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# IDENTIFICATION AND CLASSIFICATION OF RISKS IN THE NEW ZEALAND PLYWOOD SUPPLY CHAIN

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Thesis presented in fulfilment of the requirements for the degree of

**Master of Supply Chain Management**

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## ABSTRACT

Activities in the supply chain cover a wide-ranging area from upstream to downstream in order to deliver products and services to end customers. Because of the supply chain's width and scope, the activities in it consume a substantial portion of total costs to industries. Therefore, managing supply chain costs can be difficult and yet it is important for companies to have efficient and effective supply chains. Having a better supply chain performance is challenging but various strategies have been implemented in many companies. These strategies have proved capable of enhancing supply chain efficiencies and effectiveness. At the same time, the strategies have also stretched the supply chain's structure wider than before. The change of this structure has made the supply chain become more vulnerable and as a result, the supply chain faces greater risks. Previous studies have shown that risks in supply chain not only interrupt a single company but also terminate the whole organisation. The situation above infers the importance of supply chain risk management in companies.

Supply chain risk management enhances companies' performance to prevent, respond and recover if there are disruptions. Many disruptions can be found in various industries, including plywood sector in this country. New Zealand plywood in general is considered to be a high-value product that requires good quality logs, but for New Zealand plywood mills, obtaining good quality logs is costly. This is because log prices in New Zealand have been increasing due to strong demand of logs from overseas. Increasing log prices obviously delivers more benefits to the foresters as they can earn more profits, while plywood mills are grappling to overcome increasing log prices as input costs increase. This situation highlights the interactions and interdependencies between entities within plywood supply chain in New Zealand. The interdependencies risks and uncertainties too along with benefits. To meet these challenges, supply chains must work toward a unified system and coordinate with each other.

Given the current situation in New Zealand, this study aims to identify risks in the plywood supply chain by identifying and analysing the risks and

implications for customer value. The risk sources have been predicted and classified into supply, demand and operational. Furthermore, the methodology chosen is qualitative along with a case study approach. Therefore, information regarding risks in the plywood supply chain was gathered by interviewing experts from local plywood mills in New Zealand. The interviews were semi-structured to obtain a comprehensive understanding.

The results have been categorised according to a preliminary classification: supply, demand and operational risks. From supply risks there are log quality, log prices, continuity of raw material and transport and distribution. Secondly, demand risks consist of fluctuating demand and market competition. Lastly, operational risks are machine breakdown, inventory and people. All risks from various sources indicate causal relationships between risks in the same sources and across the sources. In addition to the main results, there are also findings from outside the classification: regulation, financial, environment and globalisation. These are considered to be external factors that either directly influence the risks or the relationships among them.

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# 1 Introduction

## 1.1 Introduction

This introduction section provides a general context to this study. It begins with a background that describes motives in this study, then it is followed by the purpose and the questions which provide the boundaries associated with this study. The final part of the introduction is an outline that shows the discussion order in this study.

## 1.2 Background

### 1.2.1 Increasing supply chain risk management

Supply chain management (SCM) can be defined as a group of activities to deliver products or services to end customers. Typically the activities work like a sequence from planning, manufacturing, packaging and then delivering to end customers. To keep the activities working, it requires other support such as monitoring, controlling, outsourcing and financing (Adhitya, Srinivasan, & Karini, 2009; Bosman, 2006). The definition indicates that activities in the supply chain cover a wide ranging area; hence, it is expected to consume significant costs in the business. According to Karimi, Srinivasan, and Por (2002) activities in the supply chain can consume approximately 10-30% of total costs in industries. Given that fact, it is necessary to operate an efficient and effective supply chain in many industries.

To achieve the efficiencies and effectiveness in SCM, various strategies have been implemented and developed particularly in cost reduction, such as Just In Time (JIT) and lean manufacturing (Bosman, 2006; Federica & Massimo, 2006). The cost reduction strategies basically focus on speed and pushing the costs down. Along with these strategies many companies progressively move toward a concept of a single or few suppliers and locate their sales and distribution facilities based on the demand in every area instead of a centralisation strategy. In the end, the

companies started to focus only on their core business and pass on other non-core activities to other companies, such as third party logistic (3PL) providers. By doing this, the companies then consequentially build their own competitive advantages (O. Tang & Nurmaya Musa, 2011).

One good example is provided by Zsidisin and Ritchie (2008). They explicate one of the biggest fashion industries in Europe-Zara. This company earns an annual income and sales rate 20% higher than other retailers. The other thing, Zara is also famous for its decoupling point strategy that impacts on time reduction. The strategy makes Zara able to design, manufacture, and ship their clothes within two weeks, whereas other fashion retailers may take 24 weeks. To make the strategy work, Zara has its base in Spain for design but manufactures their fashion clothes and outsources other basic products to other countries. Using in time reduction, Zara focuses on its core fashion line while the company is still able to cover the common fashion market. In short, Zara has successfully proved that focusing on competitive advantages creates an efficient and effective system in companies.

There is always a price to be paid for every action. Having an efficient and effective supply chain may require a forfeiture in other parts of chain. Previous studies indicate that there is a trade-off between efficiency and vulnerability (Adhitya et al., 2009; Bosman, 2006; Schlegel, 2015). For instance, with the implementation of a single or few suppliers, many companies will be able to cut down their total costs but simultaneously increase dependencies between supplier and focal companies. What is more, outsourcing makes companies focus on their business and worry less about other sectors but the complexities increase afterward. Another example is delegating some jobs to other parties in different countries. That is to say companies build more links but also open more opportunities to new risks such as political, transportation, and cultural. Strategies like JIT reduces inventories and buffers in the production line, which then cuts down the inventory costs but it threatens business continuity if an unexpected event happens. All the examples above

demonstrate that implementations of the strategies have delivered more vulnerabilities to the supply chain. Being more vulnerable, the supply chain then opens up the opportunity for more risks that may disrupt it or even shut down the company.

Previous studies have illustrated the implications of risk occurrence in companies, for instance, the earthquake in Japan 2011 followed by the tsunami which triggered a nuclear disaster. The catastrophe paralysed Japan's economy as it destroyed major facilities in that country. As a consequence, it dropped car sales, particularly in the USA market as Japan was the main supplier for some automobile parts in there. Other examples are the case of a fire at Ericsson suppliers in 2000 which caused the focal company to lose \$400 million and the flooding in Thailand which shut down all computer manufacturers (Chopra & Sodhi, 2004).

The examples above demonstrate that any disruptions in companies can not only irritate a single company but also an entire industry. Similarly, Juttner (2005) stresses that any implications are not simply for the focal companies but can affect other parties who are involved in business activities. Therefore to sum up, disruptions in the supply chain can lead to a ripple effect in all organisations and yet this disruption can exist in various sectors. This is the case in this research example of the plywood industry sector in the forestry industry of New Zealand.

### **1.2.2 Overview of New Zealand forestry**

The forestry sector has been considered to be one of the major contributors to the New Zealand economy. On average, this sector contributes around 3% every year to New Zealand's Gross Domestic Product (GDP) (MPI, 2015a; Report, 2013). Its contribution generally comes from exporting wood products, which has also been projected to increase along with world demand for wood (Association, 2012).

The increase in wood demand is inevitable considering the population and economic growth in the world. Nevertheless, while wood demand seems to increase because people need more houses, wood

supply is likely to decrease due to a combination of opening land for residence, deforestation, forest degradation and the increasing global warming issue (Association, 2012). In addition, the illegal logging issue also limits fulfilment of sustainable wood demand in the world recently. This is because of a regulation, that is related to illegal logging demands that every organisation should be able to supply their logs from qualified woods.

The situation above can be seen as an opportunity for New Zealand to fill some demand in the international market. This is because New Zealand has a mature and large plantation area (Association, 2012; Stephens, 2011). This plantation provides not only a sustainable wood supply but also has positive impacts on the environment such as providing clean water and controlling erosion. However, if New Zealand expands its log market to overseas, the situation may not benefit all forestry members in New Zealand, e.g. forest owners and operators, and wood processors.

By exporting more logs to overseas, forest owners are likely to grasp more profits in the short term as market demand from overseas increases and customers tend to pay with premium prices. Conversely, wood processors are grappling to purchase good raw materials at a reasonable price. One of wood processing sectors that can be involved is the plywood sector. Plywood is one of the areas where a high-value wood product is generated, therefore it requires high-quality wood. The higher the wood quality required for plywood, the more expensive log prices are. That is to say if foresters export more logs to overseas, the plywood sector will face difficulties in obtaining good quality logs and controlling the input costs due to higher log prices.

There are various reasons that can affect log prices in New Zealand but, one major reason recently is overseas demand for logs. As can be seen in Figure 1 below, there was an increasing trend of lumber exports in the last 20 years. Previous industry reports add that the largest inclination was in the raw material e.g. logs with the main destination as China (Association, 2012; *Forestry Info Graphic*, 2012; Stephens, 2011).

The situation has driven up export log prices as well as domestic log prices. The details are presented in Figure 2 and Figure 3 below.

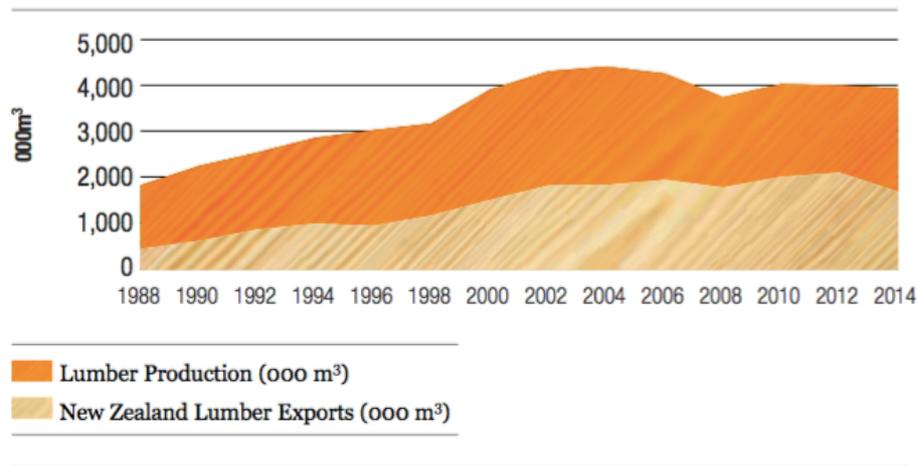


Figure 1. Lumber production and exports to December 2014

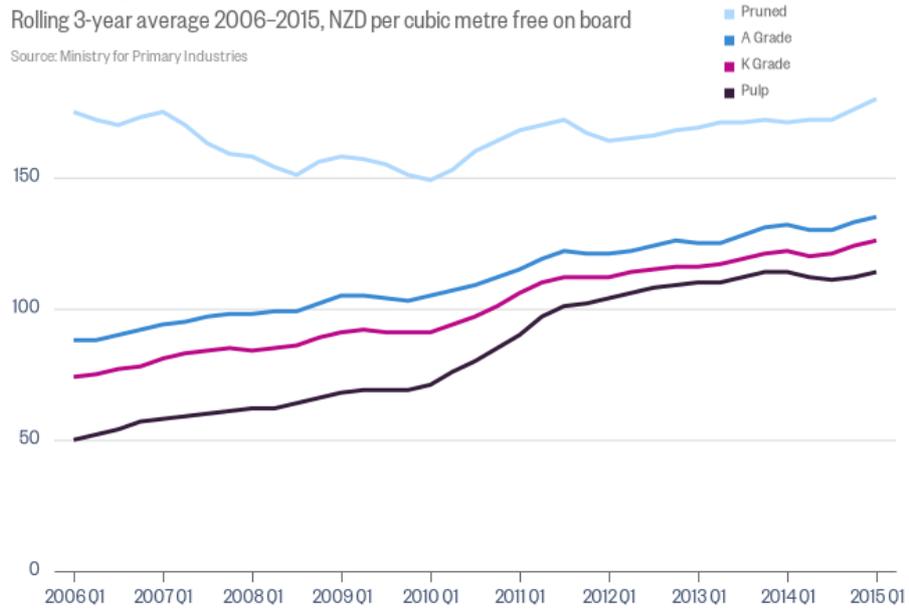


Figure 2. Average export log prices by grade in New Zealand (MPI, 2015b)

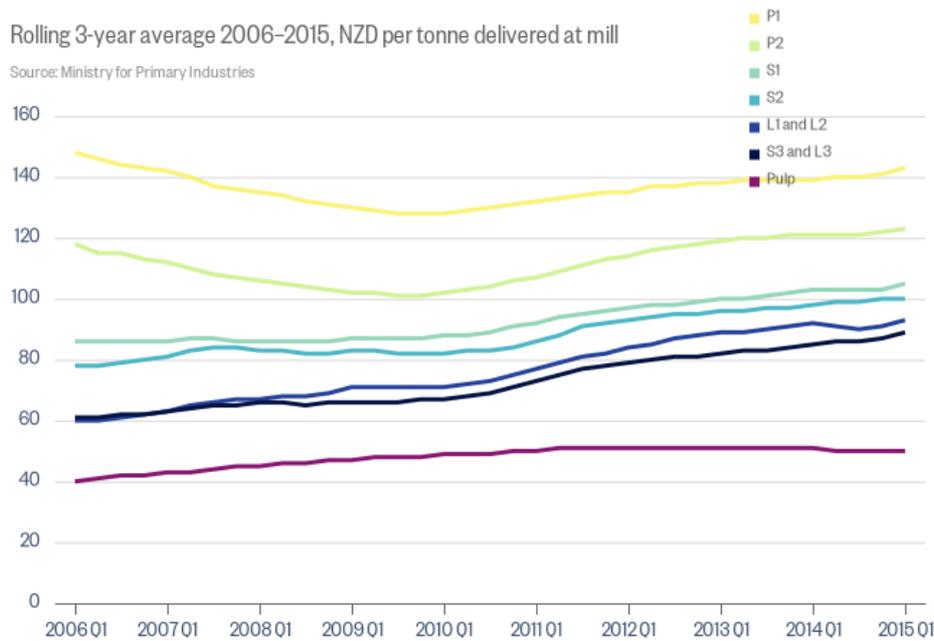


Figure 3. Average domestic log prices by grade in New Zealand(MPI, 2015b)

Based on the three figures, it can be said that the increasing number of logs being exported to overseas drives the log prices domestically and internationally.

In conclusion, overseas demand and log prices can be considered as threats to the continuity of the plywood business in New Zealand. There are other threats that may emerge from different areas, such as an area expansion of the dairy and meat industries (Dittmann, 2014; Stephens, 2011). With this situation, managing risks in the plywood supply chain can be challenging.

### 1.3 Problem definitions and objectives

The trends toward outsourcing, globalization and e-business have led to more complex dynamic supply chain network and resulted in risks shifting around the supply chain. This is shown in Harland, Brenchley, and Walker (2003) that found the increasing of network complexity produces increasing in risks. They also find that apparently focal firm had difficulties to assess and evaluate various strategies for risk management. Similarly, Smallman (1996) adds that focal firm shall be able to identify its position on risk in order to

implement risk management in the supply chain. Therefore, it is important for every company to be able identify, respond and recover from disruptions promptly and efficiently (Adhitya et al., 2009). With regard to the forestry sector in the New Zealand situation recently, this study aims to investigate risks and their implications in the plywood industry. In order to achieve the aim of this research, the following three objectives need to be addressed.

1. Identify risks involved in the plywood supply chain
2. Analyse interactions and implications among identified risks
3. Understand these risks and implications for customer value

#### 1.4 Outline of study

This study is organised into seven chapters. **This chapter** provides the motive for the study and the aim and limitations of the research. An outline is provided to give the readers the general content and context of the study. **Chapter two** gives a broad view regarding the New Zealand forest industry and the wood processor profile. This profile positions parties related to the plywood industry's contributions to the world and the New Zealand economy. Furthermore, the flow of logs is also provided to give the delineator of the log process in New Zealand. **Chapter three** presents the literature review of SCM and risk management, the conceptual model that is used in this study. On the basis of conceptual principles, the literature review is a rational guideline for the researcher during this study. **Chapter four** defines the methodology and techniques that were used to help the author answer the research questions. It contains the detailed perspective of the researcher, measurement of this research, the case study strategy, data collection methods, sampling, data analysis, and ethical considerations. **Chapter five and six** provide the results, which are themes that are related to each other and illustrate the subject situation. In general, those chapters answer the research questions through describing, understanding and explanation. **The last chapter** provides the conclusion and the recommendations for the further research which is beyond the focus of this study. However, they are presumed as the findings that lead into the new studies.

## 2 Industry profile

### 2.1 New Zealand forestry profile

More than 30% of New Zealand's land is covered by forest area. These forest areas can be divided into natural indigenous forest and exotic plantation forest. The natural indigenous area occupies around 24% of the total area or equals to 6.5 million hectares whereas the remaining 6% of total area is an exotic plantation area which equals to 1.75 million as at 1 April 2014 (Table 1.) (MPI, 2014).

The exotic plantation area spreads out all around New Zealand with distributions of 70% in the North island and 30% in South Island. In the North Island, the forest are located around the Waikato, Bay of Plenty, and other Northland regions. (MPI, 2014; Yao et al., 2013). In the South Island, the forest area is less and sparsely located-more details are presented in Figure 4.

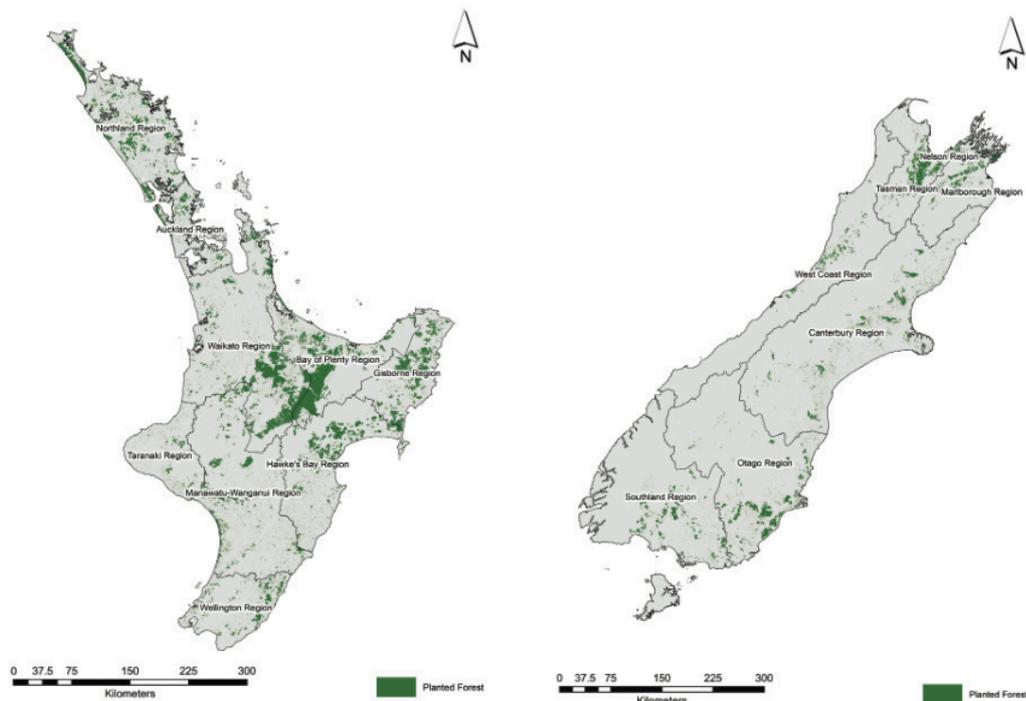


Figure 4. Map of North Island (left) and South Island (right) showing off the plantation area location (MPI, 2014).

The total plantation area consists mainly of Pinus Radiata which accounts almost for 90% of the total area. The remaining species are Douglas-fir, Cypress, and Eucalyptus. The detailed distribution can be seen in Table 1 below.

Table 1. Plantation area in New Zealand as at 1 April 2014 (MPI, 2014)

<b>Species</b>	<b>Total area planted (ha)</b>	<b>Total area of planted forest ( %)</b>
<b>Pinus Radiata</b>	1,572,200	87.7
<b>Douglas-fir</b>	105,200	5.87
<b>Cypresses</b>	9,900	0.55
<b>Other softwoods</b>	23,000	1.28
<b>Eucalyptus</b>	23,800	1.32
<b>Other hardwoods</b>	12,400	0.69
<b>Total plantation area</b>	<b>1,791,142</b>	<b>100</b>

Regardless of the wood types, the trees from the plantation area have been able to help supply raw materials to the forest industry in New Zealand.

The forest industry is considered to be the third major player in the New Zealand economy after dairy and meat. This is because on average the sector earns roughly \$5 billion or 3% of the total Gross Domestic Product (GDP). However, as a small country, New Zealand forestry contributes only 1.3% to the world's trading (MPI, 2015a).

Regardless of New Zealand's role globally, the forest industry has been steadily moving forward to keep pace with the global market along with technology development. This is shown by an increasing number of wood being harvested every year for the last 20 years. As can be seen in Figure 5, there is a rising trend of roundwood and it is predicted to increase up to 70% by the end of 2025 due to an increase in the total demand from some developing countries (Association, 2012).

## Total roundwood production

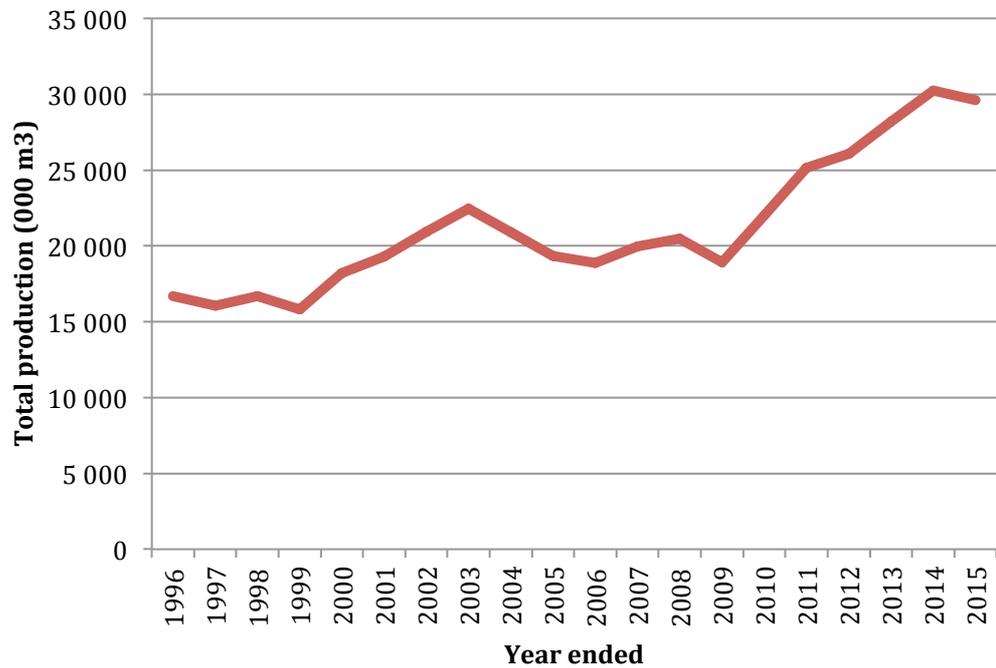


Figure 5. Total roundwood production from plantation area in New Zealand(MPI, 2015a)

The total roundwood production above generally goes to fill international and domestic demand. Both markets are able to absorb nearly 100% of the total wood every year, but nearly 50% of the total roundwood goes to the international market in the form of logs, whereas the remaining goes into the domestic market to be processed into higher-valued wood products. As such at the end of June 2015, there were 29 m<sup>3</sup> were produced from the plantation area: 45.9% of the logs was sent overseas whereas the rest of logs was used dometically (MPI, 2015c). The detail of log flow in New Zealand is shown in Figure 6 below.

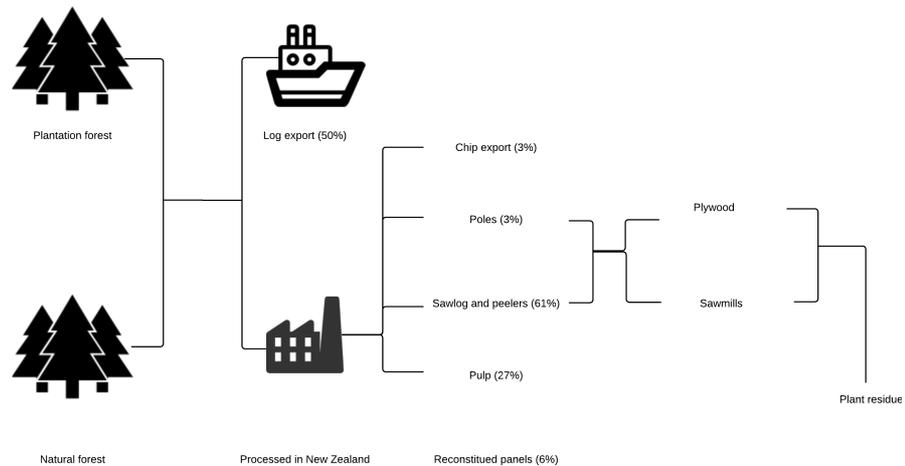


Figure 6. Log flow in New Zealand(*Forestry Info Graphic, 2012*)

As shown in Figure 6, total logs from the forest are distributed domestically and internationally. There was 50% of total roundwood production sent to international markets, whereas the other 50% is used in various domestic industries in New Zealand. The roundwoods can be processed into logs and poles, lumber, wood pulp, paper and paper board and panel products.

## 2.2 Wood processors in New Zealand

The wood processing sector in New Zealand processes roundwood from the plantation area into higher value products. This sector has been well established and stable for the last 10 years (Vroege, 2015). The wood processing sector consists of 46 sawmills, four laminated veneer lumber (LVL) mills, three plywood mills, three medium density fibreboard (MDF) mills, two particle board mills and eight remanufacturing plants, including chemical and mechanical pulpmills.

Despite the number of mills in New Zealand, wood products are generally categorised based on their structure. The categories are divided into panel products, paper and paper board, sawn timber & sleepers, wood pulp, and logs and wood chips.

### **2.2.1 Panel products**

Panel products diverge into four major products. These products are considered as panel products because they are likely to be processed through a particular method, such as binding or fixing to form composite materials.

#### **a. Veneers**

Veneers are intermediate products and can be sold directly to customers are produced by slicing the wood into thin sheets. The wood to produce good quality veneers comes from the 50% at the bottom of the tree, which is expected to have a large diameter and less knots.

#### **b. Plywood**

Plywood is manufactured by gluing all together more than one veneer to both sides of a core. The core of plywood comes in the form of solid wood or thicker veneer sheets. Given the fact that plywood and veneers have similar processes, both products are generally produced in the same mills.

#### **c. Particleboard and fibreboard**

Particleboard and fibreboard have many similarities in their processes. Both products are reconstituted wood that is developed in order to minimise the waste from other manufactures. Therefore, raw materials for these products can come from various forms e.g. flake board, wafer board. The difference between particleboard and fibreboard is in their density. Particleboard has a lower density and is commonly used in lower-end furniture whereas fibreboard is likely used for high-end furniture as it has a higher density.

### **2.2.2 Wood chips**

A wood chip product is known as a residual form that comes from other manufactured wood products. Figure 3 shows that wood chips are generated where manufacturers' produce sawn timber, poles,

posts and firewood. These manufacturers only take the part that they need for the industry and dispatch the part that they do not need. Nevertheless, wood chips, as the residual product, are known as one of the biggest supplies for pulp and paper industry. This condition emphasises the implementation of a “zero waste” strategy by applying integrated systems in the forest supply chain (Bosman, 2006).

### **2.2.3 Sawn timber and sleepers**

Sawn timber is characterised by its rectangular shape with varying length and width. It is made by cutting the log which should have a certain specification to meet the global demand. Generally, log that goes into sawn timber is graded by the visual appearance, structural quality, strength, stiffness, and cutting qualities, and it is also preferred clear of knots. In the final grade of sawn timber processing, the wood will be categorised by its visual looks. The highest grade will be used as furniture or moulding. The remaining grade may go into supporting frames for furniture, wall framing, or for the construction industries.

### **2.2.4 Wood pulp**

Wood pulp is an intermediate product that can be sold to customers. There are two types of wood pulp based on the production process: mechanical and chemical pulp. Mechanical pulp is made through standard processing to produce pulp. With this process the pulp has a high density which suits the paper or printing industry e.g. newspaper. Unlike mechanical pulp, chemical pulp is manufactured through a similar process to produce pulp but in the process some chemical materials are added to make a certain quality of the paper. Paper that is made from chemical pulp has more strength and resistance, e.g. sacks and bags.

### **2.2.5 Paper and paperboard**

Paper and paperboard are made by adding chemical materials into base pulp to produce various types of paper. Every chemical

ingredient results in different types of paper: writing paper, greaseproof paper, wrapping paper, tissue, paperboards, and corrugated boards.

#### **2.2.6 Other forestry products**

Other forestry products can vary such as poles, posts and firewood. Poles have a round shape and can be used without any further conversions. Generally this product is used in the construction industry for building foundations, retaining walls, marina piles, and telegraph poles. Furthermore, posts are similar to poles but have a smaller diameter. Mostly they are used in fences in agriculture or forestry. Lastly is firewood and this product is less popular because it has a limited purpose which is only for domestic and industrial heating or cooling.

All of the wood products above are generated from different types of wood, but the wood can come from one single log. In New Zealand there are three log types that come from the forest estate to wood processors: pruned logs, unpruned logs, and pulp and chip. Each type delivers different composition raw materials to the wood processing sectors. The differences are presented in Figure 7 and Figure 8.

As seen in Figure 7, a single pruned log of Radiata pine can generate 7% off the top to produce pulp and paper. This part has the characteristics of being small in diameter with large knots and poor form. The next 43% of the top goes into saw logs to produce sawn timber. Lastly the remaining part accounts for 50% of the tree which is the bottom part has the highest quality of pruned logs. This bottom part usually goes to plywood mills to be processed into veneers and plywood. On the other hand, Figure 8 shows the unpruned log allocation for the wood processing sector. First, the first 30% off the top goes to the pulp and paper industry, whereas the remaining 70% is used to produce saw logs and sawn timber. This is because unpruned logs generally have more knots on the body which cannot be used to produce plywood.

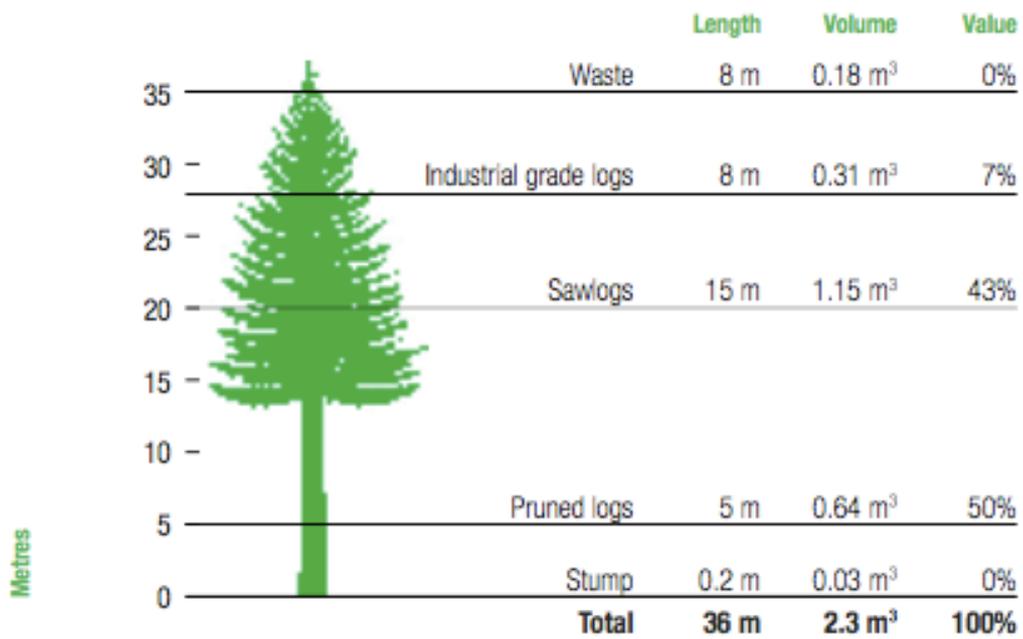


Figure 7. Typical pruned log turn out (NZOA, 2013)

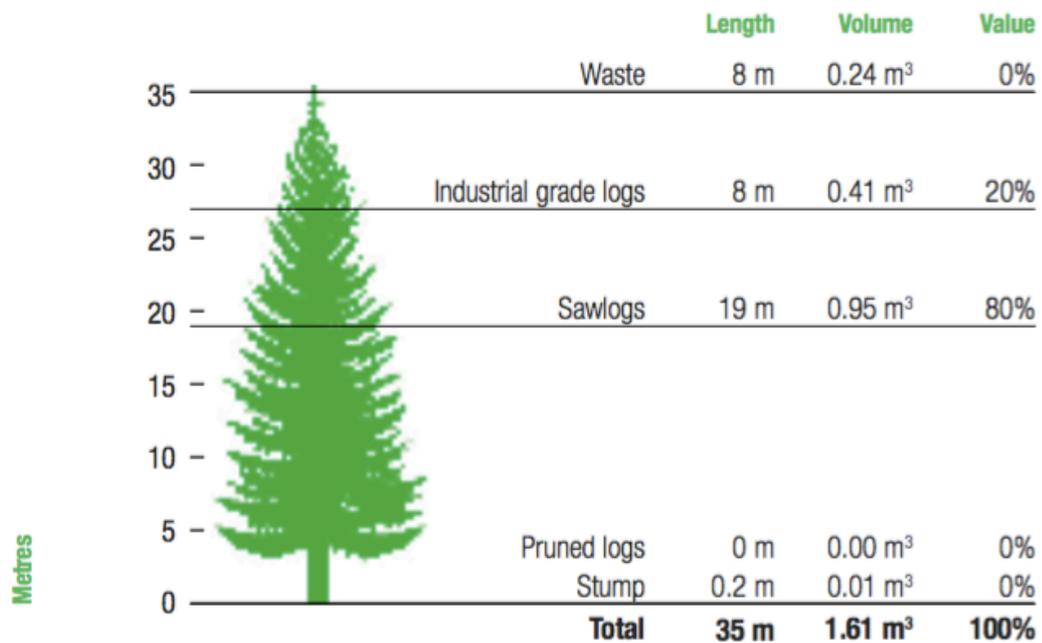


Figure 8. Typical unpruned log turn out (NZOA, 2013)

## 2.3 Plywood industry in New Zealand

Plywood was first made in 1797, but the industry established in 1905 in Portland, Oregon and for the next 15 years it focused on softwood plywood for door panels ("History of APA, Plywood, and Engineered Wood," 2015). In New Zealand, structural pine plywood started to be commercialised in 1967 when the Southern pine plywood industry began. Until today there have been three big mills that effectively produce plywood for export and domestic consumption. The production and export of forestry can be seen in Figure 9 below.

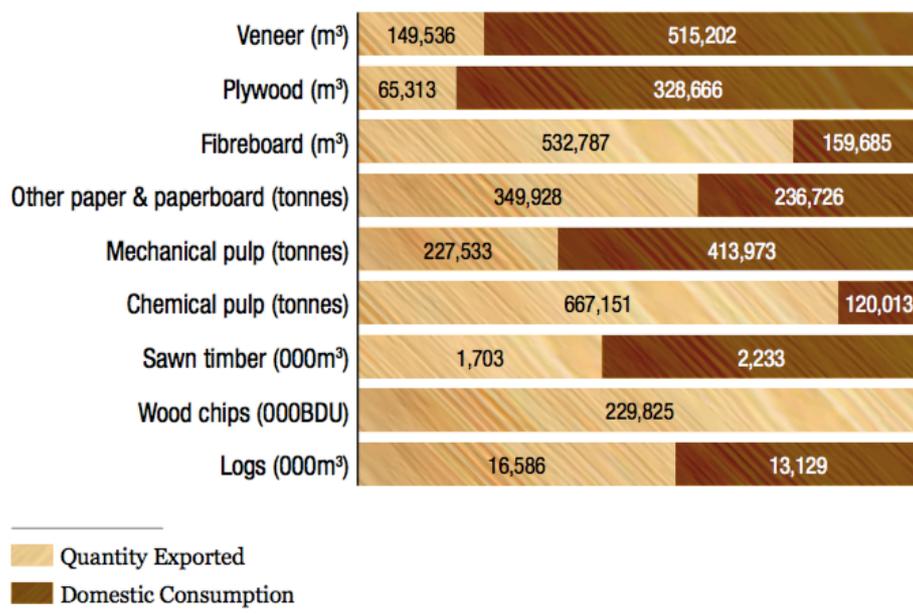


Figure 9. Production and exports of forestry products

As seen in Figure 9, in 2014 logs were the highest products manufactured and distributed to overseas and domestic markets. More than 50% of total production in 2014 was sent overseas, whereas the remaining was used domestically. Compared to logs, the total production of veneers and plywood in the same year was smaller but the total was more than 1 million m<sup>3</sup>. Unlike logs, most of production was sent overseas, more than 50% of plywood and veneers used domestically.

Even though plywood and veneers are considerably small, the total production has been steady for the last few years compared to other panel products. As can be seen in Figure 10 below, plywood and veneers have been contributing to total panel products at nearly 50 % for the last 10 years. Although there were fluctuations in the total production of panel products, plywood and veneers were able to remain stable.

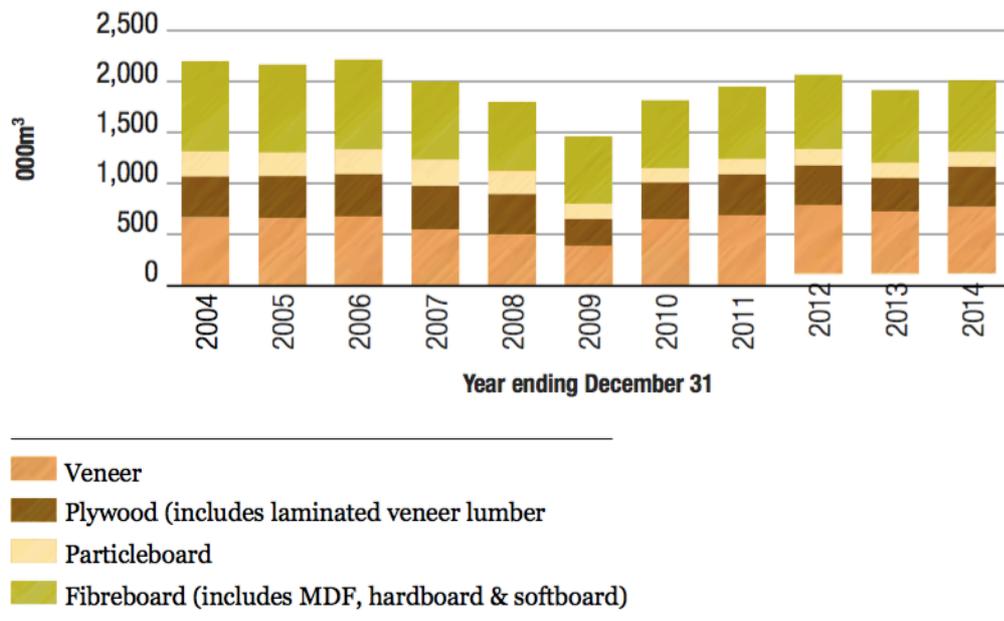


Figure 10. Total panel products production (NZOA, 2015)

Since plywood and veneers are mostly distributed in the domestic market; it is to be expected that the export value of the plywood sector has smaller contribution to logs. This is can be seen in Figure 11 below and it is to be expected that the highest contribution came from logs and wood chips since more than 50% of the total production was sent to overseas. On the other hand, panel products which include plywood and veneers with the least total exported products have contributed a considerable amount to the total exports for the last 10 years (Figure 11). That is to say, even plywood and veneers have smaller numbers in terms of the total production compared to other forestry products, so their contribution is a substantial portion of the total value exports. Therefore, given the fact most plywood and veneers go

into the domestic market and the value can be earned from plywood and veneers, the plywood sector in New Zealand is considered important.

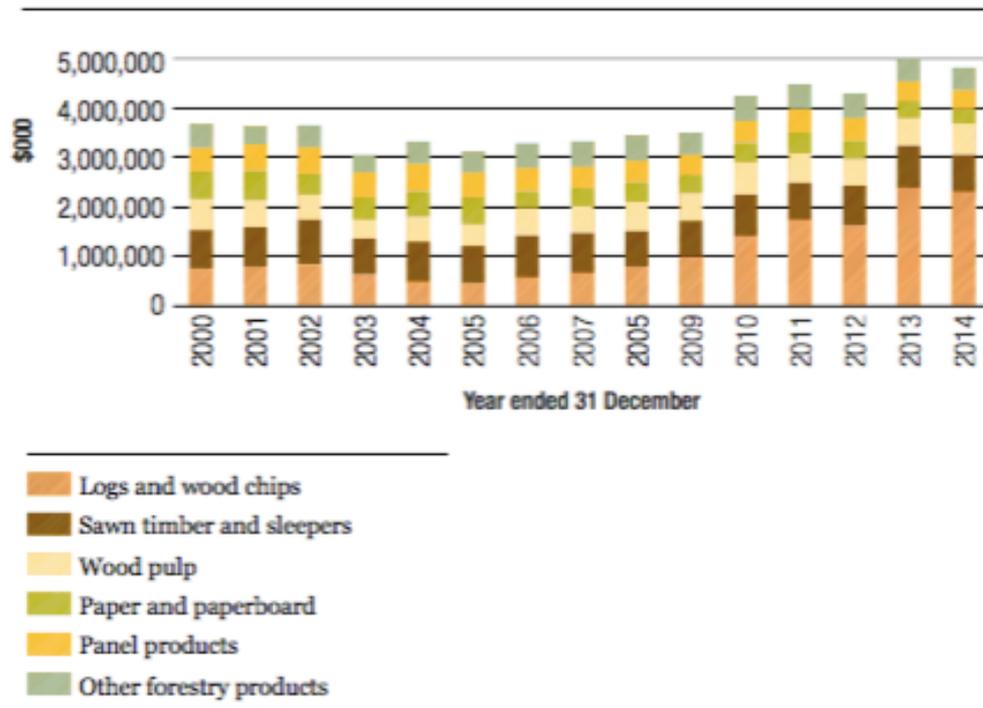


Figure 11. Major export earners (NZOA, 2015)

## 3 Literature review

### 3.1 Supply chain management

The term “supply chain management” has been considered as a concept since the early 1980s when companies started looking thoroughly at the advantages of relationship between companies. Lummus and Vokurka (1999) mention that a number of definitions have been proposed concerning the term of SCM. Various definitions could be found in many articles and yet are different in focus. For instance, Christopher (2005) looks from the management area, whereas others claim that SCM is a series of processes (Lummus & Vokurka, 1999). Other scholars define it as a group activity or entities that interact with each other by sharing information and coordinating in order to deliver the products or services to customers (CSMP, 1982; Mentzer et al., 2001). In the light of these perspectives, it can be concluded that an SCM definition has been widely defined based on the perspective of the researchers. In line with that, Ellram and Cooper (2014) agree that the concept of SCM has been developed and applied depending on the way the researchers see it. They also add that the term SCM will change if the parties do not agree with the sources. Similarly, Mentzer, Stank, and Esper (2008) confirm that the term of SCM is not only specific to one area, since this discipline covers nearly all of business. Therefore, Table 2 below presents some of the definitions that have been chosen from some articles.

Table 2. Definition of supply chain management (SCM)

<b>Author</b>	<b>SCM definitions</b>
<b>Lummus and Vokurka (1999)</b>	All activities to deliver products to customer; starts from raw material to delivery to the final customer, including information
<b>Mentzer et al. (2001)</b>	Group of entities from upstream to downstream referring to the flow of products or services, information, and money
<b>Christopher (2005)</b>	The relationship management from upstream to downstream within suppliers and customers in order to deliver more value with low cost.
<b>CSMP (1982)</b>	All activities to integrate supply and demand within and across companies in the chain

From all the definitions above, of SCM it seems that a key element in the supply chain is connecting the interdependent entities in a process of delivering products to customers. It emphasises that SCM covers a wide-ranging area and the continuity of business of each organisation in the chain hinges on the relationship between them. Given this fact, a breakdown at one business may affect every organisation with which it does business. To prevent the supply chain from every threat which may cause business failure, a company must plan risk management all along its supply chain. Risk management in a supply chain context is discussed in the next section as the core issue for this research

### **3.2 Risk management in a supply chain context**

A number of studies related to risk management are easily found in the associated literature, yet those studies generally focus on single organisations only. According to Juttner (2005), in the supply chain context, risk management should not be studied by obtaining information from solely one organisation. Similarly, Mentzer et al. (2001) concur that the supply chain should not be accepted as a single entity but it must be recognised as a collaboration that relies on the interactions between organisations' borders. On the contrary, Gilbert and Gips (2000) assert that even though managing risk is important for an organisation, to assess all possible risks can be devastating for most companies. Therefore, it is more practical and sensible

to focus on risks that will deliver significant impacts on supply chain continuity. At this point, Juttner (2005) suggests that there are at least three components in the supply chain -a supplier, a focal company, and a customer- which contribute in the upstream and downstream flow directly. Therefore, it can be concluded that managing risk in supply chain context is simply more demanding than in a single organisation only.

SCRM is believed to be a new and recent area. Mentzer et al. (2008) note that SCRM is growing rapidly between practitioners and academicians along with the emergence of the globalisation era. The first paper about SCRM emerged in 1995, which later on triggered a number of authors to study it (Paulson, 2004). Although SCRM's popularity has risen, Sodhi, Son, and Tang (2012) argue that the boundaries are endless in scope.

For instance, Singhal, Agarwal, and Mittal (2011) and Goldsby (2009) see SCRM as an extension of SCM with risk as an additional focus. In a similar way, Christopher and Peck (2004) suggest that risk management is an integral part of SCM ideology. On the other hand, some authors believe that SCRM is a an element of enterprise risk management (ERM) (Adhitya et al., 2009; Wagner & Neshat, 2012). From all these notions, Sodhi et al. (2012) have summarised it into three ways to approach SCRM. Initially, SCRM is considered as an extension of SCM, whereas the second approach infers SCRM as a part of ERM but with a more holistic area. The third idea is SCM overlaps with ERM which results in the SCRM area. For the best understanding, the possible scope can be seen in the Figure 8

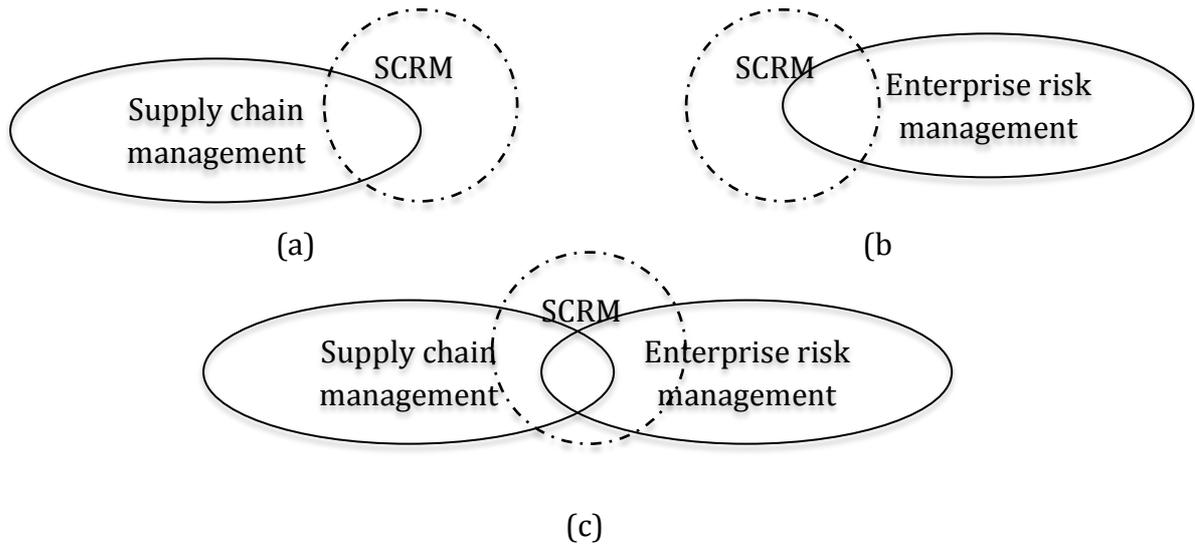


Figure 12. Possible scope of SCRM (a) SCRM is an extension of SCM; (b) SCRM is an extension of ERM; (c) the result is an overlap between ERM and SCRM (Lundqvist, 2014; C. S. Tang, 2006)

It is natural to expect a diversity in the way SCRM is approached. It can be caused by a strong correlation between SCRM and SCM itself. As Ellram and Cooper (2014) state, the term SCM itself can be changed according to the expert's needs and beliefs. In conclusion, with regard to this study, SCRM leans on the first notion – SCRM is an extension of SCM discipline with merely a focus on risk management.

In terms of risk definition, a number of various definitions of risk can be easily found in previous studies (Harland et al., 2003; Ho, Zheng, Yildiz, & Talluri, 2015; Manuj & Mentzer, 2008; Singhal et al., 2011; Talluri, Kull, Yildiz, & Yoon, 2013; Zsidisin, 2003). Nevertheless, the general definition has not been consented yet. Regardless of the unclear definition, Baird and Thomas (1990) conceive a classic idea of risk definition. They recognise risk as a variability of the possible outcomes. Similarly Ghadge, Dani, and Kalawsky (2012) summarise that numerous research refers to risk, disruption, vulnerability, uncertainty, disaster, peril, and hazard. From this point, Jüttner, Peck, and Christopher (2003) argue that despite the general accepted definition of risk, the term risk impact should be differentiated from risk sources. Planning the effective strategies for risk management, therefore, hinges on the best understanding of risk sources. Risk sources in the supply

chain can be sparse due to its nature. The next section discusses the supply chain risk sources of this study.

### 3.3 Supply chain risk sources

There are various ways to look at supply chain risks. Some authors classify the sources differently and use varied terms but yet the definitions refer to similar conditions (Pfohl, Köhler, & Thomas, 2010). Some authors simply identify risks without any classifications (Blackhurst, Scheibe, & Johnson, 2008; Bogataj & Bogataj, 2007; Chopra & Sodhi, 2004; Diabat, Govindan, & Panicker, 2012; Manuj & Mentzer, 2008; Samvedi, Jain, & Chan, 2013; O. Tang & Nurmaya Musa, 2011). Among those writers, Manuj and Mentzer (2008) and (Diabat et al., 2012) focus on supply, demand and operational risk. In line with them, Bogataj and Bogataj (2007) and Samvedi et al. (2013) also approach supply chain risk focusing on demand, supply, and operational risk, yet they add environment risks which refer to outside the supply chain systems.

Other authors classify supply chain risks in two big areas; external and internal (Christopher & Peck, 2004; Kumar, Tiwari, & Babiceanu, 2010; Olson & Wu, 2010). External risks refer to uncertainties and events that come from outside the supply chain such as natural disasters, political problems, and manmade events. On the other hand, the internal supply chain focuses on the core business activities, such as capacity, supply-demand, production, and distribution. While other authors focus on particular areas, O. Tang and Nurmaya Musa (2011) emphasise that risks in the supply chain occur due to distortion in the flows within supply chain entities. Thus, they define the risk sources into material flow, information flow and financial flow.

That said, there are always possibilities that the risks may emerge from other sources and applicability for specific domains may be different. Therefore, modifying and adjustment should be allowed to obtain the best of knowledge. Given the fact that risk sources can be sparse, and considering that the focus of this study on the day-to-day risk, risks categories from

Diabat et al. (2012) were adapted in this study. According to them, risks sources come from supply, demand, and operational.

In this study supply risks reside in potential deviations in the inbound supply chain that may cause failure from suppliers or supply markets so that the outcome results in incomplete orders (Kumar et al., 2010; Manuj & Mentzer, 2008; Zsidisin & Ritchie, 2008). Inconsistency in the supplier's performance will make the focal companies face an unpredictable performance and increase risk subsequently. There are various factors that can trigger supply risk, such as price escalation, disruption of technology, inventory, schedules, supplier bankruptcy, a communication failure, quality of goods, and delays at the suppliers end (Diabat et al., 2012; Ho et al., 2015; Zsidisin, 2003).

Demand risks reside in potential deviations in the outbound flow that may affect the fulfilment of customer orders (Kumar et al., 2010; Zsidisin & Ritchie, 2008). Large variations may emerge from customer order changes, which make the focal company have difficulty in forecasting the actual demand and so it increases demand risk. Sources of demand risk can be from changes in customer taste, shorter life cycle, failure to communicate with customers, volatile demand, and new products (Diabat et al., 2012; Manuj & Mentzer, 2008).

Operational risks reside in potential deviations in the firm that may interrupt the firm's ability to produce the desired quantity and quality at the right time (Kumar et al., 2010; Manuj & Mentzer, 2008). According to Chen, Sohal, and Prajogo (2013) variability in manufacturing can be caused by detractors and the quality of products that are released to the next stations. Detractors can cause machine breakdowns, set-ups, and operator absences, whereas the quality of products can cause the following processes in production to be unpredictable and infuse high operation risks (Chen et al., 2013; Diabat et al., 2012; Manuj & Mentzer, 2008).

There are always possibilities that other risks emerge from different sources but it would not be included in this study such as natural disaster, manmade events, political conflicts.

### 3.4 Conceptual model

Based on the literature review above, a conceptual model was proposed in Figure 13 below.

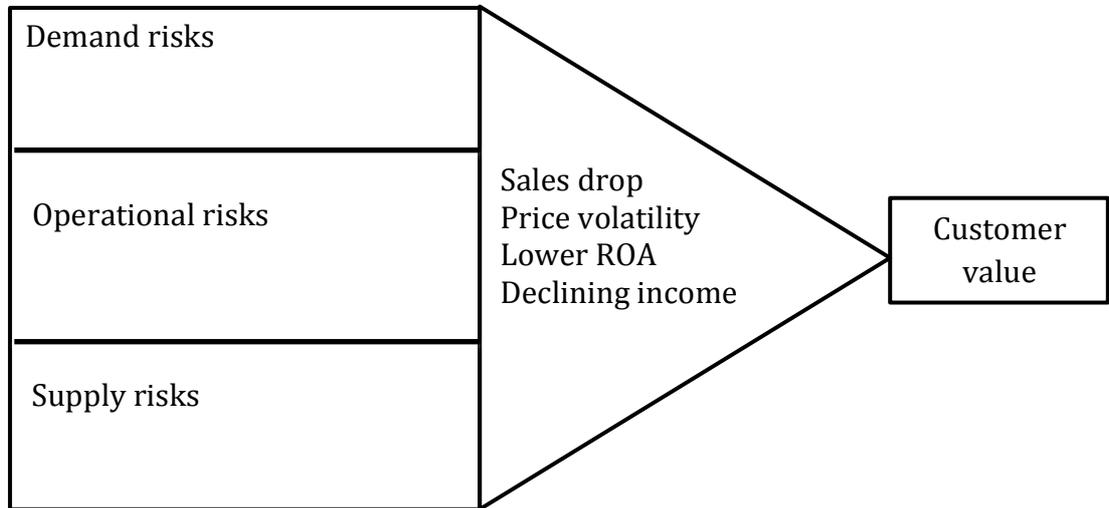


Figure 13. A proposed conceptual model

The model was proposed to give a prediction regarding the focus of the study. As the abovementioned statement shows this study focuses on three risk sources: demand, operational, and supply. The risks from the sources were expected to affect customer value through declining income, sales dropping, lower ROA as well as creating price volatility in the companies.

# 4 Methodology

## 4.1 Introduction

The methodology section provides the research design, data collection and instruments that have been used in this study. In general, this research leans towards a qualitative study, and used case study to gain in-depth data from interviewing the experts from the plywood sector. Along with this, the data analysis is explained in this chapter.

## 4.2 Research objectives and questions

The research aims to investigate risks that are faced by the local plywood industry in New Zealand. To answer this, the objectives are presented below.

4. Identify risks involved in the plywood supply chain
5. Analyse interactions and implications among identified risks
6. Understand these risks and implications for customer value

With those objectives, the researcher therefore chose a qualitative approach because it elaborates on the procedures to attain a lot of information from the participants as well as the bottom line of the situation. The next section provides the researcher's perspective regarding the research design.

## 4.3 Ontological and epistemological perspectives

A philosophical perspective should be considered before planning research since it could impact on the methodology that will be used during it. First, we should understand the ontological perspective. Ontology focuses on the entities of the nature of reality (Collis & Hussey, 2009), in other words, it refers to the way we see the real world. At this point, there are two approaches: objectivism and constructionism. Objectivists see the world's constructs from tangible objects that could have interaction with each other, whereas constructivism believes that it is the interaction between entities or individuals that constructs the nature of reality (Bryman, 2012; Grix, 2002). In addition, Bryman and Bell (2011) illustrate these perspectives using an

organisation as an example. From the objectivism perspective, organisation is tangible and comprises rules and regulations. The people within the organisation are assigned to specific jobs and the hierarchy is built based on the people, job, rules, and regulations. On the other hand, from the constructionism perspective, the organisation is constructed from the interaction of individuals in it. In other words, an organisation exists because there are interactions between people in the organisation. Table 3 below is presented to simplify the difference between objectivism and constructionism.

Table 3. Comparison between objectivism and constructionism (Bryman, 2012)

	<b>Objectivism</b>	<b>Constructionism</b>
<b>Nature of organisation</b>	Tangible object, external to the employee	Social construct, that arises from the interaction of individuals
<b>Organisational drivers</b>	Set rules, procedures, mission statement, processes and structure	Evolving negotiated order, rules, and procedures act as principles leading to a community of practice
<b>Organisational culture</b>	Shared beliefs and values of employees who have internalised commonplace social norms	Emergent reality that is constantly being constructed and reconstructed through the interactions of the employee

Subsequently, we need to understand the epistemology perspective. According to Grix (2002) epistemology is related to the way we gather the knowledge. There are two approaches to the way knowledge should be accepted: positivism and interpretivism (Bryman & Bell, 2011). Positivism approaches the social world using the perspective of natural science, for instance, the way we see atoms, neutrons, or molecules (Grix, 2002; Mertens, 2015). On the other hand, interpretivism is opposing this positivism, and in this position, the social world is approached from the social interaction between humans and their behaviours (Schutz, 1962). In addition, from the

positivism position, theory will guide the research (deductive), whereas interpretivism is when research will construct a theory (inductive) (Bryman & Bell, 2011). Table 4 below summarises the differences between these approaches.

Table 4. Comparison of positivism and interpretivism (Bryman & Bell, 2011)

	<b>Positivism</b>	<b>Interpretivism</b>
<b>Basis</b>	Natural sciences	Human interactions
<b>Approach to social science</b>	Explanation and generalisations of human behaviour	Casual explanation and interpretive understanding of human behaviour
<b>Subject matter</b>	Nature	Social reality
<b>Subject's actions</b>	Inanimate and unmotivated	Meaningful and engaged
<b>Data collection</b>	Observation, codification, and measurement	Comprehend the perspective of the human subjects
<b>Research and theory</b>	Mostly deductive	Strong inductive learning

This research will investigate the implication of managing risk in the logistics area and try to explain the impact on customer value. It will analyse the risk and the impacts based on people's experiences and perspectives. Thus, this study leans more on the constructionism position, where the customer value is delivered by the interaction between the business units and the superior management within the supply chain. From the epistemological perspective, interpretivism approaches concur with this study regarding the nature of customer value, risk, and logistics which is evolving continuously as is the growth of the market.

#### 4.4 Selection of research methodology

Generally speaking, there are two types of methods: qualitative and quantitative. Both of these methods have advantages and disadvantages. Therefore, it is necessary to understand the distinction between them, since the right method might lead to the right answer for the research.

Quantitative and qualitative can be differentiated based on the research design used in the experiment (Neuman, 2006). Quantitative leans to a deductive approach, since it tries to prove the theories by analysing numbers, statistical data, and measuring it. Even though it may collect the data using interviews or questionnaires with open-ended questions, the analysis refers to a predetermined structure and measurement to test the hypotheses. Quantitative tends to adopt natural sciences to see the social phenomena. In this context, the phenomena might be studied independently without considering the player in it. Thus, it indicates the ontological position for a quantitative approach is objective, whereas the epistemological perspective is positivism.

On the other hand, qualitative research is commonly known as research without numbers. Qualitative entails an inductive approach since it tries to generate the theories based on the phenomena. Qualitative is in accordance with constructionism, which believes in human interactions and social construction that build the social phenomena. With the tendencies to interpretivism, qualitative research answers the questions why and how, not only just what, when and where. In order to answer these questions, data collection in the qualitative method is conducted mostly using observations, words, and images.

Even though each method can be used, the selection should consider the purpose of research (Page & Meyer, 2000). The main differences have therefore been presented in Table 5 below.

Table 5. Comparison between qualitative and quantitative (Page & Meyer, 2000)

	<b>Qualitative</b>	<b>Quantitative</b>
<b>Approach</b>	Discover meaning	Test hypothesis
<b>Concepts</b>	Themes	Distinct variable
<b>Measurement</b>	Flexible, ad hoc data requirements dependent on settings	Standardised, predetermined data requirements
<b>Data</b>	Observations, words, and images	Precise and quantitative
<b>Reasoning</b>	Inductive	Deductive

<b>Procedures</b>	Tailored	Standard and replicable
<b>Analysis</b>	Construction of generalised and coherent picture through rich descriptions	Statistical analysis, table, and chart to test hypotheses
<b>Epistemology</b>	Interpretivism (social science)	Positivism (natural science)
<b>Ontology</b>	Constructionism (interactions)	Objectivism (tangible object)

From the ontological position as constructionist, I see that the supply chain is the result of the interaction between organisations in it rather than comprised of numerous organisations. Thus risks in the supply chain occur, as there are interactions between supply chain functions and the events outside. Both of them may work against each other, and it makes these events to be seen as barriers or risks for supply chain goals. Subsequently, from an epistemological position as interpretivist, risks in the supply chain should be investigated by interacting with organisations and people in it. Hence, a qualitative method is chosen to conduct this study.

#### 4.5 Research design

This research used qualitative study, which refers to the case study setting in the supply chain in New Zealand. Using a case study can give depth analysis. Even though the findings might not be applicable for every similar case, it gives the depth perspectives. Questions such as what, why and how can be answered using an exploratory study. The characteristics of the exploratory study are a loose structure and procedure, which opposes the formal study. The formal study tests the theories with fixed procedures and specifications.

For the data collection method, communication is used rather than monitoring. With communication, the researcher was helped during the interview because through this the researcher indirectly engaged with the information given by the participants. The interviews were semi-structured so during them the researcher changed some questions to gather an in-depth understanding.

In this study, the interviews were held in the mills of the companies participating in this study. The locations indicate that this study was a field study rather than a simulation and experiment. Visiting to gather the data helped the researcher to elaborate during the interviews in order to have more information regarding the aim. However, due to the limited time, a cross sectional study was used which captured the events at the one time. In this case, the events were all the information presented by the interviewee on the day of interview. The author then reported the results as what happened in the field.

## **4.6 Detailed description of research approach**

### **4.6.1 Measurement**

Measurement is one element to confirm the quality of data. The quality of data can be determined by looking at the validity and reliability of the data itself. While most quantitative researchers depend on these characteristics, Bryman (2012) argues that developing the measurement is not substantial in qualitative research. However, he also suggests that reliability and validity can be adapted in qualitative research by altering the meaning rather than modifying the measurement establishment. Similarly (Neuman, 2006) explains how reliability and validity could be used in qualitative research.

#### **a. Validity**

Validity is associated with the truthfulness of study, meaning that data should be authentic (Neuman, 2006). As the data collection would be through face-to-face interview, it should reflect the truth and authenticity of the data. However, in quantitative perspective, validity refers to the accuracy of the instrument (Bernard, 2013) . By contrast, Bryman (2012) states that in qualitative research the instrument is the investigator itself. Thus, Hesse-Biber and Leavy (2006) propose triangulation to enhance validity in qualitative research. As such triangulation in this study will refer to the respondent validation. The validation in

this study is by interviewing three major plywood suppliers in New Zealand. In addition to that, cross reference was held in every organisation by talking to some people from the same organisation.

#### **b. Reliability**

Reliability relates to the constancy of the study. It leans towards quantitative research rather than qualitative since it means that the study should be replicable in identical conditions or population so the same result could be delivered (Ritchie & Lewis, 2003). At this point, Neuman suggests that reliability in qualitative research should not be seen from the replicability of the sample.

The reliability in this study increased because all the participants were interviewed using a semi-structured interview. Although the semi-structured interview is rather flexible in terms of the question order, the aim and objectives remain the same. The aim and objectives in this study were used as a guide to elaborate on the questions.

#### **4.6.2 Participants**

An important step in a study is choosing the right sample. According to Marshall sampling represents the total population. As such there are two types of sampling approaches: non-probability and probability, which can be distinguished from the probability of being chosen (David & Sutton, 2011).

For this research, the non-probability sampling was considered more relevant to conduct this case study. In non-probability sampling, the member has a different chance to be selected from the population (Hesse-Biber & Leavy, 2006). Therefore, the strategy that had been used to approach the participants was a combination between purposive and snowball sampling. The participants were selected based on the companies. The researcher tried to get in touch with plywood manufacturers by using some list of companies that the researcher wanted

to get in touch with. Then the general inquiries were made to those companies on the list. Along with that technique, the subjects were also recruited based on the researcher acquaintances’.

In the end of study, the participants were obtained from the three biggest plywood manufactures in New Zealand. Two mills are located in a Northern area and the other is on the West Coast, South Island. The total participants were 10 from those mills. They came from different positions in the plywood supply chain, but have been participating in the plywood industry with a minimum experience of 10 years. In detail, the participants were, forest managers, mill managers, supply chain staff, supply chain managers and production staff.

#### **4.6.3 Data collection**

The data itself was categorised into two types either primary or secondary data. The primary data refers to the information that is obtained directly from the subject whereas the secondary data is collected by other researchers (Bernard, 2013). With the objectives of this study, the primary data was required because the recent events as well as perspectives were needed to represent the actual situation in the industry. Page and Meyer (2000) admit that using primary data would be more accurate, consistent, and reliable to answer the questions. On the other hand, Cooper and Schindler (2014) argue that collecting data directly to the target could be exhausting for a researcher since it there might be a lack of access, and it could be time-consuming, and expensive.

The primary data was attained by communication, and in more details, by interviewing the participants. This is even though, there are three ways to gather primary data – observation, communication, and experiment- according to Neuman (2006). The communication was chosen as the most convenient way to obtain the in-depth information from the participants. Therefore, the communication was used to conduct the interviews.

The interviews were semi-structured, which is a combination of structured and unstructured technique. In a structured interview, the questions need to be prepared with a specific order, whereas unstructured explorations take precedence over the questions. As such, in this research, the main questions were determined before the interview, but while conducting the interview there was no strict adherence to them. New questions may emerge during the interviews as the issue was explored. The outcome was the duration for the interviews varied. In this study, they last up from 30 minutes to 120 minutes for each participant. This approach is supported by Myers (2009) who suggests that the interview is a prominent technique in the business and management area.

Secondary data was used as additional resources. They were collected from the internet, libraries, journal articles, government reports, and international organisation reports that are published on official websites. Some authors assert that using secondary data might be not enough to answer the question and it is likely that the sources are less accurate (Hesse-Biber & Leavy, 2006). Similarly Ritchie and Lewis (2003) argue that the researchers might misinterpret the sources as they have different objectives from the current study. Nonetheless secondary data is easy and faster to access than primary data. Secondary data in this study helped the researcher to develop and enhance the study easily based on the understanding of findings and conclusions from the previous study.

#### **4.6.4 Data analysis**

After collecting all information from the sources, the next step was organising the information and analysing it. According to the previous discussion, the data was collected through interviews in the selected subjects. The information obtained consists of words rather than numbers. This process used Nvivo 10 for Mac to help the categorisation. The following were the steps to analyse the data.

1. Organising the data

This was an initial stage of qualitative data analysis; all notes and tapes from the interviews were transcribed into textual format. While transcribing the raw material data, a selection was made by checking and reviewing the quality of the information. The selection intended to grade the information that was related to the research questions. During this process, the researcher also made contact back to the participants to acquire more data and confirm some of the information that might be confidential.

## 2. Building the themes

After finishing the transcription and rereading, the scripts were input into the software as a database. The specific ideas were discovered through reading and transcribing the interview scripts. As the researcher read the script there were some ideas found and these were narrowed down based on the frequency. The tapering processes intended to make up the bigger picture of the situations that were found from the interview.

## 3. Connecting between themes

The next step after building the themes was identifying the relationship between these themes. The themes were connected to the triggers, and effects as well as the strategy that had been implemented by the organisations. The relationship was then drawn together to explain the relationship of the pattern.

## 4. Interpretation

Finally, the last step was interpreting what was happening in the field. It drew the findings and is discussed in the following chapters. There was additional information that is not related to the research. This additional finding was found during the analysis, which is essential for further research is presented in the recommendations part.

#### 5. Case study setting

This study was conducted by interviewing people from organisations in the New Zealand plywood industry. The researcher sought access to the organisations through emails and telephone calls including the companies' facilities, personnel and information, which was needed for the interviews. Any confidential information was destroyed after the study is finished and the information remains confidential to the other parties.

#### 6. Participants

The participants were queried by the researcher from the initial contact to ensure that there were no offensive questions or situations that endangered the companies. The participants were asked about willingness and there was no coercion during the interview. The participants were informed that they were able to withdraw from the interview at any time.

#### 7. Investigator

To initiate the interviews, the researcher explained the purposes and procedures prior the interview. During the data collection, in depth and thorough interviews were conducted, and the researcher was obliged to make the participants comfortable. The researcher committed to keeping the anonymity and confidentiality of the participants when presenting the study.

### **4.7 Ethical consideration**

Ethics in this research became important, as there were human individuals and organisations who participated in this study. The aim of the ethical consideration was to assure that the subjects who were participating in this study could not be exposed to harm. They were asked to sign at paper,

which contained the agreement from the subject to participate in the study and some provisions.

#### **4.8 Critical review research methodology**

There is a level of subjectivity involved regarding the chosen methodology. First, in terms of the participants, the number was very small because the population is also very small. There are only three plywood manufacturers in New Zealand. Therefore, the results are exclusively relevant to the New Zealand plywood industry. Furthermore, since the case study approach was used in this research, it could be difficult to find an appropriate study to suit this case.

# 5 Survey result

## 5.1 Introduction

This chapter provides information to answer research questions in this study. It begins with general information about the participants then is followed by profiles of the plywood industry in New Zealand. Furthermore, the main findings are presented regarding the risks in the plywood supply chain.

## 5.2 Participants

To obtain comprehensive information for this study, the information was collected from 10 participants. They have different backgrounds and come from the total population of the plywood mills in this country. The participants also work in various functions of the companies' organisations, which is from the senior level to down through planners and specialists at the tactical and operational level. Therefore, despite a small number of participants, they are considered to have represented plywood companies in New Zealand. Moreover because of the small number of the participants, to comply with participants' confidentiality there is no specific information regarding the respondents' backgrounds related to which companies they work as well as their position. This is because there was an agreement that information of each participant would be kept anonymous at the beginning of study and prior to the interviews.

Interviews with forest managers give an understanding regarding challenges and benefits from the supplier side. Other participants, who come from middle management provide broad information in the supply chain processes and activities for short term plans as well as recent issues in the field. On the other hand, top management give a bigger picture related to long-term plans and the current status of the company of industry. With an extensive view of supply chain functions and comprehensive expertise, the information in this study provides solid insights into the objectives of this research.

### 5.3 General profile of plywood industry in New Zealand

New Zealand is considered a small country and is remotely located from other countries. In addition, the market in New Zealand is also small in comparison to global demand. All these conditions can be attributed to New Zealand's dependency on external sources in order to achieve the living standard as well as a long sustainable economic growth (Nees, 2005).

Generally speaking, the living standard in a country is affected by economic growth and the condition of the country. As such in New Zealand, to maintain as well as increase its economy, this country depends heavily on international trade. As at the end of December 2015 total exports of goods and services were \$69.3 billion whereas total imports were only \$66.9 billion (*Goods and services trade by country: year ended December 2015*, 2015). This is an indication that New Zealand has a dependency on export earnings. However, it is noticeable that a significant portion of total exports from New Zealand is contributed by various sectors such as dairy, meat, and forestry.

The forestry sector contributes through wood trading in domestic and international markets. In these markets, products are available in various types such as logs, sawn timber, wood chips, plywood, particle board, poles, etc. (*Forestry Info Graphic*, 2012). From all the variant wood products, plywood is considered to be a high value product due to its unique structure which can be used for multifunctional purposes. For that reason, plywood has a wide-ranging market and can be easily found in many home hardware distributors as well as retailers in New Zealand.

On average, total domestic demand from local distributors and retailers in New Zealand is about 90,000 m<sup>3</sup> plywood every year. To meet that demand, the plywood is supplied by local and international suppliers. Even though local companies had once dominated the local market, currently they are only able to occupy 50% of the total demand while the remaining portion is open to Chinese and Chilean plywood suppliers. To occupy half of total demand, there are three local mills in New Zealand which are located throughout the country. With two mills based in the Northern area, whereas the other is located on the West Coast, South Island.

One mill in the South Island started to become a New Zealand privately-owned company in 1991. This mill is situated 10 km south of Greymouth, West Coast and employs 100 staff which is also the only plywood mill in the South Island. The mill generally consumes 40,000 m<sup>3</sup> logs of Pine Radiata to produce 20,000 m<sup>3</sup> plywood every year. The logs are high end timber consisting of 45% pruned logs and 55% un-pruned logs that come from the forest area in the South Island such as Marlborough, Blenheim and North Canterbury. There are two types of plywood produced in this mill: structural and non-structural plywood within a range thickness from 4mm to 32 mm. This mill concentrates on domestic demand in New Zealand through a network of builder's merchants and retailers such as ITM, Mitre 10 and Placemakers, although some product is exported to Australia and the Pacific Islands.

The second mill is based in the North Island. This mill is a New Zealand-based and registered company, but basically it belongs to a Japanese organisation. It has been involved in New Zealand forestry for the past 20 years by owning the legal rights to cutting down the forest, processing operations in New Zealand and finishing operations in Japan. Their forest area is located in the Northland, East Coast and Wairarapa regions of New Zealand's North Island. In the same location, this company also runs five mills located in the Wairarapa, Gisborne, Masterton and Kaitia but only three of them effectively run and produce more than 60,000 m<sup>3</sup> plywood annually. They produce standard plywood in New Zealand with a range from 7 mm to 19 mm for thickness and 900 x 1800 mm for width. However, in terms of market, this mill focuses on Japanese market by roughly exporting 70% of their annual production to this market, whereas the remaining 30% goes to the domestic market in New Zealand.

The third mill is also located in the North Island at Tokoroa. This company focuses on the New Zealand and Australia markets and owns distributors in both countries. In New Zealand, the distribution centre has grown throughout the country including growth regions like Auckland, Waikato/Bay of Plenty and Christchurch. This makes the plywood easily

found at traders or retailers e.g. Placemakers and Bunnings. The company exports about 30% of its annual production to Australia and 70% goes into the domestic market in New Zealand. In some cases, the plywood can also be exported to the Pacific Islands and the USA.

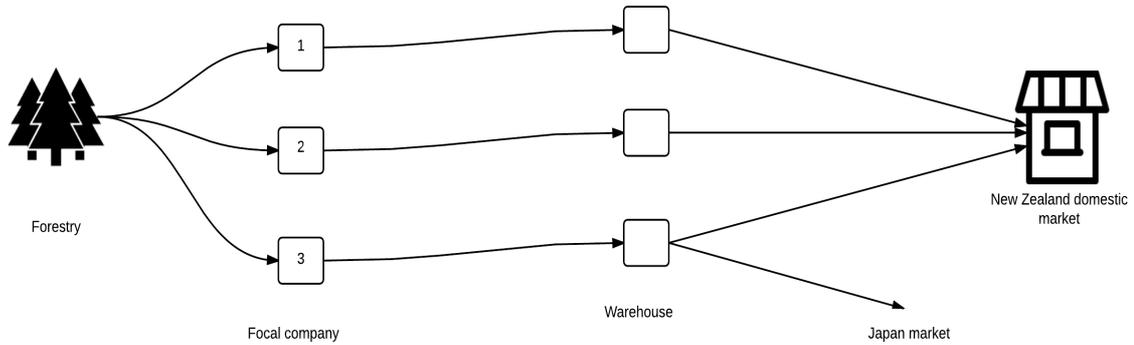


Figure 14. Plywood companies in New Zealand

The general situation of the plywood industry in New Zealand can be seen in Figure 14 above. Basically all three mills in New Zealand produce a similar standard range of structural and non-structural plywood with a different production capacity of each plywood mill. The Japanese mill in the Northern region can be considered to have the biggest production capacity of all the mills in New Zealand. The second largest capacity is the other mill on Tokora and the mill in West Coast became the smallest mill in New Zealand with regard to its production capacity. However, apparently the size of production capacity is not necessarily associated with market share in New Zealand.

First, the mill on the West Coast is the only plywood mill in the Southern region, which makes their focus market on the New Zealand's South Island. There is a possibility that their products could be sold in the Northern area but it seems difficult for the West Coast mill to penetrate the market in the North Island. This is because the two other plywood mills are headquartered in the North Island which make their distribution to market there is easier.

One of the mills in the Northern area is basically owned by a Japanese organisation. The company focuses on filling the Japanese demand for plywood instead of meeting the New Zealand demand. Therefore, this mill is considered to be a plywood supply chain for the Japanese market rather than a plywood supplier for New Zealand's market. With that condition, it leaves the other mill in the North Island to dominate the market in the Northern region. Moreover, since this mill has considerably bigger capacity than the mill on the West Coast its market has expanded to the South Island since the natural earthquake disaster in Christchurch in 2011.

In conclusion, apparently there are only two major players in New Zealand domestic market: one mill on the West Coast of the South Island and one in Tokoroa in the North Island. The Japanese mill is considered to play a small part in the New Zealand market as they only have a small market share in domestic market segmentation. This company focuses on Japanese market rather than competition in the New Zealand domestic market with other local mills.

#### **5.4 New Zealand plywood in the world**

New Zealand has a small plywood market compared to other countries. First there are only three plywood companies that exist. Secondly, because of the remote location and low population in this country it makes market demand lower than other countries with higher populations. In addition, the participants claim that the New Zealand market has been threatened by other countries with bigger plywood mills. Major competitors from overseas are China and Chile. Both products come to New Zealand as non-structural products and have a lower price than New Zealand plywood, but the quality is less than plywood from local mills. Chilean products are known to be okay for some customers whereas China is famous for its extraordinarily cheap price yet the quality is questionable.

The Chilean forest industry is considerably larger as their forest area occupies 21.5% of the country. The area can be divided into 86% of natural forest and 14% plantation area. Of the plantation area, Radiata pine takes

around 64%, which is noticeably bigger than New Zealand's plantation area. Similar to New Zealand, the forest industry in Chile is dominated by three companies who run the majority of mills. Two companies control 70% of Radiata pine plantations and make up 72% of the total export market. The overseas markets are destined mainly to China and the USA. Their market has changed slightly due to the economic crisis in 2008. The situation is explained by one of the participants' statements:

*"..they tend to their main market, which is in the States (USA). But when the USA has a slow down market, all of the sudden Chilean mills have overcapacity and they tend to look at places like Australia and NZ."*

From the statement, it can be said, that when the economic crisis started, plywood market in the USA dropped while capacity production in Chile remained stable and they needed to allocate the product to other countries. Due to the distance between Chile and New Zealand as well as Australia, both countries are considered reasonably open as new markets for Chile.

Since Chilean products came to New Zealand, apparently it has changed the domestic market in the country, which is considered as a threat for local mills. As stated:

*"Chilean products are very good quality, and the Chileans also have done a lot of work on getting international standards for their products. They put up their standard for their manufacturing facilities; they do it very, very well."*

This statement indicates that Chilean products are perceived to be good enough to compete with local plywood quality. With improvements to international standard, Chilean products will be able to interfere in and dominate the New Zealand market. This is because Chilean plywood mills seem to have bigger capacity. In addition, another participant adds that:

*" they are (Chilean industry) supported and subsidised by their government. And because they are still developing countries, they had this put in and they exported their product in very competitive and they make a good product".*

All the situations above indicate that Chilean products have potential for competing with the New Zealand market in price and quality.

Besides Chilean products, Chinese products are also ever growing in presence. Chinese plywoods are very competitive in terms of price in the New Zealand market. There are several reasons why Chinese products occupy first place as the cheapest plywood.

The first reason was claimed by the statement from a participant: “*In China, it's more about working in a slave factory*”. It is widely known that China has very cheap labour rates. In fact, as per 1 November 2015, the minimum wage in China per hour is \$0.80 per hour whereas in New Zealand it is \$14.75 per hour (Stat, 2015). This indicates a big gap between New Zealand and China labour rates, which likely makes Chinese products cheaper than plywood from local mills.

The second reason is the plywood industry in China has been growing expansively. At this moment, there are nearly 5,000 mills that actively produce plywood for local and international markets. Even though most of the mills are still considered as small medium enterprises (SMEs), they have been able to satisfy local demand with two-thirds of the total production (Minli, Toppinen, & Hänninen, 2010). With this rapid plywood industrial growth, China will have a big chance to sweep off the New Zealand market.

Furthermore, the absence of import tariff in China, particularly for raw materials e.g. logs, has exaggerated the competition in New Zealand. Foresters in New Zealand are likely to sell logs to China as they are able to pay higher than local mills. With support from government and lower tariffs to import, China could easily supply their mills with cheap raw material. With cheaper low material and lower labour rates compared to New Zealand, this makes the total production of plywood in China lower than New Zealand. The result is Chinese plywood is cheaper than plywood from local mills in New Zealand.

However, one participant claims that Chinese products are relatively questionable, as they state: “... *Chinese product is very bulky in thickness, its*

*inner layers are suspect, outer layers are very good...".* Chinese products in New Zealand are recognised as having the lowest quality compared to other products: Chilean and New Zealand plywood. Some articles reported there are issues and potential risks of buying sub-standard plywood from China ("Chinese plywood alert," 2002; "UK imports first 'legal' plywood from China," 2010).

To sum up, the situation of plywood industries in New Zealand can be illustrated in Figure 15 below.

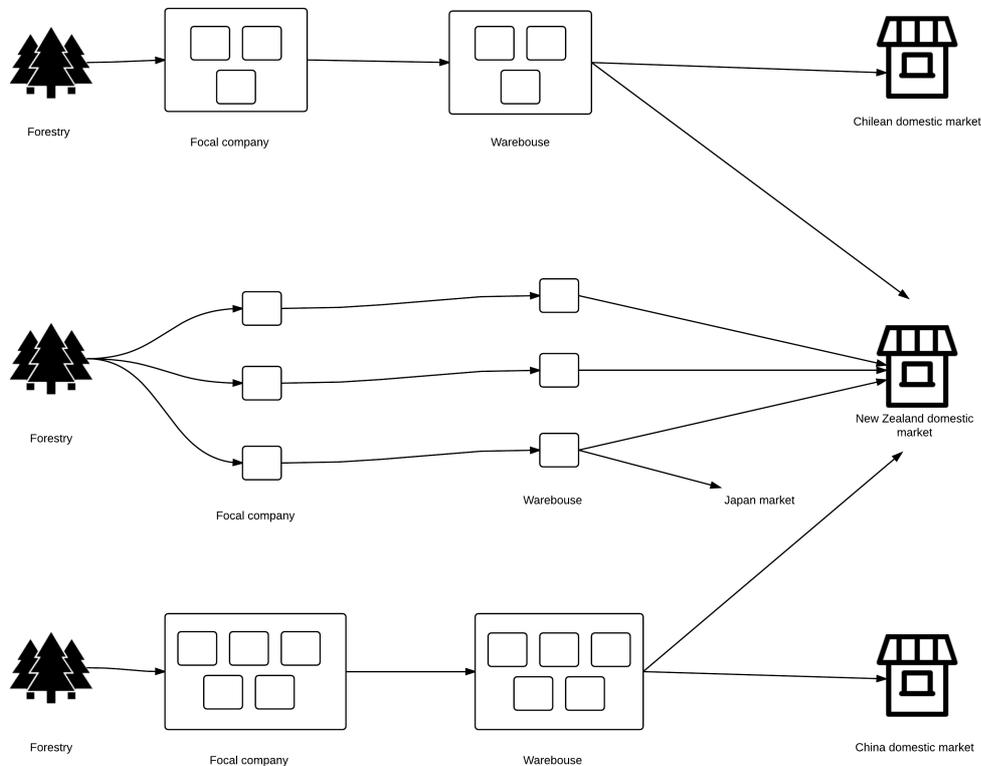


Figure 15. New Zealand plywood supply chain and others

As can be seen above in Figure 15, in New Zealand there are three big plywood mills as major suppliers in the domestic market. Along with that, there is overseas plywood mainly from China and Chile that comes to the New Zealand market. Local mills take around 50% of the total demand of domestic market in New Zealand, whereas the remainder is controlled by

overseas mills from China and Chile. However, the detailed distribution of market share between the local and overseas mills is unidentified.

## 5.5 Identifications of risks in plywood supply chain

To answer the research questions, all participants in this study were interviewed and asked about all risks that have occurred in the plywood industry. At first the participants were given an idea of the proposed conceptual model to provide the focus of the risk scope. This conceptual model was based on an initial assumption regarding risks and exposure of companies within the supply chain. An additional provision of the model to participants was expected to facilitate them in collecting and providing information regarding events in the past that are relevant to the purposes of this study.

The model that was presented to the participants can be seen in Figure 13 above. In the model, risk sources have been classified into three big areas: supply risks, demand risks, and operational risks, which refers to Diabat et al. (2012). Referring to this model and the initial assumption, the interviews were conducted and then transcribed. Furthermore, the transcripts were analysed using a thematic analysis.

### 5.5.1 Demand risks

From the demand side, two themes were found during the analysis: fluctuating demand and market competition. Fluctuating demand in this study is associated with any variations in demand from the plywood manufacturers' perspective. There are different terms used to explain the variation such as such as *"seasonally adjusted"*, *"sales fluctuated"*, *"unexpected demand"* and *"accuracy of forecasting"*, but all terms referred to changes in demand. The words were used by the participants not only to confirm the variations in customer demand but also to indicate causes of the variations.

The second theme is market competition, which was considered as one of the triggers in demand risks as all the participants believed that there is competition in the market. The competition noticeably comes between the local plywood manufacturers since they have the same

market. However, some of the participants also said that there are also competitors from overseas, particularly China and Chile, that tighten the competition in the New Zealand market.

### 5.5.2 Operational risks

There are three themes considered as operational risks: machine breakdown, inventory and people. First, when the participants were asked about threats from the operational side they instantly referred to machine condition by stating *“machine breakdown”, “plant breakdown”* and *“old machine”*. Machine breakdown is still considered as an operational risk, even though it is rather a manufacturing problem. This is because the impacts of machine breakdown could affect the production as well as other parties in the supply chain, e.g. customers’ late delivery.

The second theme is inventory, which plays an important role in production continuity and the quality of products. As one participant says: *“... if inventory goes low, you don’t have enough to make and if the inventory is high, the quality may drop.”* The statement shows that the inventory level in mills can affect the production process in the mills.

The last one is people, who are considered as one operational risk based on participants’ statements:

*“We are not prepared for the labour who are not turning for work”.*

*“New Zealand has a very bad attitude toward safety. We take risk we don’t need to take”*

*“Health and safety across the border are important”.*

The statements above indicate that people are able to trigger such operational risks from their attitude and behaviour.

### 5.5.3 Supply risks

When the researcher asked the participants about the risks from the supply chain, every participant responded differently. This is because mostly the participants work in plywood mills which are positioned somehow in-between customers and suppliers in the supply chain. As a result, the responses were basically based on how the participants looked

at the companies' position. On the one hand, mills can be seen as a supplier that is the source of plywood, but on the other hand mills can be a customer that needs logs from the forest plantation.

As the supplier, the participants referred to three major risks: log quality, log prices and continuity of raw material. Based on the interviews, the participants believed that three of those risks are correlated to each other. Log quality is in the first place as the most important priority. This is because during the interviews most participants stated log quality in the first place when a question of supply risks arose. The second place of threats is log price. Log price was related log quality by the participants because just like in many cases the quality is always followed by price. Thirdly, there is a threat from continuity of raw materials. Most of the participants referred to log supply but there is also a possibility comes from other material e.g. glue.

The last threat is transportation and distribution. This threat was considered different to other threats since it is likely to refer to the mills as a supplier in the supply chain. In terms of transportation and distribution, the participants agreed that delays to the delivery of goods or final products to customers could be one of the failures in transportation and distribution. Meanwhile, this risk can also put the mills as a customer in the supply chain. This is because plywood mills need to be supplied with raw materials, so therefore any delays or disruptions in delivering logs to the mills also can trigger supply risks.

To summarise all the identified risks from the interviews and analysis are presented in Table 6 below.

Table 6. Identified risks

<b>Demand risks</b>	<b>Operational risks</b>	<b>Supply risks</b>
Fluctuating demand	Machine breakdown	Log quality
Market competition	Inventory	Log prices
	People	Continuity of raw material
		Transport and distribution

During the interviews additional risks outside were identified: regulation, globalisation, environment, and financial. These factors are considered as risks in the supply chain as according to most the participants they have the potential to threaten the continuity of business. Some of the participants suggest that these factors can be included into the classification. Nevertheless, due to their small frequency of occurrence, the factors are categorised into external factors.

## **5.6 Factors and implications of risks in plywood supply chain**

The occurrence of risk in the plywood supply chain has certainly been triggered by some factors. To understand what the causes of risks are and the implications, each risk is discussed separately in this section. The discussion is presented in groups based on the classification of risk sources.

### **5.6.1 Demand risks**

Demand risks provide potential deviations in outbound flows that may affect the fulfilment of customer orders (Kumar et al., 2010; Zsidisin & Ritchie, 2008). With regard to this definition and the interviews, there are two major risks in demand are determined: fluctuating demand and market competition.

#### **a. Fluctuating demand**

Predominantly the participants define fluctuating demand as a condition when there are spikes in annual demand. However, factors that influence this risk were seen differently due to the participants' backgrounds. First, respondents from top management stated that,

*“The demand fluctuates with housing, pretty much, the demand is how many houses that people want to make”*

*“it’s fluctuated a little bit, it seasonally adjusted with the housing”*

The statements show that the participants consider that variation in plywood demand is strongly associated with housing demand in New Zealand. In more detail, plywood demand usually drops during wintertime and this condition is caused by decreasing house demand in the market. Reduction in housing demand exists because people start to lessen housing construction due to moisture and rainfall that softens the ground, which makes it difficult to build houses. Thus, it can be said that plywood demand in New Zealand is seasonal. Johnson (2001) finds the same thing in his study. He notes that companies should expect to have seasonal fluctuations in their demand. Seasonal demand is able to be controlled because it has a regular pattern of plywood demand every year: demand drops during winter but rises in summer. However, since the changes during summer and winter cause a variation in the plywood demand every year, it is considered as one of the factors that triggers fluctuating demand.

The second reason for fluctuating demand comes from operation management. Stated by a numbers of employees from the operational level below.

*"It is easy to predict in aggregate level, but when it comes to lower level, the demand is different"*

*"...we don't know what kind of a product, what kind of plywood in terms of at a Stock Keeping Unit (SKU) level. The forecast will match very well at a family group level because they may forecast to the particular family. But instead of selling 2.4 metre or 8 ft. long, that month, they may be asking more than 2.7 metre."*

*"One major risk that we face here in this site is the accuracy of forecasting from sales and from the market, because if we don't have a forecast, we don't know what to plan. Like I said, we make, 300*

*varieties, if we make full pack, and half pack, we still make more than 200 varieties”*

*“if we get the forecast wrong there, we cannot plan log supply correctly, because we need certain quality of logs, for different things.”*

*“So the risks, the business risks are the forecast is not correct and if it is wrong.”*

Based on the interviews the participants focus on inaccurate forecasting periodically. A deviation between forecast and actual demand is expected in every period due to forecast methods. Demand in the mills usually be forecasted in aggregate level rather than per item or SKU but customer buy on SKU level not at aggregate level. What is more customers preference for products is always changing which makes forecast more difficult for the mills. Particular in New Zealand, one participant stated:

*“They want plywood have a clear faces, pruned clean veneer, they usually for C grade face 2 mm has to be parted and if it has live knots on the face, people presume that is D”.*

From the statement above it can be said that New Zealand has a unique characteristic of plywood preferences. Customers in New Zealand have been spoiled with a good clear plywood with a certain grade and recently good quality of pruned logs has been decreasing steadily for the last 7 years. This can be seen in Table 7 below.

Table 7. Composition of pruned and unpruned logs (MPI, 2013, 2015c)

	2007	2008	2009	2010	2011	2012	2013	2014
<b>Pruned</b>	61%	59%	60%	60%	59%	58%	57%	54%
<b>Unpruned</b>	39%	41%	40%	40%	41%	42%	43%	46%

Decreasing pruned logs makes plywood in the market with the same quality as before is seen differently by customers. Customers assume that plywood quality in the market is lower than the standard quality in New Zealand. As a consequence, the mills have to produce plywood with higher quality but sell it at a cheaper price.

Similar to this study, Diabat et al. (2012) find that customer preference in food industry affects changes in demand. In their study, they put customers as the major reason for fluctuation demand which can be customer taste, failure in communication with customers, increase customers bargain power which lead to demand volatility.

Throughout the discussion above, there are two major factors that can influence fluctuation in plywood demand: housing demand and forecast inaccuracy. Housing demand influences variation in plywood demand with its seasonality, whereas inaccuracy forecast is controlled by customer preferences in New Zealand. To overcome the fluctuating demand in plywood, the management decided to build an inventory during winter when the mills make another variant of non-structural plywood.

#### **b. Market competition**

The second challenge from the demand side is about the New Zealand plywood market share. This is showed by participants' statements below:

*"We have got competition in the market from the local mills. We that competition in the market, and you also have got a really significant imported product. We have a lot of plywood being made in Chile that is imported here."*

*"China is ever growing in presence, and Chinese quality is improving"*

*"so the competition that comes from specifically the Chileans plywood is actually good thing."*

*"The risk outside is just pure by competition."*

*“The imported product comes in non-structure, so it has non structured quality, it does but it states it’s a non-structured, other wood they put in the building which requires some pressing this stuff will not occupy. But we still seeing some made project with imported plywood, they use non-structured product. Simply because the price, otherwise they don’t care.”*

*“New Zealand is relatively a small market than global marketplace”*

*“I said, New Zealand market has been very insulated from very long time. So the price will be very very high and you can pretty well dictate the terms, but that is no longer case.”*

All the participants concur that this market share has changed recently. It because the market in New Zealand is small and there are more products available in the plywood market from international and domestic industries. On the one hand, the situation benefits customers in New Zealand, but on the other hand local mills suffer as the competition in the market increases. In addition, from the statements above, the participants also imply that they are threatened from imported plywood rather than local product. The situations indicate that New Zealand industries not well prepared for competition in the market.

Market in New Zealand is rather an oligopoly market. A few companies have dominated New Zealand market for a very long time and during that time they were able to dictate and control plywood price easily for years because the market was small and isolated from other competitors. The condition has been changed recently possibly due to globalisation, increasing population as well as demand from customers.

For the last few years plywood demand increased progressively, but local mills have limited capacity which opens more opportunities for competitors from overseas. In fact, at this moment on average plywood demand in New Zealand annually is estimated

about 90,000 m<sup>3</sup> per annum. With this amount, the local mills would be able to cover only 50% and the remaining will be covered by imported plywood from overseas.

Imported plywood that is available in the New Zealand market mostly comes from Chile and China. Both Chilean and Chinese products have cheaper prices than local plywood from New Zealand mills, which is a major reason they have successfully interrupted the local market. As stated by one of the participants *“the customer buys on price and they perceive the Chilean product to be okay; they perceive the Chinese stuff to be you get what you get pay for.”* In this statement, he also implies that price makes competition harder for local plywood mills, but he questions the quality of imported plywood.

Overall, market competition in New Zealand is influenced by changes in market share which is particularly caused by more competitors' products in the local market. To control the risk, the government and companies have implemented strict certifications, EWPA and ANZ/AS 2269, for structural plywood that comes to New Zealand. EWPA stands for Engineered Wood Products Association of Australasia and this organisation provides services regarding the certification of plywood. Plywood certified by EWPA is stamped with EWPA and JAS-ANZ (Joint Accreditation Scheme of Australia and New Zealand). The stamps function as a brand on plywood, which indicates that the plywood has been manufactured under a quality control and product that is relevant to the Australian and New Zealand standard. The manufacturing standard to process structural plywood is determined in ANZ/AS 2269.

In fact, many products from China and Chile are mostly non-structural plywood but are sometimes used as structural plywood in New Zealand. This situation indicates that customer preferences or choices in terms of buying products cannot be controlled. Thus, at some point market competition seems hard to be managed, even in a

small market like New Zealand. Olson and Wu (2010) suggest that risks from competitors could be considered external risks, which cannot be controlled, and it is a never ending threat.

### 5.6.2 Operational risk

Operational risk in this study resides on potential deviations in inbound supply chain that may cause failure to fulfil customers demand (Kumar et al., 2010; Manuj & Mentzer, 2008). From the interviews, there are three typical risks in the mills: machine breakdowns, people, and inventory.

#### a. Machine breakdown

Most participants from the interviews agreed that machine breakdown is one of the critical issues in the operation that mostly occurs during plywood production as shown in the statements below:

*“The operation risks, you have got machine breakdown”*

*“These breakdowns, you can probably say about that one, the recoveries = reworking whip products. So people make mistakes”*

*“Machine failures if the machinery is a bit old”*

*“Mainly the plant breakdown, machinery breakdown, which keeps the... for example if something seriously happen with the lathe, they can be hung up until 3-4 days in the yard”*

*“There is a breakdown, for the machine for the few hours, production is down, so production is down then plan we will have behind plan.”*

Most participants from the interviews agreed that machine breakdown is one of the critical issues in the operation that mostly occurs during plywood production.

In more detail, according to the participants from operational management, log quality problems happen more frequently than other factors and then it directly impacts on machine performance. The problems arise when there is a foreign object on the log's surface due to the way logs are kept in the mills. Normally logs are left in outdoor areas which means there are greater possibilities of getting unwanted objects on their surface. Therefore, when the logs are sent into the production line, they will be processed first by the lathe machine. The machine will process the log by peeling it from the surface, and if there is a foreign object on the surface, it could break knives in the lathe which then stops the lathe machine.

Secondly, other threats come from maintenance and the age of machines. It seems that both factors are related to each other. This is because as the machines in the mills are getting older, they will require more maintenance. As informed by the participants, on average plywood companies in New Zealand are 25 years old but some of their mills use machines that are older than this. Therefore, it can be concluded that the mills here are required to have regular maintenance.

The conclusion is there are two major factors that can trigger machine breakdown in the production line: log quality and machine conditions. Log quality can frequently stop the machine by breaking some parts in it, whereas machine conditions are related to age and routine maintenance from the companies. Log quality is also considered to be a primary issue in most mills due to its frequency of occurrence. However, machine conditions deliver more loss for companies as they are a long-term investment that requires expensive maintenance. Regardless of all the implications, both log quality and machine conditions are able to deliver threats to machine breakdown which bring delays to produce the right quantity and quality of products in time. Similar to this study, Gaudenzi and Borghesi (2006), Kumar et al. (2010), Manuj and Mentzer (2008), Samvedi et al. (2013),

and (Tuncel & Alpan, 2010) categorise machine breakdown as one of the operational threats for the supply chain, which can bring threats to customer order fulfilment.

Furthermore, to lessen the level of occurrence, mostly the mills in New Zealand implement regular maintenance for their machine. Even though this method does not significantly reduce any factors from outside the machines, e.g. log quality, it can reduce the probability of machine breakdown due to its conditions. At this point, Kenné, Dejax, and Gharbi (2012) build a method to predict the machine failure to keep production continuity. With their method the companies could reduce the breakdowns and retain continuity in production.

## **b. People**

The second risk from the operational side is people. As can be seen in the statements:

*“Up to now New Zealand is very bad attitude towards safety. We take risk we don't need to take.”*

*“ The more important age is people, um I have in a staff of 270 I have 6 of them around 70 years old, and they are working in this factory, I have 24 more than 65 years old, so it's quite a big group, and I have the huge numbers between the age of 50-65.”*

*“The labour not turning up for work, there is always guy will do that.”*

*“Operationally in the factory, the major risk is health and safety across the borders”*

*“ Managing people in the mill can be challenging”.*

From the statements participants refer to their employees to be a risk in operational side. All the employees in the mills have the potential to deliver operational risks. The first factor that is likely to

happen during mill production is the absence of workers. This is the most unwanted situation in companies as productivity of the mills can drop and yet this threat cannot be predicted and controlled. Some reasons are the workers are sick or suddenly they have family issues. However, there are various possibilities that can be an excuse for not turning up to work.

Second factor is age. It becomes a major concern for one mill because age could affect people performance during work; although the age will age not affect the end quality of plywood. Employees of a young age or young adults seem to lack motivation to work in the mills, whereas the elderly can be difficult due to their health issues. Therefore, it can be said that the managers prefer to employ more adults than young adults or the elderly and this was confirmed:

*"..I really want 25-45 years old marriage 2 kids, because they are staying. They need to stay because they have to pay the bills, they have to pay the mortgage".* That is to say, even though the mills are able to have employees of old age, a population with a productive age still becomes mills' preference.

The last factor that can make people be a threat in the operational side is the employees' behaviour towards work and safety, either in the mills or in forest areas. As a statement from a mill manager says: *"... Forestry has a lot of dead because the harvest went up significantly. New people came into the industry..."* This statement also implies the main reason for many accidents in the forest sector, which is a lack of training, particularly for new people. In the same way, Wu, Blackhurst, and Chidambaram (2006) emphasise that knowledge, resources, training and transferring the knowledge significantly affect the future workforce.

To sum up, three potential factors from people that can trigger operational risks are: the absence of workers, age distribution, and the attitude or training towards health and safety. All factors are equally important since they can deliver the same impact and a major

loss to companies. However, age distribution and employees' attitude toward health and safety can be easily controlled, whereas the absence of workers is beyond the company's control. Age distribution is controlled in the recruitment process by sorting the preferred age, whereas employees' attitude is controlled by training and implementing a safe working environment, e.g. hanging posters, stickers, or any signs to remind the workers such as "GO HOME SAFE". Moreover, although the absence of workers is unlikely to be controlled, some mitigation strategies have been implemented in the mills, such as if there is a shortage of teams then the mills will be focusing on primary lines until back-up teams come.

### **c. Inventory**

In many industries inventory is considered to be a critical area and has been of central attention for academics and practitioners (Williams & Tokar, 2008). This is because inventory has always had a high contribution to total costs in companies. therefore, there are many ways to reduce inventory costs and yet it apparently leads to other consequences. As such, in this study, even though it is considered as one of the operational risks, the inventory level in some mills seems an implication of other risk sources. For instance, inaccurate forecast of customer demand, log quality, machine breakdown, fluctuating demand, and transportation and distribution.

If there is a mistake in the forecast, the possibilities are that companies can hold an excess inventory or they are short of products. Whichever the condition is, companies still suffer from higher inventory holding costs or the costs of losing customers. Similarly, for other risk sources such as machine breakdown, which will increase the work in progress (WIP) products and log quality, this will push the inventory of raw material up.

Therefore, in general, inventory is not a risk that appears itself; it is rather an outcome of the actions in other risk sources.

Nevertheless, the implications of inventory costs in companies can be repercussions. An example from one manager was, “... you cannot carry all the stock, just money sitting there dying, especially exchange rate moves, and we have got the massive volume back there...”, in which he points out the decrease in the exchange rate by holding more inventories. In line with this, Chopra and Sodhi (2004) affirm that excess inventory and failing price will be a killer combination for many companies. On the contrary, even though holding inventory in companies can be menacing, Williams and Tokar (2008) point out that inventory exists to provide buffer between supply and demand processes. In many instances, therefore, understanding the supply demand mechanism is necessary to build good inventory management.

### 5.6.3 Supply risks

Supply risks reside in potential deviations in the firm’s ability to supply or deliver the market which results in incomplete customer orders (Kumar et al., 2010; Manuj & Mentzer, 2008; Zsidisin & Ritchie, 2008). From the interviews there are various reasons that can cause supply risk since it depends on how the companies situate themselves in the supply chain.

#### a. Log quality

When the participants being asked regarding supply risks, almost all participants instantly refer to logs quality as statements below.

*“The log quality, logs are not all the same”*

*“You are not gonna have the unpruned and the market doesn’t accepted anymore, that is real issue for supply.”*

*“We have a raw material very strict specification on what we will take, and we grade our logs, physically grade all the logs to ensure they meet the specification”*

*“There are a lot of quality issues”*

*“Quality sometimes you can have an issue in quality”*

*“We don’t meet the product requirement, so they have like knot size, big the branch size is the big issue for the mill at the moment”*

With that responses, in general the participants view their position in the supply chain as customers that require to be supplied with good quality logs. The problem emerges because logs come from nature and it is always different. Although in New Zealand the logs come from a forest estate which is a semi-controlled environment, each log is naturally always different every time. There are many variations in logs that cannot be controlled, even with treatment, e.g. pruning. It can be knot size, big branches, composition of pruned logs and moisture. Therefore, in order to produce good quality plywood logs must meet the requirements for logs such as AS/NZS 2269.0-plywood and EWPA Quality Control. The standards aim to control the specifications of logs that come to the mills.

#### **b. Log prices**

When a question regarding implications of logs quality was asked, all the participants from different mills consented to log prices.

*“This press on forest owners to supply, that must provide broaden log market. So we can get in dried it up with the export price. There is potential risk there. Price is one of them, so the cost of log could go up, and it can also come down.”*

*“Pruned log is very expensive”*

*“price risks around log”*

*“high specification we pay more than everybody else will do for that*

*particular log”*

*“We cannot look into long term supply agreement, and quite often comes with the premium price”*

The interviews show that like in many products price is always associated with quality and demand. One major reason is because plywood mills need certain specifications of logs to make good quality plywood. As a consequence if a mill becomes very demanding regarding its log requirements, they are expected to pay a higher price for logs.

Nevertheless as the interviews went on and more questions were asked, apparently there is another factor that also influences log prices in New Zealand. According to some participants

*“..China drives the log prices in New Zealand, because they pay well for the logs..”*

*“..so forest owners, he wants to make the most, money, he possibly can, he is going to try and uses the demand in China to raise price in New Zealand”.*

From the statements, it seems that in New Zealand log prices are also influenced by overseas demand of logs particularly from China. The demand from overseas has been pushing the log prices up recently. To control the log prices, mills sign agreements with foresters so they can lock the log prices in for a certain period which automatically stabilises their input costs. Even though companies have agreements, sometimes prices can become uncontrolled due to other unexpected factors. As Federica and Massimo (2006) assert that price risk cannot be controlled because it comes from the external supply chain.

### c. Continuity of raw material supply

The next risk from supply side is continuity of raw material supply as can be seen in the statements below.

*“Probability risk around supplier of log”*

*“Log is resource availability and it’s quite real. Fortunately for me and we have a grown resource pruned and it is increasing. So it is an opportunity as I see it.”*

*“In the future it may not be quite so easy because of the way the forest was handled 25-30 years ago, is this gonna be reduction on the pruned log that we require.”*

*“So the risk on the context of the supply of the log is resource availability and it’s quite real.”*

*“The shortage of pruned log is because 25 years ago, they did not do any pruning in the forest, so now we are getting that because the tree that we planted 25 years ago is getting towards maturity..”.*

From the statements above participants are concerned with the continuity of log supply rather than other raw materials e.g. glue. It is because even though the mills are able to obtain the best quality for raw materials, if they are not able to sustain the supply the company will not survive the business competition.

Continuity of log supply is strongly associated with mills requirement because there are standards of logs for making plywood in a certain grade. However, as a natural source, logs come in different quality every time, it is mills’ duty to meet to obtain the right quality to make a good plywood.

Therefore, to overcome the problem, the most mills usually adjust their specifications for raw material. Adjustment in quality aims to maintain the production of plywood, but at the same time it may drop the quality of plywood. Different strategies have been

implemented to overcome the problem. Firstly from top management states,

*“.. I rent them an office base, I talk to them every day, and my forest manager and production team have a meeting every Monday. “*

*“ ... it is important to have them understand in our quality, there is a decision they make in the forest affects what happens in the mill, without that understanding, they just cut. They cut the branches off; they get it in the truck..”*

From top management, people whose jobs are focused on long term plans usually make agreements or contracts with foresters to ensure continuity of log supplies for certain periods. People whose responsibilities are in daily production suggest that a good communication between foresters and the production team can reduce the probability of getting logs out from specifications. In other words, continuity can be established by maintaining a good relation and communication between mills and foresters. In similar way Diabat et al. (2012) also propose a strategy to beat poor quality of supply goods by building a trust with supplier.

Nevertheless, while other mills face difficulties in providing pruned logs, one mill that owns legal cutting for forests encounters different challenges, which is related to their ownership. The relationship is rather unique, as the company needs to deal with the government as well as Maori ownership. However, this exclusivity emerges as an advantage and threats for the company itself. With the exclusivity this mill has more supply of pruned log than they can consume, which can push up the log prices.

Other mill in South Island has rather a different strategy. This mill has a strict rule specification of raw materials, particularly logs, which puts them in a difficult situation. However, this mill holds an inventory for the next 15 days to ensure their mill is running every day. In addition, this mill also employs two suppliers to lessen the

risks of not getting logs that are needed. It is also suggested that multiple suppliers can reduce the quality failures in a focal company (Tuncel & Alpan, 2010; Zsidisin & Ritchie, 2008). In a similar way, Talluri et al. (2013) note that having a single supplier could trigger to other supplier risks because a company's dependency on a supplier could lead to quality failures.

To sum up, there are four ways to sustain continuity of good log supplies: having agreements and contracts between focal companies and foresters, creating a good communication between people who are involved in the plywood supply chain, holding a reasonable inventory of raw materials, and having multiple suppliers.

#### **d. Transportation and distribution**

The transportation and distribution side is a process of getting products from the point of origin to the point of destination. Responses from the participants regarding the questions of risks in transportation and distribution depend on how they perceive the mill's position in the supply chain. On one side, the participants acknowledge the companies as customers who need a supply of logs and other raw materials for plywood production. On the other hand, they also consider the mills as suppliers who need to provide plywood to customers.

In general, all the respondents do not have a significant problem of getting logs from suppliers and delivering products to customers. However, the worst case could be the weather in New Zealand. The weather can change unexpectedly, for instance, during the winter where there are storms and wind, which may cause delays in the port. This condition can result in lateness or failing delivery to customers, which subsequently leads to losing customers.

### **5.7 Summary of risks in New Zealand plywood companies**

All the identified risks above were generated from the interviews with all the participants who are working in different companies. This means that

the risks are rather a constellation of all risks in different companies, although not all the plywood companies face all identified risks. There are some companies that do not experience certain risks. This is because each company has a different supply chain structure and characteristic. Therefore, Table 8 is provided to show the differences and similarities of risks that are faced in each participants' company.

For instance, for demand risks Company 3 does not experience fluctuating demand, whereas the other companies need to face fluctuating demand and market competition. This could be because the company has the smallest production capacity compared to other companies, but nearly 94% of their total production can be absorbed by the domestic market. The situation makes demand that comes through Company 3 less fluctuating compared to other mills with bigger capacity. Similarly, Company 1 does not see inventory as a threat from the operational side and transportation distribution is one of their supply risks. This is because Company 1 has a complete fully integrated supply chain, particularly for the Japanese plywood market. The company merely focuses on the Japanese plywood market instead of selling the products in the domestic market. As they already have a targeted market in Japan, inventory is not a primary concern in operational risk. They simply produce plywood for the Japanese market which has a considerably bigger demand than New Zealand. Therefore, as there is an excess of plywood due to fluctuation in Japanese demand, it can be pushed into the domestic market rather than sitting as inventory in the mill.

Table 8. Comparison of risks between New Zealand plywood companies

<b>Factors</b>	<b>Company 1</b>	<b>Company 2</b>	<b>Company 3</b>
<b>Demand risks</b>			
Fluctuating demand	V	V	X
Market competition	V	V	V
<b>Operational risks</b>			
Machine breakdowns	V	V	V
People	V	V	V
Inventory	X	V	V
<b>Supply risks</b>			
Log quality	V	V	V
Log price	V	V	V
Continuity of raw materials	V	V	V
Transportation and distribution	X	V	V
<b>External risks</b>			
Regulation	V	V	V
Environmental	V	X	V
Financial	V	X	X
Globalisation	V	V	V

Regardless of the contrast of the potential risks in every company, predominantly three plywood mills in New Zealand experience the same risks. However, the causes of the risks in each company are varied. Different reasons trigger similar risks to each company as can be seen in Table 9 below.

Table 9. Cause of risks in different companies

Factor	Company 1	Company 2	Company 3
<b>Demand risks</b>			
Fluctuating demand	Customers expect different quality than produced plywood Seasonally adjusted with housing	Difference between forecasted demand and actual demand Difference in aggregate level and per item Unexpected demand	
Market competition	Competition from Chile and China New Zealand is a small market, isolated	Competition from local mills Competition from Chilean and Chinese plywood Small market in New Zealand	Risk outside by competition Market share is going down Competition Chilean and Chinese products
<b>Operational risks</b>			
Machine breakdowns	Machinery is a bit old Less automation and more people	Machine breakdowns for hours and production is down	Machine breakdowns Plant breakdowns
People	Labor is not turning up to work Age the labour	People make mistakes and break the machine Major risks of health and safety across the board	Labour is not turning to work
Inventory		Too much inventory or less than the actual demand	Inventory for logs is 15 days Too much inventory
<b>Supply risks</b>			
Log quality	Logs are a natural resource	Logs are not the same Log quality is an issue	Raw material has a strict specifications
Log price	Pruned log is very expensive	Price around logs could go up and down	The company pays higher price than others
Continuity of raw materials	Availability of raw material Forestry overstocks with	Risks around supplier of logs.	There would be a reduction in the pruned logs

	unpruned logs		Pruned logs diminish from supplier
Transportation and distribution		Failing delivery Shipping is done by third party	Back loading Freight cost is critical
<b>External risks</b>			
Regulation	Regulation of health and safety License to operate the company	Labour rates	Health and safety certification New Zealand needs to keep up with infrastructures
Environment	The weather can be devastating because logs cannot be delivered in the right time Weather has washed out the road		Road closed due to weather e.g. snow
Financial	Security of payment		
Globalisation	Globalisation is seen as a threat and opportunity	Global recession is happening	

## 6 Discussion

### 6.1 Interactions among risks in plywood supply chain

In the beginning, a conceptual model was proposed as an estimation of risk roles and their influences in organisations, which is shown in Figure 9. After the analysis, the researcher tried to fit the results into the preliminary conceptual model and present it in Figure 16 below.

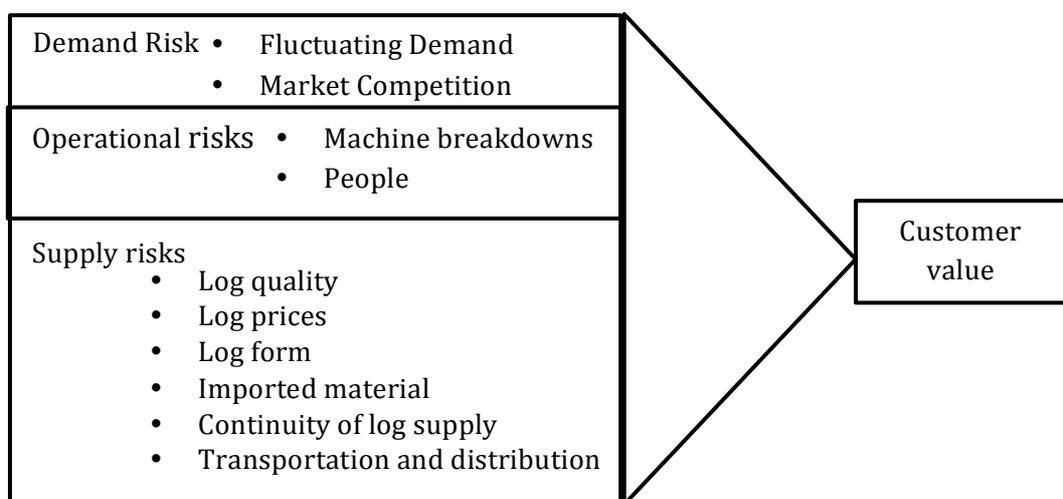


Figure 16. A preliminary conceptual model

In this model, each identified risk is compartmentalised into three different boxes. Boxes indicate the classification which refers to risk sources: demand risks, operational risks and supply risks. In addition, every risk in the boxes is also not connected with other risk factors within the same source or between the sources. That is to say, the preliminary model in Figure 16 shows that risks from any sources independently affect supply chain, which later on continues to impact on customer value at the end. What is more, based on the interviews there are additional factors outside the classification which were not expected. Therefore, the additional factors cannot be allocated into the preliminary model.

As the study goes and through analysis of the information, the facts from interviews are quite different to the first presumptions. The reality of

the findings indicate that instead of separately playing a part in the supply chain, the risks rather demonstrate a causal relationship among them in each source and further across other risk sources. Therefore, a new model is presented in Figure 17 to illustrate the relationships among risks in the system.

## 6.2 Relationship between risks and other factors

A new model as displayed in Figure 17 below is generated to illustrate the relationships among identified risks in New Zealand plywood mills.

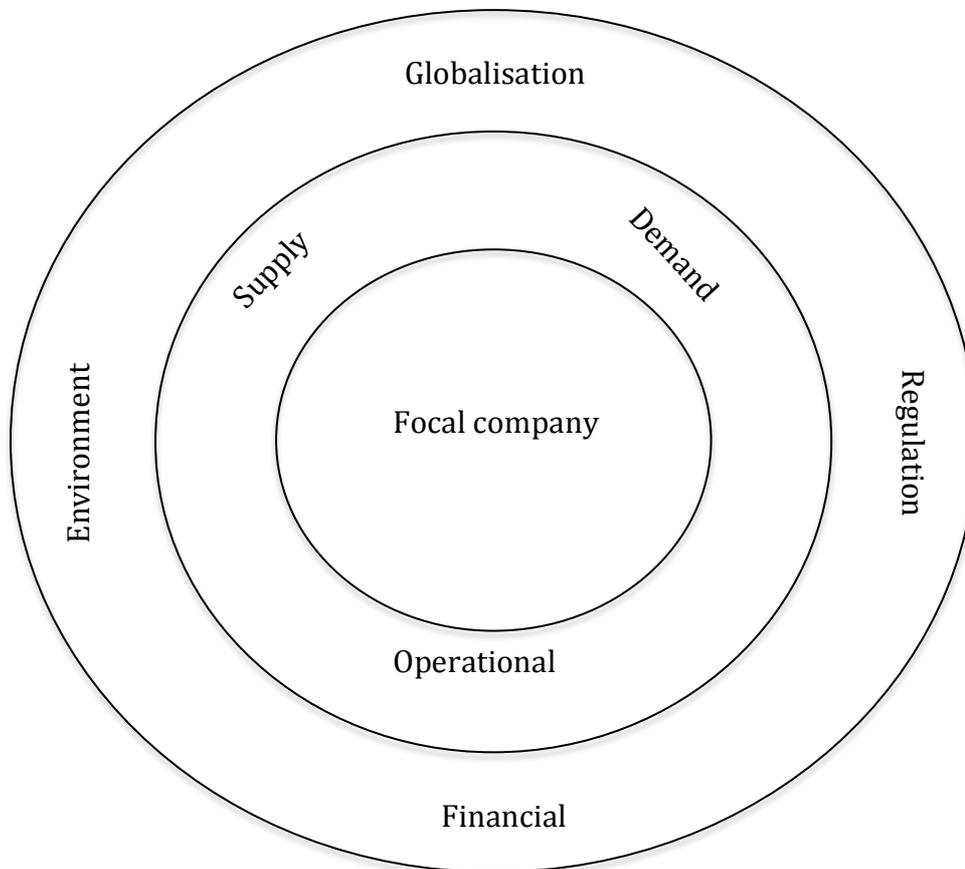


Figure 17. A new model

As can be seen in Figure 17 above that focal company is affected directly by three major risks: supply, operational and demand. These areas are considered to interact with each other and simultaneously affect the focal company. Through interviews the researcher found that almost all the risks in three areas are rather connected as cause-effect relationships wherein one

of each risk is either a source or trigger that will lead to a further risk in other areas of a supply chain.

**a. Demand risks**

From the demand side, the risks come from market competition and fluctuating demand. As the market changes due to more competitors in the New Zealand domestic market, demand to local mills has fluctuated slightly. This fluctuation leads to one of the operational risks which is inventory. Inventory might escalate because demand to local mills drops, whereas the mills cannot drop the capacity either. Along with that fact, market competition is also affected by log prices from a supplier, which can cause an increasing total production cost for local mills. This will make local mills become less competitive in final price.

**b. Operational risks**

In operational risks, machine breakdowns in the production line can cause an inventory risk in the mills. At the same time, any machine breakdowns are mostly caused by people, who are one of the operational risks. People in the field have various backgrounds and skills which may cause failures in the production line. In addition, people may also sabotage the production process that leads to machine breakdowns and inventory risks in the mills. Sabotage could be manipulated on the machine so it seems like a breakdown. The production line will be stopped because of the machine. However, at that time the machine already produced a few products that do not match specifications which will be stored with other WIP products. In this case, indirectly people's attitude could also impact on the inventory level of the companies. It is likely that machine breakdown is rather a result due to the quality of logs. In many instances, logs are kept outside in the yard which means they get foreign objects on their surface. This object is a potential threat as it can break knives in lathes.

### **c. Supply risks**

In the supply sources, there are four risks which are almost always connected to each other. First, from log prices, which are likely affected by log quality; the higher the quality required by the mills, the higher the price will be. On the other hand, log prices can also be affected by the transportation and distribution cost as the location between mills and suppliers is likely to contribute to high costs. Furthermore, a link between log quality and continuity of raw material exists as logs are natural sources. Logs can be different every time, so it can be possible that there is a time when log quality drops, which will affect continuity of log supplies to mills. Lastly, transportation and distribution is connected to continuity of raw materials because when there is a disturbance, e.g. a road closed during a delivery process, it can be possible that suppliers are not able to send logs to mills.

Further, it turns out that the relationship between risks in supply, demand and operational are also affected by outside factors which are regulation, globalisation, financial and environment. These four factors obviously exist, but affect the dynamism of the focal company indirectly.

#### **a. Globalisation**

Globalisation is indicated by the availability of any products everywhere. This also means that producers from anywhere can sell their products to other parts of the world easily. The evidence that globalisation has threatened local mills is the changed market share in New Zealand. Not only one local mill in New Zealand has to compete with other local mills, but also overseas mills that import their products here.

#### **b. Regulation**

There are various ways regulation could be one of the factors that affect the local mills. New Zealand has numerous regulations for running a business. First, the labour rates, where there is a minimum payment for every worker in New Zealand, whereas in other countries

there may be no strict rule about minimum wages, e.g China, Indonesia. The restriction about labour rates in New Zealand potentially makes total production of plywood higher than its competitors. This makes the local mills less competitive, particularly in price. Secondly, there is a strict rule with regard to structural plywood as well as the health and safety of employees. This regulation has to be completed by local mills to keep meeting the infrastructure regularly.

#### **c. Financial**

In many instances, the term financial is associated with cost at the end. In fact, financial risk from the outside affects not only cost but also the relationship between companies. An obvious financial risk for local plywood mills is the exchange rate. The exchange rate of the New Zealand dollar to other currencies cannot be controlled or predicted from time to time. The most possible thing to be done is by settling an agreement between suppliers and focal companies to lock the exchange rate in for a certain amount of time.

#### **d. Environment**

The environment has the lowest probability of occurrence but it has a significant impact on companies. Until today, plywood mills have not experienced disaster from the environment, although sometimes the weather in New Zealand could threaten transportation and distribution which affects customers at the end.

The other possibility is that the environment may receive impacts from the mills due to activities in the production process. During the plywood process, water is used predominantly to clean the logs and also adjust moisture in the plywood. The water that is used for the production process will then be discharged to the environment, which has the potential to harm the neighbourhood.

Since the model in Figure 17 is proposed is based on the information in the interviews from three plywood companies in New Zealand. Therefore, it

is considered that the model is relevant to all local plywood companies. In other word, the model can be implemented in the local mills in New Zealand to identify the risks sources.

What is more the model in Figure 17 is rather different to the previous study by Diabat et al. (2012). They assert that each risk should be categorised separately and alleviating one risk will not help alleviating other risks. On the other hand, in this study, there are more risk sources founded outside the supply, demand and operational risks. These risk sources are considered not directly connected to focal company, but it affects the focal company through the supply, demand, and operational risks. In addition to that, this model provides the position of focal company on risks which is expected to facilitate the focal company to identify and mitigate the risks. Bottom line is the new model is expected to provide a general model in the process of risk identification particularly in plywood supply chains.

### **6.3 Risk sources in other plywood industries**

Every business is different and there are various reasons that can make a business in different countries has different characteristics.

As such tropical plywood industry. This sector apparently is under threat from other plywood industry (Rutten & Hock, 2004). As the softwood plywood industry is growing rapidly, this sector faces many challenges mostly from failing price, log supply and changes in health and safety standards. This is shown by some upheavals in Brazil, Indonesia, China and Japan who are known because of their role in the tropical plywood industry. China is ever growing market in plywood. This country used to be a major plywood importer but now become the world's third-largest tropical plywood producers. While China's industry grows the other tropical plywood players suffer from declination of international trade (ITTO, 2003).

Log supply seems to be a main trigger for supply side but it seems that demand-side has more influences to risks. The demand side has several factors such as issues related to tropical plywood price risks and lack of transparency in the market. For instance in Indonesia. Indonesia was the

biggest supplier for tropical plywood in the world but it has changed since APKINDO abandoned the price leadership role (Rutten & Hock, 2004). It leaves market operation with challenges in negotiating price. They also add that there has been price changes over six-month period, which indicates that tropical log prices are very volatile.

On the other hand, in softwood plywood currently, India is the fastest growing market for plywood. It is mainly because of the growing population in India every year. In addition, as India's economy is growing at the same time current housing is escalating. The escalating demand in housing makes demand for plywood increase (Kiiski, 2012). The situation can be a demand risk for plywood sector in India because the plywood sector in India is still growing but the demand for plywood is escalating quickly. Similar to India, Japan experienced the increasing plywood demand from local market because of the population growth. Japan and India seem to import more products if the domestic plywood does not realise the opportunity to cope with the demand. On the contrary, the local mills are threatened by imported products because the local demand is steady.

A disturbance from demand risk in Japan and India has led to other risk source: supply risk. Log imports have grown with plywood demand in both countries. Similarly, China also faces a risk in log supply, although China does not necessarily experience an increasing in plywood demand. China needs more logs because of their industry grows fast and also because of their needs to meet the overseas plywood demand. As a matter of fact, even though China does not possess a large plantation area, this country happens to be the biggest plywood supplier at the moment. In summary, the three countries above obviously face the same risk in supply chain with New Zealand plywood mills: log supply. The risk from log supply in the three countries above can be the price as well as the quality. This is because these countries are also importers of the Pine Radiata from New Zealand.

Furthermore, according to Kiiski (2012), one mill in Russia has a similar operational risk like New Zealand. Due to location of the Russian mill, it is difficult for mill to find competent employees. The location also triggers

another risk in supply risk: transportation and distribution. The distance between the mill and nearest city is a day's drive which can make trouble in delivery. Other study from India focuses on risks that are caused by plywood industry. A study case from one plywood industry in India shows that there are several areas need to be considered as risks in plywood (Dahiya, 2014). The first is operational issue: health issue of the labour. A Labour intensive process in this mill creates more jobs for local community but many labours are migrant or from town and they come to work in the plywood mill. They do not have enough skill and expertise to work in management level. Therefore mostly, they work as labour and are housed in a camp provided by company which often creates health issue. The second issue is from environment. The mill is situated near the local community which can cause another issues, e.g social issue: clash between local community and migrant labour. Along with that, there is a limited environmental controls from government particularly for SMEs.

In summary, it seems that plywood industry in different countries face similar risks. Although factors that trigger the risk sources can be varying, in general plywood supply chain in the other countries experience similar risk sources. Therefore, the model in Figure 17 above seems to fit in different plywood companies including Chilean and Chinese mills who are the major competitors for New Zealand.

# 7 Conclusion and recommendation

## 7.1 Conclusion

The implementation of strategies to increase efficiencies and effectiveness has pushed supply chains towards more vulnerabilities. Vulnerabilities in supply cause the supply chain to face greater risks that may disrupt companies. Based on previous events and unbalanced situations between foresters and wood processors, this study aimed to investigate risks and their implications in the New Zealand plywood industry. The research has been carried out on the three objectives below:

1. Identify risks that are involved in the plywood supply chain
2. Analyse interactions and implications among identified risks
3. Understand these risks and implications for customer value

1. Demand risks

- a. Fluctuating demand

Fluctuating plywood demand in New Zealand is affected by seasonality of housing demand and inaccuracy of forecast. Companies' strategies to hedge variations in demand by holding inventory and making other variants of non-structural plywood.

- b. Market competition

In New Zealand, market competition has increased recently due to changes in total market share. The main reason for the alteration is more products available in the local market that have changed the market. At this moment, the plywood that is available in the local market comes from local mills and international mills. It gives benefits for customers, but affects local mills with tight competition particularly on price margin. To control it, the government and wood industries have implemented strict rules regarding plywood that comes into local market.

## 2. Operational risks

### a. Machine breakdown

Machine breakdown is a major production risk that could happen in companies. There are two major factors that can affect the machine performance: log quality and machine conditions. In general, both factors are unlikely to occur over time, but the effects can result in a significant loss for companies. Hence, there is regular maintenance to keep the machine in condition.

### b. People

Risks from people are difficult to manage and can vary. Three factors from people that can trigger failure in the operational side are: absence of workers, age distribution and attitude towards health and safety. The major problem is the absenteeism of workers as it cannot be controlled. Other factors can be controlled during the recruitment process to control age distribution, training, and implementation of a safe working environment for employees.

### c. Inventory

Inventory is rather an implication of actions that are taken to manage other risks. As such some strategies to hedge variations in fluctuating demand have led to higher inventory levels. Subsequently, for operational risk, if there is a breakdown in the production line the inventory level of WIP will increase. From supply side, if the mills are not able to obtain logs within specifications, the result is increasing inventory of raw material. Despite all the negative aspects of having a high inventory level, inventory aims to stabilise the gap between supply and demand.

## 3. Supply risks

### a. Log quality

Log quality is out of control because it comes from natural resources. Instead of controlling the quality, mills focus on gaining logs with regard to plywood specifications. To hedge the variations

of logs, mills can have agreements with foresters in terms of specifications and continuity, create a good communication between foresters and the production team, hold inventory or have multiple suppliers.

b. Log prices

In New Zealand, log prices have been increasing due to overseas demand. The situation makes local mills experience difficulties in obtaining good quality logs with a reasonable price for their input costs. A strategy to hedge variations in the quality of logs can be implemented to lock the price in by signing a contract with foresters.

c. Continuity of raw materials

Continuity of raw materials is strongly associated with raw materials quality, particularly logs. Both risks simultaneously emerge as supply risks. This is because companies do not need the best quality of logs but lack of sustainability. Companies rather obtain a sustainable log with less quality but within the specifications required.

d. Transportation and distribution

In general, transportation and distribution is not a major threat to mills in New Zealand as they have indirect communications with end customers. However, a problem sometimes comes from the weather which may cause a delay in delivering products.

4. Other risks

There are four additional risks outside the classification and yet they have indirect significant impacts on other risks: globalisation, regulation, financial, and environment. Even though each risk from the outside does not point to one consequence, it simultaneously affects risks in the classifications.

Finally, to sum up, all the identified risks are related to each other by causal relationships and one-sided relationships. All the relationships establish reciprocal effects that make risks that can be prioritised. The action from one risk source impacts on the other part of supply chain or even further.

## **7.2 Limitation of study**

As is the case for most research, this study has several limitations that affect the interpretations. First, due to the limited time, the study focuses only on the plywood industry New Zealand and is not taken into other types of wood processor industries. Furthermore, managers' interpretations could limit the interpretations of the results.

## **7.3 Recommendations**

This research has achieved its objectives in large part, but there are some identifiable unexpected findings that come along with the results, which can be suggestions for further research.

First, from the beginning of this study, the researcher categorised the presumption of the risk sources in such a way that is presented as a conceptual model. However, as the study progressed there were some findings that could not be fitted into the presumed model. The researcher has found that instead of focusing on the internal supply chain, there are influences from outside the system which have major impacts on the same risk sources inside the supply chain e.g. the financial, regulation and globalisation. They have significant implications on the supply and demand risks. Therefore, an area for further research could be categorisation of the risk sources from outside and inside the supply chain.

In addition, one of the mills in New Zealand, is using trucks as the main transportation in the distribution of all raw materials as well as finished good products. At this moment, the mill is using a back loading method which can trigger other risks that could lead to a bigger loss to the company. Although there is no significant disruption so far, this situation could be an interesting topic with regard to transportation and distribution in New Zealand.



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