.4 **Non-Response Bias**

Lambert and Harrington (1990) provided a definition for non-response bias as the difference between the answers of non-respondents and respondents. In this study, non-response bias was assessed through comparing the responses of first and second waves of returned surveys (Armstrong & Overton 1977; Krause, Pagell & Curkovic 2001; Narasimhan & Das 2001; Stanley & Wisner 2001).

As explained in the research methodology chapter, the first wave of responses is related to 175 completed surveys gathered by Nine Rewards Company. The second wave comprises of 124 completed questionnaires from other resources including LinkedIn and Australian Universities' suppliers. Non-responsive bias has been tested over three main constructs of the research model: Uncertainty, DFL, and Performance.

Since the normality assumption is violated, parametric t-test is not suitable for analysis of non-response bias. Hence, Non-Parametric Two Independent Mann-Whitney test has been utilised.

4.4.1 Uncertainty

Smart PLS software is utilised to generate the scores of overall uncertainty from its constructs (demand, supply, and internal uncertainty). Table 4-28 presents the mean rank of overall uncertainty for the first and second waves of responses as 146.12 and 155.47 respectively.

Table 4-28: Non-Response Bias – Overall uncertainty ranks for two waves of responses

	Group	N	Mean Rank	Sum of Ranks
Unc_Ovr	1	175	146.12	25571.50
	2	124	155.47	19278.50
	Total	299		

Non-Parametric Two Independent Mann-Whitney Test has been utilizes to investigate whether the mean rank of overall uncertainty for two waves is statistically different.

Table 4-29: Non-Parametric Two Independent Mann-Whitney Test - Overall Uncertainty

	Unc_Ovr
Mann-Whitney U	10171.500
Wilcoxon W	25571.500
Z	-.921
Asymp. Sig. (2-tailed)	.357

Table 4-29 presents the outcome of Mann-Whitney test on two groups of responses for overall uncertainty. Since P-value (0.357) is more than 0.05, it could be concluded that there is no statistically significant difference between the mean ranks of two waves of responses (at 95% confidence interval).

4.4.2 DFL

As explained in research methodology chapter, DFL is calculated from leagility index scores. The average of DFL variables' scores is calculated for the non-response bias test. Table 4-30 presents the mean rank of deviation from leagility for the first and second waves of responses as 146.68 and 154.68 respectively.

Table 4-30: Non-Response Bias - DFL ranks for two waves of responses

	Group	N	Mean Rank	Sum of Ranks
DFL_Avr	1	175	146.68	25669.50
	2	124	154.68	19180.50
	Total	299		

Non-Parametric Two Independent Mann-Whitney Test has been utilizes to investigate whether the mean rank of DFL for two waves is statistically different.

Table 4-31: Non-Parametric Two Independent Mann-Whitney Test - DFL

	DFL_Avr
Mann-Whitney U	10269.500
Wilcoxon W	25669.500
Z	-.791
Asymp. Sig. (2-tailed)	.429

Table 4-31 presents the outcome of Mann-Whitney test on two groups of responses for deviation from leagility. Since P-value (0.429) is more than 0.05, it could be concluded that there is no statistically significant difference between the mean ranks of two waves of responses (at 95% confidence interval).

4.4.3 Performance

The average of performance variables' scores is calculated for the non-response bias test. Table 4-32 presents the mean rank of performance for the first and second waves of responses as 147.21 and 153.94 respectively.

Table 4-32: Non-Response Bias - Performance ranks for two waves of responses

	Group	N	Mean Rank	Sum of Ranks
P_Avr	1	175	147.21	25761.00
	2	124	153.94	19089.00
	Total	299		

Non-Parametric Two Independent Mann-Whitney Test has been utilizes to investigate whether the mean rank of performance for two waves is statistically different.

Table 4-33: Non-Parametric Two Independent Mann-Whitney Test - Performance

	P_Avr
Mann-Whitney U	10361.000
Wilcoxon W	25761.000
Z	-.666
Asymp. Sig. (2-tailed)	.506

Table 4-33 presents the outcome of Mann-Whitney test on two groups of responses for performance. Since P-value (0.506) is more than 0.05, it could be concluded that there is no statistically significant difference between the mean ranks of two waves of responses (at 95% confidence interval).

4.5 **Reliability**

The reliability of a measure indicates the extent to which it is without bias (error free) and hence ensures consistent measurements across time and across the various items in the instrument. In other words, the reliability of a measure is an indication of the stability and consistency with which the instrument measures the concept and helps to assess the goodness of a measure. In this study, Cronbach Alpha which is a perfectly adequate index of inter-item consistency reliability is utilised.

Detailed result of reliability analysis for each construct of the research model is presented in Appendix 6: Reliability, Consistency, and Stability of the Measurement Model. A summary of the Cronbach's Alpha statistics for all constructs is provided in Table 4-34. This is the preliminary evaluation of reliability and it will be tested along with factor loadings through PLS analysis.

Table 4-34: Reliability Statistics – Cronbach's Alpha

Construct	Cronbach's Alpha	Cronbach's Alpha Based on Standardised Items	N of Items
Demand Uncertainty	.721	.734	5
Supply Uncertainty	.760	.761	5
Internal Uncertainty	.633	.636	6
Leagility Index	.965	.966	6
DFL	.805	.806	6
Competition Intensity	.871	.871	6
Customers' expectation	.819	.829	4
Performance	.763	.775	5
Market Segment	.860	.856	5

As presented above, the value of Cronbach's Alpha for all measurement instruments is above the acceptable limit (0.6). It indicates satisfactory levels of stability and internal consistency of the constructs' variables exist.

Although the measurement tools has been identified stable, further analysis is required to ensure how Cronbach's Alpha is impacted if one of the variables is removed from a measurement tool. The details of the complementary analysis are provided in

Appendix 6: Reliability, Consistency, and Stability of the Measurement Model. The analysis for all constructs indicates there is no or insignificant improvement is Cronbach's Alpha where one variable is removed from the scale. Therefore, the current structure of variables for all constructs is preserved for this stage and further investigation regarding the factor loading of each variable will be undertaken when SEM model is analysed.

The other issue which should be investigated for a measurement model is inter-item correlation. If correlation among two variables which are utilised to measure a construct would be high, the variables could be replaced by one another. Therefore, correlation among variables of each construct is measured and presented in correlation matrixes in Appendix 6: Reliability, Consistency, and Stability of the Measurement Model. The value of correlation coefficients for the variables of all constructs indicates that none of the variables are highly correlated.

4.6 **Summary**

The screening questions have filtered the respondents to only qualified executives with minimum three years' work experience who are either working in manufacturing industry or dealing with the management (demand/supply/distribution) of manufacturing products.

Demographic analysis indicated that 94.3% of the respondents are working in managerial level. In other words, majority of respondents are highly qualified to express their ideas regarding supply chain strategy. In addition, the education level of more than 50% of respondents is bachelor and certificate. It shows a considerable opportunity of improvement exists in Australian firms if scientific methods of supply chain management are utilised. Majority of participants are highly experienced (87.3% > 5 years; 39.46% > 25 years' work experience) which is a decent indication of utilising qualified participants in the current study.

In excess of 10 industries have been explored in the current research and the fragmentation of sectors is suitable indicating that the findings of the study could be applicable to a vast range of industries. Looking into the establishment date of companies revealed that majority of companies (85.28%) has been set up for more than ten years indicating that majority of companies have been established for long enough to pass the initial stages of business life cycle. Annual revenue and number of employees have been considered to estimate the size of companies which have been involved in this study. Both indicators demonstrated that a vast range of company sizes (small, medium, and large size) has been engaged in the study. Therefore, the outcome of the study could be generalised irrespective of size of the company.

Descriptive analysis provides primary outlines regarding the measures and the samples. For example, the mean of all variables of uncertainty constructs (demand, supply, and internal uncertainties) is above the mid-point (4) of Likert Scale indicating that overall uncertainty in today's business environment is high.

As normality distribution of variables involved in this study has been evaluated as it is one of the prerequisites of a range of analysis methods. As per the outcome of normality test, there is a significant departure from normality for all variables involved in the research model. Therefore, a variance-based SEM such as Partial least squares Modelling would be the preferred method of analysis compared to covariance-based SEM methods which require the variables to be normally distributed.

When data is collected over multiple time frames, non-response test is carried out to ensure there is no significant difference between them. In this study, non-response bias was assessed through comparing the responses of first and second waves of returned surveys and no significant difference has been identified.

In order to evaluate the reliability of the measurement instrument, the value of Cronbach's Alpha which is a perfectly adequate index of inter-item consistency reliability, was calculated for all constructs. As the value was above the acceptable limit (0.6) for all constructs, satisfactory levels of stability and internal consistency of the constructs' variables exist.

CHAPTER 5: MODEL ANALYSIS AND FINDINGS

This chapter presents the results and discussion of the methods outlined in chapter 3, Research Methodology. Sections of this chapter include: (a) analysis of the main model and interpretation of results, (b) the outcome of complementary analysis including moderation effect and investigation into the market segment.

5.1 Method of Analysis

To calculate the parameters of a structural equation modelling (SEM), there are normally two approaches: the covariance-based method and the variance-based (or components-based) method (Haenlein & Kaplan 2004). There is a casual attitude to use the term SEM as a synonym for covariance-based SEM. There are several different tools available in the form of software packages to perform this sort of analysis including AMOS, EQS, SEPATH, and COSAN, and LISREL.

On the other side, one of the well-accepted methods of variance-based SEM is partial least squares (PLS) path modelling. There are different tools available to perform PLS analysis including Smart PLS and PLS graph.

When covariance-based SEM reaches to its limitations, variance-based SEM would be the appropriate method of analysis. PLS has the advantage that it "involves no assumptions about the population or scale of measurement" (Haenlein & Kaplan 2004) and eventually works with no need for distributional assumptions. PLS also works better when sample size is small.

5.1.1 Normality

Another frequently cited reason to choose PLS or SEM as a method of analysis involves the assumptions requirements regarding the distribution of data. For majority of techniques employing by SEM such as Maximum Likelihood, normal distribution for data is a preliminary assumption whereas no distributional assumptions is required for PLS path modelling (Shackman 2013). In other words, estimation of parameters in SEM would be accurate on condition that data meets certain normal distribution requirements. On the other hand, computation of the parameters in PLS does not require normally distributed data.

As per the outcome of normality test performed earlier, there is a significant departure from normality for all variables involved in this study. Therefore, PLS as a method of analysis has been selected for the current study.

5.1.2 Sample Size

There is an ad hoc rule to select the minimum sample size for structural equation modelling. Since the early 1990s, researchers have referred to an ad hoc rule of thumb indicating minimum ten observations per indicator are required for the sufficiency of sample sizes. Although several frequently cited publications referred to this ad hoc rule, there are few studies refer to the original book published by Nunnally (1967).

The research model of the current study includes 33 indicators including one of the moderators' variables. Therefore, to consider covariance-based SEM as an appropriate method of analysis, minimum 330 observations are required to ensure the accuracy of analysis outcomes. Since 299 samples have been collected in this research, it seems using structural equation modelling as a method of analysis would be inappropriate. As mentioned earlier, PLS offers several potential benefits to business researchers including the smaller sample size requirements (Shackman 2013). Therefore, PLS seems to be a more appropriate method of analysis for this study.

5.2 **Analysis of the Research Model**

In this study, SmartPLS V 2.0 has been selected to perform PLS path modelling analysis (Ringle, Wende & Will 2005). SmartPLS is a software application for (graphical) path modelling with latent variables (LVP). The partial least squares (PLS)-method is used for the LVP-analysis.

The structural model of this study has been built in SmartPLS software (Figure 5-1). Three main constructs – uncertainty, DFL, and performance – have been created with their variables. As uncertainty is a second order construct, demand, supply, and internal uncertainty constructs have been included to the model.

5.2.1 Structural Model 1 – Model Estimates

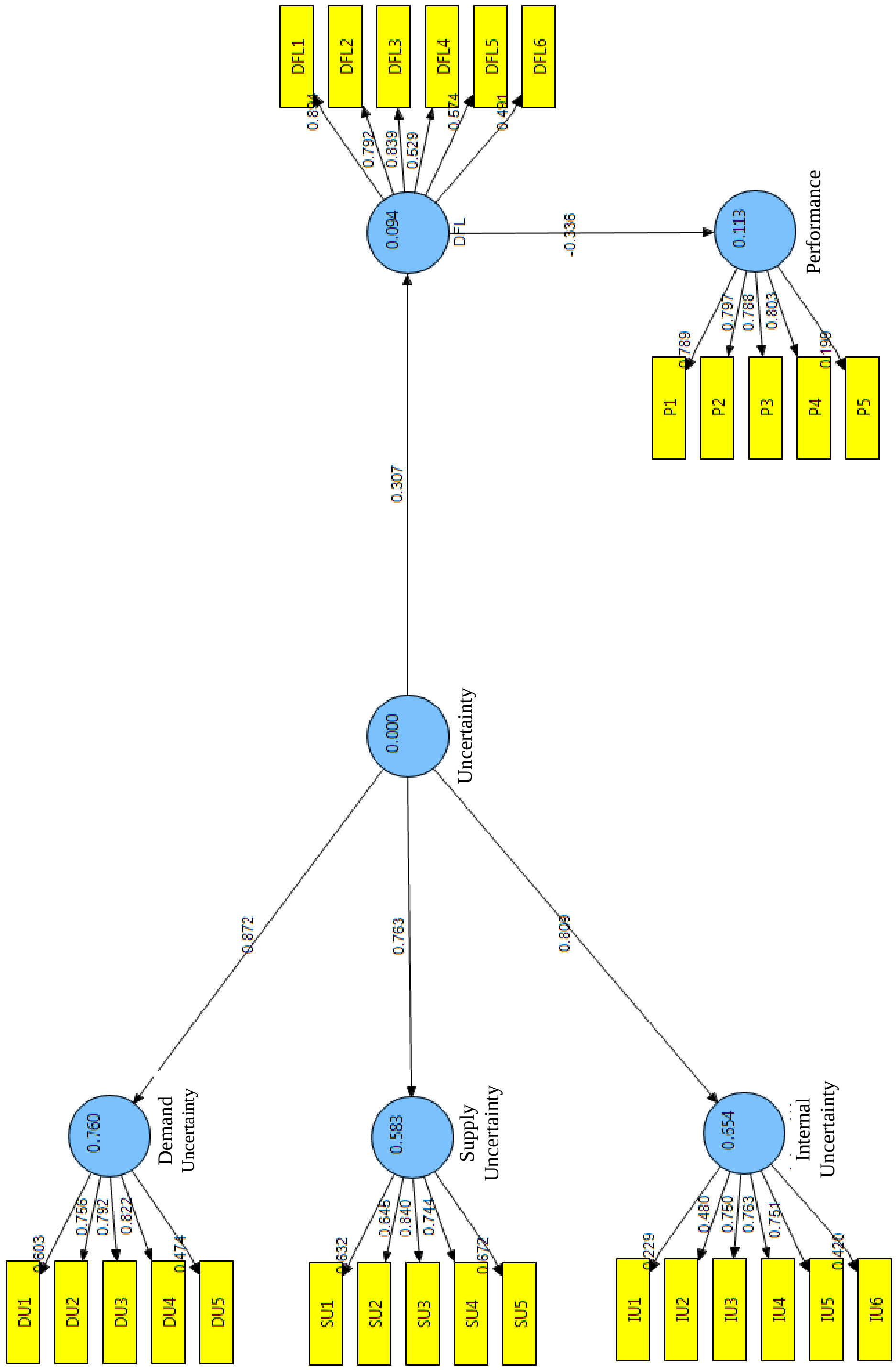

Figure 5-1: Structural Model 1 – Model Estimates

I) Factor Loadings

Table 5-1 presents the factor loadings for the structural model 1.

Table 5-1: Structural Model 1 - Factor Loadings

	DFL	Demand Uncertainty	Internal Uncertainty	Performance	Supply Uncertainty
DFL1	0.8936	0	0	0	0
DFL2	0.7918	0	0	0	0
DFL3	0.8387	0	0	0	0
DFL4	0.5286	0	0	0	0
DFL5	0.5745	0	0	0	0
DFL6	0.4914	0	0	0	0
DU1	0	0.6033	0	0	0
DU2	0	0.7562	0	0	0
DU3	0	0.7915	0	0	0
DU4	0	0.8224	0	0	0
DU5	0	0.4737	0	0	0
IU1	0	0	0.2286	0	0
IU2	0	0	0.4801	0	0
IU3	0	0	0.7499	0	0
IU4	0	0	0.7634	0	0
IU5	0	0	0.7507	0	0
IU6	0	0	0.4204	0	0
P1	0	0	0	0.7885	0
P2	0	0	0	0.7972	0
P3	0	0	0	0.7884	0
P4	0	0	0	0.8031	0
P5	0	0	0	0.1991	0
SU1	0	0	0	0	0.6317
SU2	0	0	0	0	0.645
SU3	0	0	0	0	0.8396
SU4	0	0	0	0	0.7438
SU5	0	0	0	0	0.672

As explained in research methodology chapter, the convergent validity would be supported if the factor loadings between the construct and each related variable are 0.7 or more (Carmines & Zeller 1979; Hulland 1999). As highlighted above, factor loading of some variables do not meet the criteria. Variables with lowest factor loading will be removed from the model and analysis will be performed to the point that convergent validity would be established.

II) Path Coefficients

As uncertainty is a second order construct, the factor loading between the first order constructs (demand, supply, and internal uncertainty) are also should meet the convergent validity criteria. As shown in Table 5-2, the factor loading of uncertainty constructs are more than the threshold (0.7).

Table 5-2: Structural Model 1 - Path Coefficients

	DFL	Demand Uncertainty	Internal Uncertainty	Performance	Supply Uncertainty
DFL	0	0	0	-0.3364	0
Demand Uncertainty	0	0	0	0	0
Internal Uncertainty	0	0	0	0	0
Performance	0	0	0	0	0
Supply Uncertainty	0	0	0	0	0
Uncertainty	0.3072	0.8717	0.8089	0	0.7633

III) Quality Criteria

As explained in research methodology chapter, in order to assess the internal consistency of the measurement items, average variance extracted (AVE), composite reliability, and Cronbach's Alpha should be assessed. The minimum value for the composite reliability and Cronbach's Alpha is considered as 0.7 and the value of AVE above 0.5 is deemed to satisfactory. As shown in Table 5-3, there are serious issues with quality criteria for structural model 1. Therefore, the items with low factor loading will be removed from the model to achieve desired internal consistency.

Table 5-3: Structural Model 1 - Quality Criteria

	AVE	Composite Reliability	R Square	Cronbach's Alpha	Communality	Redundancy
DFL	0.4966	0.8489	0.0944	0.8062	0.4966	0.0435
Demand Uncertainty	0.4926	0.8241	0.7599	0.7338	0.4926	0.3694
Internal Uncertainty	0.3614	0.7503	0.6543	0.6363	0.3614	0.2301
Performance	0.5127	0.8239	0.1131	0.7748	0.5127	0.0472
Supply Uncertainty	0.505	0.8345	0.5826	0.7608	0.505	0.2763
Uncertainty	0.2928	0.8551	0	0.8196	0.2928	0

5.2.2 Structural Model 1 - Bootstrapping

As depicted in Figure 5-2, the stability of the estimates was tested via a bootstrap re-sampling procedure (5000 sub-samples).

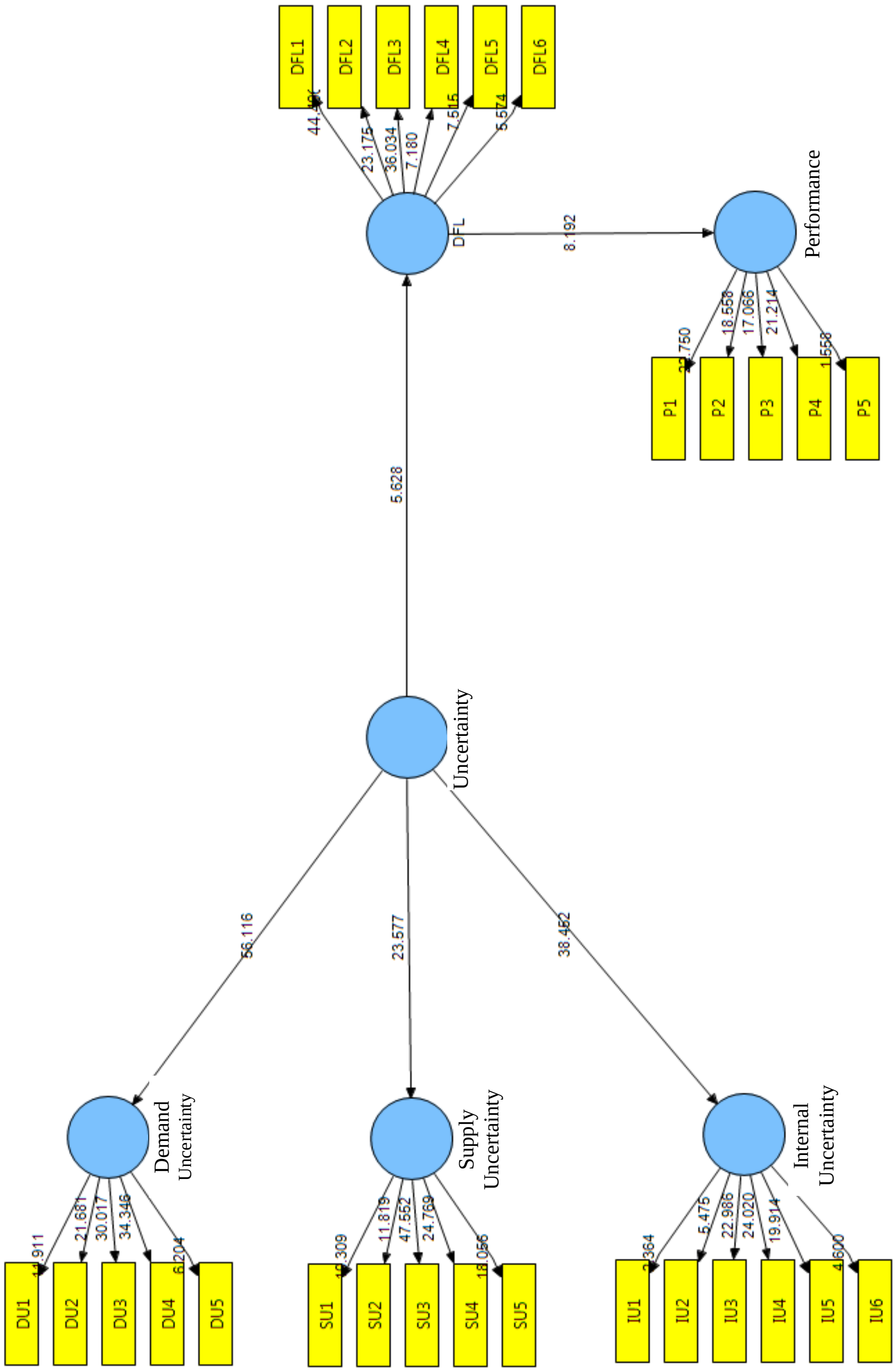

Figure 5-2: Structural Model 1 - Bootstrapping

I) t-Statistics

Table 5-4 presents t-statistics for the estimates of variables to constructs as a result of bootstrapping process. As highlighted below, t-statistic of P5 to Performance estimate is less than 1.96 indicating the estimate is not stable and should be removed.

Table 5-4: Structural Model 1 - Bootstrapping - t-Statistics

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	t Statistics (|O/STERR|)
DFL1 <- DFL	0.8936	0.891	0.0201	0.0201	44.4056
DFL2 <- DFL	0.7918	0.7889	0.0342	0.0342	23.1754
DFL3 <- DFL	0.8387	0.8362	0.0233	0.0233	36.0341
DFL4 <- DFL	0.5286	0.5232	0.0736	0.0736	7.1804
DFL5 <- DFL	0.5745	0.5709	0.0764	0.0764	7.5148
DFL6 <- DFL	0.4914	0.4867	0.0881	0.0881	5.5742
DU1 <- Demand Uncertainty	0.6033	0.6003	0.0507	0.0507	11.9105
DU2 <- Demand Uncertainty	0.7562	0.7559	0.0349	0.0349	21.681
DU3 <- Demand Uncertainty	0.7915	0.7915	0.0264	0.0264	30.017
DU4 <- Demand Uncertainty	0.8224	0.8225	0.0239	0.0239	34.3458
DU5 <- Demand Uncertainty	0.4737	0.4699	0.0764	0.0764	6.2041
IU1 <- Internal Uncertainty	0.2286	0.2235	0.0967	0.0967	2.3635
IU2 <- Internal Uncertainty	0.4801	0.4734	0.0877	0.0877	5.475
IU3 <- Internal Uncertainty	0.7499	0.7493	0.0326	0.0326	22.9858
IU4 <- Internal Uncertainty	0.7634	0.763	0.0318	0.0318	24.02
IU5 <- Internal Uncertainty	0.7507	0.7485	0.0377	0.0377	19.9136
IU6 <- Internal Uncertainty	0.4204	0.4149	0.0914	0.0914	4.5999
P1 <- Performance	0.7885	0.7851	0.0347	0.0347	22.7501
P2 <- Performance	0.7972	0.7873	0.043	0.043	18.5576
P3 <- Performance	0.7884	0.7801	0.0462	0.0462	17.066

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	t Statistics (|O/STERR|)
P4 <- Performance	0.8031	0.798	0.0379	0.0379	21.2145
P5 <- Performance	0.1991	0.1863	0.1278	0.1278	1.558
SU1 <- Supply Uncertainty	0.6317	0.6267	0.0613	0.0613	10.3085
SU2 <- Supply Uncertainty	0.645	0.6409	0.0546	0.0546	11.8186
SU3 <- Supply Uncertainty	0.8396	0.8405	0.0177	0.0177	47.5525
SU4 <- Supply Uncertainty	0.7438	0.7434	0.03	0.03	24.769
SU5 <- Supply Uncertainty	0.672	0.6722	0.0372	0.0372	18.0556

II) t-Statistics Constructs

Table 5-5 displays t-statistics for the construct to construct estimates of the structural model 1 as a result of bootstrapping process. As highlighted below, all t-statistics are above 1.96, indicating estimates are stable.

Table 5-5: Structural Model 1 - Bootstrapping - t-Statistics Constructs

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	t Statistics (|O/STERR|)
DFL -> Performance	-0.3364	-0.3493	0.0411	0.0411	8.1915
Uncertainty -> DFL	0.3072	0.3126	0.0546	0.0546	5.6282
Uncertainty -> Demand Uncertainty	0.8717	0.8725	0.0155	0.0155	56.1157
Uncertainty -> Internal Uncertainty	0.8089	0.8119	0.021	0.021	38.4525
Uncertainty -> Supply Uncertainty	0.7633	0.7641	0.0324	0.0324	23.5771

5.2.3 Structural Model 2 – Model Estimates

As per information provided by analysis of structural model 1, variables with low factor loadings (DU5, SU1, IU1, DFL6, and P5) have been removed from the model. Figure 5-3depicts estimates of the structural model 2.

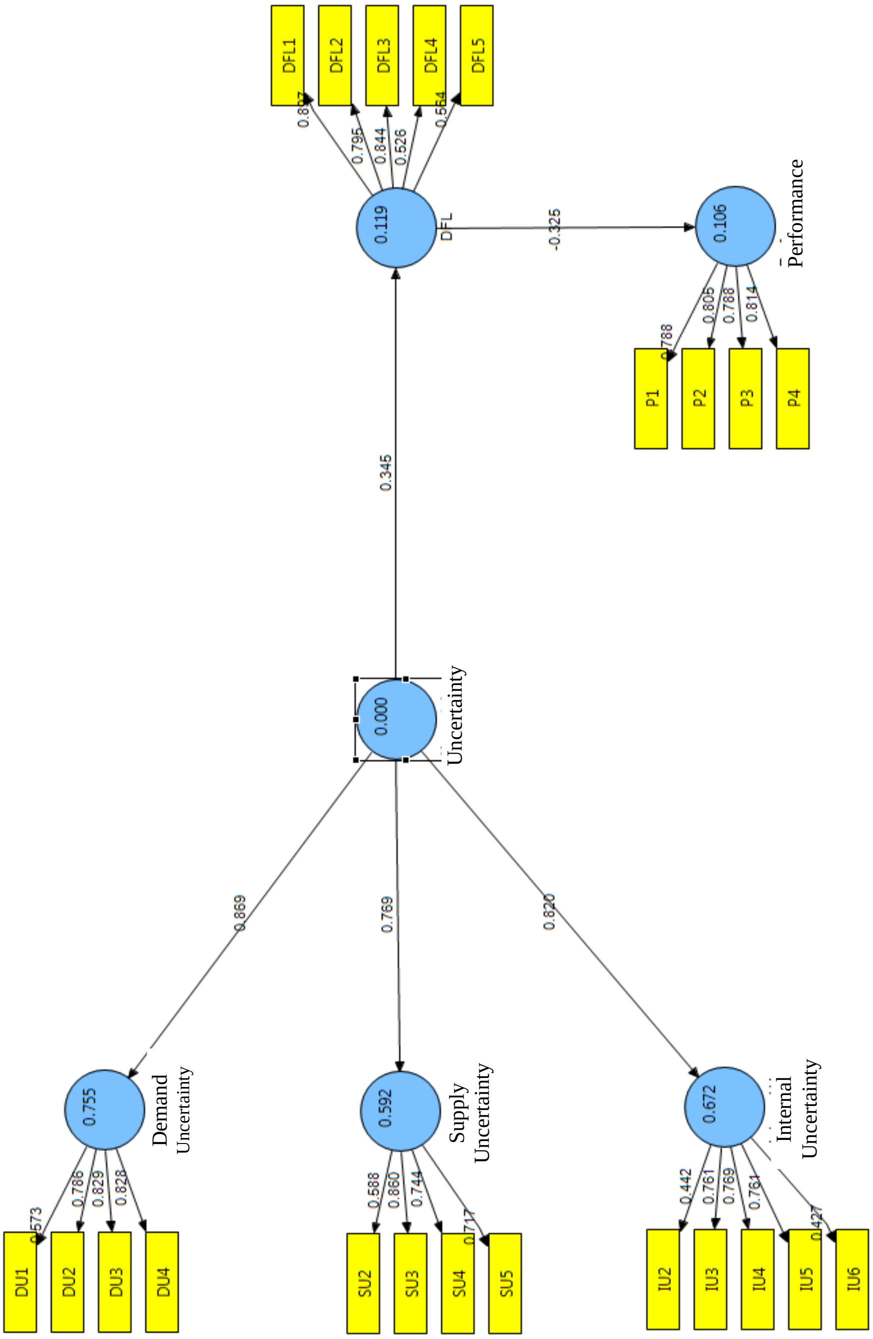

Figure 5-3: Structural Model 2 – Model Estimates

I) Factor Loadings

Table 5-6 presents factor loadings for structural model 2. As highlighted below, variables with low factor loadings still exist in the model 2. Therefore, analysis should be redone after removing the low factor loading variables from the model.

Table 5-6: Structural Model 2 - Factor Loadings

	DFL	Demand Uncertainty	Internal Uncertainty	Performance	Supply Uncertainty
DFL1	0.8971	0	0	0	0
DFL2	0.7954	0	0	0	0
DFL3	0.8444	0	0	0	0
DFL4	0.5259	0	0	0	0
DFL5	0.5637	0	0	0	0
DU1	0	0.5732	0	0	0
DU2	0	0.7856	0	0	0
DU3	0	0.8291	0	0	0
DU4	0	0.8285	0	0	0
IU2	0	0	0.4423	0	0
IU3	0	0	0.7613	0	0
IU4	0	0	0.7691	0	0
IU5	0	0	0.7607	0	0
IU6	0	0	0.4267	0	0
P1	0	0	0	0.7879	0
P2	0	0	0	0.8046	0
P3	0	0	0	0.7881	0
P4	0	0	0	0.8142	0
SU2	0	0	0	0	0.5883
SU3	0	0	0	0	0.8605
SU4	0	0	0	0	0.7442
SU5	0	0	0	0	0.7171

II) Path Coefficients

As uncertainty is a second order construct, the factor loading between the first order constructs (demand, supply, and internal uncertainty) should also meet the convergent validity criteria. As shown in Table 5-7, the factor loading of uncertainty constructs are more than the threshold (0.7).

Table 5-7: Structural Model 2 - Path Coefficients

	DFL	Demand Uncertainty	Internal Uncertainty	Performance	Supply Uncertainty
DFL	0	0	0	-0.3253	0
Demand Uncertainty	0	0	0	0	0
Internal Uncertainty	0	0	0	0	0
Performance	0	0	0	0	0
Supply Uncertainty	0	0	0	0	0
Uncertainty	0.3447	0.8686	0.8196	0	0.7695

III) Quality Criteria

As explained in research methodology chapter, in order to assess the internal consistency of the measurement items, average variance extracted (AVE), composite reliability, and Cronbach's Alpha should be assessed. The minimum value for the composite reliability and Cronbach's Alpha is 0.7 and the value of AVE above 0.5 is deemed to satisfactory. As shown in Table 5-8, there are serious issues with quality criteria for structural model 2. Therefore, the items with low factor loading will be removed from the model to achieve desired internal consistency.

Table 5-8: Structural Model 2 - Quality Criteria

	AVE	Composite Reliability	R Square	Cronbach's Alpha	Communality	Redundancy
DFL	0.5489	0.8536	0.1189	0.7888	0.5489	0.0641
Demand Uncertainty	0.5799	0.8441	0.7545	0.7552	0.5799	0.4328
Internal Uncertainty	0.4255	0.7766	0.6717	0.6528	0.4255	0.2802
Performance	0.638	0.8758	0.1058	0.8121	0.638	0.0658
Supply Uncertainty	0.5387	0.8211	0.5921	0.7135	0.5387	0.312
Uncertainty	0.3398	0.8604	0	0.8211	0.3398	0

5.2.4 Structural Model 2 - Bootstrapping

As depicted in Figure 5-4, the stability of the estimates was tested via a bootstrap re-sampling procedure (5000 sub-samples).

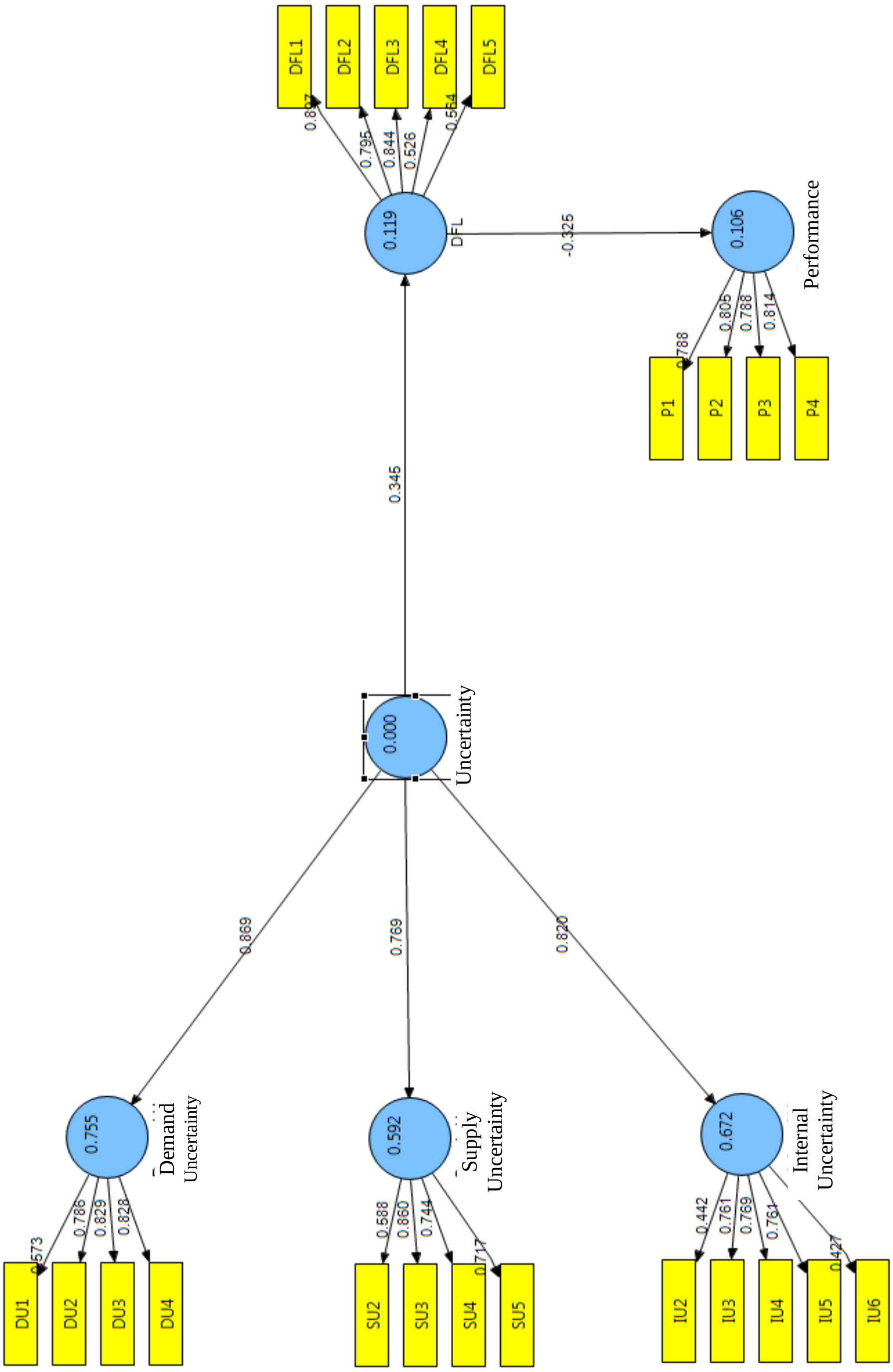

Figure 5-4: Structural Model 2 - Bootstrapping

I) t-Statistics

Table 5-9 presents t-statistics for the estimates of variables to constructs as a result of bootstrapping process. As highlighted below, t-statistic of all estimates is above 1.96 indicating that estimates are stable.

Table 5-9: Structural Model 2 - Bootstrapping - t-Statistics

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	t Statistics (|O/STERR|)
DFL1 <- DFL	0.8971	0.8961	0.017	0.017	52.859
DFL2 <- DFL	0.7954	0.7941	0.029	0.029	27.4494
DFL3 <- DFL	0.8444	0.8426	0.0227	0.0227	37.1209
DFL4 <- DFL	0.5259	0.5221	0.0674	0.0674	7.8016
DFL5 <- DFL	0.5637	0.5602	0.0681	0.0681	8.274
DU1 <- Demand Uncertainty	0.5732	0.5712	0.0527	0.0527	10.8776
DU2 <- Demand Uncertainty	0.7856	0.7846	0.0299	0.0299	26.2495
DU3 <- Demand Uncertainty	0.8291	0.8289	0.0209	0.0209	39.6514
DU4 <- Demand Uncertainty	0.8285	0.8286	0.0211	0.0211	39.3166
IU2 <- Internal Uncertainty	0.4423	0.4381	0.0828	0.0828	5.3444
IU3 <- Internal Uncertainty	0.7613	0.7601	0.029	0.029	26.2097
IU4 <- Internal Uncertainty	0.7691	0.7691	0.0314	0.0314	24.5205
IU5 <- Internal Uncertainty	0.7607	0.7589	0.0348	0.0348	21.8379
IU6 <- Internal Uncertainty	0.4267	0.4217	0.0907	0.0907	4.7072
P1 <- Performance	0.7879	0.7877	0.0333	0.0333	23.6615
P2 <- Performance	0.8046	0.8003	0.0353	0.0353	22.7705
P3 <- Performance	0.7881	0.7845	0.0413	0.0413	19.069
P4 <- Performance	0.8142	0.8133	0.0292	0.0292	27.8762
SU2 <- Supply Uncertainty	0.5883	0.5855	0.0575	0.0575	10.2291
SU3 <- Supply Uncertainty	0.8605	0.8603	0.0156	0.0156	55.0574
SU4 <- Supply Uncertainty	0.7442	0.7438	0.0324	0.0324	22.9929
SU5 <- Supply Uncertainty	0.7171	0.7165	0.0337	0.0337	21.2952

II) t-Statistics Constructs

Table 5-10 displays t-statistics for the construct to construct estimates of the structural model 2 as a result of bootstrapping process. As highlighted below, all t-statistics are above 1.96, indicating that estimates are stable.

Table 5-10: Structural Model 2 - Bootstrapping - t-Statistics Constructs

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	t Statistics (|O/STERR|)
DFL -> Performance	-0.3253	-0.3335	0.0489	0.0489	6.648
Uncertainty -> DFL	0.3447	0.3484	0.0505	0.0505	6.828
Uncertainty -> Demand Uncertainty	0.8686	0.8696	0.0154	0.0154	56.5695
Uncertainty -> Internal Uncertainty	0.8196	0.821	0.0207	0.0207	39.6763
Uncertainty -> Supply Uncertainty	0.7695	0.7696	0.0303	0.0303	25.3779

5.2.5 Structural Model 3 – Model Estimates

As per information provided by analysis of structural model 2, variables with low factor loadings (IU2, and DFL5) have been removed from the model. Figure 5-5 depicts estimates of the structural model 3.

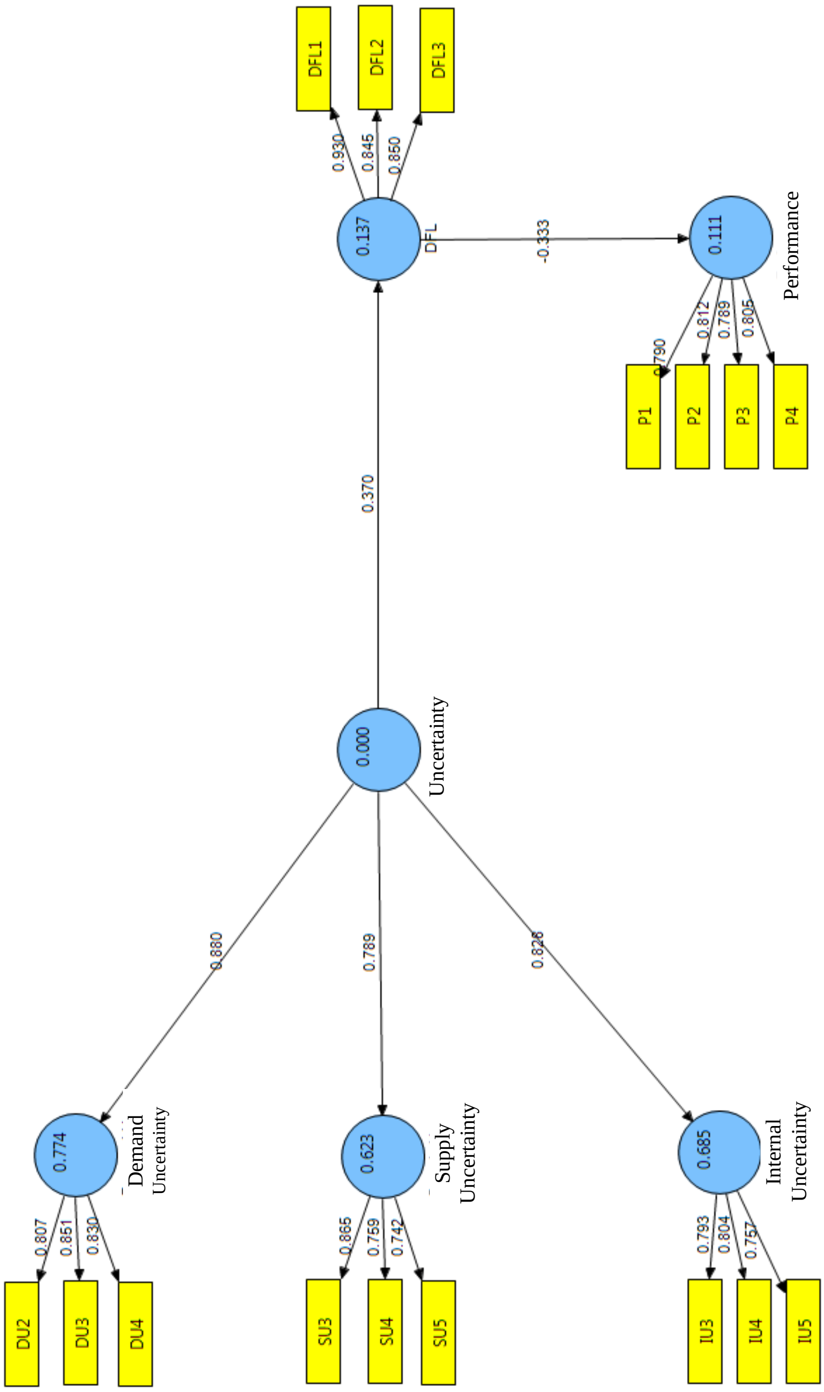

Figure 5-5: Structural Model 3 – Model Estimates

I) Factor Loadings

Table 5-11 presents factor loadings for structural model 3. As highlighted below, all factor loadings are above 0.7 indicating that measures have acceptable convergent validity.

Table 5-11: Structural Model 3 - Factor Loadings

	DFL	Demand Uncertainty	Internal Uncertainty	Performance	Supply Uncertainty
DFL1	0.9302	0	0	0	0
DFL2	0.8455	0	0	0	0
DFL3	0.8504	0	0	0	0
DU2	0	0.8071	0	0	0
DU3	0	0.8509	0	0	0
DU4	0	0.8301	0	0	0
IU3	0	0	0.7929	0	0
IU4	0	0	0.8036	0	0
IU5	0	0	0.7572	0	0
P1	0	0	0	0.7902	0
P2	0	0	0	0.8118	0
P3	0	0	0	0.789	0
P4	0	0	0	0.8049	0
SU3	0	0	0	0	0.865
SU4	0	0	0	0	0.7594
SU5	0	0	0	0	0.742

II) Path Coefficients

As uncertainty is a second order construct, factor loading between the first order constructs (demand, supply, and internal uncertainty) should also meet the convergent validity criteria. As shown in Table 5-12, the factor loading of uncertainty constructs are more than the threshold (0.7).

Table 5-12: Structural Model 3 - Path Coefficients

	DFL	Demand Uncertainty	Internal Uncertainty	Performance	Supply Uncertainty
DFL	0	0	0	-0.3326	0
Demand Uncertainty	0	0	0	0	0
Internal Uncertainty	0	0	0	0	0
Performance	0	0	0	0	0
Supply Uncertainty	0	0	0	0	0
Uncertainty	0.3699	0.8797	0.8279	0	0.7892

III) Quality Criteria

As explained in research methodology chapter, in order to assess the internal consistency of the measurement items, average variance extracted (AVE), composite reliability, and Cronbach's Alpha should be assessed. The minimum value for the composite reliability and Cronbach's Alpha is 0.7 and value of AVE above 0.5 is deemed to be in satisfactory level. As shown in Table 5-13, all quality criteria are within acceptable limit. Therefore, measures have an acceptable internal consistency.

Table 5-13: Structural Model 3 - Quality Criteria

	AVE	Composite Reliability	R Square	Cronbach's Alpha	Communality	Redundancy
DFL	0.7677	0.9082	0.1369	0.8477	0.7677	0.1051
Demand Uncertainty	0.6881	0.8687	0.7739	0.7735	0.6881	0.5311
Internal Uncertainty	0.6159	0.8278	0.6854	0.7081	0.6159	0.4214
Performance	0.6384	0.876	0.1106	0.8121	0.6384	0.0692
Supply Uncertainty	0.6252	0.8328	0.6228	0.7176	0.6252	0.3892
Uncertainty	0.5176	0.8786	0	0.8438	0.5176	0

5.2.6 Structural Model 3 - Bootstrapping

As depicted in Figure 5-6, the stability of the estimates was tested via a bootstrap re-sampling procedure (5000 sub-samples).

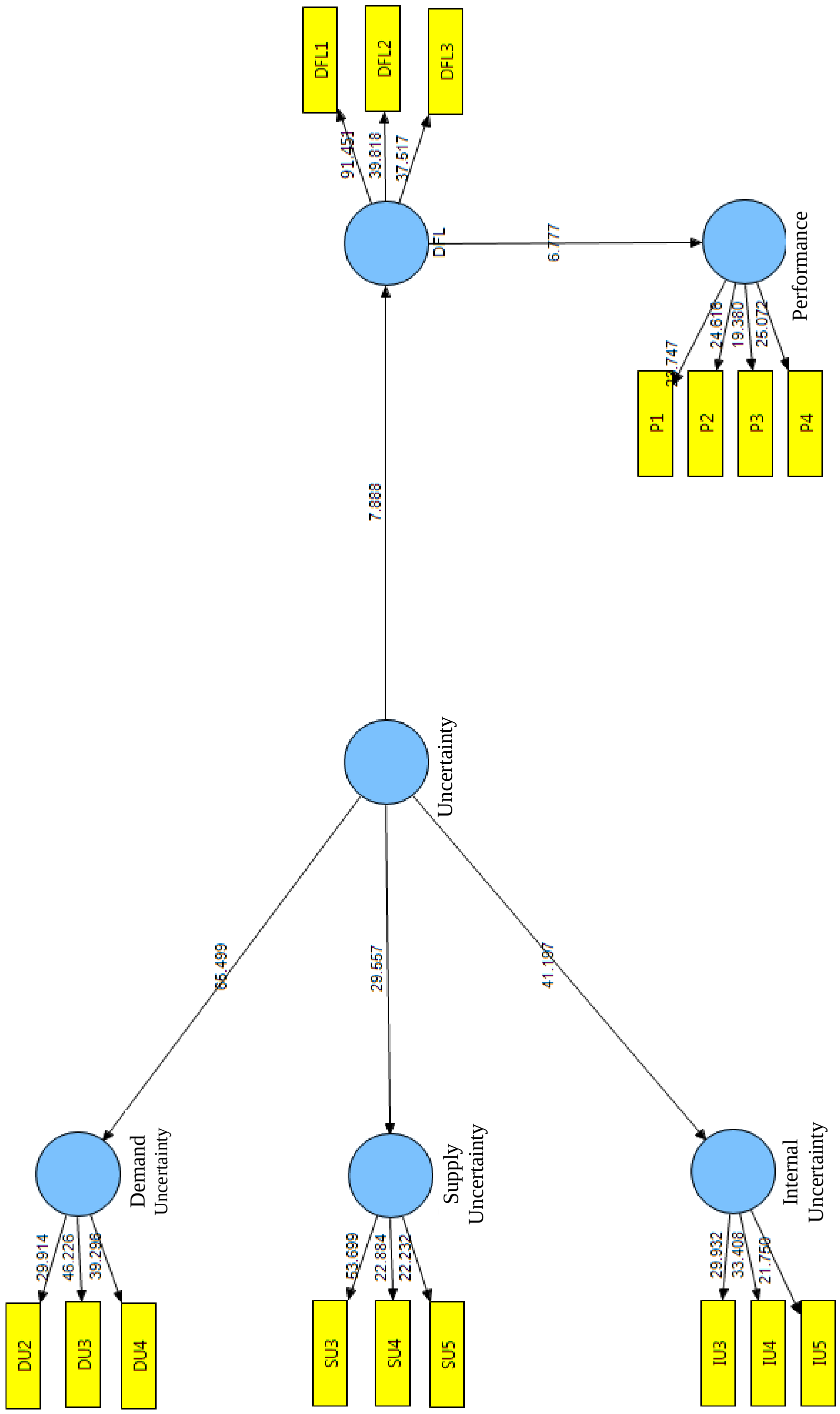

Figure 5-6: Structural Model 3 - Bootstrapping

I) t-Statistics

Table 5-14 presents t-statistics for the estimates of variables to constructs as a result of bootstrapping process. As highlighted below, t-statistic of all estimates is above 1.96 indicating that estimates are stable.

Table 5-14: Structural Model 3 - Bootstrapping - t-Statistics

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	t Statistics (|O/STERR|)
DFL1 <- DFL	0.9302	0.93	0.0102	0.0102	91.4514
DFL2 <- DFL	0.8455	0.845	0.0212	0.0212	39.8178
DFL3 <- DFL	0.8504	0.8496	0.0227	0.0227	37.5171
DU2 <- Demand Uncertainty	0.8071	0.807	0.027	0.027	29.9137
DU3 <- Demand Uncertainty	0.8509	0.8508	0.0184	0.0184	46.2261
DU4 <- Demand Uncertainty	0.8301	0.8304	0.0211	0.0211	39.2956
IU3 <- Internal Uncertainty	0.7929	0.7924	0.0265	0.0265	29.9316
IU4 <- Internal Uncertainty	0.8036	0.8041	0.0241	0.0241	33.4075
IU5 <- Internal Uncertainty	0.7572	0.7559	0.0348	0.0348	21.7501
P1 <- Performance	0.7902	0.7909	0.0333	0.0333	23.7466
P2 <- Performance	0.8118	0.8081	0.033	0.033	24.6159
P3 <- Performance	0.789	0.7849	0.0407	0.0407	19.3801
P4 <- Performance	0.8049	0.8032	0.0321	0.0321	25.0723
SU3 <- Supply Uncertainty	0.865	0.8649	0.0161	0.0161	53.699
SU4 <- Supply Uncertainty	0.7594	0.7583	0.0332	0.0332	22.8842
SU5 <- Supply Uncertainty	0.742	0.7416	0.0334	0.0334	22.2321

II) t-Statistics Constructs

Table 5-15 displays t-statistics for the construct to construct estimates of the structural model 3 as a result of bootstrapping process. As highlighted below, all t-statistics are above 1.96, indicating that estimates are stable.

Table 5-15: Structural Model 3 - Bootstrapping - t-Statistics Constructs

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	t Statistics (|O/STERR|)
DFL -> Performance	-0.3326	-0.3387	0.0491	0.0491	6.7767
Uncertainty -> DFL	0.3699	0.3712	0.0469	0.0469	7.8875
Uncertainty -> Demand Uncertainty	0.8797	0.8802	0.0134	0.0134	65.4993
Uncertainty -> Internal Uncertainty	0.8279	0.8281	0.0201	0.0201	41.1971
Uncertainty -> Supply Uncertainty	0.7892	0.789	0.0267	0.0267	29.5571

III) Discriminant Validity

As explained in research methodology chapter, in PLS path modelling, discriminant validity is assessed as satisfactory when the square roots of the AVE values are higher than correlation coefficients between the variables (Fornell & Larcker 1981).

Table 5-16: Discriminant Validity - Main Research Model

	AVE	DFL	Performance	Uncertainty
DFL	0.7677	0.8762		
Performance	0.6384	-0.3326	0.7990	
Uncertainty	0.5176	0.3699	-0.1656	0.7194

As shown in Table 5-16, the square roots of AVEs, highlighted as yellow in diagonal direction, are greater than correlation coefficients between the variables. Therefore, the requirements for discriminant validity are satisfied.

As second order constructs exist in the research model to measure uncertainty concept, the correlation coefficients among its constructs (demand, supply, and internal uncertainty) have been measured to ensure no issue exists regarding discriminant validity.

Table 5-17 presents correlation coefficients among uncertainty constructs (demand, supply, and internal uncertainty). None of the correlations are above 0.9 indicating that discriminant validity is satisfied.

Table 5-17: Discriminant Validity - Correlation among second order constructs

		Demand Uncertainty	Internal Uncertainty	Supply Uncertainty
Demand Uncertainty	Pearson Correlation	1	.621**	.539**
	Sig. (2-tailed)	.000	.000	.000
	N	299	299	299
Internal Uncertainty	Pearson Correlation	.621**	1	.460**
	Sig. (2-tailed)	.000		.000
	N	299	299	299
Supply Uncertainty	Pearson Correlation	.539**	.460**	1
	Sig. (2-tailed)	.000	.000	
	N	299	299	299

**. Correlation is significant at the 0.01 level (2-tailed).

5.2.7 Findings

Structural model of the current research has been developed in SmartPLS path modelling software package to verify the hypotheses of the study. Model was improved through removing the variables with low factor loadings. The quality criteria were checked against the thresholds referred in the literature and they have been found within the acceptable limit. Therefore, the outcome of the analysis could be utilised to address the hypotheses.

I) Impact of Uncertainty on DFL

As indicated below, the first hypothesis of the study is related to investigate the relationship between the level of uncertainty and deviation from leagility (DFL).

> *H_1: Low Level of Uncertainty would let the companies adopt more balanced supply chains (less DFL)*

The results of the PLS analysis using all n=299 data points have been used to address the study hypotheses. The path coefficients are the standardised beta coefficients. The result of analysis indicates that level of uncertainty ($\beta = 0.370$, $p<0.05$) has significant and positive impact on deviation from leagility (DFL). Thus, H_1 is supported.

The interpretation of this finding relies on the concept of DFL. As explained in previous chapters, DFL is the absolute distance of supply chain design from a balanced supply chain. Balanced supply chain is a position the magnitude of leanness and agility is equal. Critical review of literature revealed that there is a contradiction of findings regarding the influence of uncertainty on the supply chain design. A couple of researchers (Fisher 1997; Samuel, Mohit & Shi 2002) indicated that lean supply chain is more appropriate for functional products (low uncertainty) and agile supply chain is match with innovative products (high uncertainty), whereas others (Selldin & Olhager 2007) stated that this relationship is not statistically supported.

Since the early 1990s companies have confronted substantial challenges in their operating environments, including declining or stagnant market volumes, shorter technology and product life cycles, more demanding consumers and hyper-competition that drive companies to rationalise resources (e.g. supply chain) wherever possible (Kotzab et al. 2009). There are two different viewpoints to characterise the environment. From a strategic management perspective, the state of environment is characterised by Hyper-competition (D'Aveni & Gunther 1994). Hyper-competition is a rapid escalation of competitive forces among direct business competitors which leads to higher uncertainty level for businesses.

From a logistics or supply chain perspective, Christopher (2000) described the distinctive nature or features of such environments as requiring a market responsiveness which could be realised through setting up of agile supply chains. Market fluctuations in terms of product volume and variety to meet customer requirements could be addressed easier through agile supply chains. In addition, Christopher and Towill (2000) also emphasised the trend of migration from lean and functional supply chains to more agile and customised.

However, management of supply chain is not limited solely to just address the volatility of the market by improving agility and responsiveness. In fact, hyper-competition and rising uncertainty intensifies pricing pressures on companies which requires cost cutting through implementation of lean supply chain. Therefore, integration of leanness and agility is required to keep business profitable.

In this regard, DFL would be a measurement tool to investigate the extent a business incorporates both aspects of leanness and agility in supply chain. Analysis indicates that in less uncertain position, deviation from leagility is lower. It means that when uncertainty level is lower, more balanced leagile supply chain is utilised.

Based on the conceptual model proposed by Fisher (1997), in lower level of uncertainty, lean supply chain would be utilised, whereas agile supply chain would be more suitable when uncertainty level is higher. However, findings of the current study contradicts Fisher's model. In high level of uncertainty, two types of supply chain models exist: (a) leagile supply chains with very high magnitude of leanness (b) leagile supply chains with very high magnitude of agility. On the other hand, in low level of uncertainty, companies employ more balanced leagile supply chain.

To explain the new model, it would be useful to review a framework proposed by Mason-Jones, Naylor and Towill (2000) as shown in Table 5-18.

Table 5-18: Market Winners - Market Qualifiers Matrix for Agile Versus Lean Supply Chain Source: Mason-Jones, Naylor and Towill (2000)

	Market Qualifier	Market Winner
Agile Supply Chain	• Quality • Cost • Lead Time	• Service Level
Lean Supply Chain	• Quality • Lead Time • Service Level	• Cost

Table 5-18 presents the fundamental differences in focus between the lean and agile concepts depending upon the market qualifiers and the market winners. To enter to a market, market qualifiers are the minimum requirements which are necessary to provide a product or service. However, the criterion for being a winner in a market is referred to as market winner. Based on conceptual model proposed by Mason-Jones, Naylor and Towill (2000), agile supply chain is more suitable when market winner is service level, whereas companies adopt lean supply chain when market winner is cost.

Analysis of the research model revealed that in high uncertainty level, companies adopt leagile supply chain with either high magnitude of leanness or high magnitude of agility. As resources of a company are limited, the most focus would be on providing the market winner. Therefore, in highly uncertain condition, when the market winner is cost, leagile supply chain with higher magnitude of leanness would be preferable; whereas leagile supply chain with higher magnitude of agility would be adopted when the market winner is service level.

Comparatively, as uncertainty level declines, given the market winner is achieved, the other aspect of supply chain would be reinforced to provide higher level of market qualifiers whereby the firm performance proves. To reiterate, if market winner is service level, in highly uncertain situation, a firm adopts a leagile supply chain with high magnitude of agility to provide highest possible service level.

Relatively, if market winner is service level, same as previous scenario, but uncertainty level would be low, the magnitude of agility would be still more than leanness. However, the balance would be different. More magnitude of leanness would be employed to provide a better level of market qualifier (ex. cost) which improves the firm performance.

II) Impact of DFL on Firm Performance

The second hypothesis of the study investigates the relationship between DFL and firm performance. A comparative approach has been utilised to measure the firm performance whereby respondents were requested to rate their firm based on how well the company performs relative to its competitors in terms of cost, flexibility, delivery speed, profitability, and growth in market share.

H_2: A more balanced supply chains leads to better firm performance.

The results of the PLS analysis using all of 299 data points have been used to address the study hypotheses. The result of analysis indicates that DFL (β = - 0.333, $p<0.05$) has significant and negative impact on firm performance (DFL). In another words, firms with more balanced supply chain (less DFL) would perform better. Thus, H_2 is supported.

The interpretation of this result relies on the first hypothesis finding. It was concluded that in low uncertainty level, companies adopt more balanced supply chain. When both aspects of leanness and agility are employed in design of supply chain, it is expected that market qualifiers and market winners are both achieved in highest possible level based on firm resources. Therefore, firm performance of companies with more balanced supply chain is significantly higher.

In conclusion:

H1	Low Level of Uncertainty would let the companies adopt more balanced supply chains (less DFL)	**Supported**
H2	A more balanced supply chains leads to better firm performance.	**Supported**

5.3 **Analysis of Uncertainty Constructs**

As explained in research methodology chapter, a comprehensive model of uncertainty is utilised in this study whereby demand, supply, and internal uncertainty have been included to measure uncertainty concept.

There are three reasons that as a complimentary analysis, the relationship between each construct of uncertainty and DFL is individually investigated.

- As researchers historically employed one or combination of two aspects of uncertainty in their research, reanalyse the research model for each uncertainty constructs would help to compare the findings with others.
- It would be useful to investigate which construct has the highest impact on DFL.
- If the model would not fit for each uncertainty construct while it is significant for the comprehensive concept of uncertainty, it could be concluded that uncertainty as a driver of supply chain design, might be included in research models as a comprehensive concept.

In this regard, the analysis has been carried out individually for each construct of uncertainty.

5.3.1 Impact of Demand Uncertainty on DFL

The first and maybe the most important construct of uncertainty concept is the demand uncertainty. The PLS analysis is carried out to investigate the hypothesis below.

$H_{1\text{-}1}$: Low Level of Demand Uncertainty would let the companies adopt more balanced supply chains (less DFL)

The estimates which are the outcome of PLS analysis are presented in Figure 5-7.

I) Structural Model – Model Estimates

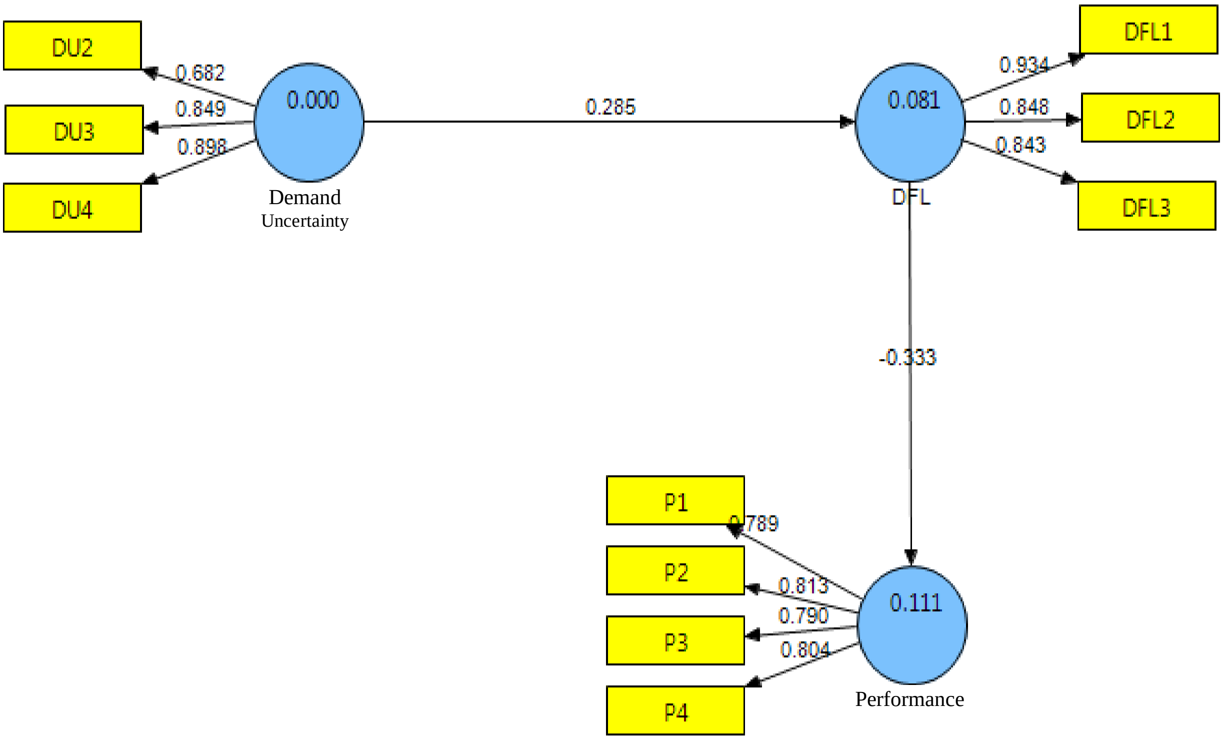

Figure 5-7: Structural Model - Impact of Demand Uncertainty on DFL

II) Factor Loadings

Table 5-19 presents the factor loadings for the structural model to explore the impact of demand uncertainty on DFL. As highlighted below, all factor loadings except DU2 to Demand Uncertainty (0.6824) are above 0.7. It was mentioned the minimum factor loading for exploratory research should be 0.6 and for explanatory analysis 0.7 is more acceptable. As 0.6824 is above 0.6 and it is very close to 0.7, it has been considered to be in acceptable range. Therefore, convergent validity is supported.

Table 5-19: Factor Loadings – Impact of Demand Uncertainty on DFL

	DFL	Demand Uncertainty	Performance
DFL1	0.9337	0	0
DFL2	0.8483	0	0
DFL3	0.8433	0	0
DU2	0	0.6824	0
DU3	0	0.8494	0
DU4	0	0.8976	0
P1	0	0	0.7894
P2	0	0	0.8127
P3	0	0	0.7897
P4	0	0	0.8044

III) Path Coefficients

Table 5-20 presents the path coefficient for the relationship between demand uncertainty and DFL. The outcome of analysis indicates that demand uncertainty positively impacts on DFL ($\beta = 0.2851$, $p<0.05$). However, the estimate should be statistically investigated through bootstrapping process.

Table 5-20: Path Coefficients – Impact of Demand Uncertainty on DFL

	DFL	Demand Uncertainty	Performance
DFL	0	0	-0.3332
Demand Uncertainty	0.2851	0	0
Performance	0	0	0

IV) Quality Criteria

In order to assess the internal consistency of the measurement items, average variance extracted (AVE), composite reliability, and Cronbach's Alpha should be assessed. The minimum value for the composite reliability and Cronbach's Alpha is 0.7 and value of AVE above 0.5 is deemed to be in satisfactory level. As shown in Table 5-21, all quality criteria are within acceptable limit. Therefore, measures have an acceptable internal consistency.

Table 5-21: Quality Criteria - Impact of Demand Uncertainty on DFL

	AVE	Composite Reliability	R Square	Cronbach's Alpha	Communality	Redundancy
DFL	0.7675	0.9081	0.0813	0.8477	0.7675	0.0621
Demand Uncertainty	0.6643	0.8542	0	0.7735	0.6643	0
Performance	0.6385	0.876	0.111	0.8121	0.6385	0.0695

V) Structural Model - Bootstrapping

As depicted in Figure 5-8, the stability of the estimates is tested via a bootstrap re-sampling procedure (5000 sub-samples).

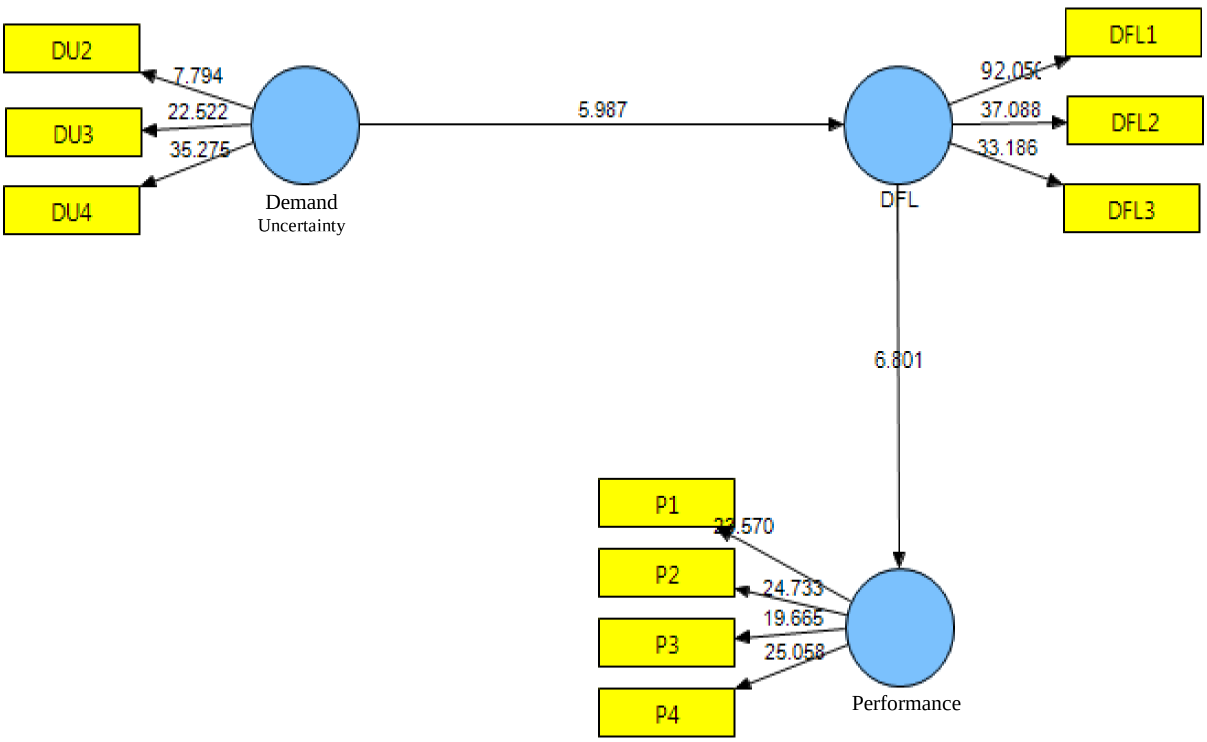

Figure 5-8: Bootstrapping - Impact of Demand Uncertainty on DFL

VI) t-Statistics

Table 5-22 presents t-statistics for the estimates of variables to constructs as a result of bootstrapping process. As highlighted below, t-statistic of all estimates is above 1.96 indicating that estimates are stable.

Table 5-22: t-Statistics - Impact of Demand Uncertainty on DFL

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	t Statistics (|O/STERR|)
DFL1 <- DFL	0.9337	0.9332	0.0101	0.0101	92.0505
DFL2 <- DFL	0.8483	0.8465	0.0229	0.0229	37.0882
DFL3 <- DFL	0.8433	0.8433	0.0254	0.0254	33.1864
DU2 <- Demand Uncertainty	0.6824	0.6677	0.0876	0.0876	7.7944
DU3 <- Demand Uncertainty	0.8494	0.8444	0.0377	0.0377	22.5219
DU4 <- Demand Uncertainty	0.8976	0.896	0.0254	0.0254	35.275
P1 <- Performance	0.7894	0.789	0.0335	0.0335	23.5695
P2 <- Performance	0.8127	0.8088	0.0329	0.0329	24.7327
P3 <- Performance	0.7897	0.7857	0.0402	0.0402	19.6648
P4 <- Performance	0.8044	0.8029	0.0321	0.0321	25.0583

VII) t-Statistics Constructs

Table 5-23 displays t-statistics for the construct to construct estimates of the structural model as a result of bootstrapping process. As highlighted below, all t-statistics are above 1.96, indicating that estimates are stable.

Table 5-23: t-Statistics Constructs - Impact of Demand Uncertainty on DFL

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	t Statistics (|O/STERR|)
DFL -> Performance	-0.3332	-0.3393	0.049	0.049	6.8011
Demand Uncertainty -> DFL	0.2851	0.2938	0.0476	0.0476	5.9871
Demand Uncertainty -> Performance	-0.095	-0.0998	0.0221	0.0221	4.2908

VIII) Discriminant Validity

As explained in research methodology chapter, in PLS path modelling, discriminant validity is assessed as satisfactory when the square roots of the AVE values are higher than correlation coefficients between the variables.

Table 5-24: Discriminant Validity - Impact of Demand Uncertainty on DFL

	AVE	DFL	Demand Uncertainty	Performance
DFL	0.7675	0.8761		
Demand Uncertainty	0.6643	0.2851	0.8150	
Performance	0.6385	-0.3332	-0.1510	0.7991

As shown in Table 5-24, the square roots of AVEs, highlighted as yellow in diagonal direction, are greater than correlation coefficients between the variables. Therefore, the requirements for discriminant validity are satisfied.

IX) Findings

As construct and discriminant validity requirements are met, it could be concluded that research model fits the data. Consequently, it is statistically substantiated that demand uncertainty positively impacts on DFL (β = 0.2851, $p<0.05$). In other words, Low Level of Demand Uncertainty would let the companies to adopt more balanced supply chains (less DFL). Accordingly, H_{1-1} is supported.

The interpretation of findings would be quite similar to the effect of uncertainty on DFL. In high demand uncertainty level, firms allocate resources to achieve minimum required market qualifiers and put more focus on achieving the best possible degree of market winner, whereas in low demand uncertainty level, market qualifiers would be improved to achieve a higher firm performance.

5.3.2 Impact of Supply Uncertainty on DFL

The second construct of uncertainty concept is the supply uncertainty. The PLS analysis is carried out to investigate the hypothesis below.

H_{1-2}: Low Level of Supply Uncertainty would let the companies adopt more balanced supply chains (less DFL)

The estimates which are the outcome of PLS analysis are presented in Figure 5-9.

I) Structural Model – Model Estimates

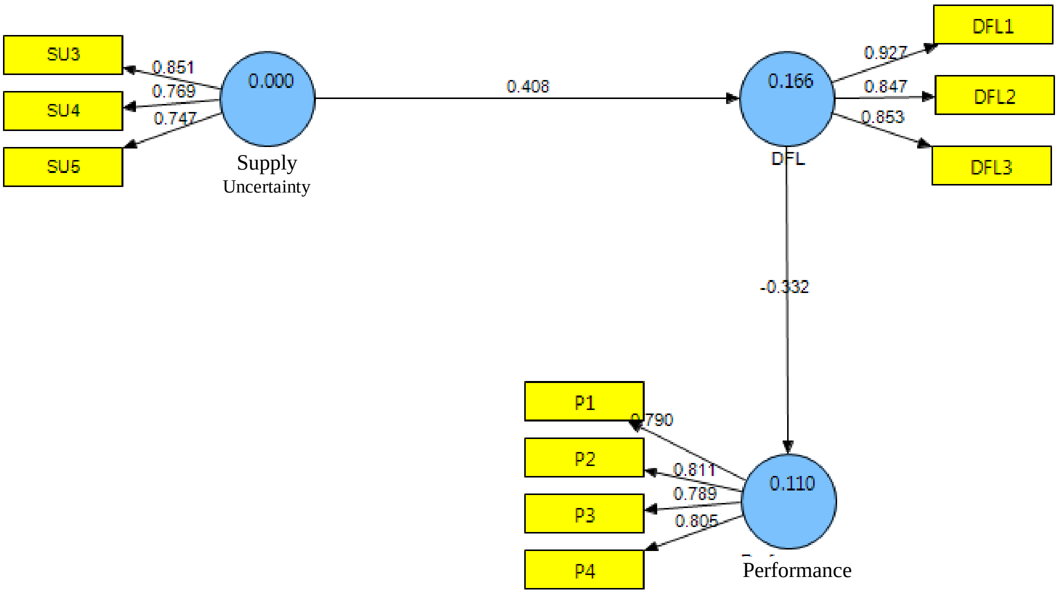

Figure 5-9: Structural Model - Impact of Supply Uncertainty on DFL

II) Factor Loadings

Table 5-25 presents factor loadings for structural model 3. As highlighted below, all factor loadings are above 0.7 indicating that measures have acceptable convergent validity.

Table 5-25: Factor Loadings – Impact of Supply Uncertainty on DFL

	DFL	Performance	Supply Uncertainty
DFL1	0.9267	0	0
DFL2	0.8467	0	0
DFL3	0.8529	0	0
P1	0	0.7904	0
P2	0	0.8115	0
P3	0	0.7889	0
P4	0	0.805	0
SU3	0	0	0.8514
SU4	0	0	0.7693
SU5	0	0	0.7471

III) Path Coefficients

Table 5-26 presents the path coefficient for the relationship between supply uncertainty and DFL. The outcome of analysis indicates that supply uncertainty positively impacts on DFL (β = 0.3701, $p<0.05$). However, the estimate should be statistically investigated through bootstrapping process.

Table 5-26: Path Coefficients – Impact of Supply Uncertainty on DFL

	DFL	Performance	Supply Uncertainty
DFL	0	-0.2872	0
Performance	0	0	0
Supply Uncertainty	0.3701	0	0

IV) Quality Criteria

In order to assess the internal consistency of the measurement items, average variance extracted (AVE), composite reliability, and Cronbach's Alpha should be assessed. The minimum value for the composite reliability and Cronbach's Alpha is 0.7 and value of AVE above 0.5 is deemed to be in satisfactory level. As shown in Table 5-27, all quality criteria are within acceptable limit. Therefore, measures have an acceptable internal consistency.

Table 5-27: Quality Criteria - Impact of Supply Uncertainty on DFL

	AVE	Composite Reliability	R Square	Cronbach's Alpha	Communality	Redundancy
DFL	0.7677	0.9083	0.1663	0.8477	0.7677	0.1272
Performance	0.6384	0.8759	0.11	0.8121	0.6384	0.0688
Supply Uncertainty	0.625	0.8329	0	0.6976	0.625	0

V) Structural Model - Bootstrapping

As depicted in Figure 5-10, the stability of the estimates is tested via a bootstrap re-sampling procedure (5000 sub-samples).

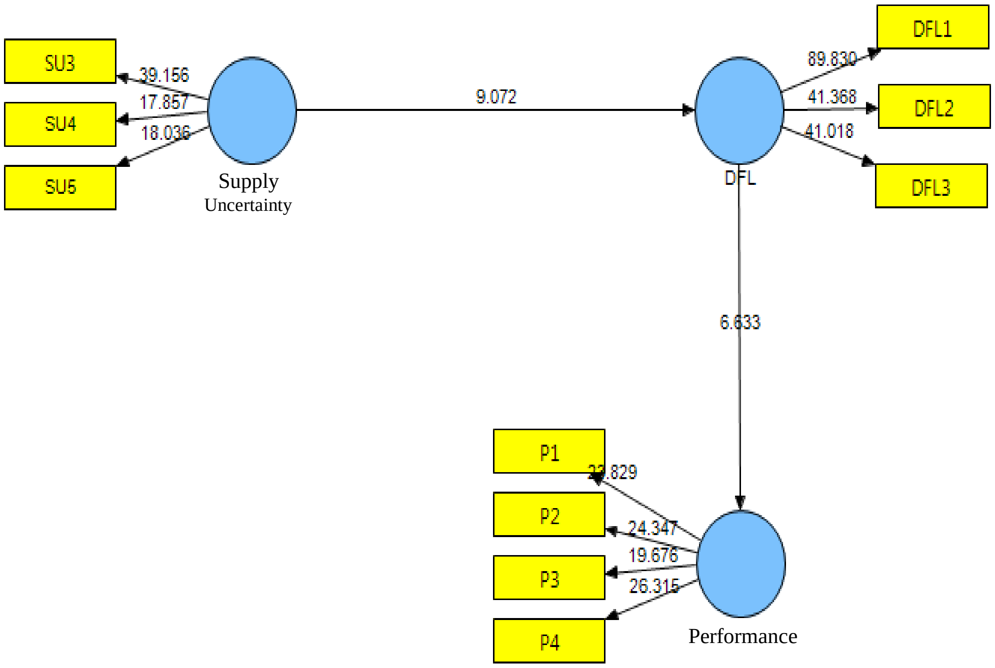

Figure 5-10: Bootstrapping - Impact of Supply Uncertainty on DFL

VI) t-Statistics

Table 5-28 presents t-statistics for the estimates of variables to constructs as a result of bootstrapping process. As highlighted below, t-statistic of all estimates is above 1.96 indicating that estimates are stable.

Table 5-28: t-Statistics - Impact of Supply Uncertainty on DFL

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	t Statistics (|O/STERR|)
DFL1 <- DFL	0.9267	0.9265	0.0103	0.0103	89.8302
DFL2 <- DFL	0.8467	0.8458	0.0205	0.0205	41.3678
DFL3 <- DFL	0.8529	0.8531	0.0208	0.0208	41.0183
P1 <- Performance	0.7904	0.7905	0.0332	0.0332	23.8286
P2 <- Performance	0.8115	0.8075	0.0333	0.0333	24.3468
P3 <- Performance	0.7889	0.7851	0.0401	0.0401	19.6758
P4 <- Performance	0.805	0.8037	0.0306	0.0306	26.3146
SU3 <- Supply Uncertainty	0.8514	0.8503	0.0217	0.0217	39.1564
SU4 <- Supply Uncertainty	0.7693	0.7659	0.0431	0.0431	17.8568
SU5 <- Supply Uncertainty	0.7471	0.747	0.0414	0.0414	18.0359

VII) t-Statistics Constructs

Table 5-29 displays t-statistics for the construct to construct estimates of the structural model as a result of bootstrapping process. As highlighted below, all t-statistics are above 1.96, indicating that estimates are stable.

Table 5-29: t-Statistics Constructs - Impact of Supply Uncertainty on DFL

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	t Statistics (|O/STERR|)
DFL -> Performance	-0.3317	-0.3367	0.05	0.05	6.6331
Supply Uncertainty -> DFL	0.4078	0.412	0.0449	0.0449	9.0721
Supply Uncertainty -> Performance	-0.1353	-0.1382	0.0229	0.0229	5.9131

VIII) Discriminant Validity

As explained in research methodology chapter, in PLS path modelling, discriminant validity is assessed satisfactory when the square roots of the AVE values are higher than correlation coefficients between the variables.

Table 5-30: Discriminant Validity - Impact of Supply Uncertainty on DFL

	AVE	DFL	Supply Uncertainty	Performance
DFL	0.7677	0.8762		
Supply Uncertainty	0.6384	0.3701	0.7990	
Performance	0.625	-0.2872	-0.0730	0.7906

As shown in Table 5-30, the square roots of AVEs, highlighted as yellow in diagonal direction, are greater than correlation coefficients between the variables. Therefore, the requirements for discriminant validity are satisfied.

IX) Findings

As construct and discriminant validity requirements are met, it could be concluded that research model fits the data. Consequently, it is statistically substantiated that supply uncertainty positively impacts on DFL ($\beta = 0.408$, $p<0.05$). In other words, Low Level of Supply Uncertainty would let the companies to adopt more balanced supply chains (less DFL). Accordingly, H_{1-2} is supported.

The interpretation of findings would be quite similar to the effect of uncertainty on DFL. In high supply uncertainty level, firms allocate resources to achieve minimum required market qualifiers and put more focus on achieving the best possible degree of market winner, whereas in low demand uncertainty level, market qualifiers would be improved to achieve a higher firm performance.

5.3.3 Impact of Internal Uncertainty on DFL

The third construct of uncertainty concept is the internal uncertainty. The PLS analysis is carried out to investigate the hypothesis below.

H_{1-3}: Low Level of Internal Uncertainty would let the companies adopt more balanced supply chains (less DFL)

The estimates which are the outcome of PLS analysis are presented in Figure 5-11.

I) Structural Model – Model Estimates

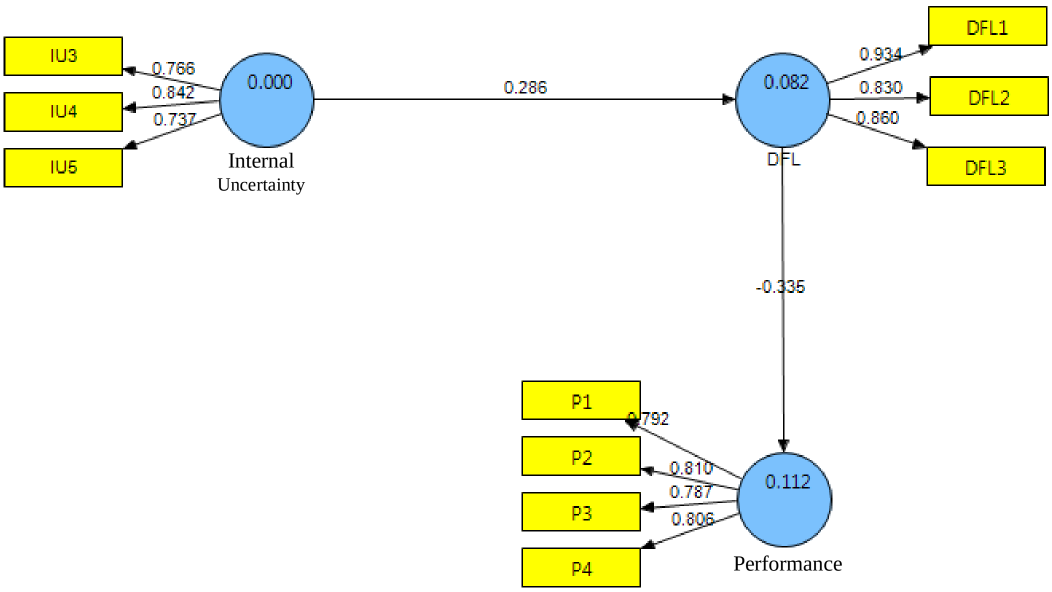

Figure 5-11: Structural Model - Impact of Internal Uncertainty on DFL

II) Factor Loadings

Table 5-31 presents factor loadings for structural model 3. As highlighted below, all factor loadings are above 0.7 indicating that measures have acceptable convergent validity.

Table 5-31: Factor Loadings – Impact of Internal Uncertainty on DFL

	DFL	Internal Uncertainty	Performance
DFL1	0.9344	0	0
DFL2	0.8297	0	0
DFL3	0.8604	0	0
IU3	0	0.7661	0
IU4	0	0.8416	0
IU5	0	0.737	0
P1	0	0	0.7921
P2	0	0	0.8102
P3	0	0	0.787
P4	0	0	0.806

III) Path Coefficients

Table 5-32 presents the path coefficient for the relationship between internal uncertainty and DFL. The outcome of analysis indicates that internal uncertainty positively impacts on DFL ($\beta = 0.286$, $p<0.05$). However, the estimate should be statistically investigated through bootstrapping process.

Table 5-32: Path Coefficients – Impact of Internal Uncertainty on DFL

	DFL	Internal Uncertainty	Performance
DFL	0	0	-0.3348
Internal Uncertainty	0.286	0	0
Performance	0	0	0

IV) Quality Criteria

In order to assess the internal consistency of the measurement items, average variance extracted (AVE), composite reliability, and Cronbach's Alpha should be assessed. The minimum value for the composite reliability and Cronbach's Alpha is 0.7 and value of AVE above 0.5 is deemed to be in satisfactory level. As shown inTable 5-33, all quality criteria are within acceptable limit. Therefore, measures have an acceptable internal consistency.

Table 5-33: Quality Criteria - Impact of Internal Uncertainty on DFL

	AVE	Composite Reliability	R Square	Cronbach's Alpha	Communality	Redundancy
DFL	0.7673	0.908	0.0818	0.8477	0.7673	0.0627
Internal Uncertainty	0.6128	0.8255	0	0.6881	0.6128	0
Performance	0.6382	0.8759	0.1121	0.8121	0.6382	0.07

V) Structural Model - Bootstrapping

As depicted in Figure 5-12, the stability of the estimates is tested via a bootstrap re-sampling procedure (5000 sub-samples).

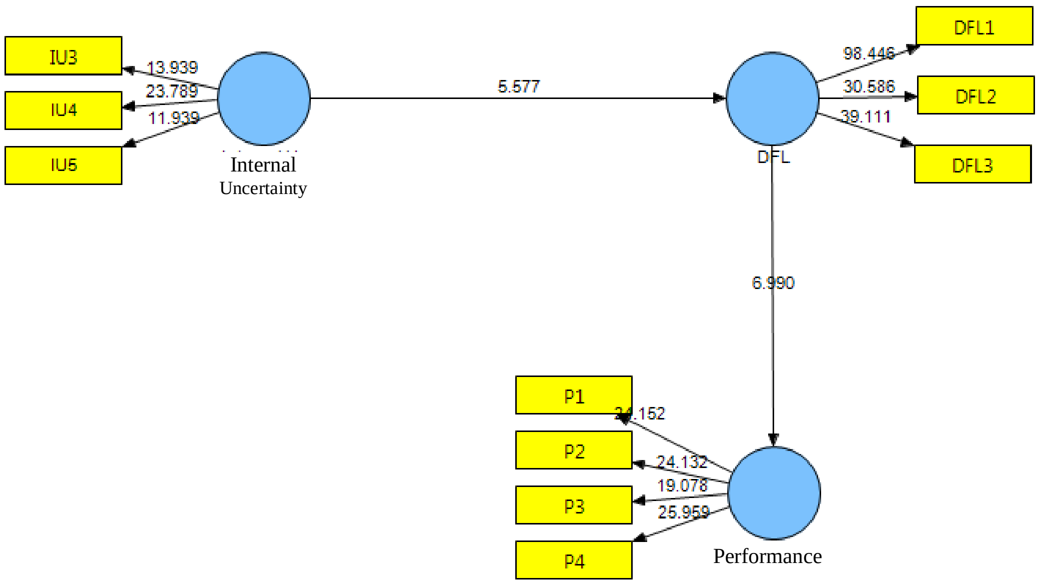

Figure 5-12: Bootstrapping - Impact of Internal Uncertainty on DFL

VI) t-Statistics

Table 5-34 presents t-statistics for the estimates of variables to constructs as a result of bootstrapping process. As highlighted below, t-statistic of all estimates is above 1.96 indicating that estimates are stable.

Table 5-34: t-Statistics - Impact of Internal Uncertainty on DFL

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	t Statistics (|O/STERR|)
DFL1 <- DFL	0.9344	0.9342	0.0095	0.0095	98.4458
DFL2 <- DFL	0.8297	0.8288	0.0271	0.0271	30.5863
DFL3 <- DFL	0.8604	0.8601	0.022	0.022	39.1105
IU3 <- Internal Uncertainty	0.7661	0.76	0.055	0.055	13.9394
IU4 <- Internal Uncertainty	0.8416	0.8409	0.0354	0.0354	23.7889
IU5 <- Internal Uncertainty	0.737	0.7298	0.0617	0.0617	11.9394
P1 <- Performance	0.7921	0.7925	0.0328	0.0328	24.1518
P2 <- Performance	0.8102	0.8061	0.0336	0.0336	24.132
P3 <- Performance	0.787	0.7829	0.0413	0.0413	19.0781
P4 <- Performance	0.806	0.8042	0.031	0.031	25.9587

VII) t-Statistics Constructs

Table 5-35 displays t-statistics for the construct to construct estimates of the structural model as a result of bootstrapping process. As highlighted below, all t-statistics are above 1.96, indicating that estimates are stable.

Table 5-35: t-Statistics Constructs - Impact of Internal Uncertainty on DFL

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	t Statistics (|O/STERR|)
DFL -> Performance	-0.3348	-0.3407	0.0479	0.0479	6.99
Internal Uncertainty -> DFL	0.286	0.2937	0.0513	0.0513	5.5768

VIII) Discriminant Validity

As explained in research methodology chapter, in PLS path modelling, discriminant validity is assessed satisfactory when the square roots of the AVE values are higher than correlation coefficients between the variables.

Table 5-36: Discriminant Validity - Impact of Internal Uncertainty on DFL

	AVE	DFL	Internal Uncertainty	Performance
DFL	0.7673	0.8759		
Internal Uncertainty	0.6128	0.281	0.7828	
Performance	0.6382	-0.333	-0.187	0.7989

As shown in Table 5-36, the square roots of AVEs, highlighted as yellow in diagonal direction, are greater than correlation coefficients between the variables. Therefore, the requirements for discriminant validity are satisfied.

IX) Findings

As construct and discriminant validity requirements are met, it could be concluded that research model fits the data. Consequently, it is statistically substantiated that internal uncertainty positively impacts on DFL ($\beta = 0.286$, $p<0.05$). In other words, Low Level of Internal Uncertainty would let the companies to adopt more balanced supply chains (less DFL). Accordingly, H_{1-3} is supported.

The interpretation of findings would be quite similar to the effect of uncertainty on DFL. In high internal uncertainty level, firms allocate resources to achieve minimum required market qualifiers and put more focus on achieving the best possible degree of market winner, whereas in low demand uncertainty level, market qualifiers would be improved to achieve a higher firm performance.

5.3.4 *Findings*

PLS analysis on uncertainty constructs revealed that all three constructs, demand uncertainty ($\beta = 0.2851$, $p<0.05$), supply uncertainty ($\beta = 0.3701$, $p<0.05$), and internal uncertainty ($\beta = 0.286$, $p<0.05$), have significant positive impact on deviation from leagility.

In majority of articles, demand uncertainty has been referred to as the most crucial element of uncertainty as a key driver of supply chain design. However, the findings of the current study indicate that supply uncertainty with path coefficient of 0.371 has the highest impact. Consequently, more focus on supply uncertainty is required to design more productive supply chain.

In conclusion:

H1-1	Low Level of Demand Uncertainty would let the companies adopt more balanced supply chains (less DFL)	**Supported**
H1-2	Low Level of Supply Uncertainty would let the companies adopt more balanced supply chains (less DFL)	**Supported**
H1-3	Low Level of Internal Uncertainty would let the companies adopt more balanced supply chains (less DFL)	**Supported**

5.4 **Moderation Effect of Competition Intensity**

As explained by Kotzab et al. (2009), hyper-competition is one of today's external forces which affects all aspects of business including supply chain. In more competitive environment, both leanness and agility should be improved to help companies to achieve a better competitive position. Therefore, it would be wise to investigate the moderation effect of competition intensity to the relationship between uncertainty and DFL.

SmartPLS package software is utilised as it provides and implements a tool to support the product indicator approach for moderating effects recommended by Chin, Marcolin and Newsted (2003).

Moderation effect of competition intensity is investigated firstly on the relationship between overall uncertainty and DFL. Then, further investigation is carried out on potential moderation effect of competition intensity on individual constructs of uncertainty (demand/supply/internal uncertainty).

5.4.1 Overall Uncertainty

In order to simplify the model, instead of uncertainty second order measurement model, the uncertainty scores calculated by the SmartPLS are utilised.

Figure 5-13 presents the structural model to investigate the moderation effect of competition intensity on the relationship between uncertainty and DFL (Hypothesis 3).

H_3: The relationship between Uncertainty and DFL is moderated by the level of Competition.

I) Structural Model

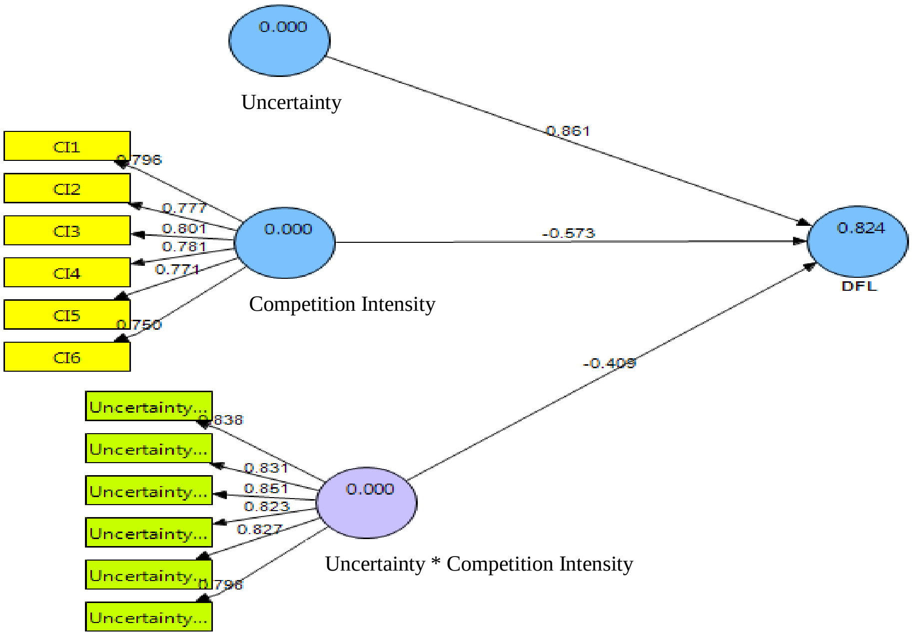

Figure 5-13: Structural Model - Moderation Effect of Competition Intensity

II) Factor Loadings

Table 5-37 presents factor loadings for the structural model. As highlighted below, all factor loadings are above 0.7 indicating that measures have acceptable convergent validity.

Table 5-37: Factor Loadings - Moderation Effect of Competition Intensity

	Competition Intensity	DFL	Uncertainty * Competition Intensity
CI1	0.7962	0	0
CI2	0.7773	0	0
CI3	0.8012	0	0
CI4	0.7811	0	0
CI5	0.7715	0	0
CI6	0.7498	0	0
DFL1	0	0.9266	0
DFL2	0	0.8507	0

	Competition Intensity	DFL	Uncertainty * Competition Intensity
DFL3	0	0.8489	0
Uncertainty*CI1	0	0	0.8382
Uncertainty*CI2	0	0	0.8306
Uncertainty*CI3	0	0	0.8509
Uncertainty*CI4	0	0	0.8226
Uncertainty*CI5	0	0	0.8272
Uncertainty*CI6	0	0	0.7982

III) Path Coefficient

Table 5-38 presents the path coefficient for the relationship between independent variables (uncertainty, competition intensity, and interaction between uncertainty and competition intensity) and dependent variable (DFL). The outcome of analysis indicates that uncertainty positively impacts on DFL (β = 0.8607, $p<0.05$), whereas, competition intensity negatively impacts on DFL (β = -0.5729, $p<0.05$). In addition, interaction element has a negative impact on DFL (β = -0.4092, $p<0.05$). However, the estimate should be statistically investigated through bootstrapping process.

Table 5-38: Path Coefficient - Moderation Effect of Competition Intensity

	Competition Intensity	DFL	Uncertainty	Uncertainty * Competition Intensity
Competition Intensity	0	-0.5729	0	0
DFL	0	0	0	0
Uncertainty	0	0.8607	0	0
Uncertainty * Competition Intensity	0	-0.4092	0	0

IV) Quality Criteria

In order to assess the internal consistency of the measurement items, average variance extracted (AVE), composite reliability, and Cronbach's Alpha should be assessed. The minimum value for the composite reliability and Cronbach's Alpha is 0.7 and value of AVE above 0.5 is deemed to be in satisfactory level. As shown in Table 5-39, all quality criteria are within acceptable limit. Therefore, measures have an acceptable internal consistency.

Table 5-39: Quality Criteria - Moderation Effect of Competition Intensity

	AVE	Composite Reliability	R Square	Cronbach's Alpha	Communality	Redundancy
Competition Intensity	0.6079	0.9029	0	0.8711	0.6079	0
DFL	0.7677	0.9082	0.8238	0.8477	0.7677	0.2989
Uncertainty	1	1	0	1	1	0
Uncertainty * Competition Intensity	0.6857	0.929	0	0.9089	0.6857	0

V) Bootstrapping

As depicted in Figure 5-14, the stability of the estimates is tested via a bootstrap re-sampling procedure (5000 sub-samples).

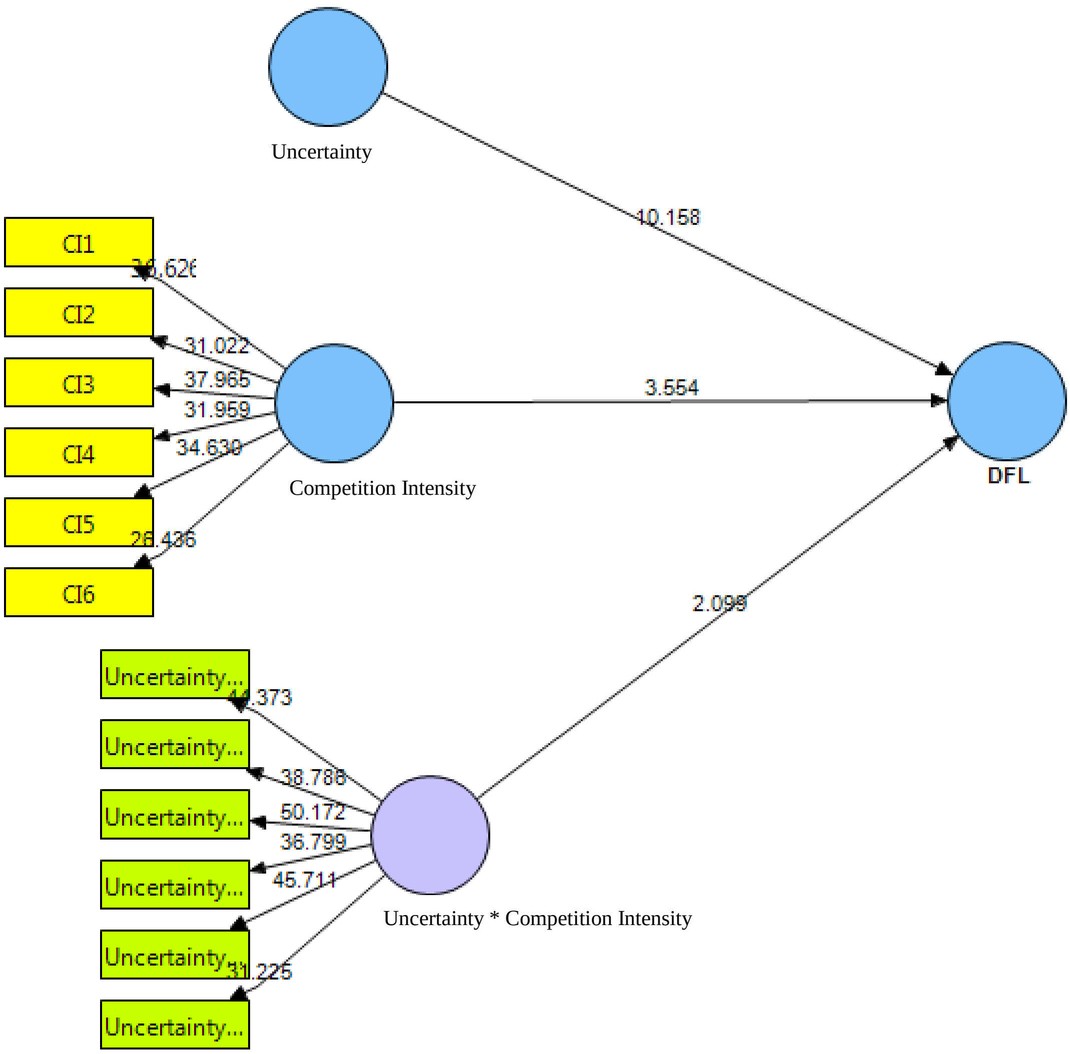

Figure 5-14: Bootstrapping - Moderation Effect of Competition Intensity

VI) t-Statistics

Table 5-40 presents t-statistics for the estimates of variables to constructs as a result of bootstrapping process. As highlighted below, t-statistic of all estimates is above 1.96 indicating that estimates are stable.

Table 5-40: t-Statistics - Moderation Effect of Competition Intensity

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	t Statistics (|O/STERR|)
CI1 <- Competition Intensity	0.7962	0.7956	0.0217	0.0217	36.626
CI2 <- Competition Intensity	0.7773	0.7766	0.0251	0.0251	31.0221
CI3 <- Competition Intensity	0.8012	0.8003	0.0211	0.0211	37.9645
CI4 <- Competition Intensity	0.7811	0.7804	0.0244	0.0244	31.9594
CI5 <- Competition Intensity	0.7715	0.7714	0.0223	0.0223	34.6296
CI6 <- Competition Intensity	0.7498	0.749	0.0284	0.0284	26.4364
DFL1 <- DFL	0.9266	0.9264	0.0105	0.0105	88.351
DFL2 <- DFL	0.8507	0.8503	0.0163	0.0163	52.1403
DFL3 <- DFL	0.8489	0.8484	0.0185	0.0185	45.8839
Uncertainty*CI1 <- Uncertainty * Competition Intensity	0.8382	0.8375	0.0189	0.0189	44.3729
Uncertainty*CI2 <- Uncertainty * Competition Intensity	0.8306	0.8296	0.0214	0.0214	38.7856
Uncertainty*CI3 <- Uncertainty * Competition Intensity	0.8509	0.8496	0.017	0.017	50.1717
Uncertainty*CI4 <- Uncertainty * Competition Intensity	0.8226	0.821	0.0224	0.0224	36.7994
Uncertainty*CI5 <- Uncertainty * Competition Intensity	0.8272	0.8276	0.0181	0.0181	45.7109
Uncertainty*CI6 <- Uncertainty * Competition Intensity	0.7982	0.7972	0.0256	0.0256	31.2245

VII) t-Statistics Constructs

Table 5-41 displays t-statistics for the construct to construct estimates of the structural model as a result of bootstrapping process. As highlighted below, all t-statistics are above 1.96, indicating that estimates are stable.

Table 5-41: t-Statistics Constructs - Moderation Effect of Competition Intensity

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	t Statistics (|O/STERR|)
Competition Intensity -> DFL	-0.5729	-0.5792	0.1613	0.1613	3.5526
Uncertainty -> DFL	0.8607	0.8582	0.0847	0.0847	10.1581
Uncertainty * Competition Intensity -> DFL	-0.4092	-0.4029	0.2038	0.2038	2.0077

VIII) Findings

PLS analysis has been carried out to investigate the moderation effect of competition intensity in the relationship between the uncertainty and DFL (Hypothesis 3).

H_3: The relationship between Uncertainty and DFL is moderated by the level of Competition.

The model fits the data as the quality criteria meet the requirements and t-statistics indicate that the estimates are stable. Therefore, estimates are statistically meaningful.

The outcome of analysis revealed that competition intensity negatively impacts DLF (β = -0.573, $p<0.05$). In other words, when competition is fiercer, companies adopt a more balanced supply chain. The justification of this finding relies on the fact that when competition is intense, companies are struggling to provide a product/service which has not only an excellent market winner, but also an improved level of market qualifier. Accordingly, both aspects of leanness and agility should be considered to improve price competitiveness and service level at the same time. As a result, deviation from leagility would be less in high level of competition.

In order to investigate the moderation effect, a new variable has been calculated as a result of multiplying the scores of independent variable (uncertainty) by moderator (competition intensity). As path coefficient of interaction variable (β = -0.409, $p<0.05$) is significant, it could be concluded that the relationship between uncertainty and DFL is moderated by the level of competition. Thus, H_3 is supported.

It has been identified that the path coefficient between the interaction variable and DFL is negative (β = -0.409, p<0.05). The negative figure indicates that in higher level of competition, the effect of uncertainty on DFL would decrease. As explained earlier, in high uncertainty level, companies adopt a supply chain which provides the minimum level of market qualifier and more focus would be on providing an improved level of market winner. On the other hand, competition acts at the opposite direction. High level of competition would force the companies to not only focus on the market winner but also provide an improved level of market qualifiers. Therefore, by increasing the level of competition, the effect of uncertainty on DFL would decline.

IX) Graph of Moderation Effect of Competition Intensity

In order to get a better understanding of moderation effect of competition intensity on the relationship between uncertainty and DFL, the moderation effect needs to be depicted in a graph. The graphical tool used to depict the moderation effect is ModGraph (Jose 2013). To graph the moderation effect, ModGraph requires some basic information regarding the variables of the model. As shown in Figure 5-15, the following statistics have been entered into ModGraph.

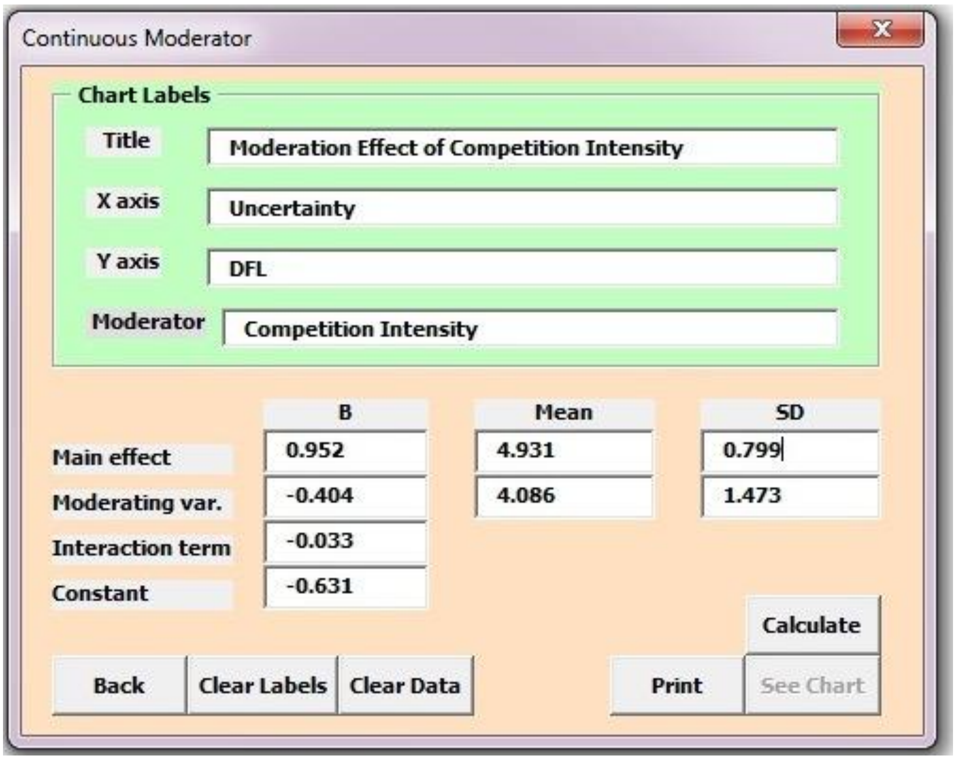

Figure 5-15: ModGraph basic statistics to graph moderation effect of Competition Intensity

Based on provided statistics, ModGraph calculates DFL values for low, medium, and high values of Uncertainty against low, medium, and high value of competition intensity (Table 5-42).

Table 5-42: ModGraph calculated points to graph moderation effect of Competition Intensity

DFL (The blue figures in this table)		Uncertainty		
		Low	**Med**	**High**
Competition Intensity	**High**	0.30	0.91	1.53
	Medium	1.09	1.75	2.40
	Low	1.89	2.58	3.27

Figure 5-16 presents the graphical representation of completion intensity moderation effect on the relationship between uncertainty and DFL. Eyeballing the graph does not show a significant difference between the slopes regarding the impact of uncertainty on DFL over different levels of competition intensity. Therefore, slopes have been calculated to support the previous findings.

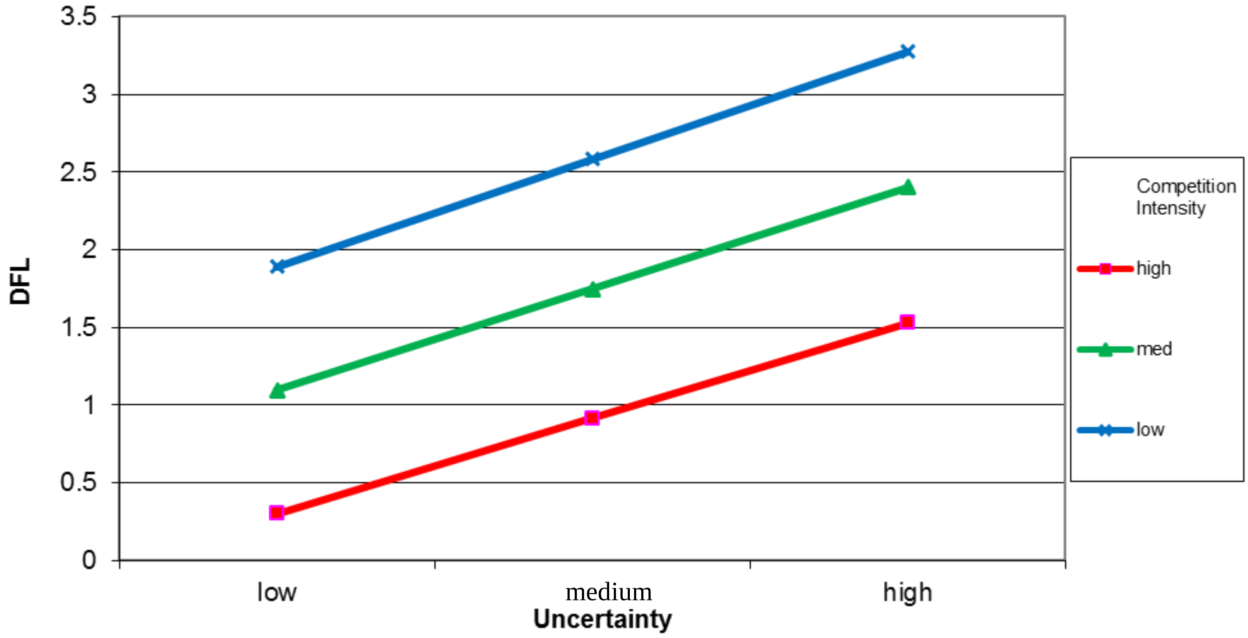

Figure 5-16: Graphical representation of Competition Intensity moderation effect

Table 5-43 presents the slopes regarding the effect of uncertainty on DFL over different levels of competition intensity. The calculated slopes supports the earlier interpretation of moderation analysis as in higher competition intensity, the effect of uncertainty on DFL would decrease.

Table 5-43: Slopes regarding the effect of uncertainty on DFL over different levels of Competition intensity

		Slopes
Competition Intensity	**Low**	1.001
	Med	0.952
	High	0.9034

5.4.2 Demand Uncertainty

The same analysis is carried out on the relationship between the demand uncertainty and DFL to investigate whether competition intensity could be a moderator.

I) Structural Model

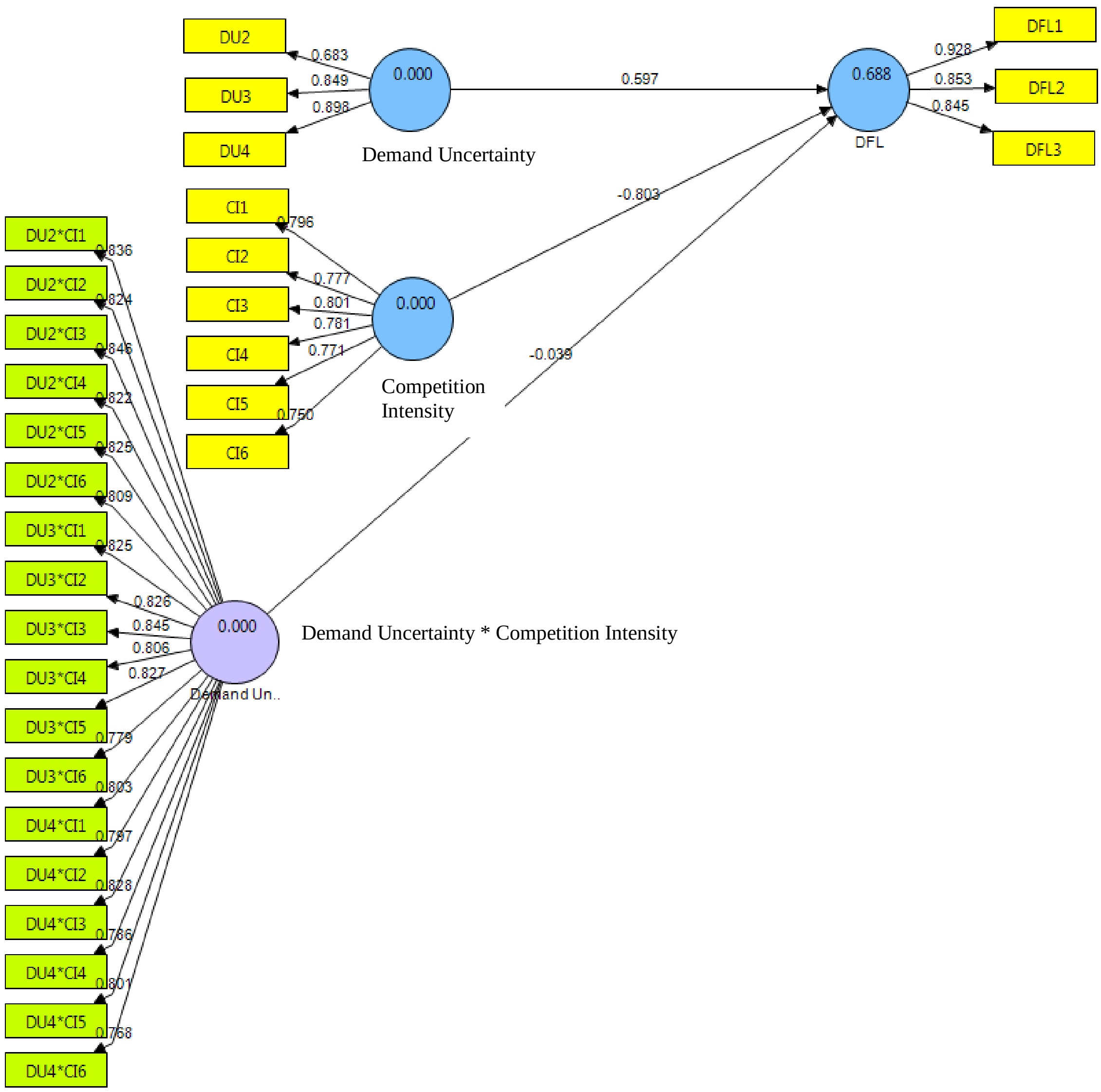

Figure 5-17: Structural Model - Moderation Effect of Competition Intensity (Demand Uncertainty on DFL)

Figure 5-17 presents the structural model to investigate the moderation effect of competition intensity on the relationship between demand uncertainty and DFL (Hypothesis 3-1).

$H_{3\text{-}1}$: The relationship between Demand Uncertainty and DFL is moderated by the level of Competition.

II) Factor Loadings

Table 5-44 presents factor loadings for the structural model. As highlighted below, all factor loadings are above 0.7 indicating that measures have acceptable convergent validity.

Table 5-44: Factor Loadings - Moderation Effect of Competition Intensity (Demand Uncertainty on DFL)

	Competition Intensity	DFL	Demand Uncertainty	Demand Uncertainty * Competition Intensity
CI1	0.7963	0	0	0
CI2	0.7774	0	0	0
CI3	0.8011	0	0	0
CI4	0.7811	0	0	0
CI5	0.7715	0	0	0
CI6	0.7497	0	0	0
DFL1	0	0.9281	0	0
DFL2	0	0.8527	0	0
DFL3	0	0.8451	0	0
DU2	0	0	0.6834	0
DU2*CI1	0	0	0	0.8364
DU2*CI2	0	0	0	0.824
DU2*CI3	0	0	0	0.8463
DU2*CI4	0	0	0	0.822
DU2*CI5	0	0	0	0.8246
DU2*CI6	0	0	0	0.8085
DU3	0	0	0.8492	0
DU3*CI1	0	0	0	0.8253
DU3*CI2	0	0	0	0.8256
DU3*CI3	0	0	0	0.8455
DU3*CI4	0	0	0	0.8057
DU3*CI5	0	0	0	0.827
DU3*CI6	0	0	0	0.7793
DU4	0	0	0.8975	0
DU4*CI1	0	0	0	0.8027
DU4*CI2	0	0	0	0.7971

	Competition Intensity	DFL	Demand Uncertainty	Demand Uncertainty * Competition Intensity
DU4*CI3	0	0	0	0.8283
DU4*CI4	0	0	0	0.7865
DU4*CI5	0	0	0	0.8013
DU4*CI6	0	0	0	0.7678

III) Path Coefficient

Table 5-45 presents the path coefficient for the relationship between independent variables (demand uncertainty, competition intensity, and interaction between demand uncertainty and competition intensity) and dependent variable (DFL). The outcome of analysis indicates that demand uncertainty positively impacts on DFL ($\beta = 0.5972$, $p<0.05$), whereas, competition intensity negatively impacts on DFL ($\beta = -0.803$, $p<0.05$). In addition, interaction element has a negative impact on DFL ($\beta = -0.0391$, $p<0.05$). However, the estimate should be statistically investigated through bootstrapping process.

Table 5-45: Path Coefficient - Moderation Effect of Competition Intensity (Demand Uncertainty on DFL)

	Competition Intensity	DFL	Demand Uncertainty	Demand Uncertainty * Competition Intensity
Competition Intensity	0	-0.803	0	0
DFL	0	0	0	0
Demand Uncertainty	0	0.5972	0	0
Demand Uncertainty * Competition Intensity	0	-0.0391	0	0

IV) Quality Criteria

In order to assess the internal consistency of the measurement items, average variance extracted (AVE), composite reliability, and Cronbach's Alpha should be assessed. The minimum value for the composite reliability and Cronbach's Alpha is 0.7 and value of AVE above 0.5 is deemed to be in satisfactory level. As shown in Table 5-46, all quality criteria are within acceptable limit. Therefore, measures have an acceptable internal consistency.

Table 5-46: Quality Criteria - Moderation Effect of Competition Intensity (Demand Uncertainty on DFL)

	AVE	Composite Reliability	R Square	Cronbach's Alpha	Communality	Redundancy
Competition Intensity	0.6079	0.9029	0	0.8711	0.6079	0
DFL	0.7676	0.9082	0.6878	0.8477	0.7676	0.2771
Demand Uncertainty	0.6645	0.8544	0	0.7735	0.6645	0
Demand Uncertainty * Competition Intensity	0.6632	0.9725	0	0.9704	0.6632	0

V) Bootstrapping

As depicted in Figure 5-18, the stability of the estimates is tested via a bootstrap re-sampling procedure (5000 sub-samples).

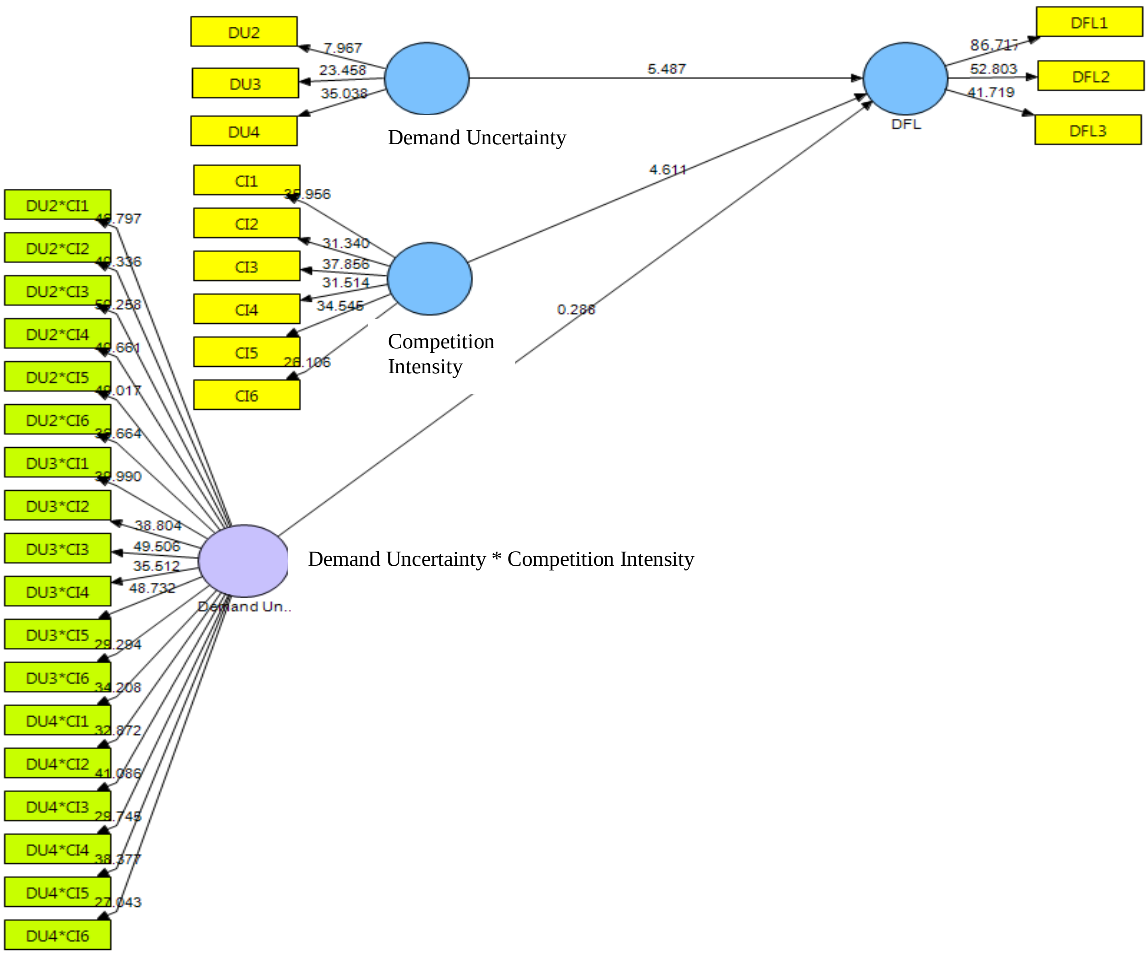

Figure 5-18: Bootstrapping - Moderation Effect of Competition Intensity (Demand Uncertainty on DFL)

VI) t-Statistics

Table 5-47 presents t-statistics for the estimates of variables to constructs as a result of bootstrapping process. As highlighted below, t-statistic of all estimates is above 1.96 indicating that estimates are stable.

Table 5-47: t-Statistics - Moderation Effect of Competition Intensity (Demand Uncertainty on DFL)

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	t Statistics (|O/STERR|)
CI1 <- Competition Intensity	0.7963	0.796	0.0221	0.0221	35.9564
CI2 <- Competition Intensity	0.7774	0.7775	0.0248	0.0248	31.3401
CI3 <- Competition Intensity	0.8011	0.8004	0.0212	0.0212	37.8563
CI4 <- Competition Intensity	0.7811	0.78	0.0248	0.0248	31.5139
CI5 <- Competition Intensity	0.7715	0.7713	0.0223	0.0223	34.5454
CI6 <- Competition Intensity	0.7497	0.7493	0.0287	0.0287	26.1056
DFL1 <- DFL	0.9281	0.9278	0.0107	0.0107	86.7168
DFL2 <- DFL	0.8527	0.8527	0.0161	0.0161	52.8028
DFL3 <- DFL	0.8451	0.8447	0.0203	0.0203	41.7194
DU2 <- Demand Uncertainty	0.6834	0.6705	0.0858	0.0858	7.9674
DU2*CI1 <- Demand Uncertainty * Competition Intensity	0.8364	0.8362	0.0179	0.0179	46.7968
DU2*CI2 <- Demand Uncertainty * Competition Intensity	0.824	0.824	0.0204	0.0204	40.3359
DU2*CI3 <- Demand Uncertainty * Competition Intensity	0.8463	0.8456	0.0168	0.0168	50.2585
DU2*CI4 <- Demand Uncertainty * Competition Intensity	0.822	0.821	0.0202	0.0202	40.6606
DU2*CI5 <- Demand Uncertainty * Competition Intensity	0.8246	0.8252	0.0168	0.0168	49.0175
DU2*CI6 <- Demand Uncertainty * Competition Intensity	0.8085	0.8084	0.0221	0.0221	36.6642
DU3 <- Demand Uncertainty	0.8492	0.8434	0.0362	0.0362	23.4575
DU3*CI1 <- Demand Uncertainty * Competition Intensity	0.8253	0.8252	0.0206	0.0206	39.9903
DU3*CI2 <- Demand Uncertainty * Competition Intensity	0.8256	0.8257	0.0213	0.0213	38.8042
DU3*CI3 <- Demand Uncertainty * Competition Intensity	0.8455	0.8448	0.0171	0.0171	49.5061
DU3*CI4 <- Demand Uncertainty * Competition Intensity	0.8057	0.8043	0.0227	0.0227	35.512
DU3*CI5 <- Demand Uncertainty * Competition Intensity	0.827	0.8272	0.017	0.017	48.7325
DU3*CI6 <- Demand Uncertainty * Competition Intensity	0.7793	0.7786	0.0266	0.0266	29.2943
DU4 <- Demand Uncertainty	0.8975	0.8966	0.0256	0.0256	35.0382
DU4*CI1 <- Demand Uncertainty * Competition Intensity	0.8027	0.8014	0.0235	0.0235	34.2077
DU4*CI2 <- Demand Uncertainty * Competition Intensity	0.7971	0.7961	0.0242	0.0242	32.8721
DU4*CI3 <- Demand Uncertainty * Competition Intensity	0.8283	0.8268	0.0202	0.0202	41.0864
DU4*CI4 <- Demand Uncertainty *	0.7865	0.7841	0.0264	0.0264	29.7452

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	t Statistics (|O/STERR|)
Competition Intensity					
DU4*CI5 <- Demand Uncertainty * Competition Intensity	0.8013	0.8008	0.0209	0.0209	38.3768
DU4*CI6 <- Demand Uncertainty * Competition Intensity	0.7678	0.7664	0.0284	0.0284	27.0432

VII) t-Statistics Constructs

Table 5-48 displays t-statistics for the construct to construct estimates of the structural model as a result of bootstrapping process. As highlighted below, the t-statistics of the relationship between moderating factor and DFL (0.286) is below 1.96. Therefore, competition intensity is not a moderator on the relationship between demand uncertainty and DFL.

Table 5-48: t-Statistics Constructs - Moderation Effect of Competition Intensity (Demand Uncertainty on DFL)

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	t Statistics (|O/STERR|)
Competition Intensity -> DFL	-0.803	-0.8161	0.1742	0.1742	4.6107
Demand Uncertainty -> DFL	0.5972	0.59	0.1088	0.1088	5.4865
Demand Uncertainty * Competition Intensity -> DFL	-0.0391	-0.0194	0.2223	0.2223	0.286

VIII) Findings

PLS analysis has been carried out to investigate the moderation effect of competition intensity in the relationship between the demand uncertainty and DFL (Hypothesis 3-1).

> *H_{3-1}: The relationship between Demand Uncertainty and DFL is moderated by the level of Competition.*

The model fits the data as the quality criteria meet the requirements. However, t-statistic indicates that the estimate is not stable. As path coefficient of interaction variable ($\beta = -0.039$, $p<0.05$) is not significant (t-statistic=0.286), it could be concluded that the relationship between demand uncertainty and DFL is not moderated by the level of competition. Thus, H_{3-1} is not supported.

5.4.3 Supply Uncertainty

The same analysis is carried out on the relationship between the supply uncertainty and DFL to investigate whether competition intensity could be a moderator.

I) Structural Model

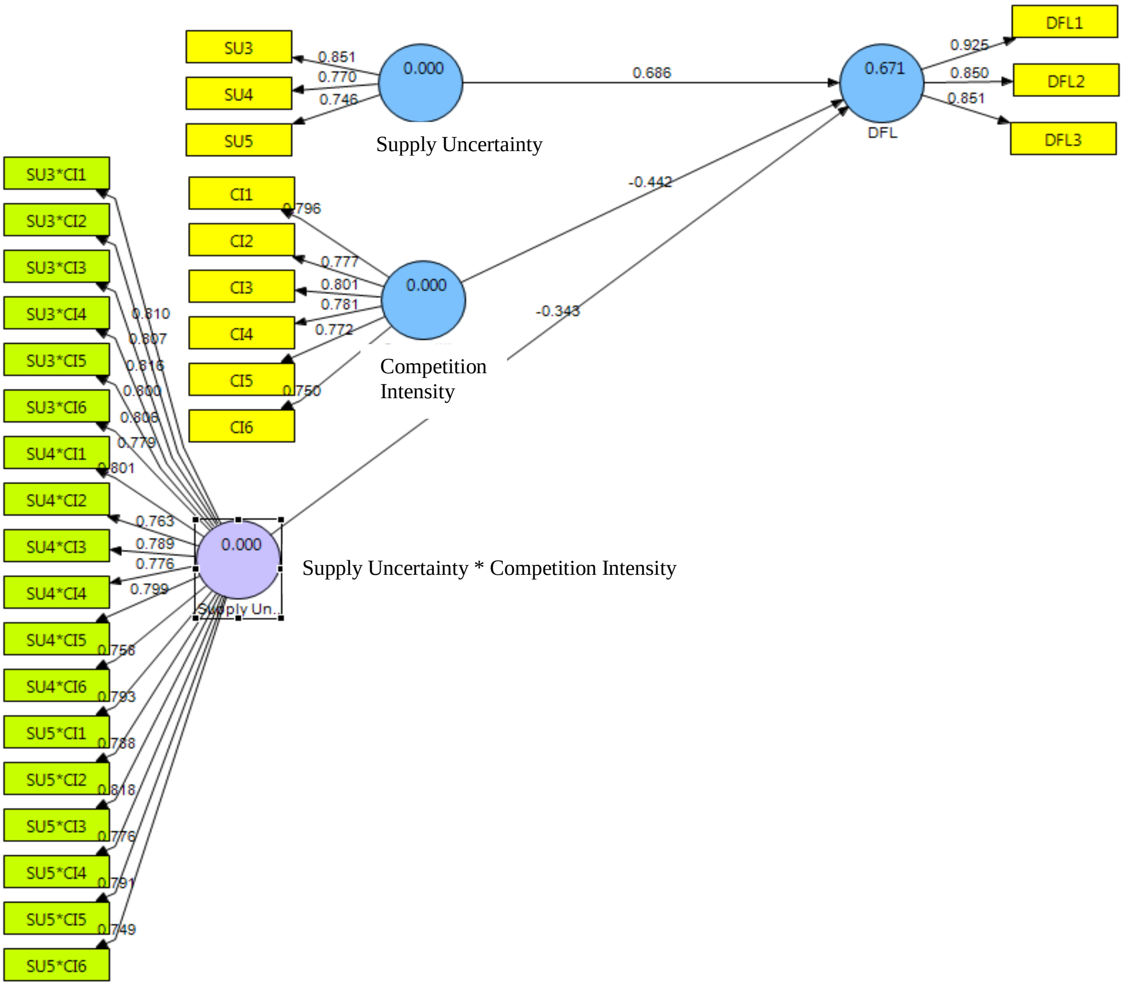

Figure 5-19: Structural Model - Moderation Effect of Competition Intensity (Supply Uncertainty on DFL)

Figure 5-19 presents the structural model to investigate the moderation effect of competition intensity on the relationship between supply uncertainty and DFL (Hypothesis 3-2).

H_{3-2}: The relationship between Supply Uncertainty and DFL is moderated by the level of Competition.

II) Factor Loadings

Table 5-49 presents factor loadings for the structural model. As highlighted below, all factor loadings are above 0.7 indicating that measures have acceptable convergent validity.

Table 5-49: Factor Loadings - Moderation Effect of Competition Intensity (Supply Uncertainty on DFL)

	Competition Intensity	DFL	Supply Uncertainty	Supply Uncertainty * Competition Intensity
CI1	0.7961	0	0	0
CI2	0.7772	0	0	0
CI3	0.8012	0	0	0
CI4	0.7811	0	0	0
CI5	0.7715	0	0	0
CI6	0.7499	0	0	0
DFL1	0	0.9251	0	0
DFL2	0	0.8504	0	0
DFL3	0	0.8508	0	0
SU3	0	0	0.8514	0
SU3*CI1	0	0	0	0.8096
SU3*CI2	0	0	0	0.8074
SU3*CI3	0	0	0	0.8161
SU3*CI4	0	0	0	0.7998
SU3*CI5	0	0	0	0.8064
SU3*CI6	0	0	0	0.7793
SU4	0	0	0.7699	0
SU4*CI1	0	0	0	0.8006
SU4*CI2	0	0	0	0.7628
SU4*CI3	0	0	0	0.7885
SU4*CI4	0	0	0	0.7765
SU4*CI5	0	0	0	0.7995
SU4*CI6	0	0	0	0.7576
SU5	0	0	0.7464	0
SU5*CI1	0	0	0	0.7927
SU5*CI2	0	0	0	0.7877
SU5*CI3	0	0	0	0.818
SU5*CI4	0	0	0	0.7755
SU5*CI5	0	0	0	0.791
SU5*CI6	0	0	0	0.7488

III) Path Coefficient

Table 5-50 presents the path coefficient for the relationship between independent variables (supply uncertainty, competition intensity, and interaction between supply uncertainty and competition intensity) and dependent variable (DFL). The outcome of analysis indicates that supply uncertainty positively impacts on DFL (β = 0.6864, p<0.05), whereas, competition intensity negatively impacts on DFL (β = -0.4419, p<0.05). In addition, interaction element has a negative impact on DFL (β = -0.3431, p<0.05). However, the estimate should be statistically investigated through bootstrapping process.

Table 5-50: Path Coefficient - Moderation Effect of Competition Intensity (Supply Uncertainty on DFL)

	Competition Intensity	DFL	Supply Uncertainty	Supply Uncertainty * Competition Intensity
Competition Intensity	0	-0.4419	0	0
DFL	0	0	0	0
Supply Uncertainty	0	0.6864	0	0
Supply Uncertainty * Competition Intensity	0	-0.3431	0	0

IV) Quality Criteria

In order to assess the internal consistency of the measurement items, average variance extracted (AVE), composite reliability, and Cronbach's Alpha should be assessed. The minimum value for the composite reliability and Cronbach's Alpha is 0.7 and value of AVE above 0.5 is deemed to be in satisfactory level. As shown in Table 5-51, all quality criteria are within acceptable limit. Therefore, measures have an acceptable internal consistency.

Table 5-51: Quality Criteria - Moderation Effect of Competition Intensity (Supply Uncertainty on DFL)

	AVE	Composite Reliability	R Square	Cronbach's Alpha	Communality	Redundancy
Competition Intensity	0.6079	0.9029	0	0.8711	0.6079	0
DFL	0.7676	0.9082	0.6711	0.8477	0.7676	0.275
Supply Uncertainty	0.625	0.8329	0	0.6976	0.625	0
Supply Uncertainty * Competition Intensity	0.6243	0.9676	0	0.9649	0.6243	0

V) Bootstrapping

As depicted in Figure 5-20, the stability of the estimates is tested via a bootstrap re-sampling procedure (5000 sub-samples).

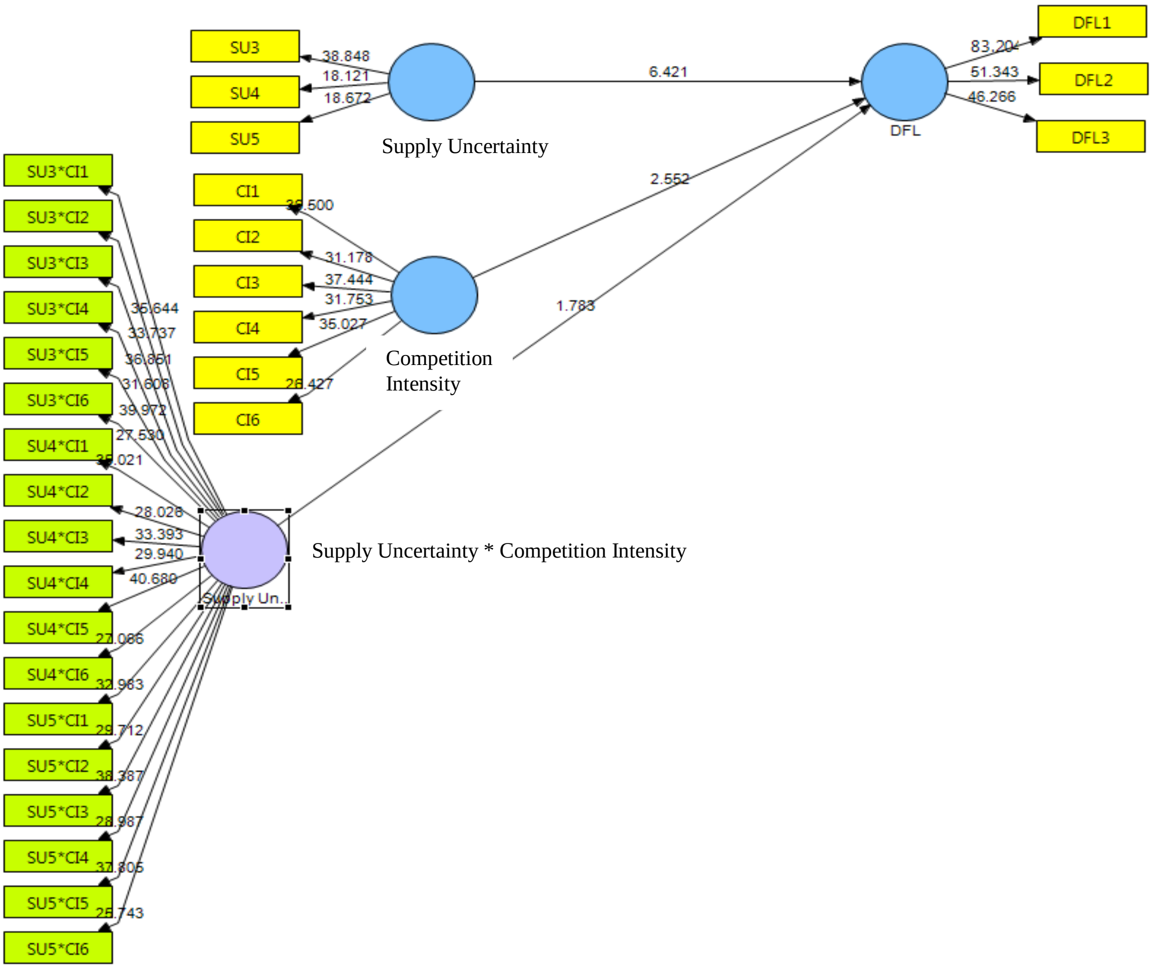

Figure 5-20: Bootstrapping - Moderation Effect of Competition Intensity (Supply Uncertainty on DFL)

VI) t-Statistics

Table 5-52 presents t-statistics for the estimates of variables to constructs as a result of bootstrapping process. As highlighted below, t-statistic of all estimates is above 1.96 indicating that estimates are stable.

Table 5-52: t-Statistics - Moderation Effect of Competition Intensity (Supply Uncertainty on DFL)

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	t Statistics (|O/STERR|)
CI1 <- Competition Intensity	0.7961	0.7956	0.0218	0.0218	36.5003
CI2 <- Competition Intensity	0.7772	0.7766	0.0249	0.0249	31.1778
CI3 <- Competition Intensity	0.8012	0.8	0.0214	0.0214	37.4442
CI4 <- Competition Intensity	0.7811	0.7799	0.0246	0.0246	31.7534
CI5 <- Competition Intensity	0.7715	0.7715	0.022	0.022	35.0267
CI6 <- Competition Intensity	0.7499	0.7499	0.0284	0.0284	26.4271
DFL1 <- DFL	0.9251	0.9252	0.0111	0.0111	83.204
DFL2 <- DFL	0.8504	0.8497	0.0166	0.0166	51.3432
DFL3 <- DFL	0.8508	0.8501	0.0184	0.0184	46.2655
SU3 <- Supply Uncertainty	0.8514	0.8501	0.0219	0.0219	38.848
SU3*CI1 <- Supply Uncertainty * Competition Intensity	0.8096	0.8078	0.0227	0.0227	35.6442
SU3*CI2 <- Supply Uncertainty * Competition Intensity	0.8074	0.8057	0.0239	0.0239	33.7374
SU3*CI3 <- Supply Uncertainty * Competition Intensity	0.8161	0.8138	0.0221	0.0221	36.8508
SU3*CI4 <- Supply Uncertainty * Competition Intensity	0.7998	0.797	0.0253	0.0253	31.6082
SU3*CI5 <- Supply Uncertainty * Competition Intensity	0.8064	0.8063	0.0202	0.0202	39.9722
SU3*CI6 <- Supply Uncertainty * Competition Intensity	0.7793	0.7781	0.0283	0.0283	27.5302
SU4 <- Supply Uncertainty	0.7699	0.7673	0.0425	0.0425	18.1215
SU4*CI1 <- Supply Uncertainty * Competition Intensity	0.8006	0.7992	0.0229	0.0229	35.021
SU4*CI2 <- Supply Uncertainty * Competition Intensity	0.7628	0.7614	0.0272	0.0272	28.0262
SU4*CI3 <- Supply Uncertainty * Competition Intensity	0.7885	0.787	0.0236	0.0236	33.3934
SU4*CI4 <- Supply Uncertainty * Competition Intensity	0.7765	0.7736	0.0259	0.0259	29.9398
SU4*CI5 <- Supply Uncertainty * Competition Intensity	0.7995	0.8001	0.0197	0.0197	40.6801
SU4*CI6 <- Supply Uncertainty * Competition Intensity	0.7576	0.7568	0.028	0.028	27.0663
SU5 <- Supply Uncertainty	0.7464	0.7457	0.04	0.04	18.6722
SU5*CI1 <- Supply Uncertainty * Competition Intensity	0.7927	0.7919	0.024	0.024	32.9833
SU5*CI2 <- Supply Uncertainty * Competition Intensity	0.7877	0.7869	0.0265	0.0265	29.7116
SU5*CI3 <- Supply Uncertainty * Competition Intensity	0.818	0.8165	0.0213	0.0213	38.3875
SU5*CI4 <- Supply Uncertainty	0.7755	0.7735	0.0268	0.0268	28.9873

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	t Statistics (|O/STERR|)
* Competition Intensity					
SU5*CI5 <- Supply Uncertainty * Competition Intensity	0.791	0.792	0.0209	0.0209	37.8051
SU5*CI6 <- Supply Uncertainty * Competition Intensity	0.7488	0.7487	0.0291	0.0291	25.7429

VII) t-Statistics Constructs

Table 5-53 displays t-statistics for the construct to construct estimates of the structural model as a result of bootstrapping process. As highlighted below, the t-statistics of the relationship between moderating factor and DFL (1.7834) is below 1.96. Therefore, competition intensity is not a moderator on the relationship between supply uncertainty and DFL.

Table 5-53: t-Statistics Constructs - Moderation Effect of Competition Intensity (Supply Uncertainty on DFL)

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	t Statistics (|O/STERR|)
Competition Intensity -> DFL	-0.4419	-0.4449	0.1731	0.1731	2.5522
Supply Uncertainty -> DFL	0.6864	0.6835	0.1069	0.1069	6.4211
Supply Uncertainty * Competition Intensity -> DFL	-0.3431	-0.3522	0.1924	0.1924	1.7834

VIII) Findings

PLS analysis has been carried out to investigate the moderation effect of competition intensity in the relationship between the supply uncertainty and DFL (Hypothesis 3-2).

$H_{3\text{-}2}$: The relationship between Supply Uncertainty and DFL is moderated by the level of Competition.

The model fits the data as the quality criteria meet the requirements. However, t-statistic indicates that the estimate is not stable. As path coefficient of interaction variable (β = -0.3431, $p<0.05$) is not significant (t-statistic=1.7834), it could be concluded that the relationship between supply uncertainty and DFL is not moderated by the level of competition. Thus, H_{3-2} is not supported.

5.4.4 Internal Uncertainty

The same analysis is carried out on the relationship between the internal uncertainty and DFL to investigate whether competition intensity could be a moderator.

I) Structural Model

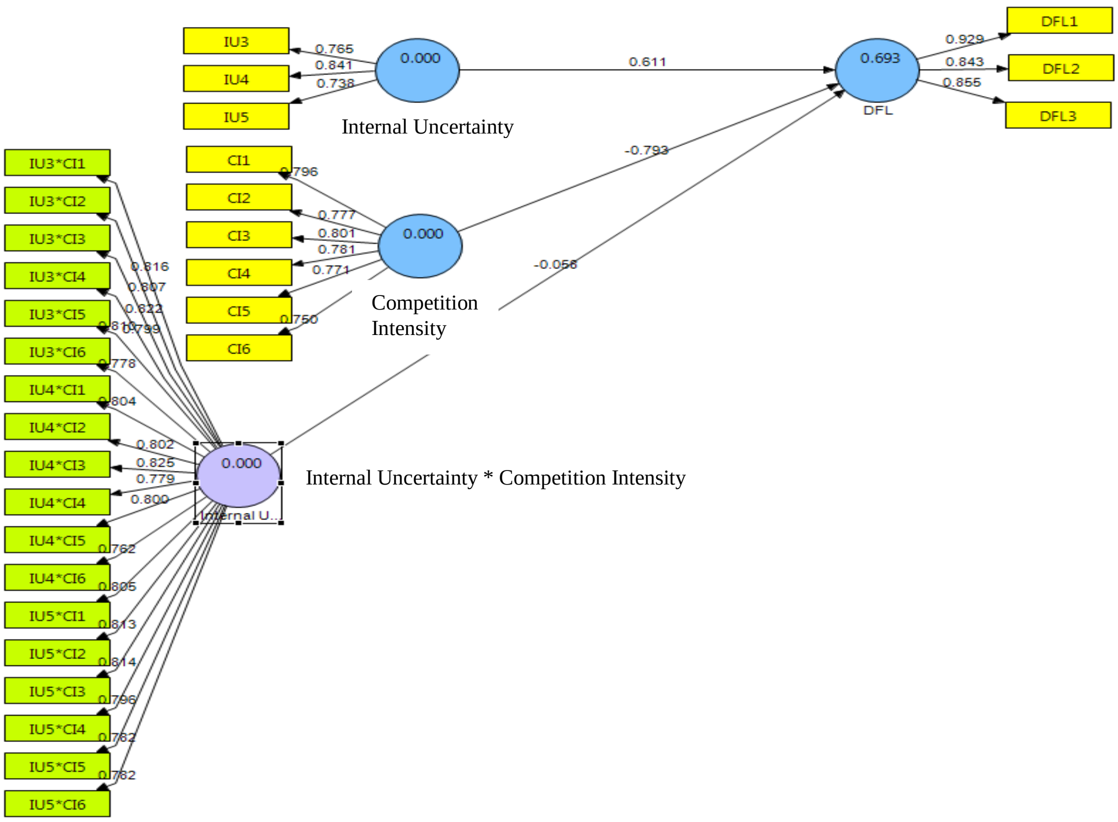

Figure 5-21: Structural Model - Moderation Effect of Competition Intensity (Internal Uncertainty on DFL)

Figure 5-21 presents the structural model to investigate the moderation effect of competition intensity on the relationship between internal uncertainty and DFL (Hypothesis 3-3).

H_{3-3}: The relationship between Internal Uncertainty and DFL is moderated by the level of Competition.

II) Factor Loadings

Table 5-54 presents factor loadings for the structural model. As highlighted below, all factor loadings are above 0.7 indicating that measures have acceptable convergent validity.

Table 5-54: Factor Loadings - Moderation Effect of Competition Intensity (Internal Uncertainty on DFL)

	Competition Intensity	DFL	Internal Uncertainty	Internal Uncertainty * Competition Intensity
CI1	0.7959	0	0	0
CI2	0.7774	0	0	0
CI3	0.8014	0	0	0
CI4	0.7812	0	0	0
CI5	0.7715	0	0	0
CI6	0.7497	0	0	0
DFL1	0	0.9287	0	0
DFL2	0	0.8426	0	0
DFL3	0	0.8549	0	0
IU3	0	0	0.7654	0
IU3*CI1	0	0	0	0.8165
IU3*CI2	0	0	0	0.8072
IU3*CI3	0	0	0	0.822
IU3*CI4	0	0	0	0.7992
IU3*CI5	0	0	0	0.8103
IU3*CI6	0	0	0	0.7781
IU4	0	0	0.841	0
IU4*CI1	0	0	0	0.8041
IU4*CI2	0	0	0	0.8024
IU4*CI3	0	0	0	0.8248
IU4*CI4	0	0	0	0.7787
IU4*CI5	0	0	0	0.7998
IU4*CI6	0	0	0	0.7617
IU5	0	0	0.7384	0
IU5*CI1	0	0	0	0.8048
IU5*CI2	0	0	0	0.8129
IU5*CI3	0	0	0	0.8144
IU5*CI4	0	0	0	0.7956
IU5*CI5	0	0	0	0.7818
IU5*CI6	0	0	0	0.7819

III) Path Coefficient

Table 5-55 presents the path coefficient for the relationship between independent variables (internal uncertainty, competition intensity, and interaction between internal uncertainty and competition intensity) and dependent variable (DFL). The outcome of analysis indicates that internal uncertainty positively impacts on DFL ($\beta = 0.6109$, $p<0.05$), whereas, competition intensity negatively impacts on DFL ($\beta = -0.793$, $p<0.05$). In addition, interaction element has a negative impact on DFL ($\beta = -0.0583$, $p<0.05$). However, the estimate should be statistically investigated through bootstrapping process.

Table 5-55: Path Coefficient - Moderation Effect of Competition Intensity (Internal Uncertainty on DFL)

	Competition Intensity	DFL	Internal Uncertainty	Internal Uncertainty * Competition Intensity
Competition Intensity	0	-0.793	0	0
DFL	0	0	0	0
Internal Uncertainty	0	0.6109	0	0
Internal Uncertainty * Competition Intensity	0	-0.0583	0	0

IV) Quality Criteria

In order to assess the internal consistency of the measurement items, average variance extracted (AVE), composite reliability, and Cronbach's Alpha should be assessed. The minimum value for the composite reliability and Cronbach's Alpha is 0.7 and value of AVE above 0.5 is deemed to be in satisfactory level. As shown in Table 5-56, all quality criteria are within acceptable limit. Therefore, measures have an acceptable internal consistency.

Table 5-56: Quality Criteria - Moderation Effect of Competition Intensity (Internal Uncertainty on DFL)

	AVE	Composite Reliability	R Square	Cronbach's Alpha	Communality	Redundancy
Competition Intensity	0.6079	0.9029	0	0.8711	0.6079	0
DFL	0.7678	0.9082	0.6926	0.8477	0.7678	0.2797
Internal Uncertainty	0.6128	0.8256	0	0.6881	0.6128	0
Internal Uncertainty * Competition Intensity	0.6399	0.9697	0	0.9671	0.6399	0

V) Bootstrapping

As depicted in Figure 5-22, the stability of the estimates is tested via a bootstrap re-sampling procedure (5000 sub-samples).

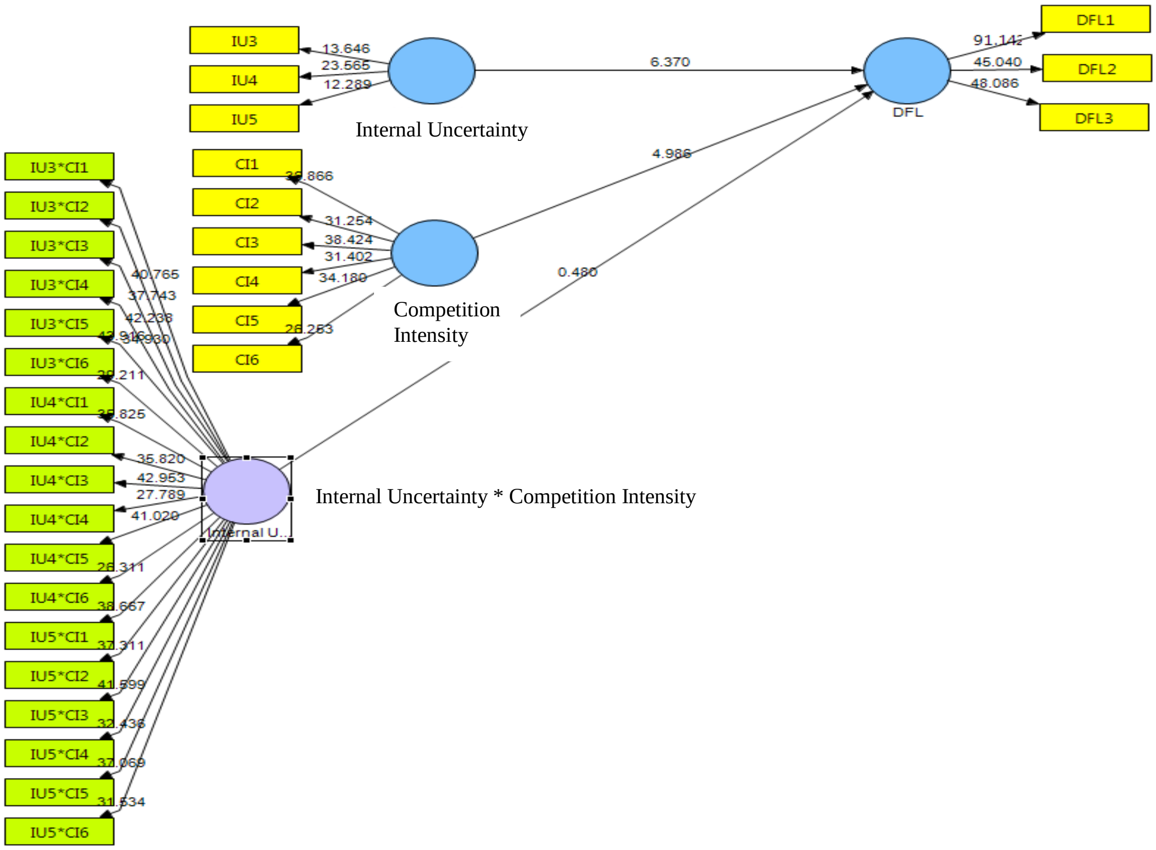

Figure 5-22: Bootstrapping - Moderation Effect of Competition Intensity (Internal Uncertainty on DFL)

VI) t-Statistics

Table 5-57 presents t-statistics for the estimates of variables to constructs as a result of bootstrapping process. As highlighted below, t-statistic of all estimates is above 1.96 indicating that estimates are stable.

Table 5-57: t-Statistics - Moderation Effect of Competition Intensity (Internal Uncertainty on DFL)

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	t Statistics (|O/STERR|)
CI1 <- Competition Intensity	0.7959	0.7954	0.0216	0.0216	36.8659
CI2 <- Competition Intensity	0.7774	0.7767	0.0249	0.0249	31.2539
CI3 <- Competition Intensity	0.8014	0.8008	0.0209	0.0209	38.4235
CI4 <- Competition Intensity	0.7812	0.7795	0.0249	0.0249	31.4022
CI5 <- Competition Intensity	0.7715	0.7715	0.0226	0.0226	34.1801
CI6 <- Competition Intensity	0.7497	0.7488	0.0286	0.0286	26.2533
DFL1 <- DFL	0.9287	0.9285	0.0102	0.0102	91.1423
DFL2 <- DFL	0.8426	0.8421	0.0187	0.0187	45.0402
DFL3 <- DFL	0.8549	0.8542	0.0178	0.0178	48.0857
IU3 <- Internal Uncertainty	0.7654	0.7577	0.0561	0.0561	13.646
IU3*CI1 <- Internal Uncertainty * Competition Intensity	0.8165	0.8158	0.02	0.02	40.7647
IU3*CI2 <- Internal Uncertainty * Competition Intensity	0.8072	0.8065	0.0214	0.0214	37.7428
IU3*CI3 <- Internal Uncertainty * Competition Intensity	0.822	0.8212	0.0195	0.0195	42.2381
IU3*CI4 <- Internal Uncertainty * Competition Intensity	0.7992	0.797	0.0229	0.0229	34.9304
IU3*CI5 <- Internal Uncertainty * Competition Intensity	0.8103	0.8108	0.0185	0.0185	43.9162
IU3*CI6 <- Internal Uncertainty * Competition Intensity	0.7781	0.7769	0.0266	0.0266	29.2106
IU4 <- Internal Uncertainty	0.841	0.8411	0.0357	0.0357	23.5649
IU4*CI1 <- Internal Uncertainty * Competition Intensity	0.8041	0.803	0.0224	0.0224	35.8255
IU4*CI2 <- Internal Uncertainty * Competition Intensity	0.8024	0.801	0.0224	0.0224	35.8197

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	t Statistics (|O/STERR|)
IU4*CI3 <- Internal Uncertainty * Competition Intensity	0.8248	0.8233	0.0192	0.0192	42.9532
IU4*CI4 <- Internal Uncertainty * Competition Intensity	0.7787	0.7758	0.028	0.028	27.7892
IU4*CI5 <- Internal Uncertainty * Competition Intensity	0.7998	0.7998	0.0195	0.0195	41.0197
IU4*CI6 <- Internal Uncertainty * Competition Intensity	0.7617	0.7602	0.029	0.029	26.3114
IU5 <- Internal Uncertainty	0.7384	0.7318	0.0601	0.0601	12.2891
IU5*CI1 <- Internal Uncertainty * Competition Intensity	0.8048	0.8039	0.0208	0.0208	38.6673
IU5*CI2 <- Internal Uncertainty * Competition Intensity	0.8129	0.8119	0.0218	0.0218	37.311
IU5*CI3 <- Internal Uncertainty * Competition Intensity	0.8144	0.8133	0.0196	0.0196	41.5987
IU5*CI4 <- Internal Uncertainty * Competition Intensity	0.7956	0.7927	0.0245	0.0245	32.4364
IU5*CI5 <- Internal Uncertainty * Competition Intensity	0.7818	0.7822	0.0211	0.0211	37.0688
IU5*CI6 <- Internal Uncertainty * Competition Intensity	0.7819	0.7807	0.0248	0.0248	31.5343

VII) t-Statistics Constructs

Table 5-58 displays t-statistics for the construct to construct estimates of the structural model as a result of bootstrapping process. As highlighted below, the t-statistics of the relationship between moderating factor and DFL (0.4804) is below 1.96. Therefore, competition intensity is not a moderator on the relationship between internal uncertainty and DFL.

Table 5-58: t-Statistics Constructs - Moderation Effect of Competition Intensity (internal Uncertainty on DFL)

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	t Statistics (|O/STERR|)
Competition Intensity -> DFL	-0.793	-0.8173	0.1591	0.1591	4.9856
Internal Uncertainty -> DFL	0.6109	0.5937	0.0959	0.0959	6.37
Internal Uncertainty * Competition Intensity -> DFL	-0.0583	-0.1622	0.1213	0.1213	0.4804

VIII) Findings

PLS analysis has been carried out to investigate the moderation effect of competition intensity in the relationship between the internal uncertainty and DFL (Hypothesis 3-3).

$H_{3\text{-}3}$: The relationship between Internal Uncertainty and DFL is moderated by the level of Competition.

The model fits the data as the quality criteria meet the requirements. However, t-statistic indicates that the estimate is not stable. As path coefficient of interaction variable (β = -0.0583, $p<0.05$) is not significant (t-statistic=0.4804), it could be concluded that the relationship between internal uncertainty and DFL is not moderated by the level of competition. Thus, $H_{3\text{-}3}$ is not supported.

5.4.5 Findings

In conclusion:

H3	The relationship between Uncertainty and DFL is moderated by the level of Competition.	**Supported**
H3-1	The relationship between Demand Uncertainty and DFL is moderated by the level of Competition.	**Not Supported**
H3-2	The relationship between Supply Uncertainty and DFL is moderated by the level of Competition.	**Not Supported**
H3-3	The relationship between Internal Uncertainty and DFL is moderated by the level of Competition.	**Not Supported**

5.5 **Moderation Effect of Customers' expectation**

As explained by Kotzab et al. (2009), external forces including customers' expectation affect all aspects of business including supply chain. The level of customers' expectation influences the minimum level of market qualifier and market winner a firm should provide. Customers' expectation could be interpreted in different ways including expecting more competitive price and higher service level. Accordingly, both aspects of leanness and agility should be improved to help companies to satisfy higher level of customers' expectation. Therefore, it would be wise to investigate the moderation effect of customers' expectation to the relationship between uncertainty and DFL.

SmartPLS package software provides and implements a tool to support the product indicator approach for moderating effects recommended by Chin, Marcolin and Newsted (2003).

Moderation effect of customers' expectation is investigated firstly on the relationship between overall uncertainty and DFL. Then, further investigation is carried out on potential moderation effect of customers' expectation on individual constructs of uncertainty (demand/supply/internal uncertainty).

5.5.1 Overall Uncertainty

In order to simplify the model, instead of uncertainty second order measurement model, the uncertainty scores calculated by the SmartPLS are utilised.

Figure 5-23 presents the structural model to investigate the moderation effect of customers' expectation on the relationship between uncertainty and DFL (Hypothesis 4).

H_4: The relationship between Uncertainty and DFL is moderated by the level of Customers' Expectations.

I) Structural Model

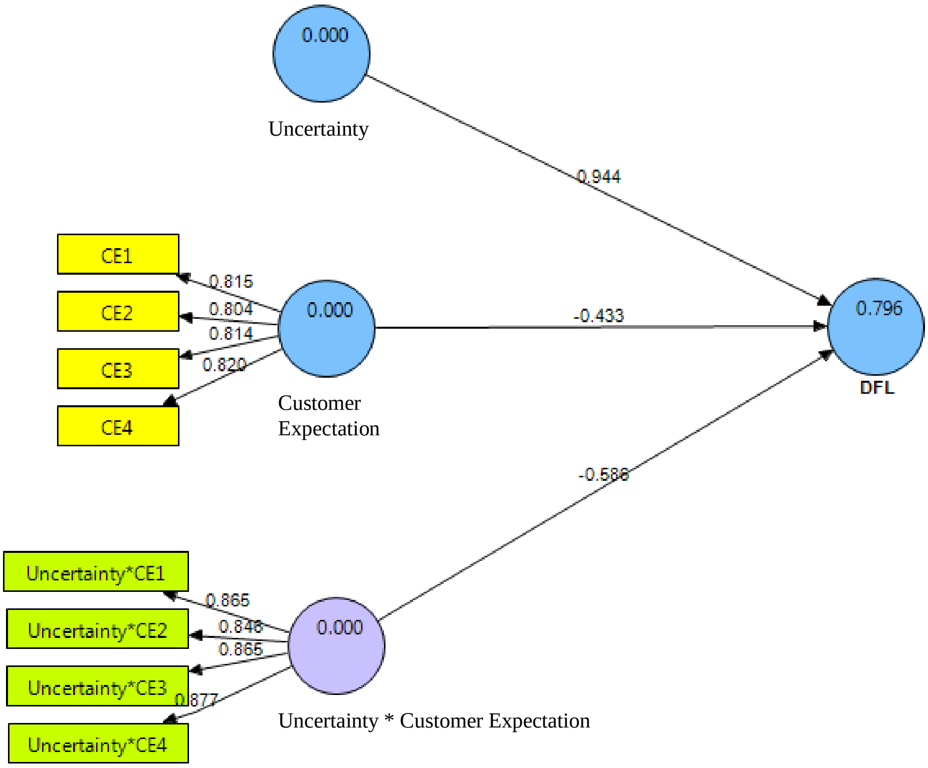

Figure 5-23: Structural Model - Moderation Effect of Customers' expectation

II) Factor Loadings

Table 5-59 presents factor loadings for the structural model. As highlighted below, all factor loadings are above 0.7 indicating that measures have acceptable convergent validity.

Table 5-59: Factor Loadings - Moderation Effect of Customers' expectation

	Customers' expectation	DFL	Uncertainty	Uncertainty * Customers' expectation
CE1	0.8155	0	0	0
CE2	0.8036	0	0	0
CE3	0.8136	0	0	0
CE4	0.8205	0	0	0
DFL1	0	0.9267	0	0

	Customers' expectation	DFL	Uncertainty	Uncertainty * Customers' expectation
DFL2	0	0.8489	0	0
DFL3	0	0.8507	0	0
Uncertainty	0	0	1	0
Uncertainty*CE1	0	0	0	0.8647
Uncertainty*CE2	0	0	0	0.8461
Uncertainty*CE3	0	0	0	0.8649
Uncertainty*CE4	0	0	0	0.8768

III) Path Coefficient

Table 5-60 presents the path coefficient for the relationship between independent variables (uncertainty, customers' expectation, and interaction between uncertainty and customers' expectation) and dependent variable (DFL). The outcome of analysis indicates that uncertainty positively impacts on DFL (β = 0.944, p<0.05), whereas, customers' expectation negatively impacts on DFL (β = -0.433, p<0.05). In addition, interaction element has a negative impact on DFL (β = -0.586, p<0.05). However, the estimate should be statistically investigated through bootstrapping process.

Table 5-60: Path Coefficient - Moderation Effect of Customers' expectation

	Customers' expectation	DFL	Uncertainty	Uncertainty * Customers' expectation
Customers' expectation	0	-0.4332	0	0
DFL	0	0	0	0
Uncertainty	0	0.9445	0	0
Uncertainty * Customers' expectation	0	-0.5859	0	0

IV) Quality Criteria

In order to assess the internal consistency of the measurement items, average variance extracted (AVE), composite reliability, and Cronbach's Alpha should be assessed. The minimum value for the composite reliability and Cronbach's Alpha is 0.7

and value of AVE above 0.5 is deemed to be in satisfactory level. As shown in Table 5-61, all quality criteria are within acceptable limit. Therefore, measures have an acceptable internal consistency.

Table 5-61: Quality Criteria - Moderation Effect of Customers' expectation

	AVE	Composite Reliability	R Square	Cronbach's Alpha	Communality	Redundancy
Customers' expectation	0.6615	0.8866	0	0.8295	0.6615	0
DFL	0.7677	0.9082	0.7962	0.8477	0.7677	0.2615
Uncertainty	1	1	0	1	1	0
Uncertainty * Customers' expectation	0.7451	0.9212	0	0.8866	0.7451	0

V) Bootstrapping

As depicted in Figure 5-24, the stability of the estimates is tested via a bootstrap re-sampling procedure (5000 sub-samples).

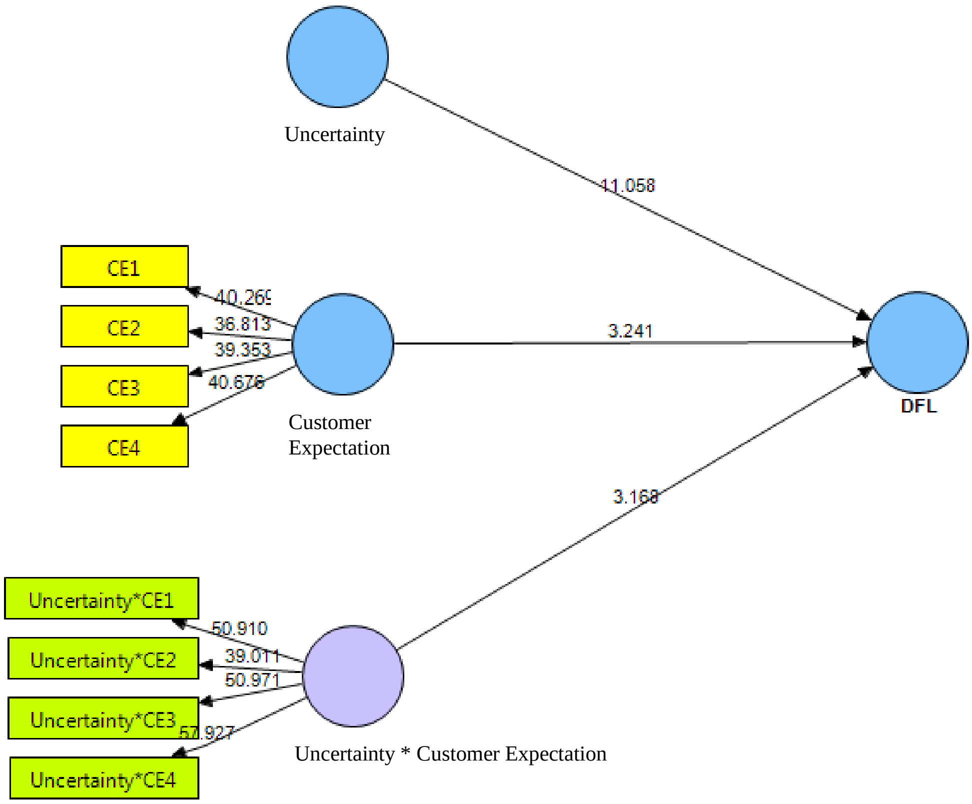

Figure 5-24: Bootstrapping - Moderation Effect of Customers' expectation

VI) t-Statistics

Table 5-62 presents t-statistics for the estimates of variables to constructs as a result of bootstrapping process. As highlighted below, t-statistic of all estimates is above 1.96 indicating that estimates are stable.

Table 5-62: t-Statistics - Moderation Effect of Customers' expectation

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	t Statistics (|O/STERR|)
CE1 <- Customers' expectation	0.8155	0.8142	0.0203	0.0203	40.2685
CE2 <- Customers' expectation	0.8036	0.8032	0.0218	0.0218	36.8125
CE3 <- Customers' expectation	0.8136	0.8126	0.0207	0.0207	39.3525
CE4 <- Customers' expectation	0.8205	0.8199	0.0202	0.0202	40.676
DFL1 <- DFL	0.9267	0.9265	0.0106	0.0106	87.0924
DFL2 <- DFL	0.8489	0.848	0.017	0.017	49.8216
DFL3 <- DFL	0.8507	0.85	0.0184	0.0184	46.1207
Uncertainty*CE1 <- Uncertainty * Customers' expectation	0.8647	0.8633	0.017	0.017	50.9104
Uncertainty*CE2 <- Uncertainty * Customers' expectation	0.8461	0.8442	0.0217	0.0217	39.0109
Uncertainty*CE3 <- Uncertainty * Customers' expectation	0.8649	0.8642	0.017	0.017	50.9712
Uncertainty*CE4 <- Uncertainty * Customers' expectation	0.8768	0.8765	0.0151	0.0151	57.9273

VII) t-Statistics Constructs

Table 5-63 displays t-statistics for the construct to construct estimates of the structural model as a result of bootstrapping process. As highlighted below, all t-statistics are above 1.96, indicating that estimates are stable.

Table 5-63: t-Statistics Constructs - Moderation Effect of Customers' expectation

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	t Statistics (|O/STERR|)
Customers' expectation -> DFL	-0.4332	-0.4416	0.1336	0.1336	3.2415
Uncertainty -> DFL	0.9445	0.9394	0.0854	0.0854	11.0584
Uncertainty * Customers' expectation -> DFL	-0.5859	-0.5761	0.1849	0.1849	3.1685

VIII) Findings

PLS analysis has been carried out to investigate the moderation effect of customers' expectation in the relationship between the uncertainty and DFL (Hypothesis 4).

H_4: The relationship between Uncertainty and DFL is moderated by the level of Customers' Expectations.

The model fits the data as the quality criteria meet the requirements and t-statistics indicate that the estimates are stable. Therefore, estimates are statistically meaningful.

The outcome of analysis revealed that customers' expectation negatively impacts DLF (β = -0.433, $p<0.05$). In other words, when customers are more demanding, companies adopt a more balanced supply chain. The justification of this finding relies on the fact that when the level of customers' expectation is higher, companies are struggling to provide a product/service which has not only an excellent market winner, but also an improved level of market qualifier. Accordingly, both aspects of leanness and agility should be considered to improve price competitiveness and service level at the same time. As a result, deviation from leagility would be less in high level of customers' expectation.

In order to investigate the moderation effect, a new variable has been calculated as a result of multiplying the scores of independent variable (uncertainty) by moderator (customers' expectation). As path coefficient of interaction variable (β = -0.586, $p<0.05$) is significant, it could be concluded that the relationship between uncertainty and DFL is moderated by the level of customers' expectation. Thus, H_4 is supported.

It has been identified that the path coefficient between the interaction variable and DFL is negative (β = -0.586, $p<0.05$). The negative figure indicates that in higher level of customers' expectation, the effect of uncertainty on DFL would decrease. As explained earlier, in high uncertainty level, companies adopt a supply chain which provides the minimum level of market qualifier and more focus would be on providing an improved level of market winner. On the other hand, level of customers' expectation acts at the opposite direction. High level of customers' expectation would force the companies to not only focus on the market winner but also provide an improved level of market qualifiers. Therefore, by increasing the level of customers' expectation, the effect of uncertainty on DFL would decline.

IX) Graph of Moderation Effect of Customers' expectation

In order to get a better understanding of moderation effect of customers' expectation on the relationship between uncertainty and DFL, the moderation effect needs to be depicted in a graph. The graphical tool used to depict the moderation effect is ModGraph (Jose 2013). To graph the moderation effect, ModGraph requires some basic information regarding the variables of the model. As shown in Figure 5-25, the following statistics have been entered into ModGraph.

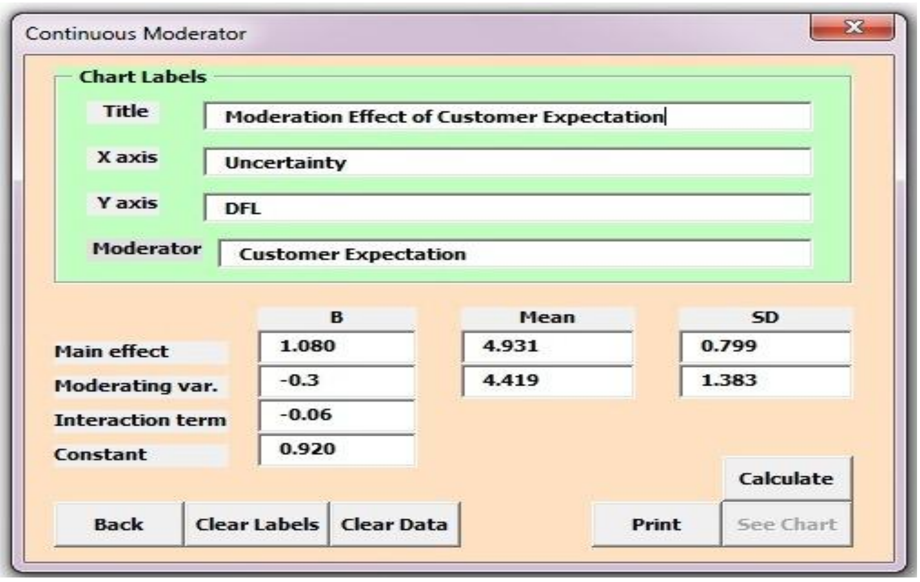

Figure 5-25: ModGraph basic statistics to graph moderation effect of Customers' expectation

Based on provided statistics, ModGraph calculates DFL values for low, medium, and high values of Uncertainty against low, medium, and high value of customers' expectation (Table 5-64).

Table 5-64: ModGraph calculated points to graph moderation effect of Customers' expectation

DFL (The blue figures in this Table)		Uncertainty		
		Low	Med	High
Customers' expectation	High	2.20	2.79	3.37
	Medium	2.96	3.61	4.26
	Low	3.72	4.44	5.15

Figure 5-26 presents the graphical representation of customers' expectation moderation effect on the relationship between uncertainty and DFL. Eyeballing the graph does not show a significant difference between the slopes regarding the impact of uncertainty on DFL over different levels of customers' expectation. Therefore, slopes have been calculated to support the previous findings.

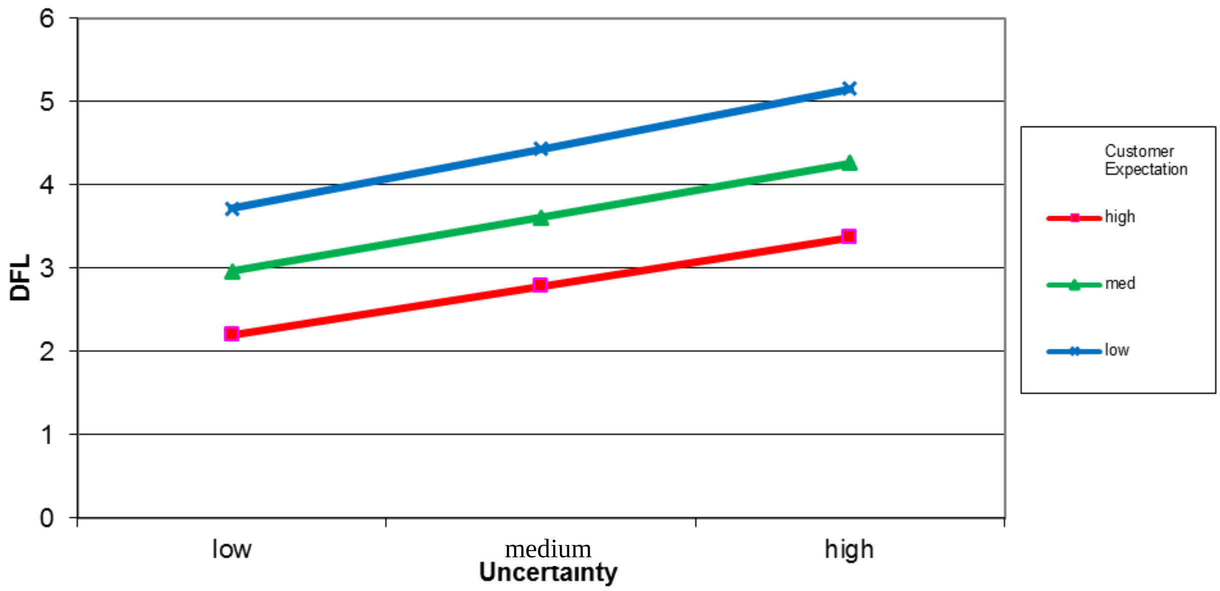

Figure 5-26: Graphical representation of Customers' expectation moderation effect

Table 5-65 presents the slopes regarding the effect of uncertainty on DFL over different levels of customers' expectation. The calculated slopes supports the earlier interpretation of moderation analysis as in higher level of customers' expectation, the effect of uncertainty on DFL would decrease.

Table 5-65: Slopes regarding the effect of uncertainty on DFL over different levels of Customers' expectation

		Slopes
Customers' expectation	Low	1.16298
	Med	1.08
	High	0.99702

5.5.2 Demand Uncertainty

The same analysis is carried out on the relationship between the demand uncertainty and DFL to investigate whether customers' expectation could be a moderator.

I) Structural Model

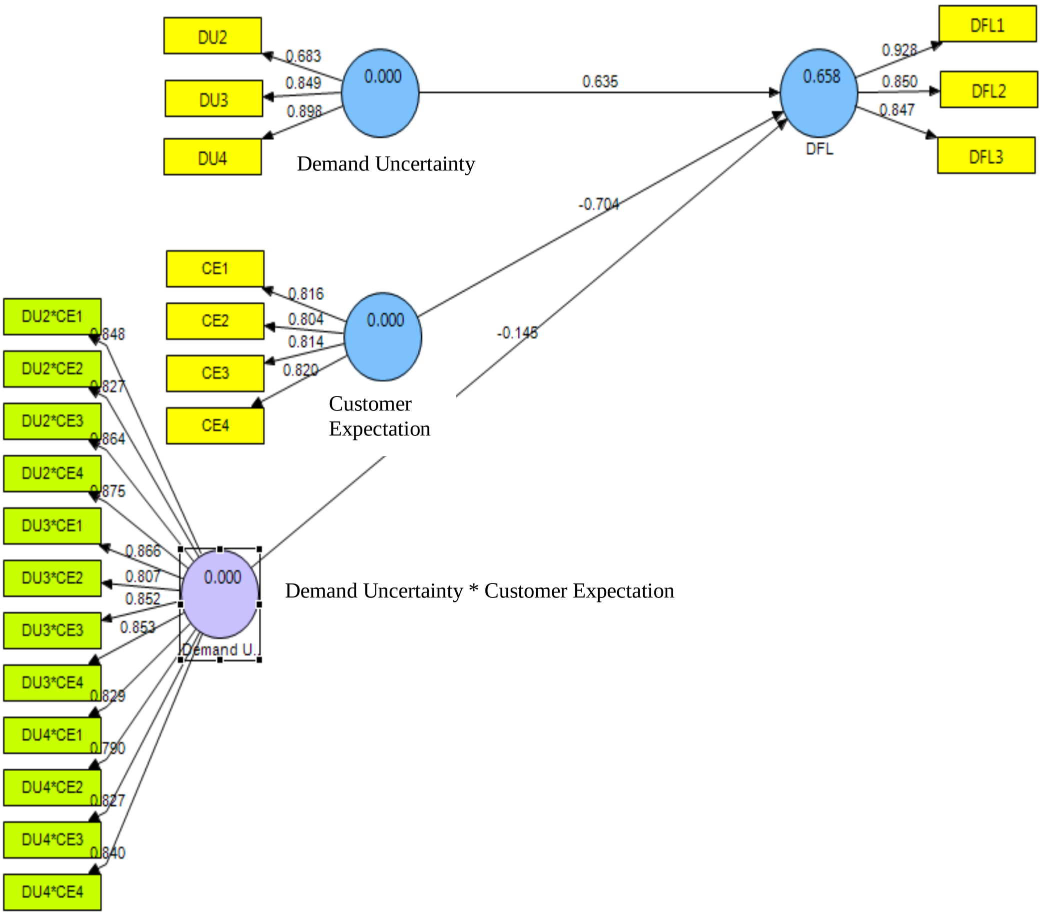

Figure 5-27: Structural Model - Moderation Effect of Customers' expectation (Demand Uncertainty on DFL)

Figure 5-27 presents the structural model to investigate the moderation effect of customers' expectation on the relationship between demand uncertainty and DFL (Hypothesis 4-1).

H_{4-1}: The relationship between Demand Uncertainty and DFL is moderated by the level of Customers' expectation.

II) Factor Loadings

Table 5-66 presents factor loadings for the structural model. As highlighted below, all factor loadings are above 0.7 indicating that measures have acceptable convergent validity.

Table 5-66: Factor Loadings - Moderation Effect of Customers' expectation (Demand Uncertainty on DFL)

	Customers' expectation	**DFL**	**Demand Uncertainty**	**Demand Uncertainty * Customers' expectation**
CE1	0.8155	0	0	0
CE2	0.8036	0	0	0
CE3	0.8136	0	0	0
CE4	0.8204	0	0	0
DFL1	0	0.9285	0	0
DFL2	0	0.8504	0	0
DFL3	0	0.8472	0	0
DU2	0	0	0.6829	0
DU2*CE1	0	0	0	0.8478
DU2*CE2	0	0	0	0.827
DU2*CE3	0	0	0	0.8638
DU2*CE4	0	0	0	0.8752
DU3	0	0	0.8492	0
DU3*CE1	0	0	0	0.866
DU3*CE2	0	0	0	0.8071
DU3*CE3	0	0	0	0.852
DU3*CE4	0	0	0	0.853
DU4	0	0	0.8976	0
DU4*CE1	0	0	0	0.8292
DU4*CE2	0	0	0	0.7896
DU4*CE3	0	0	0	0.8269
DU4*CE4	0	0	0	0.8403

III) Path Coefficient

Table 5-67 presents the path coefficient for the relationship between independent variables (demand uncertainty, customers' expectation, and interaction between demand uncertainty and customers' expectation) and dependent variable (DFL). The outcome of analysis indicates that demand uncertainty positively impacts on DFL (β = 0.6349, $p<0.05$), whereas, customers' expectation negatively impacts on DFL (β = -0.7043, $p<0.05$). In addition, interaction element has a negative impact on DFL (β = -0.1454, $p<0.05$). However, the estimate should be statistically investigated through bootstrapping process.

Table 5-67: Path Coefficient - Moderation Effect of Customers' expectation (Demand Uncertainty on DFL)

	Customers' expectation	DFL	Demand Uncertainty	Demand Uncertainty * Customers' expectation
Customers' expectation	0	-0.7043	0	0
DFL	0	0	0	0
Demand Uncertainty	0	0.6349	0	0
Demand Uncertainty * Customers' expectation	0	-0.1454	0	0

IV) Quality Criteria

In order to assess the internal consistency of the measurement items, average variance extracted (AVE), composite reliability, and Cronbach's Alpha should be assessed. The minimum value for the composite reliability and Cronbach's Alpha is 0.7 and value of AVE above 0.5 is deemed to be in satisfactory level. As shown in Table 5-68, all quality criteria are within acceptable limit. Therefore, measures have an acceptable internal consistency.

Table 5-68: Quality Criteria - Moderation Effect of Customers' expectation (Demand Uncertainty on DFL)

	AVE	Composite Reliability	R Square	Cronbach's Alpha	Communality	Redundancy
Customers' expectation	0.6615	0.8866	0	0.8295	0.6615	0
DFL	0.7677	0.9082	0.6578	0.8477	0.7677	0.2786
Demand Uncertainty	0.6644	0.8543	0	0.7735	0.6644	0
Demand Uncertainty * Customers' expectation	0.7059	0.9664	0	0.9625	0.7059	0

V) Bootstrapping

As depicted in Figure 5-28, the stability of the estimates is tested via a bootstrap re-sampling procedure (5000 sub-samples).

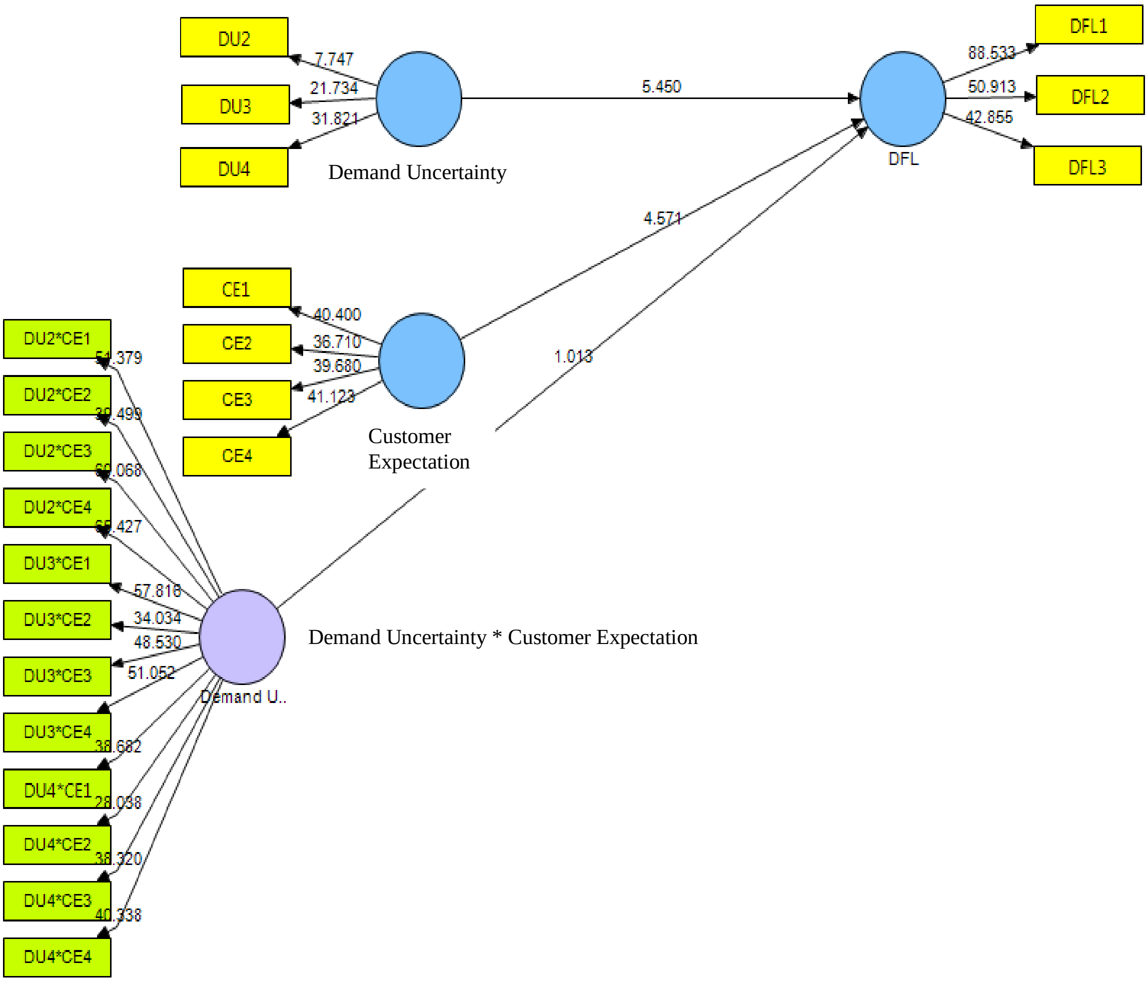

Figure 5-28: Bootstrapping - Moderation Effect of Customers' expectation (Demand Uncertainty on DFL)

VI) t-Statistics

Table 5-69 presents t-statistics for the estimates of variables to constructs as a result of bootstrapping process. As highlighted below, t-statistic of all estimates is above 1.96 indicating that estimates are stable.

Table 5-69: t-Statistics - Moderation Effect of Customers' expectation (Demand Uncertainty on DFL)

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	t Statistics (|O/STERR|)
CE1 <- Customers' expectation	0.8155	0.8146	0.0202	0.0202	40.4004
CE2 <- Customers' expectation	0.8036	0.8036	0.0219	0.0219	36.7097
CE3 <- Customers' expectation	0.8136	0.813	0.0205	0.0205	39.6799
CE4 <- Customers' expectation	0.8204	0.8194	0.02	0.02	41.1227
DFL1 <- DFL	0.9285	0.9284	0.0105	0.0105	88.5334
DFL2 <- DFL	0.8504	0.8502	0.0167	0.0167	50.9133
DFL3 <- DFL	0.8472	0.8469	0.0198	0.0198	42.8549
DU2 <- Demand Uncertainty	0.6829	0.6686	0.0881	0.0881	7.7469
DU2*CE1 <- Demand Uncertainty * Customers' expectation	0.8478	0.8476	0.0165	0.0165	51.3785
DU2*CE2 <- Demand Uncertainty * Customers' expectation	0.827	0.8267	0.0209	0.0209	39.4994
DU2*CE3 <- Demand Uncertainty * Customers' expectation	0.8638	0.864	0.0144	0.0144	60.0678
DU2*CE4 <- Demand Uncertainty * Customers' expectation	0.8752	0.8752	0.0134	0.0134	65.4265
DU3 <- Demand Uncertainty	0.8492	0.843	0.0391	0.0391	21.7343
DU3*CE1 <- Demand Uncertainty * Customers' expectation	0.866	0.8651	0.015	0.015	57.8158
DU3*CE2 <- Demand Uncertainty * Customers' expectation	0.8071	0.806	0.0237	0.0237	34.0339
DU3*CE3 <- Demand Uncertainty * Customers' expectation	0.852	0.8515	0.0176	0.0176	48.5301
DU3*CE4 <- Demand Uncertainty * Customers' expectation	0.853	0.8522	0.0167	0.0167	51.0517
DU4 <- Demand Uncertainty	0.8976	0.8965	0.0282	0.0282	31.8209
DU4*CE1 <- Demand Uncertainty * Customers' expectation	0.8292	0.8271	0.0214	0.0214	38.6817
DU4*CE2 <- Demand Uncertainty * Customers' expectation	0.7896	0.7867	0.0282	0.0282	28.0383
DU4*CE3 <- Demand Uncertainty * Customers' expectation	0.8269	0.8254	0.0216	0.0216	38.3198
DU4*CE4 <- Demand Uncertainty * Customers' expectation	0.8403	0.8384	0.0208	0.0208	40.3381

VII) t-Statistics Constructs

Table 5-70 displays t-statistics for the construct to construct estimates of the structural model as a result of bootstrapping process. As highlighted below, the t-statistics of the relationship between moderating factor and DFL (0.6956) is below 1.96. Therefore, customers' expectation is not a moderator on the relationship between demand uncertainty and DFL.

Table 5-70: t-Statistics Constructs - Moderation Effect of Customers' expectation (Demand Uncertainty on DFL)

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	t Statistics (|O/STERR|)
Customers' expectation -> DFL	-0.7043	-0.7167	0.1541	0.1541	4.571
Demand Uncertainty -> DFL	0.6349	0.6257	0.1168	0.1168	5.4367
Demand Uncertainty * Customers' expectation -> DFL	-0.1454	-0.1245	0.209	0.209	0.6956

VIII) Findings

PLS analysis has been carried out to investigate the moderation effect of customers' expectation in the relationship between the demand uncertainty and DFL (Hypothesis 4-1).

> $H_{4\text{-}1}$: *The relationship between Demand Uncertainty and DFL is moderated by the level of Customers' expectation.*

The model fits the data as the quality criteria meet the requirements. However, t-statistic indicates that the estimate is not stable. As path coefficient of interaction variable (β = -0.1454, $p<0.05$) is not significant (t-statistic=0.6956), it could be concluded that the relationship between demand uncertainty and DFL is not moderated by the level of customers' expectation. Thus, $H_{4\text{-}1}$ is not supported.

5.5.3 Supply Uncertainty

The same analysis is carried out on the relationship between the supply uncertainty and DFL to investigate whether customers' expectation could be a moderator.

I) Structural Model

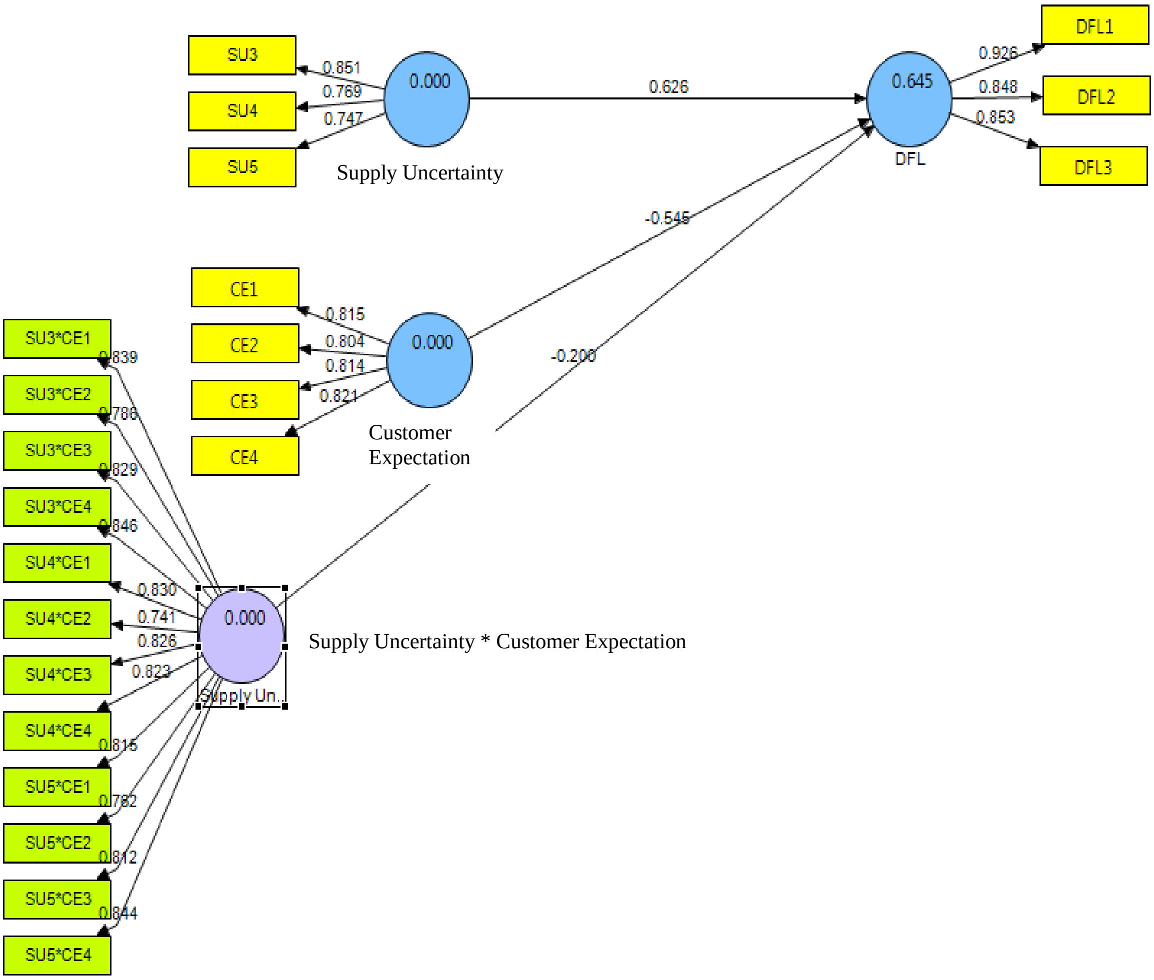

Figure 5-29: Structural Model - Moderation Effect of Customers' expectation (Supply Uncertainty on DFL)

Figure 5-29 presents the structural model to investigate the moderation effect of customers' expectation on the relationship between supply uncertainty and DFL (Hypothesis 4-2).

H_{4-2}: The relationship between Supply Uncertainty and DFL is moderated by the level of Customers' expectation.

II) Factor Loadings

Table 5-71 presents factor loadings for the structural model. As highlighted below, all factor loadings are above 0.7 indicating that measures have acceptable convergent validity.

Table 5-71: Factor Loadings - Moderation Effect of Customers' expectation (Supply Uncertainty on DFL)

	Customers' expectation	DFL	Supply Uncertainty	Supply Uncertainty * Customers' expectation
CE1	0.8154	0	0	0
CE2	0.8036	0	0	0
CE3	0.8136	0	0	0
CE4	0.8205	0	0	0
DFL1	0	0.9255	0	0
DFL2	0	0.8479	0	0
DFL3	0	0.853	0	0
SU3	0	0	0.8514	0
SU3*CE1	0	0	0	0.8389
SU3*CE2	0	0	0	0.7863
SU3*CE3	0	0	0	0.8292
SU3*CE4	0	0	0	0.846
SU4	0	0	0.7695	0
SU4*CE1	0	0	0	0.8295
SU4*CE2	0	0	0	0.7414
SU4*CE3	0	0	0	0.8264
SU4*CE4	0	0	0	0.8234
SU5	0	0	0.7469	0
SU5*CE1	0	0	0	0.8155
SU5*CE2	0	0	0	0.7616
SU5*CE3	0	0	0	0.8116
SU5*CE4	0	0	0	0.8441

III) Path Coefficient

Table 5-72 presents the path coefficient for the relationship between independent variables (supply uncertainty, customers' expectation, and interaction between supply uncertainty and customers' expectation) and dependent variable (DFL).

The outcome of analysis indicates that supply uncertainty positively impacts on DFL ($\beta = 0.6259$, $p<0.05$), whereas, customers' expectation negatively impacts on DFL ($\beta = -0.5453$, $p<0.05$). In addition, interaction element has a negative impact on DFL ($\beta = -0.1997$, $p<0.05$). However, the estimate should be statistically investigated through bootstrapping process.

Table 5-72: Path Coefficient - Moderation Effect of Customers' expectation (Supply Uncertainty on DFL)

	Customers' expectation	DFL	Supply Uncertainty	Supply Uncertainty * Customers' expectation
Customers' expectation	0	-0.5453	0	0
DFL	0	0	0	0
Supply Uncertainty	0	0.6259	0	0
Supply Uncertainty * Customers' expectation	0	-0.1997	0	0

IV) Quality Criteria

In order to assess the internal consistency of the measurement items, average variance extracted (AVE), composite reliability, and Cronbach's Alpha should be assessed. The minimum value for the composite reliability and Cronbach's Alpha is 0.7 and value of AVE above 0.5 is deemed to be in satisfactory level. As shown in Table 5-73, all quality criteria are within acceptable limit. Therefore, measures have an acceptable internal consistency.

Table 5-73: Quality Criteria - Moderation Effect of Customers' expectation (Supply Uncertainty on DFL)

	AVE	Composite Reliability	R Square	Cronbach's Alpha	Communality	Redundancy
Customers' expectation	0.6615	0.8866	0	0.8295	0.6615	0
DFL	0.7677	0.9082	0.645	0.8477	0.7677	0.2823
Supply Uncertainty	0.625	0.8329	0	0.6976	0.625	0
Supply Uncertainty * Customers' expectation	0.6617	0.9591	0	0.9538	0.6617	0

V) Bootstrapping

As depicted in Figure 5-30, the stability of the estimates is tested via a bootstrap re-sampling procedure (5000 sub-samples).

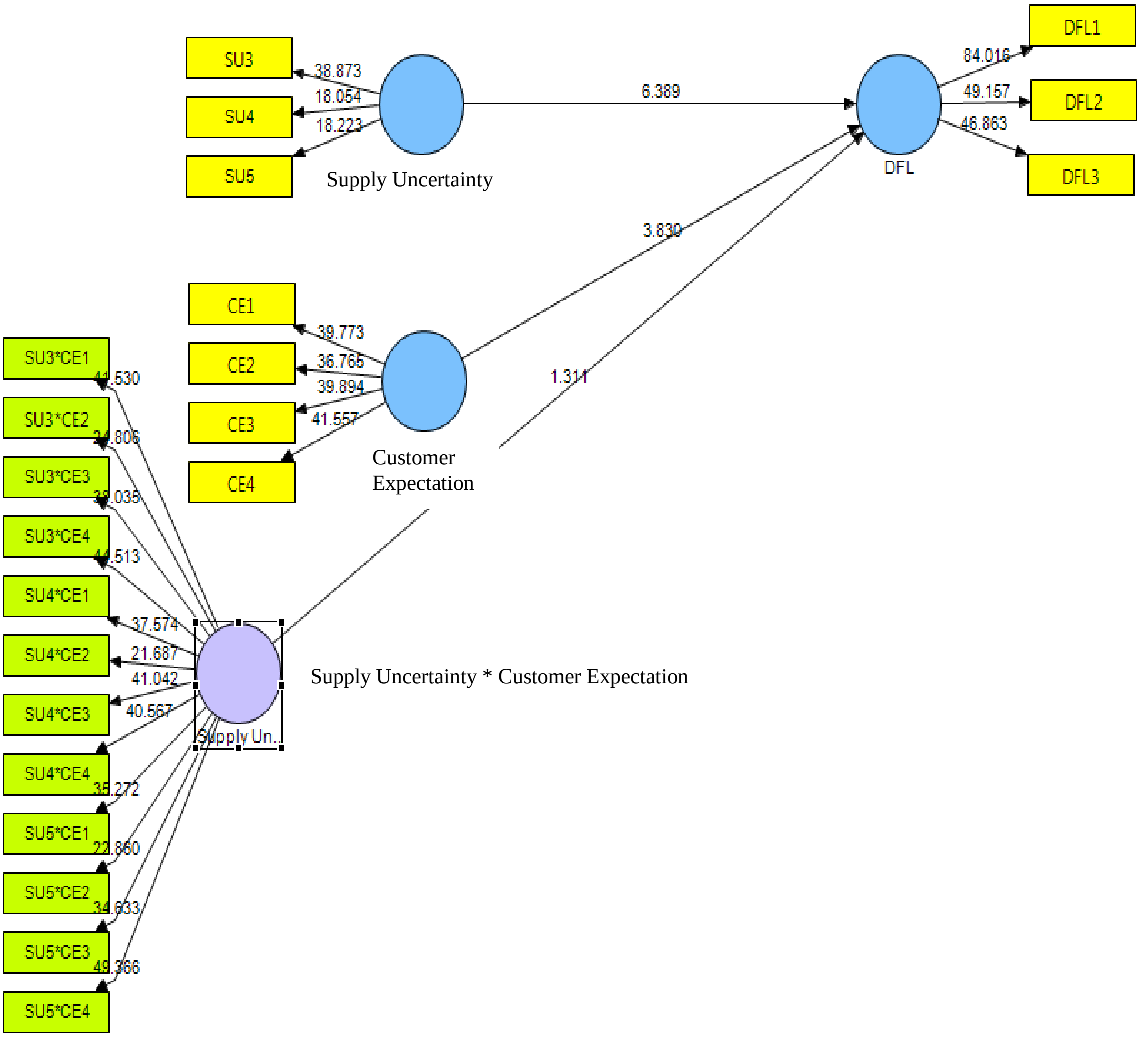

Figure 5-30: Bootstrapping - Moderation Effect of Customers' expectation (Supply Uncertainty on DFL)

VI) t-Statistics

Table 5-74 presents t-statistics for the estimates of variables to constructs as a result of bootstrapping process. As highlighted below, t-statistic of all estimates is above 1.96 indicating that estimates are stable.

Table 5-74: t-Statistics - Moderation Effect of Customers' expectation (Supply Uncertainty on DFL)

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	t Statistics (|O/STERR|)
CE1 <- Customers' expectation	0.8154	0.8145	0.0205	0.0205	39.7725
CE2 <- Customers' expectation	0.8036	0.803	0.0219	0.0219	36.765
CE3 <- Customers' expectation	0.8136	0.8124	0.0204	0.0204	39.894
CE4 <- Customers' expectation	0.8205	0.8202	0.0197	0.0197	41.557
DFL1 <- DFL	0.9255	0.9253	0.011	0.011	84.016
DFL2 <- DFL	0.8479	0.8471	0.0172	0.0172	49.1571
DFL3 <- DFL	0.853	0.8522	0.0182	0.0182	46.863
SU3 <- Supply Uncertainty	0.8514	0.8499	0.0219	0.0219	38.8729
SU3*CE1 <- Supply Uncertainty * Customers' expectation	0.8389	0.8367	0.0202	0.0202	41.5299
SU3*CE2 <- Supply Uncertainty * Customers' expectation	0.7863	0.7821	0.0317	0.0317	24.8058
SU3*CE3 <- Supply Uncertainty * Customers' expectation	0.8292	0.8272	0.0218	0.0218	38.0353
SU3*CE4 <- Supply Uncertainty * Customers' expectation	0.846	0.8453	0.019	0.019	44.5132
SU4 <- Supply Uncertainty	0.7695	0.7666	0.0426	0.0426	18.0538
SU4*CE1 <- Supply Uncertainty * Customers' expectation	0.8295	0.8279	0.0221	0.0221	37.5737
SU4*CE2 <- Supply Uncertainty * Customers' expectation	0.7414	0.7383	0.0342	0.0342	21.6873
SU4*CE3 <- Supply Uncertainty * Customers' expectation	0.8264	0.8257	0.0201	0.0201	41.0418
SU4*CE4 <- Supply Uncertainty * Customers' expectation	0.8234	0.8232	0.0203	0.0203	40.5672
SU5 <- Supply Uncertainty	0.7469	0.7465	0.041	0.041	18.2232
SU5*CE1 <- Supply Uncertainty * Customers' expectation	0.8155	0.8143	0.0231	0.0231	35.2725
SU5*CE2 <- Supply Uncertainty * Customers' expectation	0.7616	0.7592	0.0333	0.0333	22.8603

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	t Statistics (|O/STERR|)
SU5*CE3 <- Supply Uncertainty * Customers' expectation	0.8116	0.8106	0.0234	0.0234	34.633
SU5*CE4 <- Supply Uncertainty * Customers' expectation	0.8441	0.8444	0.0171	0.0171	49.3659

VII) t-Statistics Constructs

Table 5-75 displays t-statistics for the construct to construct estimates of the structural model as a result of bootstrapping process. As highlighted below, the t-statistics of the relationship between moderating factor and DFL (1.3107) is below 1.96. Therefore, customers' expectation is not a moderator on the relationship between supply uncertainty and DFL.

Table 5-75: t-Statistics Constructs - Moderation Effect of Customers' expectation (Supply Uncertainty on DFL)

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	t Statistics (|O/STERR|)
Customers' expectation -> DFL	0.5453	0.5412	0.1424	0.1424	3.8296
Supply Uncertainty -> DFL	0.6259	0.6266	0.098	0.098	6.3895
Supply Uncertainty * Customers' expectation -> DFL	0.1997	0.2309	0.1524	0.1524	1.3107

VIII) Findings

PLS analysis has been carried out to investigate the moderation effect of customers' expectation in the relationship between the supply uncertainty and DFL (Hypothesis 4-2).

$H_{4\text{-}2}$: The relationship between Supply Uncertainty and DFL is moderated by the level of Customers' expectation.

The model fits the data as the quality criteria meet the requirements. However, t-statistic indicates that the estimate is not stable. As path coefficient of interaction variable (β = -0.1997, $p<0.05$) is not significant (t-statistic=1.3107), it could be concluded that the relationship between supply uncertainty and DFL is not moderated by the level of customers' expectation. Thus, H_{4-2} is not supported.

5.5.4 Internal Uncertainty

The same analysis is carried out on the relationship between the internal uncertainty and DFL to investigate whether customers' expectation could be a moderator.

I) Structural Model

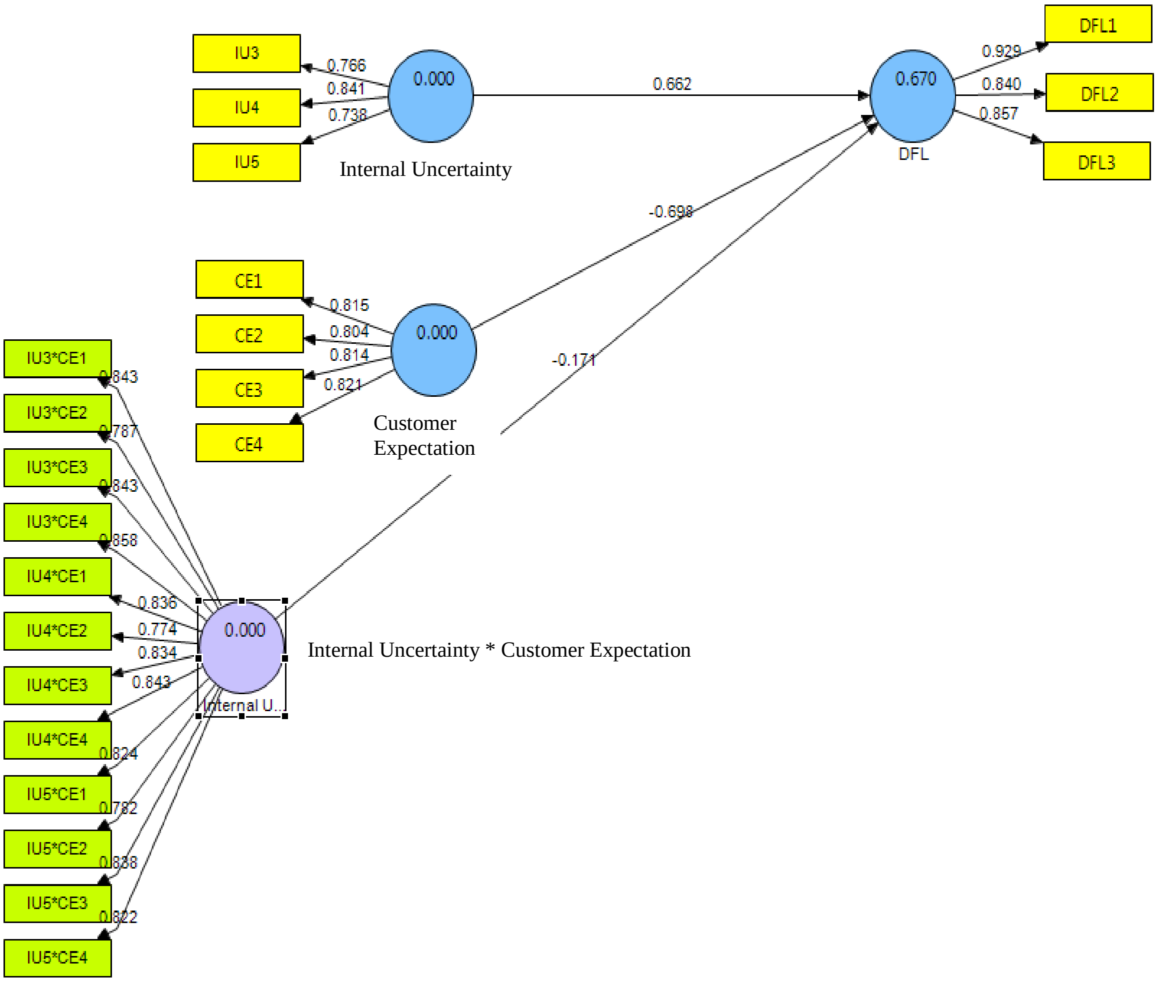

Figure 5-31: Structural Model - Moderation Effect of Customers' expectation (Internal Uncertainty on DFL)

Figure 5-31 presents the structural model to investigate the moderation effect of customers' expectation on the relationship between internal uncertainty and DFL (Hypothesis 4-3).

$H_{4\text{-}3}$: The relationship between Internal Uncertainty and DFL is moderated by the level of Customers' expectation.

II) Factor Loadings

Table 5-76 presents factor loadings for the structural model. As highlighted below, all factor loadings are above 0.7 indicating that measures have acceptable convergent validity.

Table 5-76: Factor Loadings - Moderation Effect of Customers' expectation (Internal Uncertainty on DFL)

	Customers' expectation	DFL	Internal Uncertainty	Internal Uncertainty * Customers' expectation
CE1	0.8152	0	0	0
CE2	0.8037	0	0	0
CE3	0.8137	0	0	0
CE4	0.8205	0	0	0
DFL1	0	0.929	0	0
DFL2	0	0.8401	0	0
DFL3	0	0.8569	0	0
IU3	0	0	0.7658	0
IU3*CE1	0	0	0	0.8428
IU3*CE2	0	0	0	0.7871
IU3*CE3	0	0	0	0.8427
IU3*CE4	0	0	0	0.8585
IU4	0	0	0.841	0
IU4*CE1	0	0	0	0.8356
IU4*CE2	0	0	0	0.7738
IU4*CE3	0	0	0	0.8336
IU4*CE4	0	0	0	0.843
IU5	0	0	0.7381	0
IU5*CE1	0	0	0	0.8241
IU5*CE2	0	0	0	0.7821
IU5*CE3	0	0	0	0.8384
IU5*CE4	0	0	0	0.822

III) Path Coefficient

Table 5-55 presents the path coefficient for the relationship between independent variables (internal uncertainty, customers' expectation, and interaction between internal uncertainty and customers' expectation) and dependent variable

(DFL). The outcome of analysis indicates that internal uncertainty positively impacts on DFL ($\beta = 0.6615$, $p<0.05$), whereas, customers' expectation negatively impacts on DFL ($\beta = -0.6977$, $p<0.05$). In addition, interaction element has a negative impact on DFL ($\beta = -0.1713$, $p<0.05$). However, the estimate should be statistically investigated through bootstrapping process.

Table 5-77: Path Coefficient - Moderation Effect of Customers' expectation (Internal Uncertainty on DFL)

	Customers' expectation	DFL	Internal Uncertainty	Internal Uncertainty * Customers' expectation
Customers' expectation	0	-0.6977	0	0
DFL	0	0	0	0
Internal Uncertainty	0	0.6615	0	0
Internal Uncertainty * Customers' expectation	0	-0.1713	0	0

IV) Quality Criteria

In order to assess the internal consistency of the measurement items, average variance extracted (AVE), composite reliability, and Cronbach's Alpha should be assessed. The minimum value for the composite reliability and Cronbach's Alpha is 0.7 and value of AVE above 0.5 is deemed to be in satisfactory level. As shown in Table 5-78, all quality criteria are within acceptable limit. Therefore, measures have an acceptable internal consistency.

Table 5-78: Quality Criteria - Moderation Effect of Customers' expectation (Internal Uncertainty on DFL)

	AVE	Composite Reliability	R Square	Cronbach's Alpha	Communality	Redundancy
Customers' expectation	0.6615	0.8866	0	0.8295	0.6615	0
DFL	0.7677	0.9082	0.67	0.8477	0.7677	0.2797
Internal Uncertainty	0.6128	0.8256	0	0.6881	0.6128	0

	AVE	Composite Reliability	R Square	Cronbach's Alpha	Communality	Redundancy
Internal Uncertainty * Customers' expectation	0.6791	0.9621	0	0.9573	0.6791	0

V) Bootstrapping

As depicted in Figure 5-32, the stability of the estimates is tested via a bootstrap re-sampling procedure (5000 sub-samples).

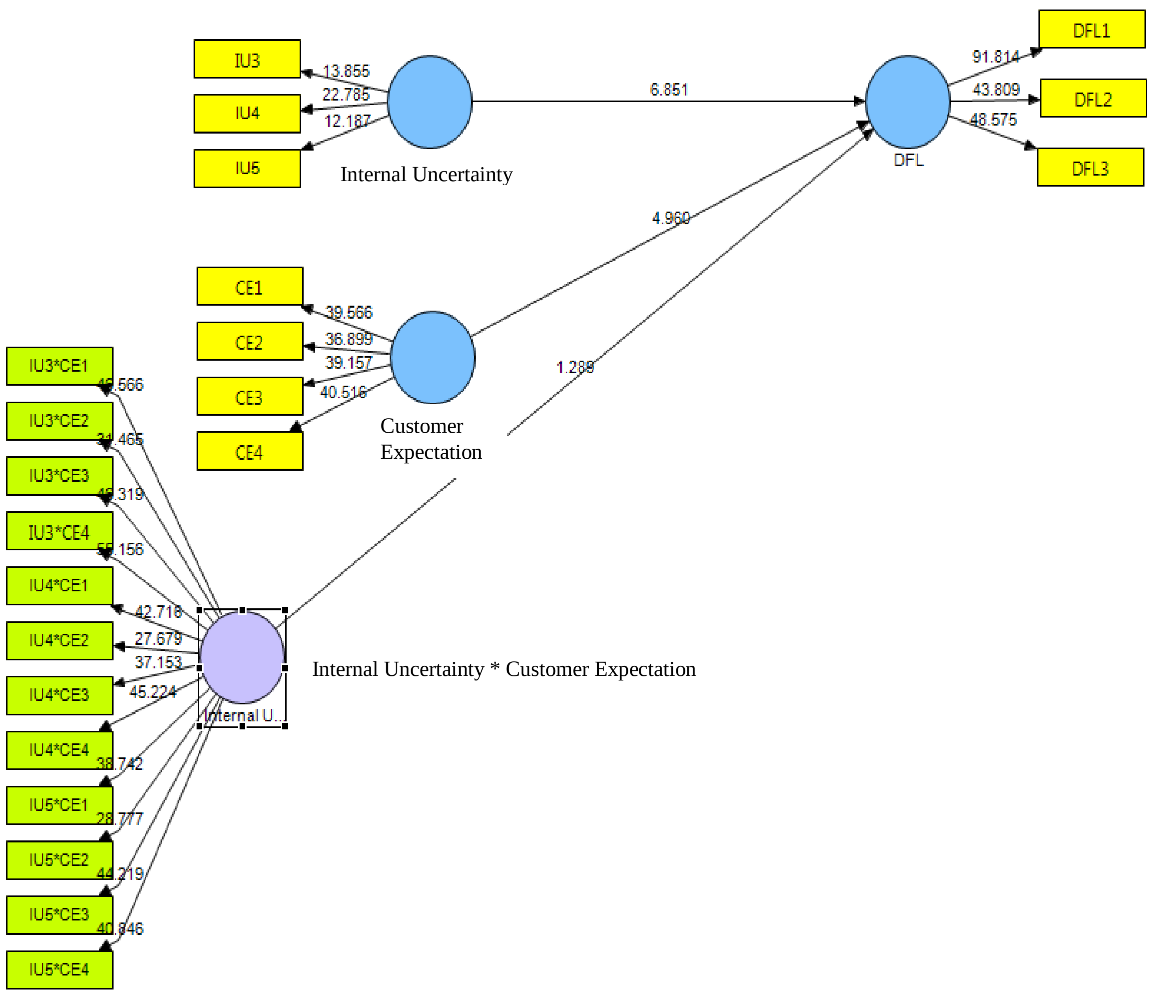

Figure 5-32: Bootstrapping - Moderation Effect of Customers' expectation (Internal Uncertainty on DFL)

VI) t-Statistics

Table 5-79 presents t-statistics for the estimates of variables to constructs as a result of bootstrapping process. As highlighted below, t-statistic of all estimates is above 1.96 indicating that estimates are stable.

Table 5-79: t-Statistics - Moderation Effect of Customers' expectation (Internal Uncertainty on DFL)

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	t Statistics (|O/STERR|)
CE1 <- Customers' expectation	0.8152	0.8141	0.0206	0.0206	39.5656
CE2 <- Customers' expectation	0.8037	0.8031	0.0218	0.0218	36.8992
CE3 <- Customers' expectation	0.8137	0.8135	0.0208	0.0208	39.1568
CE4 <- Customers' expectation	0.8205	0.8202	0.0203	0.0203	40.5156
DFL1 <- DFL	0.929	0.929	0.0101	0.0101	91.8135
DFL2 <- DFL	0.8401	0.8399	0.0192	0.0192	43.8086
DFL3 <- DFL	0.8569	0.8567	0.0176	0.0176	48.575
IU3 <- Internal Uncertainty	0.7658	0.758	0.0553	0.0553	13.8545
IU3*CE1 <- Internal Uncertainty * Customers' expectation	0.8428	0.8423	0.0181	0.0181	46.5663
IU3*CE2 <- Internal Uncertainty * Customers' expectation	0.7871	0.7861	0.025	0.025	31.4652
IU3*CE3 <- Internal Uncertainty * Customers' expectation	0.8427	0.8426	0.0182	0.0182	46.3185
IU3*CE4 <- Internal Uncertainty * Customers' expectation	0.8585	0.8587	0.0156	0.0156	55.1563
IU4 <- Internal Uncertainty	0.841	0.8399	0.0369	0.0369	22.7848
IU4*CE1 <- Internal Uncertainty * Customers' expectation	0.8356	0.8339	0.0196	0.0196	42.7157
IU4*CE2 <- Internal Uncertainty * Customers' expectation	0.7738	0.7714	0.028	0.028	27.6795
IU4*CE3 <- Internal Uncertainty * Customers' expectation	0.8336	0.8326	0.0224	0.0224	37.1533

IU4*CE4 <- Internal Uncertainty * Customers' expectation	0.843	0.8422	0.0186	0.0186	45.2239
IU5 <- Internal Uncertainty	0.7381	0.7315	0.0606	0.0606	12.1865
IU5*CE1 <- Internal Uncertainty * Customers' expectation	0.8241	0.8227	0.0213	0.0213	38.742
IU5*CE2 <- Internal Uncertainty * Customers' expectation	0.7821	0.7796	0.0272	0.0272	28.7773
IU5*CE3 <- Internal Uncertainty * Customers' expectation	0.8384	0.8372	0.019	0.019	44.2191
IU5*CE4 <- Internal Uncertainty * Customers' expectation	0.822	0.8213	0.0201	0.0201	40.8457

VII) t-Statistics Constructs

Table 5-80 displays t-statistics for the construct to construct estimates of the structural model as a result of bootstrapping process. As highlighted below, the t-statistics of the relationship between moderating factor and DFL (1.2891) is below 1.96. Therefore, customers' expectation is not a moderator on the relationship between internal uncertainty and DFL.

Table 5-80: t-Statistics Constructs - Moderation Effect of Customers' expectation (Internal Uncertainty on DFL)

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	t Statistics (|O/STERR|)
Customers' expectation -> DFL	-0.6977	-0.7277	0.1407	0.1407	4.9598
Internal Uncertainty -> DFL	0.6615	0.637	0.0966	0.0966	6.8507
Internal Uncertainty * Customers' expectation -> DFL	-0.1713	-0.1833	0.1329	0.1329	1.2891

VIII) Findings

PLS analysis has been carried out to investigate the moderation effect of customers' expectation in the relationship between the internal uncertainty and DFL (Hypothesis 4-3).

H_{4-3}: The relationship between Internal Uncertainty and DFL is moderated by the level of Customers' expectation.

The model fits the data as the quality criteria meet the requirements. However, t-statistic indicates that the estimate is not stable. As path coefficient of interaction variable (β = -0.1713, $p<0.05$) is not significant (t-statistic=1.2891), it could be concluded that the relationship between internal uncertainty and DFL is not moderated by the level of customers' expectation. Thus, H_{4-3} is not supported.

5.5.5 Findings

In conclusion:

H4	The relationship between Uncertainty and DFL is moderated by the level of Customers' expectations.	**Supported**
H4-1	The relationship between Demand Uncertainty and DFL is moderated by the level of Customers' expectations.	**Not Supported**
H4-2	The relationship between Supply Uncertainty and DFL is moderated by the level of Customers' expectations.	**Not Supported**
H4-3	The relationship between Internal Uncertainty and DFL is moderated by the level of Customers' expectations.	**Not Supported**

5.6 **DFL and Hybrid Supply Chain Design**

Findings of previous analysis revealed that DFL is a powerful index to help the executives to improve supply chain design and thus achieving a higher firm performance. Therefore, further analysis of DFL index is required to provide detailed information regarding the design of supply chains.

As explained in research methodology chapter, Fisher (1997) proposed two mutually exclusive supply chain designs: efficient and responsive. When the conceptual model was statistically tested for a considerable number of companies, it has been revealed that the model is not significant (Selldin & Olhager 2007). Analysis of DFL could provide an insight into the design of supply chains to investigate whether companies are adopting a mutually exclusive supply chain design (pure lean versus purely agile) or majority of companies are adopting a leagile supply chain (Hypothesis 5).

> *H_5: Organisations adopt hybrid supply chain rather than a purely lean or a purely agile supply chain.*

In order to investigate into the fifth hypothesis, firstly, the descriptive statistics are reviewed. Then, frequency analysis provides more information regarding the distribution of DFL.

As leagility scale is set from 1 (pure lean supply chain), 4 (balanced leagile supply chain) to 7 (pure agile supply chain), DFL range would be from 0 (balanced leagile supply chain) to 3 (pure lean or agile supply chain). As depicted in Figure 5-33, DFL from X to 3 could be considered as relatively purely lean/agile supply chains and DFL in the range of 0 to X could be referred to leagile/hybrid supply chains.

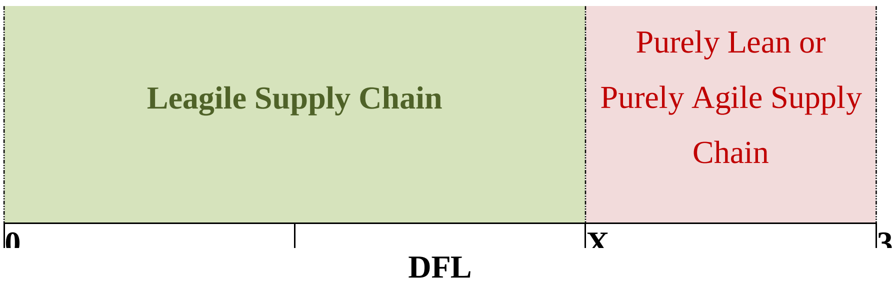

Figure 5-33: DFL range to determine leagility

In order to determine the X, the first thought was X could be 2 as DFL is between 0 and 3. Therefore, if there is significant difference between the mean of DFL and 2, it could be concluded that majority of companies are adopting leagile supply chain. However, after extensive consultation, it was decided to statistically compare the mean of DFL with (i) 3rd quartile as 75% of all data is below Q_3 (ii) mean plus 1σ as approximately 84% of data is below this point.

As the first part of analysis, descriptive statistics have been estimated (Table 5-81).

Table 5-81: DFL Descriptive Statistics

N	Valid	299
	Missing	0
Mean		1.687
Std. Deviation		.757
Skewness		-.385
Std. Error of Skewness		.141
Kurtosis		-.651
Std. Error of Kurtosis		.281
Range		3.000
Minimum		.000
Maximum		3.000
Percentiles	25	1.167
	50	1.833
	75	2.333

The mean of DFL is 1.69 and standard deviation is 0.75. The third quartile indicates that DFL of 75% of companies is less than 2.33 indicating that majority (75%) of companies adopt leagile supply chain.

As the range of DFL is between 0 (balanced leagile supply chain) and 3 (purely lean or purely agile supply chain), the mean of 1.69 may indicate that majority of companies adopts leagile supply chain. To substantiate this hypothesis through statistical analysis, the Wilcoxon Signed Ranks Test has been carried out for the cut-off point of mean plus 1σ (1.69+0.75=2.44).

Table 5-82: Ranks of DFL (Cut-off point: 2.44)

DFL_Cutoff - DFL_Avr	N	Mean Rank	Sum of Ranks
Negative Ranks	60[a]	50.60	3036.00
Positive Ranks	239[b]	174.95	41814.00
Ties	0[c]		
Total	299		

a. DFL_Cutoff < DFL_Avr

b. DFL_Cutoff > DFL_Avr

c. DFL_Cutoff = DFL_Avr

Table 5-83: Wilcoxon Signed Ranks Test to check DFL position (Cut-off point: 2.44)

	DFL_Cutoff - DFL_Avr
Z	-12.968[a]
Asymp. Sig. (2-tailed)	.000

a. Based on negative ranks.

As presented in Table 5-82 and Table 5-83, p-value of Wilcoxon Signed Ranks Test is 0.00 which is less than 0.05 indicating that mean of DFL is significantly less than 2.44. Therefore, it could be concluded that majority of companies (84%) adopt leagile supply chain rather than purely lean or purely agile supply chain.

In order to investigate further into the distribution of DFL, frequency analysis has been carried out (Table 5-84 and Figure 5-34). It is obvious that DFL of 90.3% of companies is less than 2.5 indicating that leagile supply chain is more preferable.

Table 5-84: Frequency analysis of DFL

	Frequency	Percent	Valid Percent	Cumulative Percent
.0000	11	3.7	3.7	3.7
.1667	3	1.0	1.0	4.7
.3333	1	.3	.3	5.0
.5000	8	2.7	2.7	7.7
.6667	25	8.4	8.4	16.1
.8333	7	2.3	2.3	18.4
1.0000	11	3.7	3.7	22.1
1.1667	23	7.7	7.7	29.8
1.3333	18	6.0	6.0	35.8
1.5000	9	3.0	3.0	38.8
1.6667	32	10.7	10.7	49.5
1.8333	15	5.0	5.0	54.5
2.0000	34	11.4	11.4	65.9
2.1667	25	8.4	8.4	74.2
2.3333	17	5.7	5.7	79.9
2.5000	31	10.4	10.4	90.3
2.6667	10	3.3	3.3	93.6
2.8333	12	4.0	4.0	97.7
3.0000	7	2.3	2.3	100.0
Total	299	100.0	100.0	

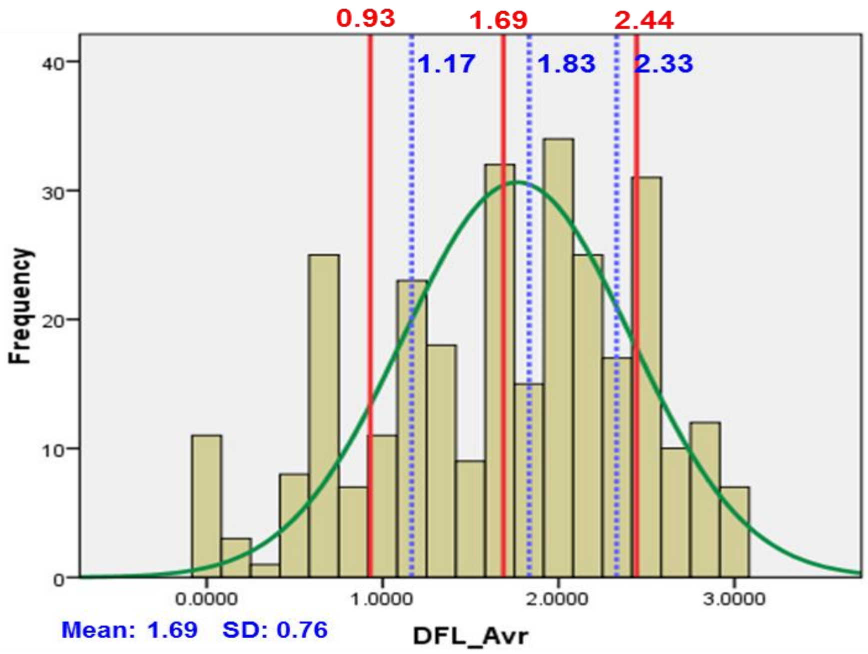

Figure 5-34: Frequency analysis of DFL

Non-parametric Wilcoxon Signed Ranks Test with cut-off point 2.33 (Q_3) has been utilised to check the current hypothesis.

Table 5-85: Ranks of DFL (Cut-off point: 2.33)

DFL_Cutoff - DFL_Avr	N	Mean Rank	Sum of Ranks
Negative Ranks	77[a]	77.90	5998.00
Positive Ranks	222[b]	175.01	38852.00
Ties	0[c]		
Total	299		

a. DFL_Cutoff < DFL_Avr

b. DFL_Cutoff > DFL_Avr

c. DFL_Cutoff = DFL_Avr

Table 5-86: Wilcoxon Signed Ranks Test to check DFL position (Cut-off point: 2.33)

	DFL_Cutoff - DFL_Avr
Z	-10.987[a]
Asymp. Sig. (2-tailed)	.000

a. Based on negative ranks.

As presented in Table 5-85 and Table 5-86, p-value of Wilcoxon Signed Ranks Test is 0.00 which is less than 0.05 indicating that mean of DFL is significantly less than 2.33. Therefore, it could be concluded that majority of companies adopt leagile supply chain rather than purely lean or purely agile supply chain.

5.6.1 Findings

As explained in research methodology chapter, DFL is estimated as absolute difference of Leagility Index (ranging from 1 to 7) from midpoint (4). Hence, DFL value ranges between 0 and 3. The DFL value of zero indicated the supply chain is balanced whereby the magnitude of leanness and agility is equal. On the other side, when the value of DFL gets closer to 3, there is a high deviation from leagility meaning the company adopts purely lean or purely agile supply chain design.

Descriptive analysis indicates that the average of DFL is 1.69 and standard deviation is 0.75. It means that the value of DFL for 84% of companies is less than 2.44 (=1.69+0.75). In addition, the third quartile value is 2.33 indicating that DFL of 75% of companies is less than 2.33 (Q_3). Frequency analysis also indicates that DFL of 90.3% of companies is less than 2.5. Therefore, the DFL of majority of companies is not close to 3.

In this regard, non-parametric Wilcoxon Signed Ranks Test with cut-off points 2.33 (Q_3) and 2.44 ($\mu+1\sigma$) is carried out and in both cases it has been found there is significant difference between the mean of DFL and cut-off points.

Given the outcome of all performed analysis, it could be concluded that majority of companies adopts leagile supply chain. Thus, H_5 is supported.

In conclusion:

H5	Organisations adopt hybrid supply chain rather than a purely lean or a purely agile supply chain.	**Supported**

5.7 **Analysis of Market Segment**

Three crucial determinants of firm success are correct market definition, market segmentation and positioning (McDonald 2012). A market segment is a sub-set of a market which consists of people or companies with at least one characteristic that make them to demand comparable product and/or services as per qualities of those products including price or function. As segment of market in which a firm is operating influences all aspects of a company, it is expected that design of supply chain could be impacted as well.

5.7.1 Leagility Index over different Market Segments

In this section, leagility index over different market segments is investigated (Hypothesis 6).

> *H_6: There is higher agility magnitude (higher LI) for companies active in up-market segment of an industry compared to down-market segment.*

To address hypothesis 6, firstly, segment of the market companies are operating should be determined. During the survey, the respondents were requested to provide information regarding the segment of market they are operating. Questions to determine the market segment designed in a way that scores of 1 to 4 indicate the firm operates in down-market and scores of 4 to 7 demonstrate the firm operates in up-market.

Table 5-87 presents the frequency analysis of market segment of firms participating in the current study.

Table 5-87: Frequency analysis of Market Segments

	Frequency	Percent	Valid Percent	Cumulative Percent
Down-Market	146	48.8	48.8	48.8
Up-Market	153	51.2	51.2	100.0
Total	299	100.0	100.0	

Frequency analysis of the market segments indicates that out of 299 companies participated in this study, 146 (48.83%) companies are operating in down-market and 153 (51.17%) companies are operating in up-market segment.

The next step would be a t-test to investigate whether the leagility index of firms operating in up-market segment is significantly different from those operating in down-market segment. As explained earlier, neither leagility index nor market segment samples follows the normality distribution. Therefore, a non-parametric Mann-Whitney test should be utilised to investigate the leagility index over different market segments.

Table 5-88: Ranks of Leagility index over different Market Segments

	Market Segments	N	Mean Rank	Sum of Ranks
LI_Avr	Down-Market	146	85.58	12494.00
	Up-Market	153	211.48	32356.00
	Total	299		

Table 5-89: Mann-Whitney test of Leagility index over different Market Segments

	LI_Avr
Mann-Whitney U	1763.000
Wilcoxon W	12494.000
Z	-12.613
Asymp. Sig. (2-tailed)	.000

As shown in Table 5-88, mean rank of leagility index for companies operating in down-market segment is 85.58 whereas mean rank of leagility index for companies operating in up-market segment is 211.48. P-value (0.00) of Mann-Whitney test indicates that there is a significant difference between two leagility index ranks (Table 5-89). It could be concluded that the leagility index of companies operating in up-market is significantly higher than companies operating in down-market segment. In other words, there is higher agility magnitude (higher LI) for companies active in up-market segment of an industry compared to down-market segment. Thus, H_6 is supported.

Figure 5-35 presents a graphical representation of leagility index of supply chains of companies operating in down-market (<4) and up-market (>4). It is obvious that market segment in which a firm is operating is a key determinant of supply chain design.

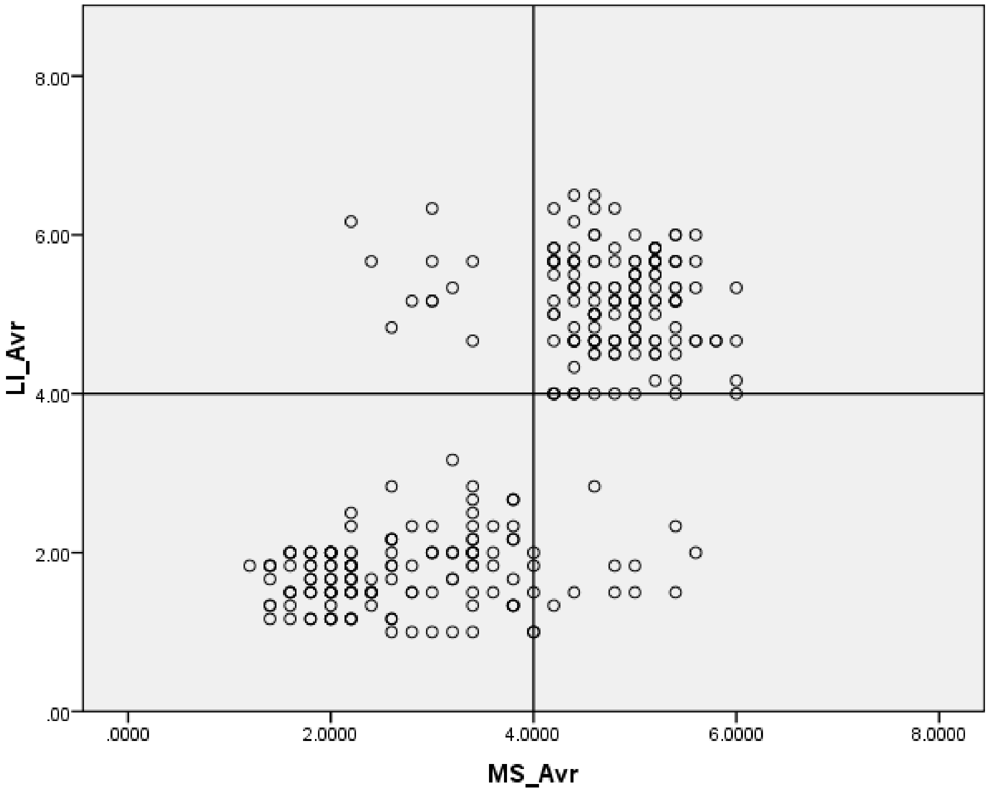

Figure 5-35: Leagility index over different Market Segments

In conclusion:

H6	There is higher agility magnitude (higher LI) for companies active in up-market segment of an industry compared to down-market segment.	**Supported**

5.7.2 Uncertainty and Market Segment

Uncertainty has always been referred to as one of the key design driver of supply chain (Towill, Naim & Wikner 1992; Lee & Whang 1997; Mason-Jones & Towill 1998; Taylor 2000; Lee, Padmanabhan & Whang 2004). On the other hand, analysis of leagility over market segments revealed that market segment in which a firm is operating impacts the design of supply chain. Therefore, it is quite important to investigate the relationship between uncertainty and market segment (Hypothesis 7).

> *H_7: There is a higher level of uncertainty for companies active in the up-market segment of an industry compared to the down-market segment.*

In order to address the Hypothesis 7, a structural model has been developed to investigate the relationship between market segment and uncertainty.

I) *Structural Model 1*

Figure 5-36 presents structural model to investigate the impact of market segment on uncertainty.

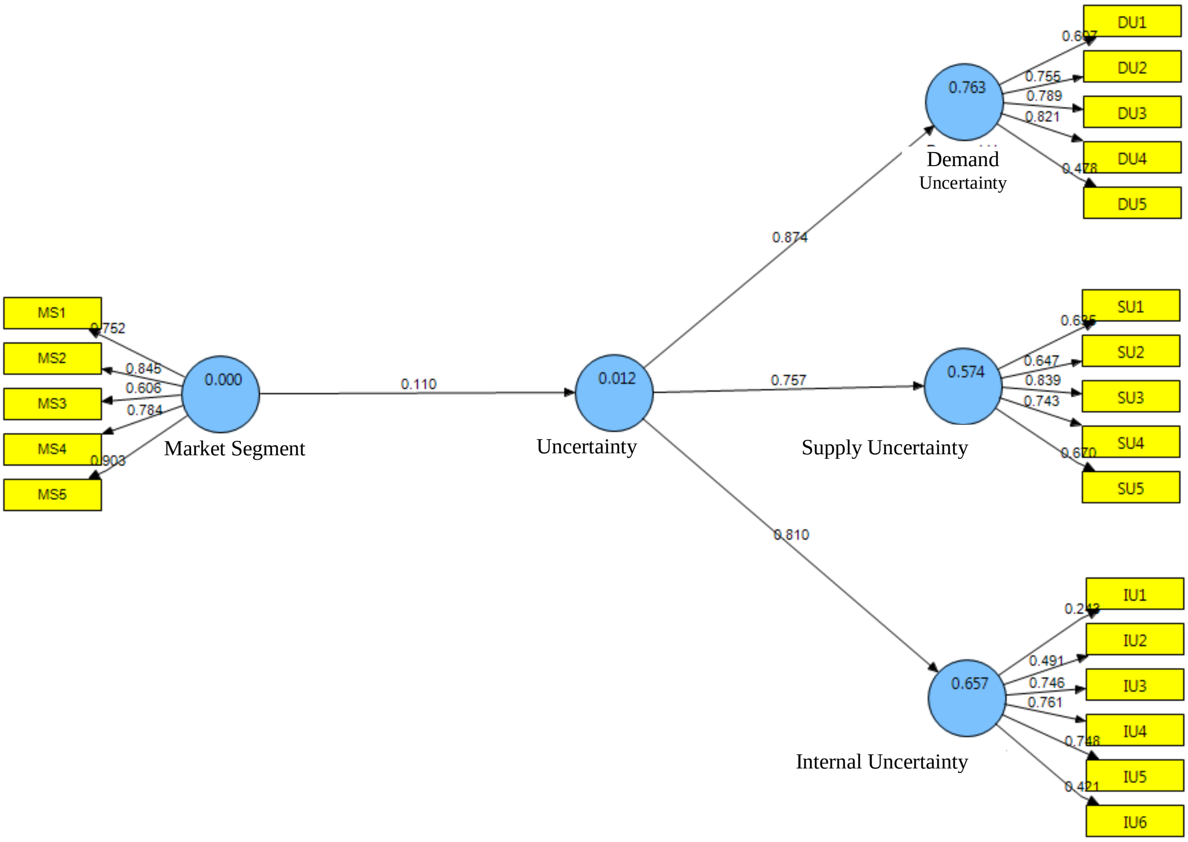

Figure 5-36: Structural Model 1 - Impact of Market Segment on Uncertainty

II) *Factor Loadings*

Table 5-90 presents the factor loadings for the structural model 1. As explained in research methodology chapter, the convergent validity would be supported if the factor loadings between the construct and each related variable are 0.7 or more. As highlighted below, factor loading of some variables do not meet the criteria. Variables with lowest factor loading will be removed from the model and analysis will be performed to the point that convergent validity would be established.

Table 5-90: Factor Loadings 1 - Impact of Market Segment on Uncertainty

	Demand Uncertainty	Internal Uncertainty	Market Segment	Supply Uncertainty
DU1	0.6074	0	0	0
DU2	0.7547	0	0	0
DU3	0.7893	0	0	0
DU4	0.8212	0	0	0
DU5	0.4775	0	0	0
IU1	0	0.2431	0	0
IU2	0	0.4906	0	0
IU3	0	0.7455	0	0
IU4	0	0.7609	0	0
IU5	0	0.7483	0	0
IU6	0	0.4207	0	0
MS1	0	0	0.752	0
MS2	0	0	0.8446	0
MS3	0	0	0.6063	0
MS4	0	0	0.7843	0
MS5	0	0	0.903	0
SU1	0	0	0	0.6347
SU2	0	0	0	0.6472
SU3	0	0	0	0.8392
SU4	0	0	0	0.7429
SU5	0	0	0	0.6702

III) Structural Model 2

Figure 5-37 presents structural model to investigate the impact of market segment on uncertainty after removing the variables with low factor loading.

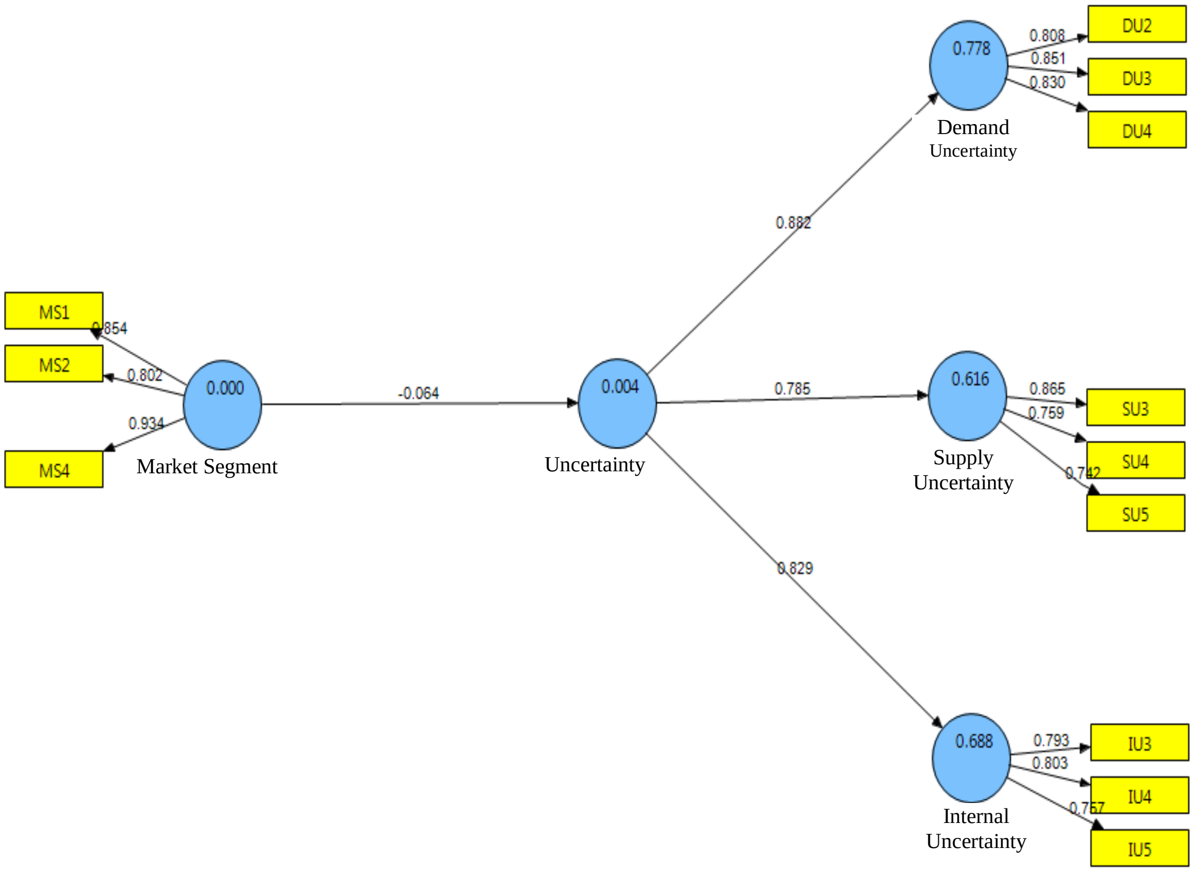

Figure 5-37: Structural Model 2 - Impact of Market Segment on Uncertainty

IV) Factor Loadings

Table 5-91 presents factor loadings for structural model 2. As highlighted below, all factor loadings are above 0.7 indicating that measures have acceptable convergent validity.

Table 5-91: Factor Loadings 2 - Impact of Market Segment on Uncertainty

	Demand Uncertainty	Internal Uncertainty	Market Segment	Supply Uncertainty
DU2	0.8077	0	0	0
DU3	0.8509	0	0	0
DU4	0.8296	0	0	0
IU3	0	0.7932	0	0
IU4	0	0.8032	0	0
IU5	0	0.7573	0	0
MS1	0	0	0.8535	0
MS2	0	0	0.8022	0
MS4	0	0	0.9343	0
SU3	0	0	0	0.8651
SU4	0	0	0	0.7594
SU5	0	0	0	0.7419

V) Path Coefficients

As uncertainty is a second order construct, factor loading between the first order constructs (demand, supply, and internal uncertainty) should also meet the convergent validity criteria. As shown in Table 5-92, the factor loading of uncertainty constructs are more than the threshold (0.7).

The path coefficient between market segment and uncertainty is estimated as -0.0637 which is very low. Bootstrapping should be carried out to ensure the path coefficient is significant.

Table 5-92: Path Coefficients - Impact of Market Segment on Uncertainty

	Demand Uncertainty	Internal Uncertainty	Market Segment	Supply Uncertainty	Uncertainty
Demand Uncertainty	0	0	0	0	0
Internal Uncertainty	0	0	0	0	0
Market Segment	0	0	0	0	**-0.0637**
Supply Uncertainty	0	0	0	0	0
Uncertainty	0.8823	0.8292	0	0.7847	0

VI) Quality Criteria

As explained in research methodology chapter, in order to assess the internal consistency of the measurement items, average variance extracted (AVE), composite reliability, and Cronbach's Alpha should be assessed. The minimum value for the composite reliability and Cronbach's Alpha is considered as 0.7 and the value of AVE above 0.5 is deemed to satisfactory. As shown in Table 5-93, there are serious issues with quality criteria for structural model 2. Therefore, it seems the desired internal consistency is not achieved.

Table 5-93: Quality Criteria - Impact of Market Segment on Uncertainty

	AVE	Composite Reliability	R Square	Cronbach's Alpha	Communality	Redundancy
Demand Uncertainty	0.6882	0.8687	0.7784	0.7735	0.6882	0.5343
Internal Uncertainty	0.6159	0.8278	0.6876	0.6881	0.6159	0.4228
Market Segment	0.7483	0.8988	0	0.852	0.7483	0
Supply Uncertainty	0.6252	0.8328	0.6157	0.6976	0.6252	0.3848
Uncertainty	0.4477	0.8786	0.0041	0.8438	0.4477	0.0018

VII) Bootstrapping

As depicted in Figure 5-38, the stability of the estimates is tested via a bootstrap re-sampling procedure (5000 sub-samples).

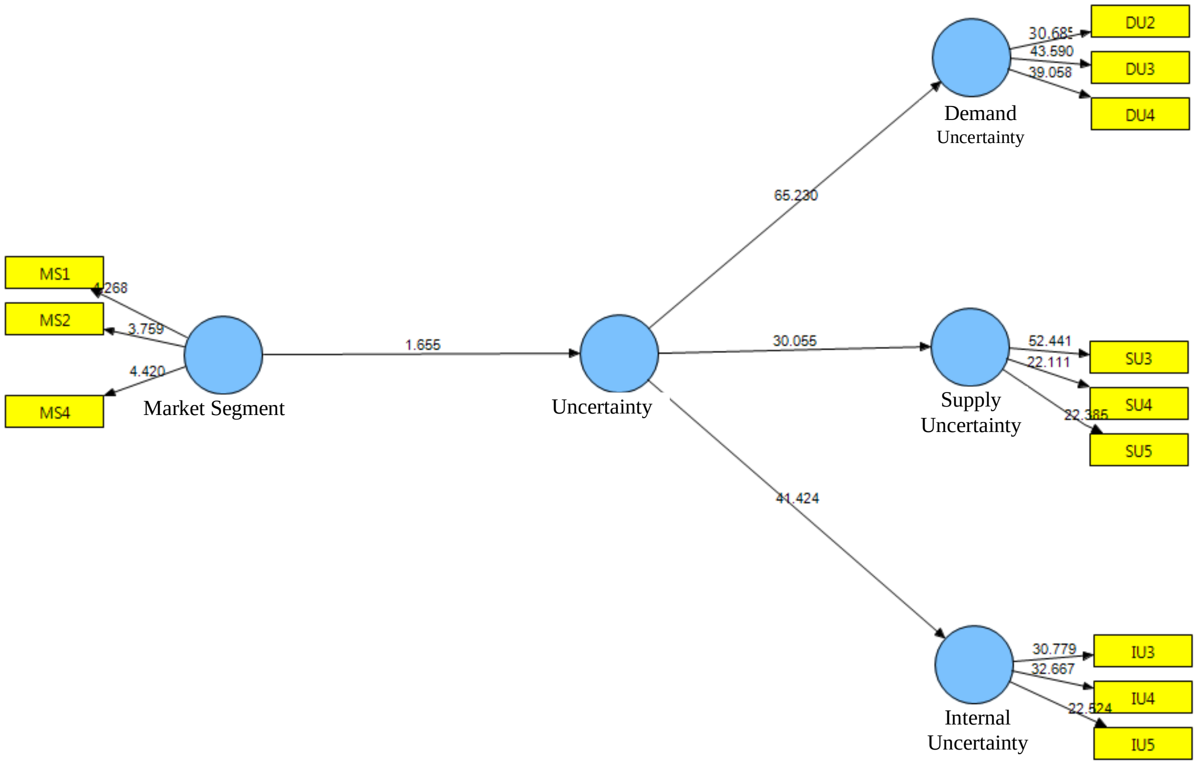

Figure 5-38: Bootstrapping - Impact of Market Segment on Uncertainty

VIII) t-Statistics

Table 5-94: t-Statistics - Impact of Market Segment on Uncertainty

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	t Statistics (|O/STERR|)
DU2 <- Demand Uncertainty	0.8077	0.8058	0.0263	0.0263	30.6849
DU3 <- Demand Uncertainty	0.8509	0.8508	0.0195	0.0195	43.5898
DU4 <- Demand Uncertainty	0.8296	0.8314	0.0212	0.0212	39.0577
IU3 <- Internal Uncertainty	0.7932	0.7912	0.0258	0.0258	30.7786
IU4 <- Internal Uncertainty	0.8032	0.8051	0.0246	0.0246	32.6666
IU5 <- Internal Uncertainty	0.7573	0.7591	0.0336	0.0336	22.5237
MS1 <- Market Segment	0.8535	0.7614	0.2	0.2	4.2683
MS2 <- Market Segment	0.8022	0.7489	0.2134	0.2134	3.759
MS4 <- Market Segment	0.9343	0.8108	0.2114	0.2114	4.4199
SU3 <- Supply Uncertainty	0.8651	0.8645	0.0165	0.0165	52.4409

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	t Statistics (|O/STERR|)
SU4 <- Supply Uncertainty	0.7594	0.759	0.0343	0.0343	22.111
SU5 <- Supply Uncertainty	0.7419	0.7415	0.0331	0.0331	22.3855

Table 5-94 presents t-statistics for the estimates of variables to constructs as a result of bootstrapping process. As highlighted above, t-statistic of all estimates is above 1.96 indicating that estimates are stable.

IX) t-Statistics Constructs

Table 5-95 displays t-statistics for the construct to construct estimates of the structural model as a result of bootstrapping process. As t-Statistics for the relationship between market segment and uncertainty (1.65) is less than 1.96, it could be concluded that the estimate is not significant. Thus H7 is not supported.

Table 5-95: t-Statistics Constructs - Impact of Market Segment on Uncertainty

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	t Statistics (|O/STERR|)
Market Segment -> Uncertainty	-0.0637	-0.1008	0.0385	0.0385	1.6548
Uncertainty -> Demand Uncertainty	0.8823	0.8831	0.0135	0.0135	65.2303
Uncertainty -> Internal Uncertainty	0.8292	0.8309	0.02	0.02	41.4236
Uncertainty -> Supply Uncertainty	0.7847	0.7862	0.0261	0.0261	30.0548

X) Findings

PLS analysis has been carried out to investigate the impact of market segment on uncertainty (Hypothesis 7). Therefore, there is no statistical proof to substantiate there is higher level of uncertainty for companies active in up-market segment of an industry compared to down-market segment.

To provide a better understanding of the relationship between market segment and uncertainty, Figure 5-39 provides a graphical representation of two variables. The uncertainty level of majority of companies is more than 4 indicating that today's business environment is highly uncertain. However, no significant relationship between market segment and uncertainty is traceable through eyeballing of the graph.

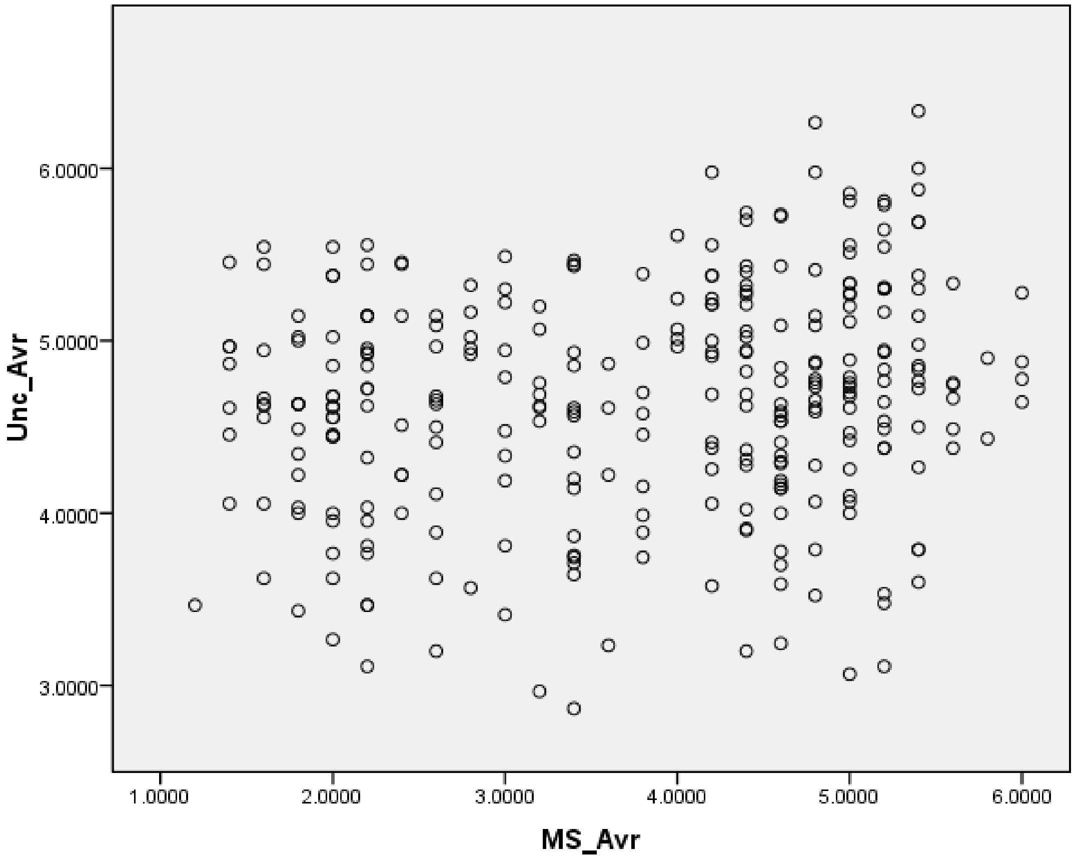

Figure 5-39: Graphical representation of the relationship between Market Segment and Uncertainty

As per outcome of analysis of the leagility index over different market segments, it has been substantiated that the magnitude of agility and leanness is impacted by the segment of the market in which a firm is operating. In other words, supply chain design is impacted by the market segment. Current analysis revealed that uncertainty as a key design driver of supply chain is not impacted by the market segment. Therefore, it could be concluded that both uncertainty and market segment should be considered as significant determinants of designing a supply chain which provides the highest value to organisation.

In conclusion:

H7	There is a higher level of uncertainty for companies active in the up-market segment of an industry compared to the down-market segment.	**Not Supported**

5.8 **Multi Group Analysis of the Research Model per Market Segment**

As explained earlier, market segment in which a firm is operating could be considered as an influencing factor on design of supply chain. However, there is no significant relationship between the market segment and uncertainty.

It has been identified that uncertainty positively impacts on DFL. However, it is unclear that whether this relationship is valid in both market segments which are up-market and down-market. Therefore, the Hypotheses 1-4 and 1-5 have been developed to address this question.

$H_{1\text{-}4}$: Low Level of Uncertainty would let the companies operating in down-market segment to adopt more balanced supply chains (less DFL)

$H_{1\text{-}5}$: Low Level of Uncertainty would let the companies operating in up-market segment to adopt more balanced supply chains (less DFL)

5.8.1 Analysis of Down-Market Segment

I) Structural Model

There are 146 companies are operating in down-market segment. Figure 5-40 presents the structural model to investigate the impact of uncertainty on DFL in down-market segment.

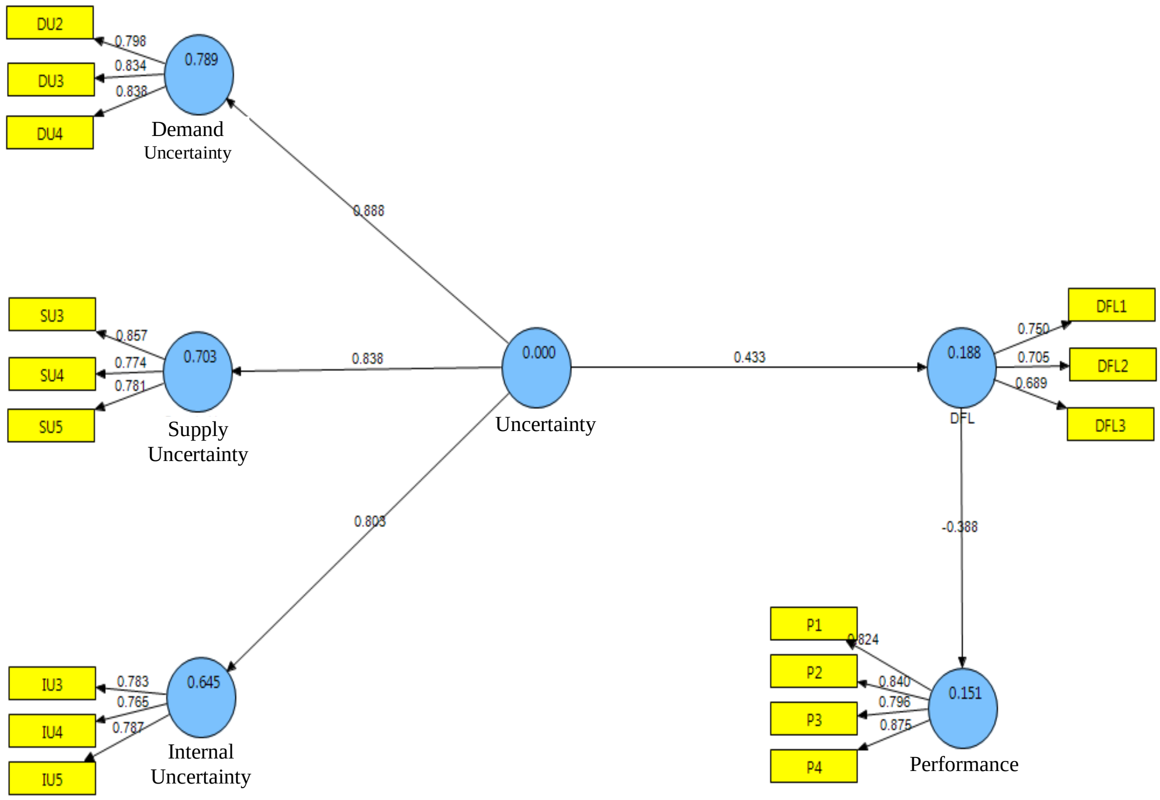

Figure 5-40: Structural Model - Down-Market Segment

II) Factor Loadings

Table 5-96 presents factor loadings for the structural model. As highlighted below, all factor loadings are above 0.7 indicating that measures have acceptable convergent validity.

Table 5-96: Factor Loadings - Down-Market Segment

	DFL	Demand Uncertainty	Internal Uncertainty	Performance	Supply Uncertainty
DFL1	0.7504	0	0	0	0
DFL2	0.7049	0	0	0	0
DFL3	0.6888	0	0	0	0
DU2	0	0.7981	0	0	0
DU3	0	0.8337	0	0	0
DU4	0	0.8379	0	0	0
IU3	0	0	0.7828	0	0
IU4	0	0	0.7652	0	0
IU5	0	0	0.7867	0	0
P1	0	0	0	0.8245	0
P2	0	0	0	0.8404	0
P3	0	0	0	0.7956	0
P4	0	0	0	0.8747	0
SU3	0	0	0	0	0.8573
SU4	0	0	0	0	0.7743
SU5	0	0	0	0	0.7813

III) Path Coefficients

As uncertainty is a second order construct, factor loading between the first order constructs (demand, supply, and internal uncertainty) should also meet the convergent validity criteria. As shown in Table 5-97, the factor loading of uncertainty constructs are more than the threshold (0.7).

Table 5-97: Path Coefficients - Down-Market Segment

	DFL	Demand Uncertainty	Internal Uncertainty	Performance	Supply Uncertainty
DFL	0	0	0	-0.3884	0
Demand Uncertainty	0	0	0	0	0
Internal Uncertainty	0	0	0	0	0
Performance	0	0	0	0	0
Supply Uncertainty	0	0	0	0	0
Uncertainty	0.4332	0.8885	0.8029	0	0.8384

IV) Quality Criteria

As explained in research methodology chapter, in order to assess the internal consistency of the measurement items, average variance extracted (AVE), composite reliability, and Cronbach's Alpha should be assessed. The minimum value for the composite reliability and Cronbach's Alpha is 0.7 and value of AVE above 0.5 is deemed to be in satisfactory level. As shown in Table 5-98, all quality criteria are within acceptable limit. Therefore, measures have an acceptable internal consistency.

Table 5-98: Quality Criteria - Down-Market Segment

	AVE	Composite Reliability	R Square	Cronbach's Alpha	Communality	Redundancy
DFL	0.5115	0.8583	0.1877	0.7005	0.5115	0.093
Demand Uncertainty	0.678	0.8633	0.7894	0.7624	0.678	0.5351
Internal Uncertainty	0.6057	0.8217	0.6446	0.7057	0.6057	0.3859
Performance	0.696	0.9015	0.1509	0.8563	0.696	0.1005
Supply Uncertainty	0.6483	0.8466	0.7029	0.7285	0.6483	0.4495
Uncertainty	0.5186	0.8832	0	0.8507	0.5186	0

V) Bootstrapping

As depicted in Figure 5-41, the stability of the estimates was tested via a bootstrap re-sampling procedure (5000 sub-samples).

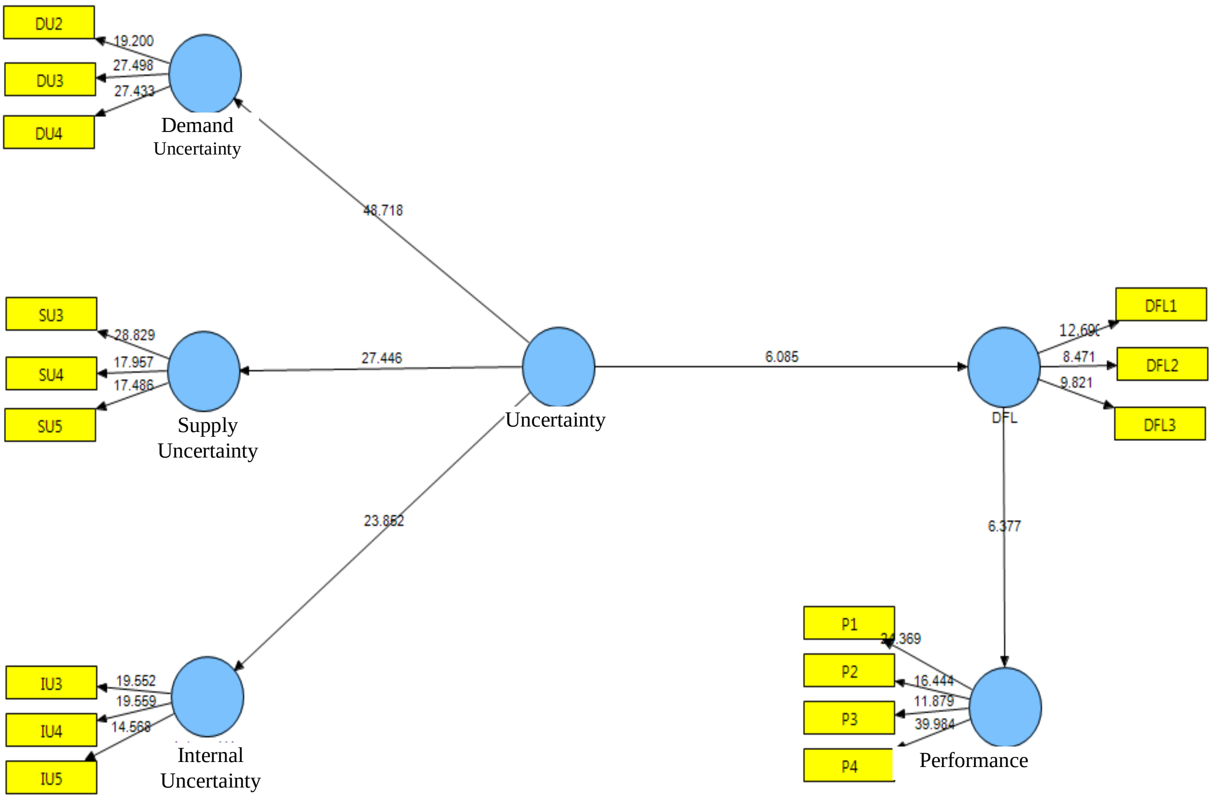

Figure 5-41: Bootstrapping - Down-Market Segment

VI) t-Statistics

Table 5-99 presents t-statistics for the estimates of variables to constructs as a result of bootstrapping process. As highlighted below, t-statistic of all estimates is above 1.96 indicating that estimates are stable.

Table 5-99: t-Statistics - Down-Market Segment

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	t Statistics (|O/STERR|)
DFL1 <- DFL	0.7504	0.7508	0.0591	0.0591	12.6898
DFL2 <- DFL	0.7049	0.6933	0.0832	0.0832	8.4707
DFL3 <- DFL	0.6888	0.6866	0.0701	0.0701	9.8211
DU2 <- Demand Uncertainty	0.7981	0.7966	0.0416	0.0416	19.1997
DU3 <- Demand Uncertainty	0.8337	0.833	0.0303	0.0303	27.4984
DU4 <- Demand Uncertainty	0.8379	0.8378	0.0305	0.0305	27.4331
IU3 <- Internal Uncertainty	0.7828	0.7808	0.04	0.04	19.5517
IU4 <- Internal Uncertainty	0.7652	0.7679	0.0391	0.0391	19.5587
IU5 <- Internal Uncertainty	0.7867	0.7819	0.054	0.054	14.5676
P1 <- Performance	0.8245	0.8256	0.0338	0.0338	24.3687
P2 <- Performance	0.8404	0.8331	0.0511	0.0511	16.4436
P3 <- Performance	0.7956	0.7867	0.067	0.067	11.8788
P4 <- Performance	0.8747	0.8779	0.0219	0.0219	39.9844
SU3 <- Supply Uncertainty	0.8573	0.8564	0.0297	0.0297	28.8291
SU4 <- Supply Uncertainty	0.7743	0.7732	0.0431	0.0431	17.9569
SU5 <- Supply Uncertainty	0.7813	0.7784	0.0447	0.0447	17.486

VII) t-Statistics Constructs

Table 5-100 displays t-statistics for the construct to construct estimates of the structural model 3 as a result of bootstrapping process. As highlighted below, all t-statistics are above 1.96, indicating that estimates are stable.

Table 5-100: t-Statistics Constructs - Down-Market Segment

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	t Statistics (|O/STERR|)
DFL -> Performance	-0.3884	-0.4025	0.0609	0.0609	6.377
Uncertainty -> DFL	0.4332	0.4352	0.0712	0.0712	6.0854
Uncertainty -> Demand Uncertainty	0.8885	0.8898	0.0182	0.0182	48.7181
Uncertainty -> Internal Uncertainty	0.8029	0.8031	0.0337	0.0337	23.8518
Uncertainty -> Supply Uncertainty	0.8384	0.8374	0.0305	0.0305	27.446

VIII) Discriminant Validity

As explained in research methodology chapter, in PLS path modelling, discriminant validity is assessed as satisfactory when the square roots of the AVE values are higher than correlation coefficients between the variables (Fornell & Larcker 1981).

Table 5-101: Discriminant Validity - Down-Market Segment

	AVE	DFL	Performance	Uncertainty
DFL	0.5115	0.7152		
Performance	0.696	-0.3884	0.8343	
Uncertainty	0.5186	0.4332	-0.1656	0.7201

As shown in Table 5-101, the square roots of AVEs, highlighted as yellow in diagonal direction, are greater than correlation coefficients between the variables. Therefore, the requirements for discriminant validity are satisfied.

IX) Findings

As convergent validity, discriminant validity, and quality criteria requirements are supported, it could be concluded the research model fits the data. Furthermore, t-statistics of the path coefficient between uncertainty and DFL (6.085) is higher than 1.96. Therefore, uncertainty positively impacts on DFL ($\beta = 0.433$, $p<0.05$) for the companies operating in down-market segment. In other words, Low Level of uncertainty would let the companies operating in down-market segment to adopt more balanced supply chains (less DFL). Thus $H_{1\text{-}4}$ is supported.

5.8.2 Analysis of Up-Market Segment

I) Structural Model

There are 153 companies are operating in up-market segment. Figure 5-40 presents the structural model to investigate the impact of uncertainty on DFL in down-market segment.

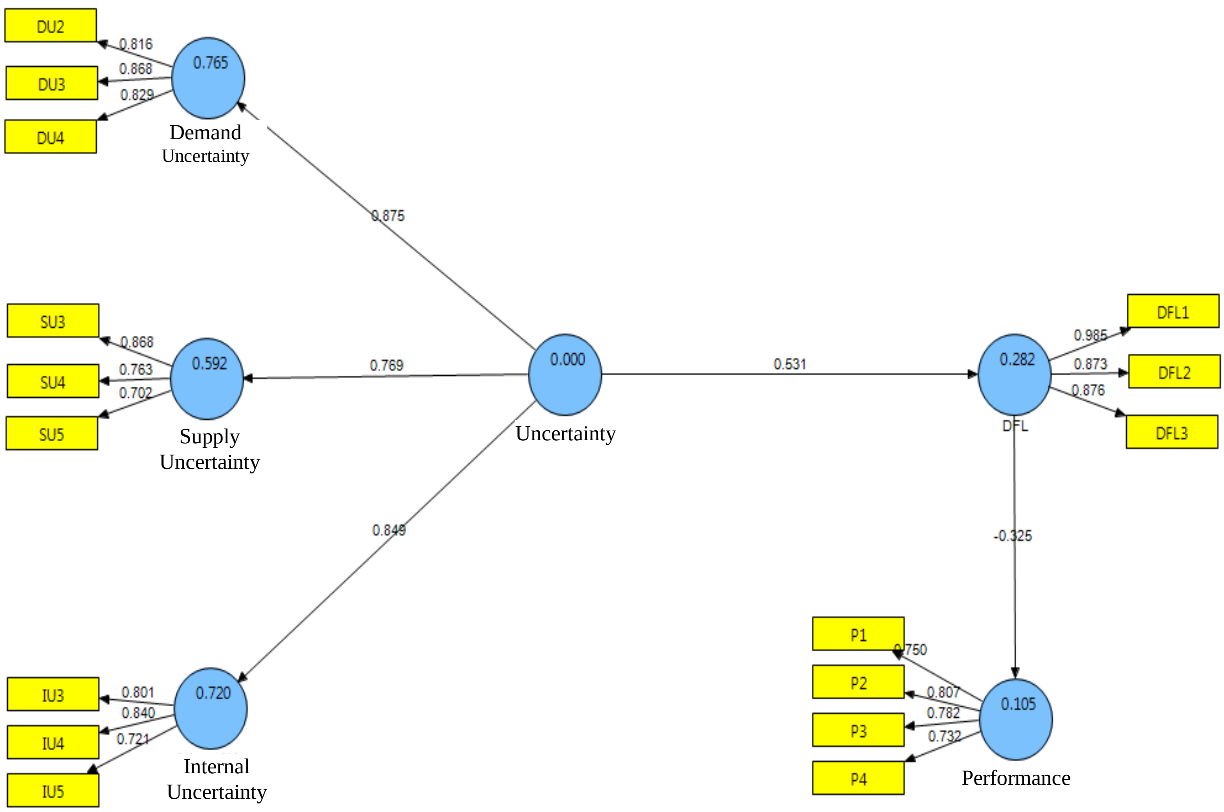

Figure 5-42: Structural Model - Up-Market Segment

II) Factor Loadings

Table 5-102 presents factor loadings for the structural model. As highlighted below, all factor loadings are above 0.7 indicating that measures have acceptable convergent validity.

Table 5-102: Factor Loadings - Up-Market Segment

	DFL	Demand Uncertainty	Internal Uncertainty	Performance	Supply Uncertainty
DFL1	0.9846	0	0	0	0
DFL2	0.8733	0	0	0	0
DFL3	0.8764	0	0	0	0
DU2	0	0.8155	0	0	0
DU3	0	0.8676	0	0	0
DU4	0	0.8287	0	0	0
IU3	0	0	0.801	0	0
IU4	0	0	0.8396	0	0
IU5	0	0	0.721	0	0
P1	0	0	0	0.7504	0
P2	0	0	0	0.8071	0
P3	0	0	0	0.7815	0
P4	0	0	0	0.7316	0
SU3	0	0	0	0	0.8679
SU4	0	0	0	0	0.7634
SU5	0	0	0	0	0.702

III) Path Coefficients

As uncertainty is a second order construct, factor loading between the first order constructs (demand, supply, and internal uncertainty) should also meet the convergent validity criteria. As shown in Table 5-103, the factor loading of uncertainty constructs are more than the threshold (0.7).

Table 5-103: Path Coefficients - Up-Market Segment

	DFL	Demand Uncertainty	Internal Uncertainty	Performance	Supply Uncertainty
DFL	0	0	0	-0.3247	0
Demand Uncertainty	0	0	0	0	0
Internal Uncertainty	0	0	0	0	0
Performance	0	0	0	0	0
Supply Uncertainty	0	0	0	0	0
Uncertainty	0.5308	0.8746	0.8486	0	0.7695

IV) Quality Criteria

As explained in research methodology chapter, in order to assess the internal consistency of the measurement items, average variance extracted (AVE), composite reliability, and Cronbach's Alpha should be assessed. The minimum value for the composite reliability and Cronbach's Alpha is 0.7 and value of AVE above 0.5 is deemed to be in satisfactory level. As shown in Table 5-104, all quality criteria are within acceptable limit. Therefore, measures have an acceptable internal consistency.

Table 5-104: Quality Criteria - Up-Market Segment

	AVE	Composite Reliability	R Square	Cronbach's Alpha	Communality	Redundancy
DFL	0.8334	0.9373	0.2817	0.8981	0.8334	0.2347
Demand Uncertainty	0.7016	0.8757	0.765	0.7876	0.7016	0.5327
Internal Uncertainty	0.6221	0.8311	0.7201	0.7034	0.6221	0.447
Performance	0.5901	0.8519	0.1054	0.7704	0.5901	0.0601
Supply Uncertainty	0.6096	0.823	0.5921	0.7057	0.6096	0.3585
Uncertainty	0.5073	0.878	0	0.8427	0.5073	0

V) Bootstrapping

As depicted in Figure 5-43, the stability of the estimates was tested via a bootstrap re-sampling procedure (5000 sub-samples).

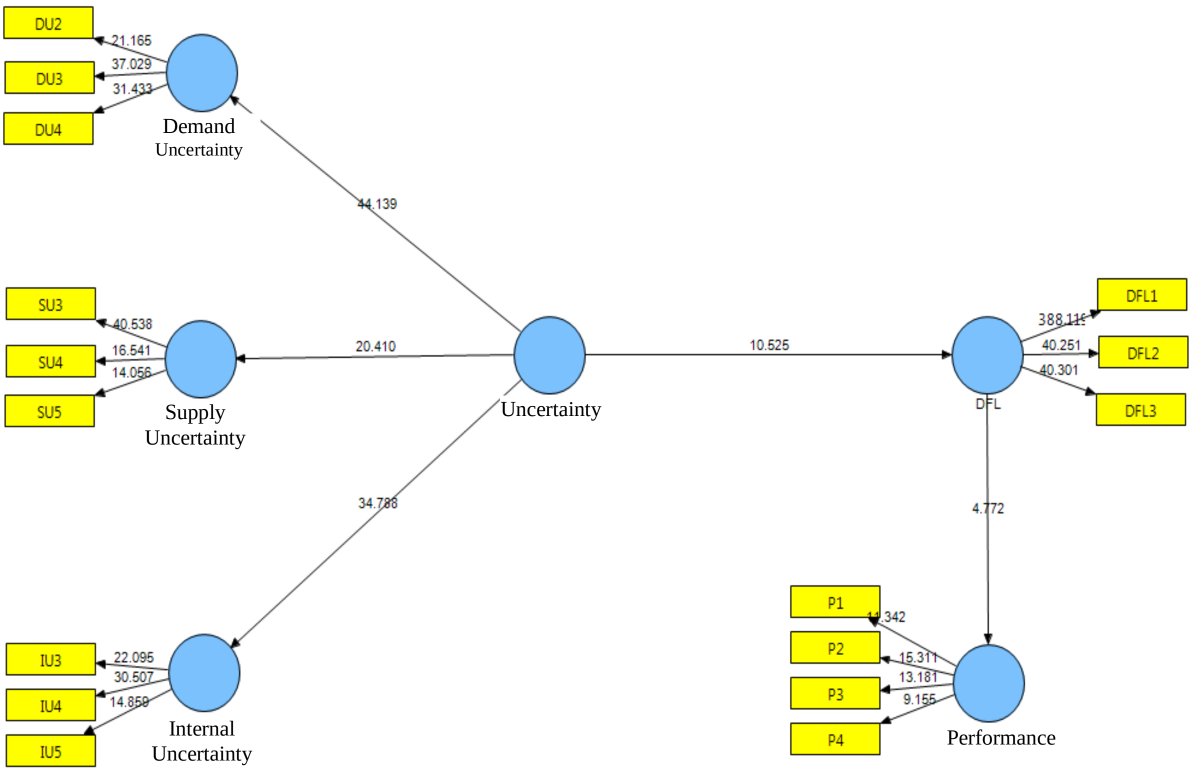

Figure 5-43: Bootstrapping - Up-Market Segment

VI) t-Statistics

Table 5-105 presents t-statistics for the estimates of variables to constructs as a result of bootstrapping process. As highlighted below, t-statistic of all estimates is above 1.96 indicating that estimates are stable.

Table 5-105: t-Statistics - Up-Market Segment

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	t Statistics (|O/STERR|)
DFL1 <- DFL	0.9846	0.9844	0.0025	0.0025	388.1186
DFL2 <- DFL	0.8733	0.8725	0.0217	0.0217	40.2512
DFL3 <- DFL	0.8764	0.8759	0.0217	0.0217	40.301
DU2 <- Demand Uncertainty	0.8155	0.8124	0.0385	0.0385	21.1648
DU3 <- Demand Uncertainty	0.8676	0.8668	0.0234	0.0234	37.0292
DU4 <- Demand Uncertainty	0.8287	0.8286	0.0264	0.0264	31.4333
IU3 <- Internal Uncertainty	0.801	0.7995	0.0363	0.0363	22.095
IU4 <- Internal Uncertainty	0.8396	0.8402	0.0275	0.0275	30.5065
IU5 <- Internal Uncertainty	0.721	0.721	0.0485	0.0485	14.8593
P1 <- Performance	0.7504	0.7494	0.0662	0.0662	11.342
P2 <- Performance	0.8071	0.7987	0.0527	0.0527	15.3109
P3 <- Performance	0.7815	0.7716	0.0593	0.0593	13.1808
P4 <- Performance	0.7316	0.7177	0.0799	0.0799	9.1552
SU3 <- Supply Uncertainty	0.8679	0.8678	0.0214	0.0214	40.5376
SU4 <- Supply Uncertainty	0.7634	0.7601	0.0462	0.0462	16.5412
SU5 <- Supply Uncertainty	0.702	0.7008	0.0499	0.0499	14.0559

VII) t-Statistics Constructs

Table 5-106 displays t-statistics for the construct to construct estimates of the structural model 3 as a result of bootstrapping process. As highlighted below, all t-statistics are above 1.96, indicating that estimates are stable.

Table 5-106: t-Statistics Constructs - Up-Market Segment

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	t Statistics (|O/STERR|)
DFL -> Performance	-0.3247	-0.3377	0.068	0.068	4.7715
Uncertainty -> DFL	0.5308	0.532	0.0504	0.0504	10.5246
Uncertainty -> Demand Uncertainty	0.8746	0.8746	0.0198	0.0198	44.1395
Uncertainty -> Internal Uncertainty	0.8486	0.8496	0.0244	0.0244	34.7882
Uncertainty -> Supply Uncertainty	0.7695	0.7699	0.0377	0.0377	20.4099

VIII) Discriminant Validity

As explained in research methodology chapter, in PLS path modelling, discriminant validity is assessed as satisfactory when the square roots of the AVE values are higher than correlation coefficients between the variables (Fornell & Larcker 1981).

Table 5-107: Discriminant Validity - Up-Market Segment

	AVE	DFL	Performance	Uncertainty
DFL	0.8334	0.9129		
Performance	0.5901	-0.3247	0.7682	
Uncertainty	0.5073	0.5308	-0.1951	0.7122

As shown in Table 5-107, the square roots of AVEs, highlighted as yellow in diagonal direction, are greater than correlation coefficients between the variables. Therefore, the requirements for discriminant validity are satisfied.

IX) Findings

As convergent validity, discriminant validity, and quality criteria requirements are supported, it could be concluded the research model fits the data. Furthermore, t-statistics of the path coefficient between uncertainty and DFL (10.525) is higher than 1.96. Therefore, uncertainty positively impacts on DFL ($\beta = 0.531$, $p<0.05$) for companies operating in up-market segment. In other words, Low Level of uncertainty would let the companies operating in up-market segment to adopt more balanced supply chains (less DFL). Thus H_{1-5} is supported.

5.8.3 Multi Group Analysis

Analysis of research model for two segments of the market, down-market and up-market revealed that uncertainty has significant and positive impact on DFL. Correlation coefficient of uncertainty and DFL for down-market and up-market is estimated as 0.433 and 0.531 respectively. Therefore, it seems the impact of uncertainty on DFL is greater for up-market segment (Hypothesis 1-6).

$H_{1\text{-}6}$: The impact of Uncertainty on DFL is greater for up-market segment compared to down-market segment.

In addition, the negative impact of DFL on performance seems to be greater for down-market segment (-0.4) compared to up-market segment (-0.34). The following hypothesis is developed to check whether the difference is significant.

$H_{1\text{-}7}$: The impact of DFL on Performance is greater for down-market segment compared to up-market segment.

The hypothesis should be tested statistically to ensure the difference is significant. Equation 1 provides the formula to assess the multi-group analysis.

Equation 1: t-Statistics to assess the multi group analysis

$$t = \frac{Path_{sample\_1} - Path_{sample\_2}}{\left[\sqrt{\frac{(m-1)^2}{(m+n-2)} * S.E._{sample1}^2 + \frac{(n-1)^2}{(m+n-2)} * S.E._{sample2}^2}\right] * \left[\sqrt{\frac{1}{m} + \frac{1}{n}}\right]}$$

Where:

$Path_{sample\_1}$: Regression Weight, Group 1

$Path_{sample\_2}$: Regression Weight, Group 2

$S.E._{sample\_1}$: Standard Error, Group 1

$S.E._{sample\_2}$: Standard Error, Group 2

I) Uncertainty and DFL

Table 5-108 presents the statistics to calculate the multi-group analysis for the impact of uncertainty on DFL per market segment. As t-statistics (1.16) is less than 1.96 and p-value (0.247) is more than 0.05, it could be concluded that there is no significant difference in impact of uncertainty on DFL between companies operating in down-market and up-market segments. Thus, H_{1-6} is not supported.

Table 5-108: Multi-group analysis - Impact of Uncertainty on DFL

	Down Market	**Up Market**
Sample Size	146	153
Regression Weight	0.43	0.53
Standard Error (S.E.)	0.0711	0.0504
t-statistic	1.160	
p-value (2-tailed)	**0.247**	
Summary of Calculations	(m-1)^2	21025
	(m+n-2)	297
	(n-1)^2	23104
	sqrt(1/m+1/n)	0.116
	1st half denom	0.358
	2nd half denom	0.198
	sqrt(1st half + 2nd half)	0.745
	Full denom	0.086
	numerator	0.1

II) DFL and Performance

Table 5-109 presents the statistics to calculate the multi-group analysis for the impact of DFL on performance per market segment. As t-statistics (0.657) is less than 1.96 and p-value (0.511) is more than 0.05, it could be concluded that there is no significant difference in impact of DFL on performance between companies operating in down-market and up-market segments. Thus, H_{1-7} is not supported.

Table 5-109: Multi-group analysis - Impact of DF on Performance

	Down Market	Up Market
Sample Size	146	153
Regression Weight	-0.40	-0.34
Standard Error (S.E.)	0.0609	0.068
t-statistic	0.657	
p-value (2-tailed)	**0.511**	
Summary of Calculations	(m-1)^2	21025
	(m+n-2)	297
	(n-1)^2	23104
	sqrt(1/m+1/n)	0.116
	1st half denom	0.263
	2nd half denom	0.360
	sqrt(1st half + 2nd half)	0.789
	Full denom	0.091
	numerator	0.06

III) Findings

Multi-group analysis of the research model revealed that there is no significant difference between the impact of uncertainty on DFL and also the effect of DFL on performance among up-market and down-market segments. In other words, in both market segments, firms adopt more balanced leagile supply chain in lower level of uncertainty with the same impact factor. Actually, it does not matter which segment a firm is operating. Uncertainty is a significant determinant to design a supply chain.

5.9 **Summary**

There are normally two approaches to estimate the parameters of a structural equation modelling (SEM),: the covariance-based method and the variance-based (or components-based) method. As normality assumption is violated for all variables and sample size (299) is not sufficient to utilise a covariance-based SEM method for the research model comprising of 33 indicators, variance-based SEM, Partial least squares Modelling has been selected as the method of analysis.

The outcome of analysis indicated low level of uncertainty would let the companies to adopt more balanced supply chains (less DFL). The result is valid for overall uncertainty and its individual constructs: demand, supply, and internal uncertainties. Furthermore, the same relationship exists for companies operating in both up-market and down-market segments.

As a significant contribution of this study, it has been identified that a more balanced supply chains (Less DFL) attains higher firm performance. Comparison between the market segments in terms of the relationship between uncertainty and DFL and also DFL and firm performance indicated that those relations do not statistically different over market segments.

Analysis of moderators highlighted that both competition intensity and level of customers' expectation moderates the relationship between the uncertainty and DFL. However, the aforementioned finding is not supported for individual constructs of uncertainty: demand, supply, and internal uncertainty. This finding emphasises that a comprehensive model of uncertainty should be employed in study of supply chain design.

Looking into the position of DFL revealed that organisations adopt hybrid supply chain rather than a purely lean or a purely agile supply chain. In addition, there is higher agility magnitude (higher LI) for companies active in up-market segment of an industry compared to down-market segment.

To address one of the research questions as whether there is higher level of uncertainty for companies active in up-market segment of an industry compared to down-market segment, the outcome of analysis indicated that there is no significant difference between the uncertainty levels over market segments.

In conclusion:

H1-4	Low Level of Uncertainty would let the companies operating in down-market segment to adopt more balanced supply chains (less DFL)	**Supported**
H1-5	Low Level of Uncertainty would let the companies operating in up-market segment to adopt more balanced supply chains (less DFL)	**Supported**
H1-6	The impact of Uncertainty on DFL is greater for up-market segment compared to down-market segment.	**Not Supported**
H1-7	The impact of DFL on Performance is greater for down-market segment compared to up-market segment.	**Not Supported**

CHAPTER 6: DISCUSSION

6.1 Overview

The supply chain's design wields an enormous influence on the value and cost of the product throughout its lifetime. As the impact of supply chain design is increasing in the business world, the 'battlefield' shifts from competition between organisations to competition between supply chains in the 21st century. In this regard, Schnetzler, Sennheiser and Weidemann (2004) emphasised that effective design of supply chain could be considered a key source of competitive advantage.

The design of Australian firms' supply chain in terms of leagility has been scrutinised in the current study which is a mixed exploratory-explanatory research. An index, known as deviation from leagility (DFL), is introduced to provide insights into the leagility status of supply chain design and how it influences a firm's performance.

Uncertainty has garnered much attention in several studies as the key design driver of supply chains. To the extent of this author's knowledge, there is no literature in which a comprehensive model of uncertainty has investigated the impact of uncertainty on supply chain design. Here, however, not only is a comprehensive model of uncertainty employed but also uncertainty constructs (demand, supply, and internal uncertainty) have been engaged individually to provide a detailed explanation for the impact of uncertainty on leagility aspects of supply chain design.

As per Institutional theory, external forces affect organisational performance. Therefore, it is crucial to examine the main external forces which could possibly influence the supply chain design. In this regard, the moderating effect of competition intensity and level of customers' expectation on the relationship between the uncertainty and DFL have been explored.

McDonald (2012) noted the crucial determinants of firm success and these are correct market definition, market segmentation and positioning. Therefore, as market segment in which a firm is operating influences all its operations, it is expected that design of supply chain could be affected as well. As per theory of market qualifiers and market winners in supply chain management proposed by Mason-Jones, Naylor and Towill (2000), design of supply chain is affected by market characteristics including price, quality, lead time, and service level. Since market segment is a sub-set of a market with at least one characteristic in common, it seems there should be a relationship between the market segment and supply chain design. Hence, the position of leagility index in different marker segments has been investigated. In addition, the research model's main relationships have been compared with reference to the up-market and down-market segments. Table 6-1 below presents the hypotheses which have been examined here. Of the 14 proposed hypotheses, statistical analysis of samples collected from Australian firms supported 12 hypotheses.

Table 6-1: Summary of Hypotheses which have been examined

Hypotheses	*Supported?*
H_1: Low Level of Uncertainty would let the companies adopt more balanced supply chains (less DFL)	**Y**
$H_{1\text{-}1}$: Low Level of Demand Uncertainty would let the companies adopt more balanced supply chains (less DFL)	**Y**
$H_{1\text{-}2}$: Low Level of Supply Uncertainty would let the companies adopt more balanced supply chains (less DFL)	**Y**
$H_{1\text{-}3}$: Low Level of Internal Uncertainty would let the companies adopt more balanced supply chains (less DFL)	**Y**
$H_{1\text{-}4}$: Low Level of Uncertainty would let the companies operating in the down-market segment adopt more balanced supply chains (less DFL)	**Y**
$H_{1\text{-}5}$: Low Level of Uncertainty would let the companies operating in the up-market segment adopt more balanced supply chains (less DFL)	**Y**
$H_{1\text{-}6}$: The impact of Uncertainty on DFL is greater for the up-market segment compared to the down-market segment.	**N**
$H_{1\text{-}7}$: The impact of DFL on Performance is greater for the down-market segment compared to the up-market segment.	**N**
H_2: A more balanced supply chains leads to better performance.	**Y**

H_3: The relationship between Uncertainty and DFL is moderated by the level of Competition.	Y
$H_{3\text{-}1}$: The relationship between Demand Uncertainty and DFL is moderated by the level of Competition.	N
$H_{3\text{-}2}$: The relationship between Supply Uncertainty and DFL is moderated by the level of Competition.	N
$H_{3\text{-}3}$: The relationship between Internal Uncertainty and DFL is moderated by the level of Competition.	N
H_4: The relationship between Uncertainty and DFL is moderated by the level of Customers' expectations.	Y
$H_{4\text{-}1}$: The relationship between Demand Uncertainty and DFL is moderated by the level of Customers' expectations.	N
$H_{4\text{-}2}$: The relationship between Supply Uncertainty and DFL is moderated by the level of Customers' expectations.	N
$H_{4\text{-}3}$: The relationship between Internal Uncertainty and DFL is moderated by the level of Customers' expectations.	N
H_5: Organisations adopt a hybrid supply chain rather than a purely lean or a purely agile supply chain.	Y
H_6: There is higher agility magnitude (higher LI) for companies active in the up-market segment of an industry compared to the down-market	Y
H_7: There is a higher level of uncertainty for companies active in the up-market segment of an industry compared to the down-market segment.	N

6.2 Discussion of Relationships among Constructs

The results of the current study provide in-depth knowledge about supply chain design in terms of leagility. Details of the implications with respect to the relationships of the model are described in this section.

6.2.1 Uncertainty and DFL

The results of the PLS analysis using all of 299 data points have been used to address the study hypotheses. The path coefficients are the standardised beta coefficients. The result of the analysis indicates that level of uncertainty ($\beta = 0.370$, $p<0.05$) has a significant and positive impact on deviation from leagility (DFL). The interpretation of this finding relies on the concept of DFL. As explained in previous chapters, DFL is the absolute distance of supply chain design from a balanced supply chain. Balanced supply chain is a position the magnitude of leanness and agility is equal. Critical review of literature revealed that findings are contradictory regarding the influence of uncertainty on supply chain design. Researchers (Fisher 1997; Samuel, Mohit & Shi 2002) indicated that a lean supply chain is more appropriate for functional products (low uncertainty) while an agile supply chain matches well with innovative products (high uncertainty). Others (Selldin & Olhager 2007) have stated that this relationship is not statistically supported.

For example, Christopher (2000) described the distinctive nature or features of such environments as requiring a market responsiveness which could be realised by setting up agile supply chains. Market fluctuations in terms of product volume and variety to meet customer requirements could be addressed easier through agile supply chains. In addition, Christopher and Towill (2000) also emphasised the trend of moving away from lean and functional supply chains to more agile and customised ones. However, management of supply chain is not limited solely to just addressing market volatility issues by improving agility and responsiveness. In fact, hyper-competition and rising uncertainty intensifies pricing pressures on companies which requires cost cutting through implementation of lean supply chain. Therefore, integration of leanness and agility is required to maintain a business profitable.

In this regard, DFL would be a measurement tool for investigating the extent to which a business incorporates both leanness and agility in its supply chain. Analysis indicates that in a less uncertain position, deviation from leagility is less. It means that when the uncertainty level is lower, a more balanced leagile supply chain is utilised.

As depicted in Figure 6-1, based on the conceptual model proposed by Fisher (1997), at the lower level of uncertainty, a lean supply chain would be utilised, whereas the agile supply chain is more suitable when the uncertainty level is higher. However, findings of this thesis contradict Fisher's model. At a high level of uncertainty, two types of supply chain models exist: (a) leagile supply chains with a very high magnitude of leanness; and (b) leagile supply chains with a very high magnitude of agility. On the other hand, at a low level of uncertainty, companies employ more a balanced leagile supply chain.

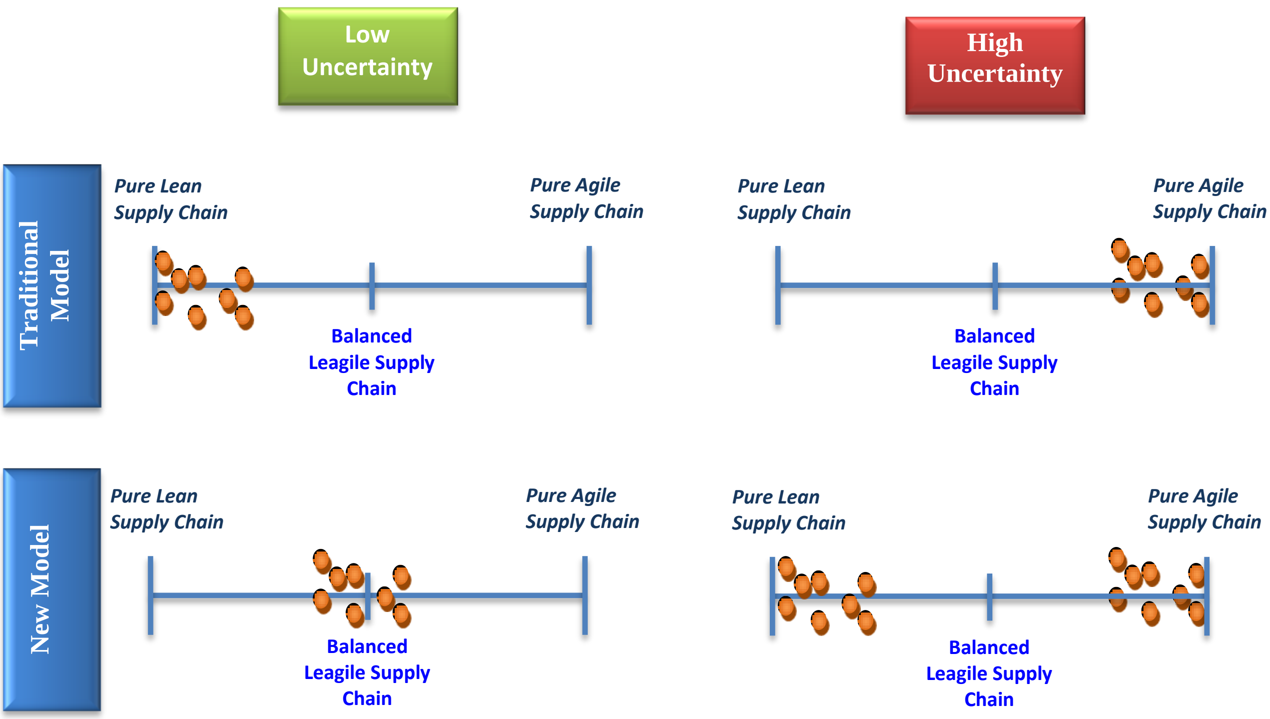

Figure 6-1: Schematic presentation of impact of uncertainty on DFL

To explain the new model, it would be useful to review a framework proposed by Mason-Jones, Naylor and Towill (2000) as shown in Table 6-2.

Table 6-2: Market Winners - Market Qualifiers Matrix for Agile versus Lean Supply Chain Source: Mason-Jones, Naylor and Towill (2000)

	Market Qualifier	Market Winner
Agile Supply Chain	• Quality • Cost • Lead Time	• Service Level
Lean Supply Chain	• Quality • Lead Time • Service Level	• Cost

Table 6-2 presents the fundamental differences between the lean and agile concepts depending on the market qualifiers and market winners. To enter a market, market qualifiers are the minimum requirements necessary to provide a product or service. However, the criterion for being a winner in a market is referred to as market winner. Based on the conceptual model proposed by Mason-Jones, Naylor and Towill (2000), an agile supply chain is more suitable when service level is the market winner, whereas companies adopt the lean supply chain when cost is the market winner.

Analysis of the research model revealed that in high uncertainty level, companies adopt leagile supply chains with either high magnitude of leanness or agility. As resources of a company are limited, the most focus would be on providing the market winner (Martin & Denis 2002). Therefore, in high uncertain scenarios, when the market winner is cost, leagile supply chain with higher magnitude of leanness is preferable. In contrast, the leagile supply chain with higher magnitude of agility is adopted when the market winner is the service level.

Comparatively, as the uncertainty level declines when the market winner is achieved, the other aspect of supply chain would be reinforced to provide higher level of market qualifiers whereby the firm's performance proves. To reiterate, if market winner is service level, in a highly uncertain situation, a firm adopts a leagile supply chain with high magnitude of agility to provide the highest possible service level.

Relatively, if market winner is service level using the previous scenario, but uncertainty level is low, the magnitude of agility would be greater than that of leanness. However, the balance would be different. More magnitude of leanness can provide a better level of market qualifier (ex. cost) which improves a firm's performance.

In sum, at a higher level of uncertainty, companies are advised to allocate resources to designing a supply chain in a way so that a minimal level of market qualifiers is provided and more effort is made to improve the market winner(s). On the other hand, at a lower level of uncertainty, more resources could be released to provide an improved level of market qualifiers.

6.2.2 Uncertainty Constructs and DFL

PLS analysis on uncertainty constructs revealed that all three constructs - demand uncertainty ($\beta = 0.2851$, $p<0.05$), supply uncertainty ($\beta = 0.3701$, $p<0.05$), and internal uncertainty ($\beta = 0.286$, $p<0.05$) - have significant positive impact on deviation from leagility. In many studies (Towill, Naim & Wikner 1992; Lee & Whang 1997; Mason-Jones & Towill 1998; Taylor 2000; Lee, Padmanabhan & Whang 2004), demand uncertainty has been referred to as the most crucial element of uncertainty - a key driver of supply chain design. However, the findings of the current study indicate that supply uncertainty with a path coefficient of 0.371 has the highest impact. Consequently, more focus on supply uncertainty is required so that a better productive supply chain is produced.

6.2.3 DFL and Firm Performance

A comparative approach has been utilised to measure firm performance whereby respondents were requested to rate their company based on how well the company performs relative to its competitors in terms of cost, flexibility, delivery speed, profitability, and growth in market share. The results of the PLS analysis using all of 299 data points have been used to address the study hypotheses. The result of analysis indicates that DFL ($\beta = - 0.333$, $p<0.05$) has a significant and negative impact on firm performance (DFL). In other words firms with more balanced supply chains (less DFL) will perform better.

As explained earlier, at a low level of uncertainty, companies adopt more balanced supply chains. When both aspects of leanness and agility are employed in their design, it is expected that market qualifiers and market winners are both achieved at the highest possible level when firm resources are available. Therefore, companies perform better when they have a balanced supply chain and their functioning is in fact significantly higher.

6.2.4 Study of Moderators

Transformation of supply chain design from what the Fisher conceptual model suggests that the findings here could derive from changes in the environment in which a firm is operating. Growing expectations of customers and increasing the level of competition intensity have impacted on all aspects of businesses including supply chain design. Therefore, a moderation effect of competition intensity and customers' expectation on the relationship between uncertainty and DFL has been investigated in this study.

I) Competition Intensity

PLS analysis investigated the moderation effect of competition intensity on the relationship between uncertainty and DFL. The analysis outcome revealed that competition intensity negatively affects DLF ($\beta = -0.573$, $p<0.05$). In other words, when competition is fiercer, companies adopt a more balanced supply chain. The justification of this finding relies on the fact that when competition is intense, companies are struggling to provide a product/service which has not only an excellent market winner, but also an improved level of market qualifier. Accordingly, both aspects of leanness and agility should be considered to improve price competitiveness and service level at the same time. As a result, deviation from leagility would be less when competition is at a higher level.

In order to investigate the moderation effect, a new variable has been calculated as a result of multiplying the scores of independent variable (uncertainty) by moderator (competition intensity). Since the path coefficient of interaction variable ($\beta = -0.409$, $p<0.05$) is significant, it could be concluded that the relationship between uncertainty and DFL is moderated by the level of competition. On this theme, it has been identified that the path coefficient between the interaction variable and DFL is negative ($\beta = -0.409$, $p<0.05$). The negative figure indicates that at a higher level of competition, the effect of uncertainty on DFL will decrease. As explained earlier, at a high uncertainty level, companies adopt a supply chain which provides the minimum level of market qualifier and more focus will be on providing an improved level of market winner. On the other hand, competition has the opposite effect. A high level of competition will force companies to not only focus on the market winner but also provide an improved level of market qualifiers. Therefore, by increasing the level of competition, the effect of uncertainty on DFL would decline.

a. Uncertainty Constructs

As explained in the results chapter, the majority of studies on supply chain leagility employed one aspect of uncertainty, i.e. demand, supply, or internal uncertainty. It is therefore necessary to check the moderation effect of competition intensity on the relationship between individual constructs of uncertainty and DFL. Analysis indicated that the moderation effect of competition intensity is not significant for any of the uncertainty constructs.

It is interesting that when the comprehensive concept of uncertainty is engaged in the model, competition intensity has been identified as a moderator. In contrast, the same analysis on the constructs of uncertainty (demand, supply, and internal uncertainty) indicates competition intensity is not statistically a moderator. This finding provides a significant theoretical contribution to supply chain design as not employing a comprehensive model of uncertainty might create considerable bias in the conclusion and findings.

II) Customers' expectation

PLS analysis has been carried out to investigate the moderation effect of customers' expectation in the relationship between the uncertainty and DFL. The outcome of analysis revealed that customers' expectation negatively impacts on DLF ($\beta = -0.433$, $p<0.05$). In other words, when customers are more demanding, companies adopt a more balanced supply chain. The justification of this finding relies on the fact that when the level of customers' expectation is higher, companies are struggling to provide a product/service which has not only an excellent market winner, but also an improved level of market qualifier. Accordingly, both aspects of leanness and agility should be considered to improve price competitiveness and service level at the same time. As a result, deviation from leagility would occur less at a high level of customers' expectation.

In order to investigate the moderation effect, a new variable has been calculated as a result of multiplying the scores of independent variable (uncertainty) by moderator (customers' expectation). As path coefficient of interaction variable ($\beta = -0.586$, $p<0.05$) is significant, it could be concluded that the relationship between uncertainty and DFL is moderated by the level of customers' expectation. Thus, H_4 is supported.

It has been identified that the path coefficient between the interaction variable and DFL is negative ($\beta = -0.586$, $p<0.05$). The negative figure indicates that for higher level of customers' expectation, the effect of uncertainty on DFL would decline. As explained earlier, in high uncertainty level, companies adopt a supply chain which provides the minimum level of market qualifier and more focus will be on providing an improved level of market winner. On the other hand, level of customers' expectation acts in a completely different way. High level of customers' expectation would force companies to not only focus on the market winner but also provide an improved level of market qualifiers. Therefore, by increasing the level of customers' expectation, the effect of uncertainty on DFL would decline.

a. Uncertainty Constructs

The moderation analysis of customers' expectation provides similar findings to competition intensity. Although customers' expectation has been identified as the moderator in the relationship between the overall uncertainty and DFL, the same result was not achieved for any of the uncertainty constructs (demand, supply, and internal uncertainty) individually. This finding may provide an insight for supply chain researchers as a comprehensive model of uncertainty should be employed to ensure less bias will occur in the findings.

6.2.5 DFL and Hybrid Supply Chain

In order to provide an in-depth insight concerning whether firms are adopting mutually exclusive supply chains (efficient and responsive), as proposed by Fisher (1997), or the majority of companies employ leagile supply chains, the range of companies' supply chain DFL is explored. With the leagility scale set from 1 (pure lean supply chain), 4 (balanced leagile supply chain) to 7 (pure agile supply chain), the DFL range would range from 0 (balanced leagile supply chain) to 3 (pure lean or agile supply chain).

The DFL value of zero indicated the supply chain is balanced whereby the magnitude of leanness and agility is equal. Conversely, when the value of DFL is closer to 3, there is a high deviation from leagility meaning the company adopts a purely lean or purely agile supply chain design.

Descriptive analysis indicates that the average of DFL is 1.69 and standard deviation is 0.75. It means that the value of DFL for 84% of companies is less than 2.44 (=1.69+0.75). In addition, the third quartile value is 2.33 indicating that DFL of 75% of companies is less than 2.33 (Q_3). Frequency analysis also indicates that DFL of 90.3% of companies is less than 2.5. Therefore, the DFL of majority of companies is not close to 3. In this regard, non-parametric Wilcoxon Signed Ranks Test with cut-off points 2.33 (Q_3) and 2.44 ($\mu+1\sigma$) is conducted and in both cases it has been found there is a significant difference between the mean of DFL and cut-off points.

Given the outcomes of all performed analyses, it could be concluded that the majority of companies adopts a leagile supply chain. In other words, the main assumption of the current study – that all supply chains are leagile with different magnitude of leanness and agility - is supported.

6.2.6 Market Segment

A market segment is a sub-set of a market consisting of people or companies with at least one characteristic that makes them demand comparable product and/or services in terms of quality, price or function. As the segment of a market in which a firm is operating influences all its functions, it is expected that design of supply chain could be impacted on as well. Regarding the theory of market qualifiers and market winners in supply chain management proposed by Mason-Jones, Naylor and Towill (2000), design of supply chain is affected by market characteristics including price, quality, lead time, and service level. Since market segment is a sub-set of a market with at least one characteristic commonly shared, it seems there should be a relationship between the market segment and supply chain design.

It is crucial to segment a market based on characteristics which possibly impact on the design of supply chain. It seems the best method of market segmentation would be to employ market qualifiers and market winners affecting the design of supply chain. The market is split into two segments: up-market and down-market. Price would be the market winner for the down-market segment and service level and quality would be market winners for up-market segment. Frequency analysis of market segment indicated that of the 299 companies participating in this study, 146 are operating in the down-market segment whereas 153 companies operate in the up-market segment.

I) Leagility Index over Market Segments

The balance of leanness versus agility, leagility index value, is examined in each market segment. In other words, it has been tested whether similarity of characteristics in each market segment accounts for the magnitude of leanness/agility employed in the supply chain's design. Since neither leagility index nor market segment samples follow the normality distribution, a non-parametric Mann-Whitney test is utilised to investigate the leagility index for different market segments. The result indicates that mean rank of leagility index for companies operating in the down-market segment is 85.58 whereas mean rank of leagility index for companies operating in the up-market segment is 211.48. P-value (0.00) of Mann-Whitney test shows there is a significant difference between two leagility index ranks.

It could be concluded that the leagility index of companies operating in the up-market scenario is significantly higher than companies operating in the down-market segment. In other words, there is higher agility magnitude (higher LI) for companies active in the up-market segment of an industry compared to the down-market segment.

II) Uncertainty and Market Segments

Previous analysis revealed that (a) uncertainty positively impacts on DFL, and (b) leagility index is influenced by market segment in which a firm is operating. Therefore, it is necessary to check whether a relationship exists between uncertainty and market segment. PLS path modelling is utilised to statistically test the potential relationship. The analysis revealed that there is no significant relationship between market segment and uncertainty.

As per outcome of analysis of the leagility index over different market segments, it has been substantiated that the magnitude of agility and leanness is influenced by the segment of the market in which a firm is doing business. In other words, supply chain design is impacted by the market segment. Current analysis revealed that uncertainty as a key design driver of supply chain is not impacted by the market segment. Therefore, it could be concluded that both the level of uncertainty and market segment in which a firm is operating should be considered when supply chain is designed or improved.

III) Multi Group Analysis

As explained earlier, market segment in which a firm is operating could be considered an influencing factor on design of supply chain. However, there is no significant relationship between the market segment and uncertainty. Therefore, it is necessary to test whether the impact of uncertainty on DFL is significant in both market segments. In addition, whether there is a significant difference between the impact of uncertainty on DFL in up-market and down-market segments has been assessed. The same multi-group analysis is designed to investigate whether the impact of DFL on firm performance is significantly different.

PLS path modelling analysis revealed that in both market segments uncertainty positively impacts on DFL (down-market: $\beta = 0.433$, $p<0.05$; up-market: $\beta = 0.531$, $p<0.05$). In other words, Low Level of uncertainty would let the companies operating in both down-market and up-market segments to adopt more balanced supply chains (less

DFL). In comparison it has been identified that in both market segments DFL negatively impacts on firm performance (down-market: $\beta = -0.40$, $p<0.05$; up-market: $\beta = -0.34$, $p<0.05$). In other words, for both market segments, firm performance would be higher when companies adopt more balanced leagile supply chains (less DFL).

Apparently, the impact of uncertainty on DFL is higher in up-market ($\beta = 0.531$) versus down-market ($\beta = 0.433$). Comparatively, the negative impact of DFL on firm performance is higher in down-market ($\beta = -0.40$) versus up-market ($\beta = -0.34$). However, it should be statistically tested whether this difference is significant. Multi-group analysis of the research model revealed there is no significant difference between the impact of uncertainty on DFL and the effect of DFL on performance of the up-market and down-market segments. In other words, in both market segments, firms adopt a more balanced leagile supply chain in lower level of uncertainty with the same impact factor. So in fact it does not matter which segment a firm is operating in. Uncertainty is a significant determinant of designing a supply chain.

6.3 **Discussion of Variables**

In light of the results, it is worth looking at the variables of each construct to investigate which questions have been removed through the validity checking process. Furthermore, the remaining variables utilised to measure the construct are subjected to interpretation.

6.3.1 Demand Uncertainty

As presented in Table 6-3, five questions have been employed to measure the demand uncertainty construct. As convergent validity would be supported if the factor loading between the construct and each related variable is 0.7 and above, some questions (DU1 and DU5) have been discarded during the analysis.

Table 6-3: Review of Demand Uncertainty variables

Code	**Questions**	**Valid**
DU1	Our master production schedule has a high degree of variation in demand over time	N/Y*
DU2	Our demand fluctuates drastically from week to week	Y
DU3	Customer requirements for products change dramatically	Y
DU4	The volume and/or composition of demand is difficult to predict	Y
DU5	We keep weeks of inventory of the critical material to meet the changing demand	N

* N/Y means the factor loading is below 0.7 and above 0.6

DU2, DU3, and DU4 directly address the demand fluctuation and they are a result of environmental uncertainty. Some aspects of demand uncertainty are out of an organisation's control and they emanate from changes in customers' needs. All three variables which have been identified as valid are questions which were obviously formulated to measure demand uncertainty as an absolute external variable.

DU1 and DU5 were discarded due to insufficient factor loading. The common characteristic of these questions is they both try to address demand uncertainty by looking into the implications of demand fluctuation inside an organisation. DU1 tries to represent one of the possible implications of demand uncertainty for internal processes, which is a high level of variations in production scheduling. It could have been a reasonable representation of demand uncertainty in earlier decades. However, with the advent of sophisticated demand prediction technologies, the majority of successful companies have developed tools to minimise the impact of demand uncertainty. Therefore, there could be some instances where demand uncertainty is high whereas its impact on internal processes would be minimised when advanced technologies are employed. Some studies which proposed 0.6 as the minimum threshold for the convergent validity are supported. The factor loading of DU1 is 0.6 which is on the border. It shows some companies are utilising demand prediction tools effectively whereby the impact of demand uncertainty on production schedule is minimised. On the other hand there are some organisations which are significantly affected by demand fluctuations.

The same argument is valid for DU5 as it represents the implications of demand fluctuation on inventory level which is an inter-organisation process. By using new technologies the inventory level could be optimised to tackle changes in demand. Therefore, depending on the technological advances a company enjoys, this question could represent demand uncertainty.

The theoretical implications of investigating the variables of demand uncertainty can be summarised as demand uncertainty being measured through variables. These are represented by demand uncertainty which is a purely external variable.

6.3.2 Supply Uncertainty

As presented in Table 6-4, five questions have been employed to measure the supply uncertainty construct. As convergent validity would be supported if the factor loading between the construct and each related variable is 0.7 and above, some questions (SU1 and SU2) have been discarded during the analysis.

Table 6-4: Review of Supply Uncertainty variables

Code	Questions	Valid
SU1	The suppliers consistently meet our requirements	N/Y*
SU2	The suppliers produce materials with consistent quality	N/Y*
SU3	It has been very easy to procure raw materials for our major product	Y
SU4	The price of raw materials and component parts has NOT changed frequently	Y
SU5	We have several alternative sources in acquiring raw materials	Y

* N/Y means the factor loading is below 0.7 and above 0.6

As presented above, the questions discarded from the analysis have a factor loading above 0.6 which is deemed sufficient by several researchers. The possible reason for the insufficient factor loading of SU1 might be related to the interpretation of this question. A supplier has to meet many requirement but not all of them directly impact on supply uncertainty.

The same argument is valid for SU2, as a supplier could provide goods and services of an inconsistent quality but they satisfy the organisation’s minimum acceptable limit. In addition, where a company engages multiple suppliers for a range of products, the overall consistency level could be satisfactory whereas the consistency level for a particular supplier is not reasonable.

6.3.3 Internal Uncertainty

As presented in Table 6-5, six questions have been employed to measure the supply uncertainty construct. Since convergent validity would be supported if the factor loading between the construct and each related variable is 0.7 and above, some questions (IU1, IU2, and IU6) have been discarded during the analysis.

Table 6-5: Review of Internal Uncertainty variables

Code	Questions	Valid
IU1	If we do not keep up with changes in technology, it will be difficult to remain competitive	N
IU2	The number of components in manufacturing is substantial	N
IU3	The production technology changes frequently	Y
IU4	The number of erroneous components in manufacturing is considerable	Y
IU5	The capacity constraints/restrictions in production is considerable	Y
IU6	The manufacturing lead time for several components is long	N

The concept of uncertainty which exists within the organisation has been described as encapsulating internal, technological and manufacturing uncertainty in different studies. Therefore, developing a homogenous scale to measure this concept is not straightforward. IU1 refers to the technological side of internal uncertainty which could be discarded for those companies that do not employ advanced technologies. IU2 could be affected by the size of company and production line. It means there could be a small number of components in the manufacturing line, however, the internal uncertainty would be high for other reasons and these have been addressed in other questions. The same argument is valid for IU6, as the source of internal uncertainty could emanate from erroneous components and not from lead time.

6.3.4 Leagility Index

As presented in Table 6-6, six questions have been employed to measure the leagility index construct. Since convergent validity would be supported if the factor loading between the construct and each related variable is 0.7 and above, some questions (DFL4, DFL5, and DFL6) have been discarded during the analysis.

Table 6-6: Review of Leagility Index variables

Code	Questions	Extremes	Valid
DFL1	Our overall supply chain is designed to	A: minimise the cost B: provide quickest response to customers' requirements	Y
DFL2	Our main manufacturing focus is on	A: maintaining high average utilisation rate B: deploying excess buffer capacity	Y
DFL3	Our inventory strategy is developed to	A: generate high turns and minimise inventory throughout the chain B: deploy significant buffer stocks of parts or finished goods	Y
DFL4	Our approach to choosing suppliers is to	A: select for cost and quality B: select for speed, flexibility, and quality	N
DFL5	Which cost source dominates your company's supply chain?	A: physical costs B: marketability costs	N
DFL6	Our supply chain helps the company to win the competition through	A: minimising the cost B: improving the service level and lead time	N

The questions with a satisfactory level of factor loadings seem to address the leagility status of supply chain from a strategic point of view. In other words, DFL4 and DFL5 which have been discarded due to low factor loading, look at the operational side of supply chain leagility. Therefore, it could be concluded that most respondents pay special attention to the strategic implications of supply chain leagility. The low factor loading of DFL6 could be a result of respondents' viewpoints with reference to a particular aspect of supply chain which helps the company to compete better. Since two reasons have been listed as the extremes of the scale, respondents might be thinking of another reason that is not within the scope of this study.

6.3.5 Competition Intensity

As presented in Table 6-7, six questions have been employed to measure the completion intensity construct. Convergent validity would be supported if the factor loading between the construct and each related variable is 0.7 and above. Analysis of competition intensity construct indicates that all questions are valid for measuring the construct.

Table 6-7: Review of Competition Intensity variables

Code	Questions	Valid
CI1	Competition in our market is cut-throat	Y
CI2	There are many "promotion wars" in our market	Y
CI3	Anything that one competitor can offer in our market, others can match readily	Y
CI4	Firms will be spending more of each sales dollar on marketing due to increased competition	Y
CI5	Firms in our industry will be aggressively fighting to hold onto their share of the market	Y
CI6	The number of competitors is high	Y

As presented above, all questions measure the level of competition intensity directly. Therefore none of the variables has been removed from the analysis due to satisfactory level of related factor loading being achieved. The factor loading of variables is between 0.75 (CI6) and 0.80 (CI3). Therefore, there is no significant difference between the impacts of variables on the construct.

6.3.6 Customers' expectation

As presented in Table 6-8, four questions have been employed to measure the customers' expectation construct. Convergent validity would be supported if the factor loading between the construct and each related variable is 0.7 and above. Analysis of customers' expectation construct indicates that all questions are valid for measuring the construct.

Table 6-8: Review of Customers' expectation variables

Code	Questions	Valid
CE1	What is the level of expectations of customers from your product? ❍ Minimum functions (customer expects only the minimum functions from the product) (1) ❍ Minimum functions to acceptable expectations (2) ❍ Acceptable expectations (customer expects the product to serve in an adequate manner) (3) ❍ Experience-based norms (most times, customers' experience of the product is good but sometimes it is only adequate) (4) ❍ Normative expectations (customers spend considerable money on the product and expect excellent quality) (5) ❍ Normative to ideal expectations (6) ❍ Ideal expectations (customer expects the product to be the best in all facets) (7)	Y
CE2	Level of customers' expectations has had an increasing trend over past five years	Y
CE3	Apart from accuracy and availability, customers expect your advice	Y
CE4	Customers are demanding more varieties, customisation, and features for the products	Y

As presented above, all questions measure the level of customers' expectation directly. Therefore, no variable has been removed from the analysis due to satisfactory level of related factor loading being achieved. The factor loading of variables is between 0.80 (CE2) and 0.82 (CE4). Therefore, there is no significant difference between the impacts of variables on the construct.

6.3.7 Market Segment

As presented in Table 6-9, five questions have been employed to measure the market segment construct. Since convergent validity would be supported if the factor loading between the construct and each related variable is 0.7 and above, some questions (MS3 and MS5) have been discarded during the analysis.

Table 6-9: Review of Market Segment variables

Code	Questions	Valid
MS1	Most of our customers are from the high-income category	N
MS2	Our customers' main criterion for selecting our product is quality rather than cost	N
MS3	Our competitors are intensively investing in cost reduction	N/Y*
MS4	In the market, our product is recognised as high quality and expensive	Y
MS5	The demand for our product increases when the average income of consumers increases	N/Y*

* N/Y means the factor loading is below 0.7 and above 0.6

The factor loadings of MS3 and MS5 are above 0.6 which has deemed acceptable in several studies. Consequently there is no significant departure from the convergent validity where these variables would be involved in an analysis. However, to be on the safe side and as the number of remaining questions is enough to represent the construct, these variables have been discarded from the analysis.

The possible issue with MS3 could be linked to respondents' insufficient knowledge of their competitors' investment in cost reduction strategies. In relation to MS5, it is worth noting that the interpretation of the question requires special attention as a complex theory exists behind the variable. Therefore, it could probably lead to some misunderstanding.

CHAPTER 7: CONCLUSION

7.1 **Overview**

Due to the hyper-competitive nature of today's business world, companies are struggling to improve their practices involved in the value stream. Supply chain as one major aspect of the value stream has gained much attention because it is assumed to help companies improve their competitive position. As a part of supply chain optimisation, an appropriate design should be adopted to ensure the desired value is achieved.

This study provides in-depth knowledge regarding the supply chain design in terms of leagility. During the past two decades, several researchers including Fisher (1997) have thought that supply chain executives should match a mutually exclusive supply chain design such as efficient versus responsive and lean versus agile with product characteristics, particularly demand/supply/internal uncertainty to achieve the highest possible value. However, when the proposed conceptual models were statistically explored (Selldin & Olhager 2007), it was concluded that the relationship is not significant.

As no clear explanation has been provided to date, this study employs a new approach to scrutinise the leanness and agility aspects of supply chains by introducing an index, deviation from leagility (DFL), whereby supply chain leagility could be investigated from a new perspective. DFL is calculated based on the absolute difference of a company's leagility status from an ideal balanced leagile position. In order to measure this leagility status, the concepts of purely lean and purely agile supply chain were modelled into one scale. In other words, the minimum value of this scale would represent a purely lean supply chain, while the maximum value would represent a purely agile supply chain, and the mid-point represents a balanced leagile supply chain. The new index, DFL, makes a significant contribution to our knowledge and understanding of supply chain design and particularly the leagility field.

The scope of the current study is limited to companies dealing with supply chains for products manufactured in Australia in different industries. The survey questionnaire was sent to 2042 potential respondents. In total, 299 completed questionnaires with a response rate of 14.6% were collected. As collected data showed a significant departure from normality and the sample size was deemed to be insufficient to fit the research model with a significant number of constructs, Partial least squares**[s?]** Modelling was selected to analyse the research model.

A summary of the questions which have been addressed in the current study is provided below:

Would Low Level of Uncertainty let the companies adopt more balanced supply chains (less DFL)?

Uncertainty has been frequently cited as the key design driver of supply chain. A comprehensive model of uncertainty including demand, supply, and internal uncertainties has been employed in this study. DFL as the index of leagility was introduced to measure the supply chain's leanness/agility status. Analysis indicated that Low Level of overall uncertainty would let the companies adopt a more balanced supply chain. In other words, when the level of uncertainty increases, based on the segment of the market a company is operating in, higher unbalanced supply chain design (either higher level of leanness or higher level of agility) is accepted.

Would Low Level of Demand/Supply/Internal Uncertainty let the companies adopt more balanced supply chains (less DFL)?

The same analysis has been carried out for each construct of uncertainty: demand, supply, and internal uncertainty. The rationale behind this analysis is explained because in the majority of studies, only one or two of uncertainty constructs were involved in the research model. Therefore, it would be useful to examine the relationship between each construct and DFL. The same result pertinent to the overall uncertainty has been found for each construct. In addition, supply uncertainty has been identified as the most influential construct concerning the constructs of uncertainty.

Would Low Level of Uncertainty let the companies operating in the down-market/up-market segment adopt more balanced supply chains (less DFL)?

Where the market is segmented based on the factors which directly influence the supply chain design, price and service level, it is expected that market segment should be considered when designing a supply chain. Therefore, the relationship between the overall uncertainty and DFL has been re-investigated using the data pertinent to each market segment (i.e. down-market and up-market) individually. Analysis indicated that in both market segments, the same relationship which has been identified in the main model (less uncertainty would result in less DFL) is still valid.

Is the impact of Uncertainty on DFL greater for the up-market segment compared to the down-market segment?

Multi-group analysis has been carried out to compare the relationship between the uncertainty and DFL with reference to market segments. It indicates there is no significant difference in terms of the impact of uncertainty on DFL between firms operating in the up-market and down-market segments.

Is the impact of DFL on Performance greater for the down-market segment compared to the up-market segment?

The same analysis (multi-group analysis) has been done to compare the relationship between the DFL and firm performance regarding market segments. The There is no significant difference in terms of the impact of the DFL on firm performance between firms operating in the up-market and down-market segments.

Does a more balanced supply chain lead to better firm performance?

The ultimate outcome of effective supply chain design has its origins in firm performance. Therefore, the relationship between the DFL and firm performance was examined. Results indicate that companies employing a more balanced leagile supply chain will perform much better in the future.

Is the relationship between Uncertainty and DFL moderated by the level of Competition?

Review of the literature revealed that level of competition would affect all aspects of an organisation’s strategy including that of supply chain. As the impact of competition intensity in indirect, the moderation effect of competition intensity on the relationship between the uncertainty and DFL has been investigated. Competition intensity has been identified as the moderator with a negative effect on the relationship between the uncertainty and DFL.

Is the relationship between Demand/Supply/Internal Uncertainty and DFL moderated by the level of Competition?

The previous moderation analysis looked at the relationship between each construct of uncertainty (demand, supply, and internal uncertainty) and DFL. Although the completion intensity has been identified as the moderator in the relationship between the overall uncertainty and DFL, the same moderation effect is not significant for uncertainty constructs individually.

Is the relationship between Uncertainty and DFL moderated by the level of Customers’ Expectations?

The review of literature revealed that the second potential moderator on the relationship between the uncertainty and DFL is the level of customers’ expectations. Analysis indicated that these expectations negatively moderate the relationship between the uncertainty and DFL.

Is the relationship between Demand/Supply/Internal Uncertainty and DFL moderated by the level of Customers’ Expectations?

The previous moderation analysis has been carried out for the relationship between each construct of uncertainty (demand, supply, and internal uncertainty) and DFL. Although the customers’ expectations had been identified as the moderator in the relationship between the overall uncertainty and DFL, the same moderation effect is not significant for uncertainty constructs individually.

Do organisations adopt a hybrid supply chain rather than a purely lean or a purely agile supply chain?

In contrast to the studies proposing mutually exclusive supply chain design that are either lean or agile, the analysis indicated that most organisations adopt a leagile supply chain that is a combination of both types.

Is there a higher agility magnitude (higher LI) for companies active in the up-market segment of an industry compared to the down-market segment?

The up-market segment has specific characteristics such as higher price tag and service level. Here, firms operating in the up-market segment of the market adopt a supply chain that is more agile than lean.

Is there higher level of uncertainty for companies active in the up-market segment of an industry compared to the down-market segment?

Analysis indicated that there is no significant difference between the level of uncertainty between the down-market and up-market segments of the market.

7.2 **Theoretical Contribution**

This study provides significant contributions to the supply chain body of knowledge. A summary of theoretical contributions is provided below.

7.2.1 Leagility

To the extent of this author's knowledge, no index has been introduced by other studies to evaluate the concept of supply chain leagility. Introducing an effective leagility index to measure leanness/agility status of supply chains is one of the major theoretical contributions of the current study. In former studies, leanness and agility were measured using separate scales. This arose from the idea that supply chain designs are mutually exclusive or even collectively exhaustive. Hence, supply chain leanness and agility were measured through two different scales. It is proposed here that such a mutually exclusive design does not exist in the real business world. However, categorisation of supply chain strategies into lean and agile could be useful for training purposes. In practice all supply chains are leagile have different magnitudes of leanness and agility. This approach could encourage the supply chain literature to achieve maximum congruence with the real business world. Investigation into the value of DFL for Australian firms supports the current proposition.

7.2.2 Moderators

There are plenty of studies that examined the relationship between the uncertainty and supply chain design. However, to extent of this author’s knowledge, none has addressed the environmental or contextual forces impacting on supply chain design.

The idea of investigating the moderation effect of environmental forces emanates from how supply chain theory has evolved. Two decades ago, mutually exclusive supply chain designs including lean versus agile were proposed. The proposition was based on the case study of only two companies. When the idea was statistically examined for a handful of companies, the proposition was not supported. No literature could provide a clear explanation of why the findings actually contradict each other.

The extensive literature review particularly in strategic management field indicated that growing expectations of customers and competition intensity have impacted on all aspects of businesses including the supply chain. It is undeniable that the levels of competition and customers’ expectations have increased in recent years. When mutually exclusive designs were initially proposed two decades ago, a firm which produced functional products could focus only on the lean side of supply chain design. Similarly, an agile supply chain was implemented by businesses producing innovative goods. However, to satisfy a higher level of customers’ expectation and in an industry that has become more competitive, both aspects of leanness and agility should be considered but with different magnitudes. Therefore, the level of customers’ expectation and competition intensity could be considered as moderators. This study has theoretically contributed to the body of supply chain design by introducing customers’ expectation and competition intensity since they negatively moderate the relationship between uncertainty and DFL.

Another significant theoretical contribution of the current study is related to the moderation effects for individual constructs of the uncertainty (demand, supply, and internal uncertainty). As stated above, both customers' expectation and competition intensity have been identified as moderators for the relationship between the overall uncertainty and DFL. However, when the same moderation effect was tested for the individual constructs of uncertainty, neither customers' expectation nor completion intensity was statistically supported to be a moderator. Findings of this analysis theoretically contribute to the supply chain body of knowledge, and researchers in this area are advised to employ a comprehensive model of uncertainty; otherwise, the findings could be distorted.

7.2.3 Market Segment

No definite literature is available to investigate the status of supply chain design for different market segments. Market segmentation can be done by employing different segmenting factors. In the current study, market segmentation was carries out based on price and service levels which differentiate up-market from down-market contexts. The theoretical contributions to the supply chain management field are as follows:

- There is no significant difference for the level of uncertainty between the up-market and down-market segments. It means that difference in price tag of the product, quality status, and service level does not necessarily mean the level of uncertainty should be different.
- As quality and service level are the market winners in the up-market segment, companies operating here adopt a higher level of agility to provide goods/services that match most closely with customers' requirements.
- Multi-group analysis of the impact of uncertainty on DFL over two market segments indicated that there is no significant difference between the effect of uncertainty on DFL over market segments. The same result has been identified for the relationship between DFL and firm performance. The findings provide a guideline for researchers to focus on the supply chain designs based on uncertainty level. This is irrespective of market segment where the market is segmented according to the factors employed in this study.

7.2.4 Uncertainty Constructs

As explained earlier, two decades ago it was proposed the main influencing factor in supply chain design was demand uncertainty. Following this, several studies emphasised the fact that demand uncertainty is not sufficient in itself to effectively guide supply chain design. Researchers introduced supply and then internal uncertainty as two other sources of uncertainty which should be employed in the uncertainty model.

No definite study has been identified to explain which uncertainty construct has contributed more to overall uncertainty. Analysis of the comprehensive overall uncertainty model including demand, supply, and internal uncertainties indicated that supply uncertainty contributes more to the overall uncertainty.

7.2.5 Demand Variables

Five questions have been employed to measure the demand uncertainty construct. As a result of convergent validity analysis, two questions have been discarded during the analysis. Investigating the questions which have been removed due to low factor loading provides additional and more focused information regarding the importance of variables.

Some aspects of demand uncertainty are out of an organisation's control and they emanate from changes in customers' needs. All three variables which have been identified as valid are questions which were obviously formulated to measure demand uncertainty as an absolute external variable.

The common characteristic of discarded questions is that they both address the demand uncertainty by at the implications of demand fluctuation within the organisation. For example one of these questions addresses the possible implications of demand uncertainty on internal processes, which is high level of variations in production scheduling. The second discarded question looks at the implications of demand fluctuation on inventory level and this is an inter-organisation process.

This analysis provides a significant theoretical contribution to supply chain design. Special attention should be paid to selecting the questions which address the demand uncertainty directly rather than measuring the implications of demand uncertainty within an organisation.

7.3 Empirical Contribution

This study looks in-depth at the leagility aspect of supply chain design. Findings provide a guideline for supply chain executives on how to design an effective supply chain that leads to superior company performance. A summary of the empirical contributions is provided below.

7.3.1 Leagility and Firm Performance

Investigation into the value of DFL for Australian firms revealed that the majority of companies adopt leagile supply chain. Furthermore, firm performance is higher when a more balanced leagile supply chain (less DFL) is employed. Therefore, it is recommended that supply chain executives should design a leagile supply chain that is a good balance of leanness and agility requirements.

7.3.2 Uncertainty

The investigation into the impact of uncertainty on DFL revealed that at the higher uncertainty level, the value of DFL is higher. In other words, at this particular level the balanced leagile supply chain is expected and firms focus more on leanness or agility depending on whether they are operating in the down-market or up-market segment. Conversely, at the low uncertainty level, firms implement a more balanced supply chain in which both aspects of leanness and agility are embedded depending on the availability of resources. The same result has been attained when constructs of uncertainty (demand, supply, and internal uncertainty) have been examined individually. As explained above, in less DFL, firm performance would be higher. Therefore, it is recommended to supply chain executives to minimise the DFL, which means the need to design a more balanced supply chain so that business performance is at its most efficient. In addition, it has been revealed that the impact of supply uncertainty on DFL is more significant than demand and internal uncertainties. Therefore, executives are recommended to spend more attention on supply uncertainty compared to other uncertainty constructs.

7.3.3 Moderators

Both competition intensity and customers' expectations have been identified as moderators on the relationship between uncertainty and DFL. Since the moderation effect is negative, it could be concluded that the impact of uncertainty on DFL will decline at higher levels of customers' expectation and marketplace competition. In other words, when uncertainty decreases, companies try to function better by accepting that they need a more balanced supply chain. However, the ability to do so would be limited by the level of external forces including competition intensity and customers' expectation. When these forces are very strong, moving toward a balanced supply chain at the lower uncertainty level would be a slow process. Supply chain executives are recommended to consider the level of external forces, particularly customers' expectations and competition intensity when they are designing an effective supply chain. Although moving toward a balanced supply chain, less DFL, would lead to better business performance, some levels of deviation from the ideal position are inevitable when the firm has to deal with external forces.

7.3.4 Market Segment

Further analysis into the DFL position of different market segments revealed the magnitude of agility of firms operating in the up-market segment is significantly higher compared to the down-market segment. Comparatively, the magnitude of leanness for the firms operating in the down-market scenario is significantly higher compared to the up-market segment. As explained earlier, supply chain executives are advised to design the best balanced supply chain if their firm is to operate successfully. However, given there is always a level of unbalanced leagility, the magnitude of agility should be higher where a firm is operating in the up-market segment; and higher leanness should be employed where an organisation is operating in the down-market context.

7.4 **Limitations and Suitability**

The current research has certain limitations that should be taken into account. Some of these limitations could be considered as useful guidelines for future studies on this subject. There are many external forces which could directly or indirectly (as a moderator or as a mediator) influence the design of supply chain. In the present study, the main forces − competition intensity and the level of customers' expectations − are investigated. It is the limitation of this study that only two external forces are employed.

In terms of supply uncertainty, there are other factors including the level of outsourcing that are not directly captured in this study. Regarding the current practice of outsourcing production of semi-finished goods to suppliers that are more efficient and cheaper, it is important to investigate the impact of outsourcing on design of supply chain.

The other limitation of this study is related to constructs of uncertainty which have been utilised to estimate the uncertainty concept. It would be advantageous if other aspects of supply chain uncertainty are involved in a future research model.

In the current research, as a cross-sectional study, all variables have been measured employing only a short time frame. A longitudinal study could provide useful information regarding the variation in leagility balance over a much longer period.

It is undeniable that companies are in different business life cycles. Organisations adopt different strategies including supply chain strategies based on the business life cycle stage. As a limitation of this study, the stage of business life cycle has not been included in the research model.

As explained in the literature review chapter, internal uncertainty includes several elements including technological, manufacturing/process, and resource-related uncertainties. During the analysis, half of the engaged variables have been identified as insignificant, and thus removed from the model. Therefore, it could be considered as one of the limitations of this study to engage only six variables to measure the internal uncertainty construct. As the concept of internal uncertainty is broad, engaging more variables could provide a more robust result.

7.5 **Recommendations for Future Research**

As stated earlier, some limitations of this study can be considered as a fruitful avenue for future studies. An exploratory study that identifies all external factors could possibly influence the design of supply chain in the future. Further studies could classify these factors and explain the magnitude of influence. Furthermore the investigation of direct or indirect impacts of outsourcing levels on DFL could explain how and why companies need to fine-tune their supply chain designs. The results could assist supply chain executives to find the best leanness-agility position when an outsourcing strategy is employed.

A longitudinal study on the variation of DFL over a certain period of time and investigation into the causes of variation would provide a useful guideline for executives. They could in fact fine-tune the supply chain design taking into account environmental changes which would impact on companies Since it is very important to adopt strategies which fit the circumstances of a firm's business life cycle and the industry it operates in, a future study should investigate the leagility status of supply chain with regard to the business life cycle stages.

7.6 **Conclusion**

The importance of supply chain in conducting the affairs of a business is undeniable. An effective supply chain design is one of the key determinants for achieving superior supply chain and business performance. Several aspects of supply chain design have been investigated over the past two decades including the study of leanness and agility status of supply chains.

Mutually exclusive supply chain design including lean versus agile and efficient versus responsive have been conceptually proposed. The statistical investigation into these mutually exclusive designs revealed that the model is not supported. No studies have been identified as having addressed this issue through a devised comprehensive model.

Finally, this study has made a significant contribution to knowledge and our understanding of supply chain design, specifically the leagility field through the introduction of a new index, DFL. In addition, a significant practical contribution has been made by providing a guideline to effectively design a supply chain. This guideline takes into account the uncertainty level, market segment, competition intensity, and level of customers' expectations so that firms perform at their best in a very competitive and increasingly globalised economy.

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APPENDICES

Appendix 1: Organisational theories in supply chain management

Theoretical Perspective	General Conceptualization	Key Articles
Transaction cost Economics	The main thrust of this theory is the cost and efforts need for two entities, buyer and seller, to fulfil an activity which could be an economic exchange or a transaction.	Coase (1937) Williamson (1981) Williamson (1985) Hobbs (1996) Holcomb and Hitt (2007) Ireland and Webb (2007) McCarter and Northcraft (2007) Morgan, Kaleka and Gooner (2007)
Agency theory	Agency theory focuses on the relationship between a “principal” and an “agent” in a business, who is involved in cooperative behaviour, but their goals and attitudes toward risk are not identical.	Morgan, Kaleka and Gooner (2007)
Resource dependence Theory (RDT)	The main concept of resource dependence theory is to achieve long term benefits than focusing of short term gains at the expense of others. In supply chain context, it would be attainable through collaboration of member entities to maximise the overall performance. One of the building blocks of RDT is that organisations would not be able completely self-sufficient in relation to strategically critical and scares resources which are required to survive.	Crook and Combs (2007) Ireland and Webb (2007)
Institutional theory	Institutional theory scrutinizes how external forces affect organisational performance. As	Hirsch (1975) DiMaggio and Powell (1983)

Theoretical Perspective	General Conceptualization	Key Articles
	stated by DiMaggio and Powell (1983), within institutional theory, three forms of isomorphic drivers present: coercive, normative, and mimetic.	Rogers et al. (2007)
Game theory	Game theory is one of the most prevailing tools for situational analysis in which the decisions of a number of agents influence each agent's payoff. Accordingly, game theory addresses the interactive optimisation issues. Although Game Theory is broadly known by its application to economic and political science problems, recently it has been applied extensively to various scientific disciplines, including this of the supply chain risk management (Papapanagiotou & Vlachos 2010).	Cachon and Netessine (2004) McCarter and Northcraft (2007)
Network theory	Network theory addresses the relations between linked entities (definition, explanation, and prediction). Since supply chains are fundamentally a form of network, this theory is a useful building block to investigate the links among the chains.	Thorelli (1986) McCarter and Northcraft (2007) Morgan, Kaleka and Gooner (2007)
Social network theory (SNT)	Social network theory suggests that the outcomes of an entity are directly related to the social relationships between companies or individuals in a company (Jones et al., 1997). Two main elements of social network theory are centrality and density (Rowley, 1997).	Jones, Hesterly and Borgatti (1997) Rowley (1997)

Theoretical Perspective	General Conceptualization	Key Articles
Social capital theory	Social capital theory suggests that the outcomes and performance of an organisation, similar to supply chain, is a function of relationships between the people (Nahapiet & Ghoshal 1998)..	Nahapiet and Ghoshal (1998) Krause, Handfield and Tyler (2007) Ireland and Webb (2007)
Strategic choice	Opposite to institutional theory which focuses on effect of external pressures to the outcomes of the company, Strategic choice theory suggests that the success of failure of an organisation is highly dependent on the managers' decisions (Child 1972).	Child (1972) Miles et al. (1978)
Resource-based view/knowledge based view (RBV)	The resource-based view theory proposed that to achieve a sustainable competitive advantage, an organisation is required to control and marshal all resources which are scarce, valuable, partially imitable, and non-substitutable (Barney 1991).	Miles et al. (1978) Barney (1991) Holcomb and Hitt (2007)
Stakeholder theory	Stakeholder theory proposes that organisations produce externalities that influence multiple parties (stakeholders), which could be within an organisation, outside the organisation, or both. Externalities mostly are the reason that stakeholders enhance pressures on organisations to deduct undesirable impacts and surge positive ones.	Donaldson and Preston (1995) Mitchell, Agle and Wood (1997) Friedman and Miles (2002)
Information theory (information asymmetry and signalling theory)	This theory suggests that the environmental information which is existent between industry and customers is not equal. In order to manage this information asymmetry environment, different theories and	Stigler (1961) Spence (1973) Simpson, Power and Samson (2007)

Theoretical Perspective	General Conceptualization	Key Articles
	approaches including ‘signalling’ required to be engaged (Simpson, Power & Samson 2007).	
Complexity theory	Complexity theory suggests when the complexity rises, organisations would face more difficulties to design suitable strategies and predict their organizational actions. It is crucial for organisations to increase sensitivity and responsiveness to their environments (Crozier & Thoenig 1976).	Crozier and Thoenig (1976) Anderson (1999)
Feedback theory	Feedback theory describes that information affects decision-making under systemic circumstances, while concurrently creating the actions planned to modify those system settings.	Forrester (1958) Forrester (1968)

Source: Ketchen and Hult (2007a); Sarkis, Zhu and Lai (2011); and Author

Appendix 2: Survey Questionnaire

INVITATION TO PARTICIPATE IN A RESEARCH PROJECT

PARTICIPANT INFORMATION

Project Title: A Study of Leagility (Leanness and Agility) and Supply Chain Design

Investigators:

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Dear Participant,

You are invited to participate in a research project being conducted by RMIT University. Please read this sheet carefully and be confident that you understand its contents before deciding whether to participate. If you have any questions about the project, please ask one of the investigators.

This research project is being undertaken as part of the requirements of a PhD candidature (Logistics) at RMIT University.

PhD Candidate: Masih Fadaki
Supervisor: Prof. Shams Rahman (http://www.rmit.edu.au/browse;ID=ss26whr31hxvz)
Co-supervisor: Prof. Caroline Chan (http://www.rmit.edu.au/browse;ID=co1wloqno24o)

This project has been approved by the RMIT Human Research Ethics Committee.

You have been selected randomly from executives working in the area of Supply Chain Management, Logistics, or Operation Managements within the manufacturing industry in Australia. It is expected to receive more than 200 completed questionnaire from the executives who have invited to participate.

Research Outline

The aim of this study is to develop a new approach to leagility and supply chain design through introducing an index, Deviation from Leagility (DFL). Several different factors are required to design an effective supply chain and make it optimised to achieve maximum performance. Cost, quality, lead time and service level are always the main market qualifiers. However, the market winner is determined by various internal and external factors. Organisations adopt different levels of leanness and agility to provide a product which could meet the market winner requirements. Moreover, these optimisations require to be implemented throughout a firm's value chain including the supply chain. In this regard, the concept of leagility has major strategic significance to create an effective supply chain to help companies to optimise cost and lead time. In the current research, a new approach to supply chain leagility is investigated aiming at addressing the following core research question:

Given that most supply chains are leagile with different magnitudes of leanness and agility, what are the key design drivers of a leagile supply chain?

As an exploratory study, the current research aims to address the following issues:

i) Develop Deviation From Leagility (DFL) index, identify location of the index, and investigate the impact of DFL on the firm performance:
Study the distribution of DFL could address the dilemma whether supply chain designs are mutually exclusive or the preferred supply chain strategy is a hybrid model. It could be achieved through cluster analysis of DFL over a spectrum to examine whether the DFL is highly distributed around the midpoint (a balanced supply chain).

ii) To examine the impact of supply chain uncertainty (demand, supply, and internal uncertainties) on DFL.

Uncertainty as the most crucial influencing factor to effective design of supply chain is investigated in a comprehensive model.

iii) Investigate the moderation effect of external forces in the relationship between supply chain uncertainty and DFL. There is a knowledge gap to identify the main causes of these changes. According, this study aims at investigating the impact of external forces including competition level and customers' expectations on leagility aspect of supply chain.

Study of DFL will develop an index to evaluate the leanness-agility level of a supply chain and it provides critical information for executives and researchers to understand whether adopting a mutually exclusive designs or a hybrid strategy for supply chain could provide better performance.

One of the main theoretical contributions of this study is to investigate the influence of uncertainties on leagility degree of companies. More agility means more cost, and more efficiency and cost reduction means less agility which leads to less customer satisfaction. As a result, leagility degree of a company should be fine-tuned to achieve the optimum leanness-agility level to achieve the best competitive position. As uncertainty is a key driving force to design the supply chain, the current research provides critical information in relation to the impact of overall uncertainty on leagility and also detailed information of uncertainty constructs' (demand, supply, and uncertainty) influence on DFL. Furthermore, a significant knowledge gap which is the influence of external factors (competition level and level of customers' expectations) on leagility will be fulfilled.

Participation Procedure

Your participation in this study is voluntary. No explanation or justification is needed if you choose to not participate. You are free to withdraw your consent to further involvement in this project at any time.

The current questionnaire includes 7 questions in relation to demographic information and 40 main questions. The questionnaire will involve approximately 20 minutes of your time. There are two types of questions in current questionnaire.

a) The scale consists of 7 options from 'Strongly Disagree' to 'Strongly Agree'. You are required to choose one option. For instance:

Questions	Strongly Disagree	Disagree	Moderately Disagree	Neutral	Moderately Agree	Agree	Strongly Agree
Competition in our market is cut-throat	❑	❑	❑	❑	❑	❑	❑

If you choose 'Strongly Agree', it means that there is a fierce competition in the market your company is operation.

b) The scale consists of 7 options. These questions reflect the phenomena/strategies/approaches which could co-exist. Each extreme of the scale reflect the one of the phenomena/strategies/approaches. The midpoint is when both phenomena/strategies/approaches exist at the same time and at the same level. For instance:

Our overall supply chain is designed to						
1	2	3	4	5	6	7
minimise cost			both equally			provide quickest response to customer's requirements

All companies are striving to both minimise the cost and improve responsiveness. Companies are investing on both, however, since resources are scarce, the magnitude of investment could be similar of different. Option 1 means the only design attribute of the current supply chain is to minimise cost and Option 7 means the only design attribute of the current supply chain is to improve responsiveness. Option 4 is a reflection of supply chains where resources are dedicated equally to achieve both goals.

Risks and Benefits

There are no anticipated risks involved in this project.

There is no direct benefit to the participant as a result of participation. Findings generated from this study will increase our understanding of supply chain design particularly adjusting the leanness-agility level to achieve the highest performance.

Confidentiality and Anonymity

We intend to protect your anonymity and the confidentiality of your responses to the fullest possible extent, within the limits of the law. All information provided by you will be treated with full confidentiality. Research data will be kept securely at RMIT University for 5 years after publication, before being destroyed.

You are not identifiable at any stage of the research. Any information that you provide can be disclosed only if (1) it is to protect you or others from harm, (2) a court order is produced, or (3) you provide the researchers with written permission.

The results of this study are intended for completion of a PhD by research thesis and may be presented at conferences/seminars and published in peer reviewed journals, as magazine articles, as an online article or part of a book section or report. Published results will not contain information that can be used to identify participants unless specific consent for this has been obtained. A copy of published results can be obtained from the author upon request.

Because of the nature of data collection, we are not obtaining written informed consent from you. Instead, we assume that you have given consent by your completion and return of the questionnaire.

Participant Rights

- The right to withdraw from participation at any time
- The right to request that any recording cease
- The right to have any unprocessed data withdrawn and destroyed, provided it can be reliably identified, and provided that so doing does not increase the risk for the participant.
- The right to have any questions answered at any time.

If you have any questions or require any further information about the research project, please do not hesitate to contact one of the investigators.

Yours sincerely

Shams Rahman	**Caroline Chan**	**Masih Fadaki**
Professor of Supply Chain Management Deputy Head of School, Research and Innovation Program Director, Master of Strategic Procurement School of Business IT and Logistics	Professor of Supply Chain Management Head, School of Business IT and Logistics School of Business IT and Logistics	PhD Candidate School of Business IT and Logistics College of Business

If you have any complaints about your participation in this project please see the complaints procedure on the Complaints with respect to participation in research at RMIT page

Panel Selection

PS1 Do you work in manufacturing industry?
- ❍ Yes (1)
- ❍ No (2)

PS2 Do you have more than three years working experience?
- ❍ Yes (1)
- ❍ No (2)

PS3 Do you deal with the management (demand/supply/distribution) of manufacturing products?
- ❍ Yes (1)
- ❍ No (2)

Demographic Information

D1 Position in the Organisation
- ❍ Managing Director (1)
- ❍ Supply Chain / Logistics Manager (2)
- ❍ Operations Manager (3)
- ❍ Procurement/Purchasing Manager (4)
- ❍ Warehouse/Store/Inventory Manager (5)
- ❍ Retail Managers (6)
- ❍ Production/Manufacturing Manager (7)
- ❍ Distribution Manager (8)
- ❍ Other (9) ____________________

D2 Education
- ❍ Diploma, certificate, and below (1)
- ❍ Bachelor (2)
- ❍ Master (3)
- ❍ PhD & Above (4)

D3 Work Experience
- ❍ < 5 years (1)
- ❍ 5-9 Years (2)
- ❍ 10-20 Years (3)
- ❍ >20 Years (4)

D4 Work Experience in Supply Chain/Logistics/Procurement/Purchasing/Operation Management

- < 5 years (1)
- 5-9 Years (2)
- 10-20 Years (3)
- >20 Years (4)

D5 Industry

- Food, beverage and tobacco products (1)
- Wood and paper products (2)
- Metal products (3)
- Textile, clothing and other manufacturing (4)
- Printing and recorded media (5)
- Non-metallic mineral products (6)
- Petroleum, coal, chemical and rubber products (7)
- Machinery, and equipment (8)
- Retail (9)
- Other. Please specify: (10) ____________________

D6 Years Since Establishment of Company

- < 5 years (1)
- 5-10 Years (2)
- >10 Years (3)

D7 Number of Employees

- 1-19 (1)
- 20-49 (2)
- 50-199 (3)
- 200-249 (4)
- 250-499 (5)
- 500-1000 (6)
- >1000 (7)

D8 Annual Revenue (Latest)

- < $2 M (1)
- $2 M - $10 M (2)
- >$10 M - $50 M (3)
- >$50 M - $100 M (4)
- >$100 M - $200 M (5)
- > $200 M (6)

Demand Uncertainty

DU1 Our master production schedule has a high degree of variation in demand over time

- Strongly Disagree (1)
- Disagree (2)
- Somewhat Disagree (3)
- Neither Agree nor Disagree (4)
- Somewhat Agree (5)
- Agree (6)
- Strongly Agree (7)

DU2 Our demand fluctuates drastically from week to week

- Strongly Disagree (1)
- Disagree (2)
- Somewhat Disagree (3)
- Neither Agree nor Disagree (4)
- Somewhat Agree (5)
- Agree (6)
- Strongly Agree (7)

DU3 Customer requirements for products change dramatically

- Strongly Disagree (1)
- Disagree (2)
- Somewhat Disagree (3)
- Neither Agree nor Disagree (4)
- Somewhat Agree (5)
- Agree (6)
- Strongly Agree (7)

DU4 The volume and/or composition of demand is difficult to predict

- Strongly Disagree (1)
- Disagree (2)
- Somewhat Disagree (3)
- Neither Agree nor Disagree (4)
- Somewhat Agree (5)
- Agree (6)
- Strongly Agree (7)

DU5 We keep weeks of inventory of the critical material to meet the changing demand

- Strongly Disagree (1)
- Disagree (2)
- Somewhat Disagree (3)
- Neither Agree nor Disagree (4)
- Somewhat Agree (5)
- Agree (6)
- Strongly Agree (7)

Supply Uncertainty

SU1 The suppliers consistently meet our requirements

- ❍ Strongly Disagree (1)
- ❍ Disagree (2)
- ❍ Somewhat Disagree (3)
- ❍ Neither Agree nor Disagree (4)
- ❍ Somewhat Agree (5)
- ❍ Agree (6)
- ❍ Strongly Agree (7)

SU2 The suppliers produce materials with consistent quality

- ❍ Strongly Disagree (1)
- ❍ Disagree (2)
- ❍ Somewhat Disagree (3)
- ❍ Neither Agree nor Disagree (4)
- ❍ Somewhat Agree (5)
- ❍ Agree (6)
- ❍ Strongly Agree (7)

SU3 It has been very easy to procure raw materials for our major product

- ❍ Strongly Disagree (1)
- ❍ Disagree (2)
- ❍ Somewhat Disagree (3)
- ❍ Neither Agree nor Disagree (4)
- ❍ Somewhat Agree (5)
- ❍ Agree (6)
- ❍ Strongly Agree (7)

SU4 The price of raw materials and component parts has NOT changed frequently

- ❍ Strongly Disagree (1)
- ❍ Disagree (2)
- ❍ Somewhat Disagree (3)
- ❍ Neither Agree nor Disagree (4)
- ❍ Somewhat Agree (5)
- ❍ Agree (6)
- ❍ Strongly Agree (7)

SU5 We have several alternative sources in acquiring raw materials

- Strongly Disagree (1)
- Disagree (2)
- Somewhat Disagree (3)
- Neither Agree nor Disagree (4)
- Somewhat Agree (5)
- Agree (6)
- Strongly Agree (7)

Internal Uncertainty

IU1 If we do not keep up with changes in technology, it will be difficult to remain competitive.

- Strongly Disagree (1)
- Disagree (2)
- Somewhat Disagree (3)
- Neither Agree nor Disagree (4)
- Somewhat Agree (5)
- Agree (6)
- Strongly Agree (7)

IU2 Number of components in manufacturing is substantial

- Strongly Disagree (1)
- Disagree (2)
- Somewhat Disagree (3)
- Neither Agree nor Disagree (4)
- Somewhat Agree (5)
- Agree (6)
- Strongly Agree (7)

IU3 The production technology changes frequently

- Strongly Disagree (1)
- Disagree (2)
- Somewhat Disagree (3)
- Neither Agree nor Disagree (4)
- Somewhat Agree (5)
- Agree (6)
- Strongly Agree (7)

IU4 Number of erroneous components in manufacturing is considerable

- Strongly Disagree (1)
- Disagree (2)
- Somewhat Disagree (3)
- Neither Agree nor Disagree (4)
- Somewhat Agree (5)
- Agree (6)
- Strongly Agree (7)

IU5 The capacity constraints/restrictions in production is considerable

- Strongly Disagree (1)
- Disagree (2)
- Somewhat Disagree (3)
- Neither Agree nor Disagree (4)
- Somewhat Agree (5)
- Agree (6)
- Strongly Agree (7)

IU6 The manufacturing lead time for several components is long

- Strongly Disagree (1)
- Disagree (2)
- Somewhat Disagree (3)
- Neither Agree nor Disagree (4)
- Somewhat Agree (5)
- Agree (6)
- Strongly Agree (7)

Leanness and Agility Level

DFL1 Our overall supply chain is designed to
A: minimise the cost
B: provide quickest response to customer's requirements

- 100% A (1)
- 84% A --- 16% B (2)
- 67% A --- %33 B (3)
- 50% A --- 50% B (4)
- 33% A --- 67% B (5)
- 16% A --- 84% B (6)
- 100% B (7)

DFL2 Our main manufacturing focus is on
A: maintain high average utilization rate
B: deploy excess buffer capacity

- 100% A (1)
- 84% A --- 16% B (2)
- 67% A --- %33 B (3)
- 50% A --- 50% B (4)
- 33% A --- 67% B (5)
- 16% A --- 84% B (6)
- 100% B (7)

DFL3 Our inventory strategy is developed to
A: generate high turns and minimise inventory throughout the chain
B: deploy significant buffer stocks of parts or finished goods

- 100% A (1)
- 84% A --- 16% B (2)
- 67% A --- %33 B (3)
- 50% A --- 50% B (4)
- 33% A --- 67% B (5)
- 16% A --- 84% B (6)
- 100% B (7)

DFL4 Our approach to choosing suppliers is to
A: select for cost and quality
B: select for speed, flexibility, and quality

- ❍ 100% A (1)
- ❍ 84% A --- 16% B (2)
- ❍ 67% A --- %33 B (3)
- ❍ 50% A --- 50% B (4)
- ❍ 33% A --- 67% B (5)
- ❍ 16% A --- 84% B (6)
- ❍ 100% B (7)

DFL5 Which cost source dominates your company's supply chain?
A: physical costs
B: marketability costs

- ❍ 100% A (1)
- ❍ 84% A --- 16% B (2)
- ❍ 67% A --- %33 B (3)
- ❍ 50% A --- 50% B (4)
- ❍ 33% A --- 67% B (5)
- ❍ 16% A --- 84% B (6)
- ❍ 100% B (7)

DFL6 Our supply chain helps the company to win the competition through
A: minimising the cost
B: improving the service level and lead time

- ❍ 100% A (1)
- ❍ 84% A --- 16% B (2)
- ❍ 67% A --- %33 B (3)
- ❍ 50% A --- 50% B (4)
- ❍ 33% A --- 67% B (5)
- ❍ 16% A --- 84% B (6)
- ❍ 100% B (7)

Competition Intensity

CI1 Competition in our market is cut-throat
- ❍ Strongly Disagree (1)
- ❍ Disagree (2)
- ❍ Somewhat Disagree (3)
- ❍ Neither Agree nor Disagree (4)
- ❍ Somewhat Agree (5)
- ❍ Agree (6)
- ❍ Strongly Agree (7)

CI2 There are many "promotion wars" in our market
- ❍ Strongly Disagree (1)
- ❍ Disagree (2)
- ❍ Somewhat Disagree (3)
- ❍ Neither Agree nor Disagree (4)
- ❍ Somewhat Agree (5)
- ❍ Agree (6)
- ❍ Strongly Agree (7)

CI3 Anything that one competitor can offer in our market, others can match readily
- ❍ Strongly Disagree (1)
- ❍ Disagree (2)
- ❍ Somewhat Disagree (3)
- ❍ Neither Agree nor Disagree (4)
- ❍ Somewhat Agree (5)
- ❍ Agree (6)
- ❍ Strongly Agree (7)

CI4 Firms will be spending more of each sales dollar on marketing due to increased competition
- ❍ Strongly Disagree (1)
- ❍ Disagree (2)
- ❍ Somewhat Disagree (3)
- ❍ Neither Agree nor Disagree (4)
- ❍ Somewhat Agree (5)
- ❍ Agree (6)
- ❍ Strongly Agree (7)

CI5 Firms in our industry will be aggressively fighting to hold onto their share of the market

- ❍ Strongly Disagree (1)
- ❍ Disagree (2)
- ❍ Somewhat Disagree (3)
- ❍ Neither Agree nor Disagree (4)
- ❍ Somewhat Agree (5)
- ❍ Agree (6)
- ❍ Strongly Agree (7)

CI6 Number of competitors is high

- ❍ Strongly Disagree (1)
- ❍ Disagree (2)
- ❍ Somewhat Disagree (3)
- ❍ Neither Agree nor Disagree (4)
- ❍ Somewhat Agree (5)
- ❍ Agree (6)
- ❍ Strongly Agree (7)

Level of Customers' Expectations

CE1 What is the level of expectations of customers from your product?

- Minimum functions (customer expects only the minimum functions from the product) (1)
- Minimum functions to acceptable expectations (2)
- Acceptable expectations (customer expects the product to serve in an adequate manner) (3)
- Experience-based norms (in most times, customer experience of the product is good but sometimes it is only adequate) (4)
- Normative 'should' expectations (customers spends considerable money for the product and expects excellent quality) (5)
- Normative to ideal expectations (6)
- Ideal expectations (customer expects the product to be the best in all facets) (7)

CE2 Level of customers' expectations has had an increasing trend over past five years

- Strongly Disagree (1)
- Disagree (2)
- Somewhat Disagree (3)
- Neither Agree nor Disagree (4)
- Somewhat Agree (5)
- Agree (6)
- Strongly Agree (7)

CE3 Apart from accuracy and availability, customers expect your advice

- Strongly Disagree (1)
- Disagree (2)
- Somewhat Disagree (3)
- Neither Agree nor Disagree (4)
- Somewhat Agree (5)
- Agree (6)
- Strongly Agree (7)

CE4 Customers are demanding more varieties, customisation, and features for the products

- Strongly Disagree (1)
- Disagree (2)
- Somewhat Disagree (3)
- Neither Agree nor Disagree (4)
- Somewhat Agree (5)
- Agree (6)
- Strongly Agree (7)

Performance

P1 How well does the company perform relative to its competitors in terms of cost?

- Much Worse (1)
- Worse (2)
- Somewhat Worse (3)
- About the Same (4)
- Somewhat Better (5)
- Better (6)
- Much Better (7)

P2 How well does the company perform relative to its competitors in terms of flexibility?

- Much Worse (1)
- Worse (2)
- Somewhat Worse (3)
- About the Smae (4)
- Somewhat Better (5)
- Better (6)
- Much Better (7)

P3 How well does the company perform relative to its competitors in terms of delivery speed?

- Much Worse (1)
- Worse (2)
- Somewhat Worse (3)
- About the Same (4)
- Somewhat Better (5)
- Better (6)
- Much Better (7)

P4 How well does the company perform relative to its competitors in terms of profitability?

- Much Worse (1)
- Worse (2)
- Somewhat Worse (3)
- About the Same (4)
- Somewhat Better (5)
- Better (6)
- Much Better (7)

P5 How well does the company perform relative to its competitors in terms of growth in market share?

- ❍ Much Worse (1)
- ❍ Worse (2)
- ❍ Somewhat Worse (3)
- ❍ About the Same (4)
- ❍ Somewhat Better (5)
- ❍ Better (6)
- ❍ Much Better (7)

Market Segment

MS1 Majority of our customers are from high-income category

- Strongly Disagree (1)
- Disagree (2)
- Somewhat Disagree (3)
- Neither Agree nor Disagree (4)
- Somewhat Agree (5)
- Agree (6)
- Strongly Agree (7)

MS2 Our customers main criteria to select our product is quality rather than cost

- Strongly Disagree (1)
- Disagree (2)
- Somewhat Disagree (3)
- Neither Agree nor Disagree (4)
- Somewhat Agree (5)
- Agree (6)
- Strongly Agree (7)

MS3 Our competitors are intensively investing on cost reduction

- Strongly Disagree (1)
- Disagree (2)
- Somewhat Disagree (3)
- Neither Agree nor Disagree (4)
- Somewhat Agree (5)
- Agree (6)
- Strongly Agree (7)

MS4 In market, our product is recognised as high quality and expensive good

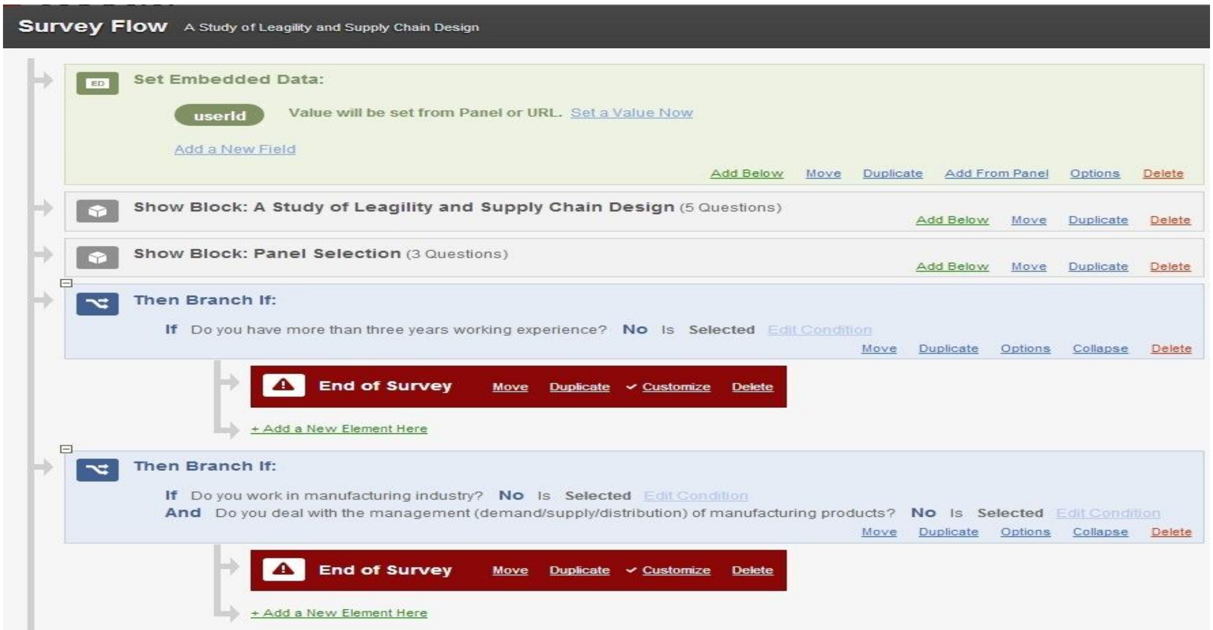
- Strongly Disagree (1)
- Disagree (2)
- Somewhat Disagree (3)
- Neither Agree nor Disagree (4)
- Somewhat Agree (5)
- Agree (6)
- Strongly Agree (7)

MS5 The demand of our product increases when the average income of consumers increases

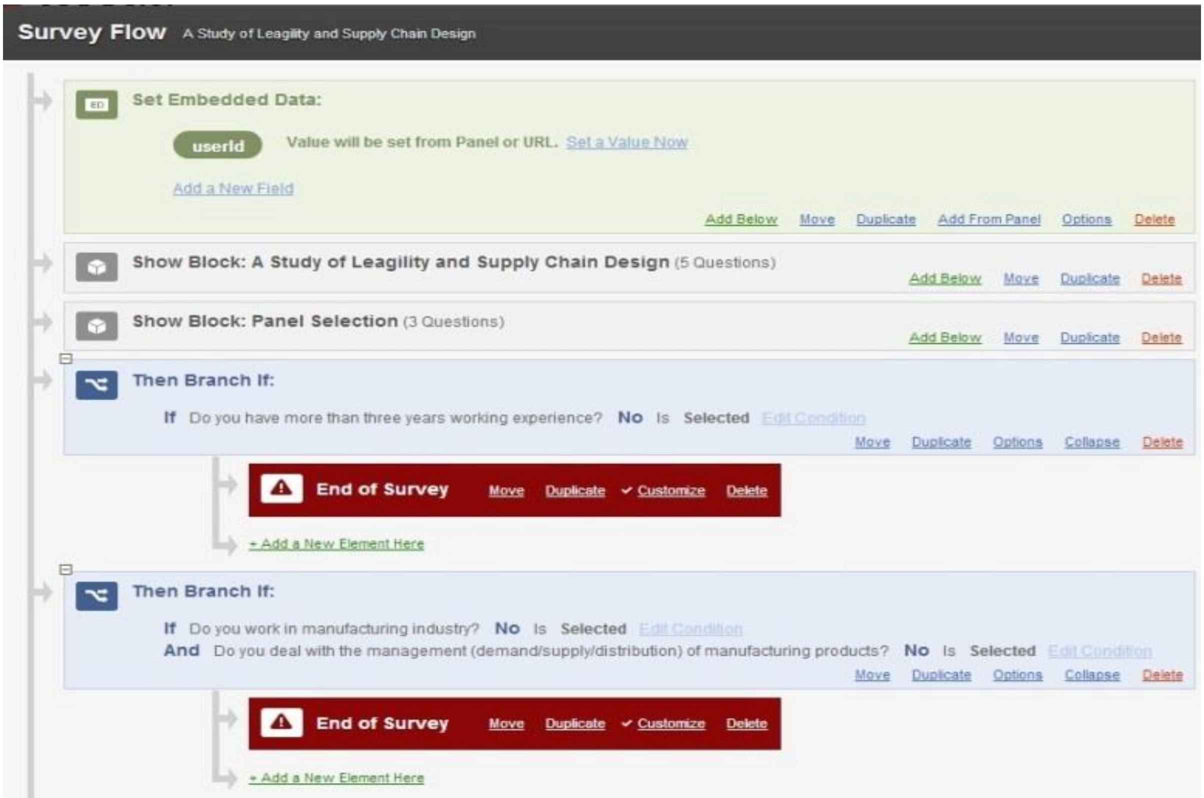
- Strongly Disagree (1)
- Disagree (2)
- Somewhat Disagree (3)
- Neither Agree nor Disagree (4)
- Somewhat Agree (5)
- Agree (6)
- Strongly Agree (7)

Appendix 3: Survey Flow

i) Survey Flow – Panel Selection Questions



ii) Survey Flow – Screening Questions



Appendix 4: Ethics Approval Notice

RMIT UNIVERSITY

Business College Human Ethics Advisory Network (BCHEAN)

Building 108, Level 11
239 Bourke Street
Melbourne VIC 3000

GPO Box 2476V
Melbourne VIC 3001
Australia

Tel. +61 3 9925 5555
Fax +61 3 9925 5624

Notice of Approval

Date:	13 December 2012
Project number:	1000474
Project title:	*A Study of Leagility and Supply Chain Design*
Risk classification:	Low Risk
Principal Investigator:	Professor Shams Rahman
Student Investigator:	Mr Masih Fadaki
Other Investigator:	Professor Caroline Chan
Project Approved:	**From: 11 December 2012 To: 7 December 2015**

Terms of approval:

1. *Responsibilities of the principal investigator*
   It is the responsibility of the principal investigator to ensure that all other investigators and staff on a project are aware of the terms of approval and to ensure that the project is conducted as approved by BCHEAN. Approval is only valid while the investigator holds a position at RMIT University.
2. *Amendments*
   Approval must be sought from BCHEAN to amend any aspect of a project including approved documents. To apply for an amendment submit a request for amendment form to the BCHEAN secretary. This form is available on the Human Research Ethics Committee (HREC) website. Amendments must not be implemented without first gaining approval from BCHEAN.
3. *Adverse events*
   You should notify BCHEAN immediately of any serious or unexpected adverse effects on participants or unforeseen events affecting the ethical acceptability of the project.
4. *Participant Information and Consent Form (PICF)*
   The PICF must be distributed to all research participants, where relevant, and the consent form is to be retained and stored by the investigator. The PICF must contain the RMIT University logo and a complaints clause including the above project number.
5. *Annual reports*
   Continued approval of this project is dependent on the submission of an annual report.
6. *Final report*
   A final report must be provided at the conclusion of the project. BCHEAN must be notified if the project is discontinued before the expected date of completion.
7. *Monitoring*
   Projects may be subject to an audit or any other form of monitoring by BCHEAN at any time.
8. *Retention and storage of data*
   The investigator is responsible for the storage and retention of original data pertaining to a project for a minimum period of five years.

Regards,
Professor Roslyn Russell
Chairperson
RMIT BCHEAN

Appendix 5: Data Collection Service Providers Active in Research Industry

Service Provider	Type of Service	Web
QOR	Completed Questionnaire	www.qor.com.au
ResearchNow	Completed Questionnaire	http://www.researchnow.com/en-US.aspx
Nine Rewards	Completed Questionnaire	http://www.ninerewards.com/?
Survey Sampling International	Completed Questionnaire	www.surveysampling.com
MyOpinions	Completed Questionnaire	http://www.myopinions.com/research/
Lightspeed /GMI	Completed Questionnaire	www.lightspeedresearch.com
Qualtrics	Completed Questionnaire	qualtrics.com
Cint	Completed Questionnaire	www.cint.com
Dun & Bradstreet Australia	Database of contacts	www.dnb.com.au

Appendix 6: Reliability, Consistency, and Stability of the Measurement Model

Demand Uncertainty

Table 9-1 presents the Cronbach's Alpha for the measurement instrument of demand uncertainty. The value of Cronbach's Alpha (0.721) is above the acceptable limit (0.7). It indicates satisfactory levels of stability and internal consistency of the construct's variables to measure demand uncertainty.

Table 9-1: Reliability Statistics - Demand Uncertainty

Cronbach's Alpha	Cronbach's Alpha Based on Standardised Items	N of Items
.721	.734	5

Table 9-2 presents correlation matrix for the variables of demand uncertainty. The value of correlation coefficients indicates that none of variables are highly correlated.

Table 9-2: Inter-Item Correlation Matrix - Demand Uncertainty

	DU1	DU2	DU3	DU4	DU5
DU1	1.000	.300	.311	.405	.332
DU2	.300	1.000	.557	.486	.165
DU3	.311	.557	1.000	.554	.152
DU4	.405	.486	.554	1.000	.292
DU5	.332	.165	.152	.292	1.000

Table 9-3 shows what Cronbach's Alpha would be if one of the demand uncertainty variables is removed and Alpha is re-calculated on the basis of the remaining variables.

Table 9-3: Cronbach's Alpha Item-Total Statistics - Demand Uncertainty

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
DU1	19.91	15.005	.471	.231	.677
DU2	19.54	15.599	.510	.361	.663
DU3	19.44	15.671	.538	.420	.655
DU4	19.56	14.213	.616	.416	.618
DU5	20.04	15.683	.317	.141	.749

The analysis indicates that Cronbach's Alpha would improve from 0.721 to 0.749, if DU5 variable would remove from the scale. As the improvement is insignificant and the current Alpha value (0.721) is above the acceptable limit, DU5 is not removed from the scale.

Supply Uncertainty

Table 9-4 presents the Cronbach’s Alpha for the measurement instrument of supply uncertainty. The value of Cronbach’s Alpha (0.760) is above the acceptable limit (0.7). It indicates satisfactory levels of stability and internal consistency of the construct’s variables to measure supply uncertainty.

Table 9-4: Reliability Statistics - Supply Uncertainty

Cronbach's Alpha	Cronbach's Alpha Based on Standardised Items	N of Items
.760	.761	5

Table 9-5 presents correlation matrix for the variables of supply uncertainty. The value of correlation coefficients indicates that none of variables are highly correlated.

Table 9-5: Inter-Item Correlation Matrix - Supply Uncertainty

	SU1	SU2	SU3	SU4	SU5
SU1	1.000	.594	.383	.418	.191
SU2	.594	1.000	.409	.335	.254
SU3	.383	.409	1.000	.511	.492
SU4	.418	.335	.511	1.000	.302
SU5	.191	.254	.492	.302	1.000

Table 9-6 shows what Cronbach's Alpha would be if one of the supply uncertainty variables is removed and Alpha is re-calculated on the basis of the remaining variables.

Table 9-6: Cronbach's Alpha Item-Total Statistics - Supply Uncertainty

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
SU1	16.89	10.246	.557	.412	.707
SU2	16.92	10.232	.557	.396	.707
SU3	15.85	10.880	.615	.429	.689
SU4	15.09	11.206	.529	.322	.717
SU5	15.65	12.444	.395	.250	.759

The analysis indicates that Cronbach's Alpha would not improve by removing one of the current variables from the scale.

Internal Uncertainty

Table 9-7 presents the Cronbach's Alpha for the measurement instrument of internal uncertainty. The value of Cronbach's Alpha (0.633) is close to the acceptable limit (0.7). Therefore, further investigation is required via measuring the composite reliability in PLS analysis.

Table 9-7: Reliability Statistics - Internal Uncertainty

Cronbach's Alpha	Cronbach's Alpha Based on Standardised Items	N of Items
.633	.636	6

Table 9-8 presents correlation matrix for the variables of internal uncertainty. The value of correlation coefficients indicates that none of variables are highly correlated.

Table 9-8: Inter-Item Correlation Matrix - Internal Uncertainty

	IU1	IU2	IU3	IU4	IU5	IU6
IU1	1.000	.428	-.002	.060	.067	.099
IU2	.428	1.000	.168	.225	.255	.122
IU3	-.002	.168	1.000	.468	.412	.239
IU4	.060	.225	.468	1.000	.391	.130
IU5	.067	.255	.412	.391	1.000	.323
IU6	.099	.122	.239	.130	.323	1.000

Table 9-9 shows what Cronbach's Alpha would be if one of the internal uncertainty variables is removed and Alpha is re-calculated on the basis of the remaining variables.

Table 9-9: Cronbach's Alpha Item-Total Statistics - Internal Uncertainty

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
IU1	25.22	17.663	.210	.194	.648
IU2	25.50	15.747	.397	.251	.576
IU3	24.98	16.520	.421	.297	.571
IU4	25.05	15.799	.410	.279	.572
IU5	24.99	15.161	.479	.290	.543
IU6	25.18	17.034	.286	.126	.619

The analysis indicates that Cronbach's Alpha would improve from 0.633 to 0.648, if IU1 variable would remove from the scale. As the improvement is insignificant and the current Alpha value (0.633) is above the acceptable limit, IU1 is not removed from the scale.

Leagility Index

Table 9-10 presents the Cronbach's Alpha for the measurement instrument of leagility index. The value of Cronbach's Alpha (0.965) is above the acceptable limit (0.7). It indicates satisfactory levels of stability and internal consistency of the construct's variables to measure leagility index.

Table 9-10: Reliability Statistics - Leagility Index

Cronbach's Alpha	Cronbach's Alpha Based on Standardised Items	N of Items
.965	.966	6

Table 9-11 presents correlation matrix for the variables of leagility index. The value of correlation coefficients indicates that LI1 and LI3 are correlated. This should be considered when main model is analysed.

Table 9-11: Inter-Item Correlation Matrix - Leagility Index

	LI1	LI2	LI3	LI4	LI5	LI6
LI1	1.000	.916	.928	.823	.791	.802
LI2	.916	1.000	.866	.771	.768	.759
LI3	.928	.866	1.000	.834	.797	.792
LI4	.823	.771	.834	1.000	.824	.850
LI5	.791	.768	.797	.824	1.000	.834
LI6	.802	.759	.792	.850	.834	1.000

Table 9-12 shows what Cronbach's Alpha would be if one of the leagility index variables is removed and Alpha is re-calculated on the basis of the remaining variables.

Table 9-12: Cronbach's Alpha Item-Total Statistics - Leagility Index

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
LI1	17.46	77.914	.927	.916	.954
LI2	17.28	81.543	.881	.845	.959
LI3	17.58	76.245	.916	.880	.956
LI4	17.47	80.284	.884	.806	.959
LI5	17.72	84.476	.862	.766	.962
LI6	17.65	80.583	.866	.788	.961

The analysis indicates that Cronbach's Alpha would not improve by removing one of the current variables from the scale.

DFL

Table 9-13 presents the Cronbach’s Alpha for the measurement instrument of DFL. The value of Cronbach’s Alpha (0.805) is above the acceptable limit (0.7). It indicates satisfactory levels of stability and internal consistency of the construct’s variables to measure deviation from leagility.

Table 9-13: Reliability Statistics - DFL

Cronbach's Alpha	Cronbach's Alpha Based on Standardised Items	N of Items
.805	.806	6

Table 9-14 presents correlation matrix for the variables of deviation from leagility. The value of correlation coefficients indicates that none of variables are highly correlated.

Table 9-14: Inter-Item Correlation Matrix - DFL

	DFL1	DFL2	DFL3	DFL4	DFL5	DFL6
DFL1	1.000	.704	.722	.311	.341	.313
DFL2	.704	1.000	.523	.194	.275	.211
DFL3	.722	.523	1.000	.368	.387	.303
DFL4	.311	.194	.368	1.000	.451	.484
DFL5	.341	.275	.387	.451	1.000	.553
DFL6	.313	.211	.303	.484	.553	1.000

Table 9-15 shows what Cronbach's Alpha would be if one of the DFL variables is removed and Alpha is re-calculated on the basis of the remaining variables.

Table 9-15: Cronbach's Alpha Item-Total Statistics - DFL

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
DFL1	8.35	14.442	.675	.674	.750
DFL2	8.57	15.313	.516	.500	.785
DFL3	8.23	14.171	.641	.555	.756
DFL4	8.40	15.805	.495	.317	.789
DFL5	8.65	14.686	.554	.386	.777
DFL6	8.42	14.956	.507	.383	.789

The analysis indicates that Cronbach's Alpha would not improve by removing one of the current variables from the scale.

Competition Intensity

Table 9-16 presents the Cronbach’s Alpha for the measurement instrument of competition intensity. The value of Cronbach’s Alpha (0.871) is above the acceptable limit (0.7). It indicates satisfactory levels of stability and internal consistency of the construct’s variables to measure competition intensity.

Table 9-16: Reliability Statistics - Competition Intensity

Cronbach's Alpha	Cronbach's Alpha Based on Standardised Items	N of Items
.871	.871	6

Table 9-17 presents correlation matrix for the variables of competition intensity. The value of correlation coefficients indicates that none of variables are highly correlated.

Table 9-17: Inter-Item Correlation Matrix - Competition Intensity

	CI1	CI2	CI3	CI4	CI5	CI6
CI1	1.000	.519	.566	.568	.533	.529
CI2	.519	1.000	.581	.530	.527	.486
CI3	.566	.581	1.000	.553	.521	.531
CI4	.568	.530	.553	1.000	.500	.552
CI5	.533	.527	.521	.500	1.000	.451
CI6	.529	.486	.531	.552	.451	1.000

Table 9-18 shows what Cronbach's Alpha would be if one of the competition intensity variables is removed and Alpha is re-calculated on the basis of the remaining variables.

Table 9-18: Cronbach's Alpha Item-Total Statistics - Competition Intensity

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
CI1	20.21	54.415	.690	.479	.846
CI2	20.24	55.192	.669	.456	.850
CI3	20.25	54.180	.702	.496	.844
CI4	20.17	55.182	.687	.476	.846
CI5	21.18	58.645	.638	.412	.855
CI6	21.01	58.134	.642	.421	.854

The analysis indicates that Cronbach's Alpha would not improve by removing one of the current variables from the scale.

Customers' expectation

Table 9-19 presents the Cronbach's Alpha for the measurement instrument of customers' expectation. The value of Cronbach's Alpha (0.819) is above the acceptable limit (0.7). It indicates satisfactory levels of stability and internal consistency of the construct's variables to measure customers' expectation.

Table 9-19: Reliability Statistics - Customers' expectation

Cronbach's Alpha	Cronbach's Alpha Based on Standardised Items	N of Items
.819	.829	4

Table 9-20 presents correlation matrix for the variables of customers' expectation. The value of correlation coefficients indicates that none of variables are highly correlated.

Table 9-20: Inter-Item Correlation Matrix - Customers' expectation

	CE1	CE2	CE3	CE4
CE1	1.000	.536	.552	.577
CE2	.536	1.000	.550	.518
CE3	.552	.550	1.000	.559
CE4	.577	.518	.559	1.000

Table 9-21 shows what Cronbach's Alpha would be if one of the customers' expectation variables is removed and Alpha is re-calculated on the basis of the remaining variables.

Table 9-21: Cronbach's Alpha Item-Total Statistics - Customers' expectation

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
CE1	13.25	18.304	.665	.445	.761
CE2	13.29	23.977	.635	.405	.794
CE3	13.36	18.346	.660	.441	.764
CE4	13.15	18.574	.663	.440	.762

The analysis indicates that Cronbach's Alpha would not improve by removing one of the current variables from the scale.

Performance

Table 9-22 presents the Cronbach's Alpha for the measurement instrument of performance. The value of Cronbach's Alpha (0.763) is above the acceptable limit (0.7). It indicates satisfactory levels of stability and internal consistency of the construct's variables to measure performance.

Table 9-22: Reliability Statistics - Performance

Cronbach's Alpha	Cronbach's Alpha Based on Standardised Items	N of Items
.763	.775	5

Table 9-23 presents correlation matrix for the variables of performance. The value of correlation coefficients indicates that none of variables are highly correlated.

Table 9-23: Inter-Item Correlation Matrix - Performance

	P1	P2	P3	P4	P5
P1	1.000	.481	.441	.528	.202
P2	.481	1.000	.619	.555	.271
P3	.441	.619	1.000	.491	.208
P4	.528	.555	.491	1.000	.280
P5	.202	.271	.208	.280	1.000

Table 9-24 shows what Cronbach's Alpha would be if one of the performance variables is removed and Alpha is re-calculated on the basis of the remaining variables.

Table 9-24: Cronbach's Alpha Item-Total Statistics - Performance

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
P1	12.77	12.069	.547	.344	.716
P2	13.07	11.069	.659	.489	.675
P3	12.95	11.595	.588	.426	.701
P4	12.81	11.143	.630	.424	.685
P5	14.11	12.517	.301	.099	.812

The analysis indicates that Cronbach's Alpha would be improved from 0.763 to 0.812, if P5 variable would remove from the scale. As the improvement is insignificant and the current Alpha value (0.763) is above the acceptable limit, P5 is not removed from the scale at this stage.

Market Segment

Table 9-25 presents the Cronbach’s Alpha for the measurement instrument of market segment. The value of Cronbach’s Alpha (0.860) is above the acceptable limit (0.7). It indicates satisfactory levels of stability and internal consistency of the construct’s variables to measure market segment.

Table 9-25: Reliability Statistics - Market Segment

Cronbach's Alpha	Cronbach's Alpha Based on Standardised Items	N of Items
.860	.856	5

Table 9-26 presents correlation matrix for the variables of market segment. The value of correlation coefficients indicates that none of variables are highly correlated.

Table 9-26: Inter-Item Correlation Matrix - Market Segment

	MS1	MS2	MS3	MS4	MS5
MS1	1.000	.618	.395	.626	.604
MS2	.618	1.000	.408	.748	.639
MS3	.395	.408	1.000	.338	.408
MS4	.626	.748	.338	1.000	.651
MS5	.604	.639	.408	.651	1.000

Table 9-27 shows what Cronbach's Alpha would be if one of the market segment variables is removed and Alpha is re-calculated on the basis of the remaining variables.

Table 9-27: Cronbach's Alpha Item-Total Statistics - Market Segment

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
MS1	15.10	29.155	.699	.494	.825
MS2	14.75	27.422	.767	.626	.806
MS3	15.49	34.472	.451	.220	.881
MS4	14.74	27.536	.750	.630	.811
MS5	14.78	28.810	.722	.527	.819

The analysis indicates that Cronbach's Alpha would be improved from 0.860 to 0.881, if MS3 variable would remove from the scale. As the improvement is insignificant and the current Alpha value (0.860) is above the acceptable limit, MS3 is not removed from the scale at this stage.