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- Preparing for the unpredictable

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Abstract

Forestry supply chains are a significant part of the Swedish economy. These supply chains are highly susceptible to storms damage. In late 2013 Sweden was hit by multiple storms. This leads to the possibility to research how supply chains react to the shocks that storms cause. The aim of this thesis is to research the costs that storms increase, the actions that are taken within the forestry supply chain, as well as possible benefactors from storms.

This thesis bases on previous work on supply chain mapping and cost theories. Three supply chains in Sweden are analyzed – Södra, SCA and Norrskog. By mapping the supply chain and analyzing what costs increase it is possible to get a general view of how supply chains react to shocks.

The findings of this thesis are that storms create a tradeoff between loss of quality and loss of efficiency for forestry companies who work with forest owners. In all three cases working with reduced efficiency was preferred over losing the quality of logs. The main cause for the loss of efficiency is increased harvesting expenses from working with storm-felled logs, increased storage costs, and slightly increased costs from hiring external forestry workers and transporters.

The main actors in dealing with effects of storms are the forestry companies. The actions that they take to reduce quality loss can be grouped in to three categories – information gathering, capacity building and negotiation. Information is continuously gathered on the storm-felled amount and species. Capacity is built up via hiring additional external forestry workers, transporters and machinery for mills. Negotiations happen with forest owners to put off contracts, with other mills in different regions on selling logs, and with the government on relaxing capacity restricting legislation.

Lastly it is concluded that no parties profit from storms. Some parties gain in terms of work stability, the industry gains certainty of being supplied with raw materials and lastly the economy gains from increased business activity.

Sammanfattning

Skogsbrukets leverantörskedjor utgör signifikanta delar av den totala ekonomin. Dessa leverantörskedjor påverkas kraftigt av förödelse, till största delen stormar. I slutet av år 2013 drabbades Sveriges skogsbruk av flertalet stormar, vilket har möjliggjort forskning på hur leverantörskedjan har reagerat på chockar likt stormar. Syftet med den här uppsatsen är att undersöka de kostnader som stormar orsakar, de åtgärder som skogsbrukets leverantörskedjor tvingats ta på grund av stormar, liksom eventuella positiva faktorer som uppstått efter stormarnas framfart.

Den här uppsatsen är baserad på tidigare forskning som har kartlagt leverantörskedjor och kostnadsteori i skogsbruket. I den här uppsatsen är tre leverantörsled analyserade från skogsbolagen Södra, SCA och Norrskog. Genom att kartlägga skogsbolagens leverantörskedjor analyserades vilken punkt av kostnadsökning som är möjlig för att ge en generell överblick om hur leverantörsledet reagerar på chocker.

Iakttagelser i den här studien visar på att stormar skapar en kompromiss mellan kvalitetsförluster och förluster av effektivitet för skogsbolagen som arbetar åt privata skogsägare. Studien visar att i alla tre undersökningsfall var förlorad effektivitet att föredra över försämrad kvalité på fällt virke. Den huvudsakliga orsaken till effektivitetsförluster var ökade skogsmaskinskostnader vid arbete med stormfällda träd, förvaringskostnader för virke och till viss del ökade kostnader för inhyrning av extern skogsbrukspersonal och transporter.

Det är skogsbolagen som huvudsakligen får ta konsekvenserna av stormarna. De främsta beslut som fattas för att reducera kvalitetsförluster kan förklaras i tre kategorier – informationsinsamling, kapacitetsbygge och förhandling. Informationsinsamling sker regelbundet av stormfällda träd av varierande arter. Kapacitetsökningen utgöras genom att hyra in extra arbetare, transporter och maskiner till sågverken. Skogsbolagen initierar förhandlingar med markägarna för att omförhandla avtal, även avtal med sågverk i olika regioner omförhandlas för virkesförsäljning. Till sist sker även förhandlingar med staten om att lösa upp strikta kapacitetslagar.

Sammanfattningsvis drar ingen aktör fördelar av stormar. Några aktörer tjänar i termer av arbetstillfällen, branschen tjänar på säkrad tillgång av virke och till viss del skapas välfärdsvinster på grund av ökad affärsverksamhet.

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1 Introduction

Forestry supply chains have a very long processing time in terms of making the final product. A great portion of that time is spent growing the trees. During this time the forest might be exposed to different kinds of risks and natural disasters such as storms. None of these natural events can be classified as predictable – yet what is known is that they happen over time (Marzano *et al*., 2013). This means that the forestry supply chain experiences irregular shocks that it cannot predict. This creates losses within the chain.

Storms are among the most noticeable risks that forests managers have to deal with (Birot & Gollier, 2001).One does not have to look far back in to the past for examples. In late 2013 Sweden was hit by several storms:

- The "St. Jude storm", known as "Simone" in Sweden, hit Southern Sweden in 28th and 29th of October (The Local Europe, 2013a)
- Storm "Hilde", which hit Northern Sweden on the 16th and 17th of November, and felled 3.5 million cubic meters of wood in Northern Sweden (Sveriges Radio, 2013a)
- Storm "Sven" which hit Southern Sweden, especially Malmö and Helsingborg, and around the west coast of Sweden from the 5th until the 7th of December (The Local Europe, 2013b)
- Storm "Ivar" which particularly affected Norrland from the 10th until the 17th of December and felled between 4.5 and 6.5 million cubic meters of wood (Sveriges Radio, 2013b)

All of these events were shocks that struck supply chains. These shocks caused different costs that affect companies – from direct costs, like the decreased quality of timber, and increased costs of harvesting, to indirect costs of adjusting plans, renegotiating agreements, and information gathering. All of these costs together make a significant impact.

1.1 Problem Background

The importance of the forestry sector cannot be understated. By being a raw material for everyday products like furniture, houses or even energy, the forestry sector has added a lot of value. According to Schuck and Schelhaas (2013) -"in Europe the estimated gross value added of the forest sector was 120 billion EUR in 2010, contributing ~1% to the overall Gross Domestic Product (GDP) of Europe and as high as 3-5% in countries like, Finland, Latvia and Sweden". According to data from the last 60 years, an average of 0.12% of total standing volumes is damaged annually, with wind damage being responsible for 51% of the total damage (Schuck & Schelhaas, 2013). This means that storm damages are the main cause of damages to forest stands.

The most notable example in Sweden is the storm "Gudrun" that happened in January of 2005. The storm caused losses of 20.8 billion SEK (majority of these losses are in the form of forest damage) (Swedish Civil Contingencies Agency, 2005). Considering that Sweden's GDP in 2005 was 2 907.4 billion SEK (taken at current prices) - this means that the losses from the storm "Gudrun" were roughly 0.7 percentage points of total GDP (Statistics Sweden, 2015). These losses are unavoidable - the only actions that can mitigate the damage and reduce the impact are preventive (Broman *et al*., 2009). Forest loggers and nurseries might be short term beneficiaries from storms, while it should be emphasized that in the "long run" the whole supply chain loses (Hanewinkel & Peyron, 2013).

The shocks of storms are mainly felt by the forest owners and forestry companies within the forestry supply chains (Broman *et al.*, 2009). This causes the chain to react in various different ways, which according to supply chain theory could increase costs. An example of this is the bullwhip effect (Chopra & Meindl, 2013). When coordination is not done properly, it is enough to have small fluctuations in supply or demand to cause the bullwhip effect (Whang *et al.*, 1997). A shock such as a storm may cause increases in inventory costs, transportation costs, labor costs, etc., all of these being born by companies within the forestry supply chain (Chopra & Meindl, 2013). It should be noted that there are also indirect costs which storms forced upon the chain. These costs are associated with planning future activities, and the reduction of value of damaged or undamaged stands that need to be taken down in the near future after the storm (Hanewinkel & Peyron, 2013).

To sum up – forestry supply chains are an important part of the economy, and in recent history storms have caused significant shocks in these forestry supply chains. These shocks force actors to adjust, react and cooperate. Little is documented on the adjustment methods within the supply chains. This leads to a gap in the academic literature.

1.2 Aim and Research Questions

The importance of forestry supply chains cannot be understated. At the same time the academic literature is lacking is partially lacking in the area of how the chain reacts to storms. This is further discussed in the literature review and the method chapters of this paper. The aim of this paper is to explore the costs or benefits and taken actions after storms within forestry supply chains, in order to cover the gap in academic literature.

Losses from storms are mentioned so often that it has become common knowledge. Often there are citations in newspapers which quote the losses that are caused by a storm, but these calculations are based on damaged assets, or damaged forest (Thompson *et al.*, 2010; Genovese *et al.*, 2011). This is not the same as losses that are experienced by the supply chain. Therefore this leads to the first research question.

Research Question 1: What costs do storms increase for forestry supply chains?

The increased costs cause the supply chain to react in order to minimize losses. Different kinds of reactions are possible depending on the specifics of the particular situation. The actions that are taken in the forestry supply chains have not been explored – which raises the second research question - on which actions in the chains are taken to adjust to shocks from storms?

Research Question 2: What actions are taken within forestry supply chains to minimize the costs from storms?

Shocks can cause different reactions in different parts of the supply chain – one actor's reaction can influence other actors. It is possible that the reaction to the shock can give a chance for other actors to profit. Briefly mentioned by Hanewinkel and Peyron (2013) in their economic analysis - storms may increase profits in the short run for forest loggers and nurseries, while Schuck and Schelhaas (2013) state that it is possible for the industry which relies on raw materials from forests to gain, in the long run "all parties" lose from the shock. Because this phenomenon has not been explicitly researched, it leads to the third research question.

Research Question 3: Which parts of the supply chain profit in the short run from shocks caused by storms?

In order to answer the three research questions, the literature review introduces depth to the discussed issues as well as a basis for the method used in this paper. Thereafter the results from the applied method are described. In the end, the conclusions restate the answers to the research questions, as well as the extent of the achieved aim.

2 Literature Review and Theoretical Framework

In order to fulfil the aim and create an approach to answering the research questions, the literature review is split into three parts, each dedicated to a different subject. The first part is about the actors within the forestry supply chain, the second part is on storms and their effects, and the last part is on costs that a supply chain can experience. The literature is searched for and gathered by using online academic databases – Google Scholar, Primo and JSTOR. Articles are searched for by suing key-word relative to the thesis - 2013 storms; forestry supply chains; forest management; supply chain management; storm costs; storm effects.

Before the issue of storms is discusses, it should be defined as a concept. According to the official historical definition wind can be called a storm when it reaches the wind velocity of 24.5 meters per second (Met Office, 2010). With changing wind velocity, the official meteorological name of the phenomenon changes. Within the context of this paper, the term "storm" is used loosely, and is referred to as any velocity of wind that has the capacity to damage forests in a significant scale, generally above 24.5 meters per second. Such a definition is consistent with other works in the field of risk management with forests (Birot & Gollier, 2001; Gardiner & Quine, 2000).

2.1 Actors in Forestry Supply Chains

Within the context of this report the term "supply chain" is defined as by Chopra & Meindl (2013). The definition is from Lee and Billington (1992), and was later adjusted by Christopher (1998): "*The supply chain is most commonly defined as a network of actors that produce and deliver products to customers. In this context, the term "actors" is preferred over "firms" as the smallest unit of supply chains, since this draws attention to the processes that are performed irrespective of the ownership structure of the actors involved*" (Lee & Billington, 1992; Christopher, 1998; Zsidisin, 2003). By using this definition it implies that the forestry supply chain involves all actors until the consuming customer. This is further discussed in chapter "3.2 Limitation".

The specifics of forestry supply chains are: (1) relatively long lead times, (2) risks in raw material supply and (3) the raw material generates a high amount of consequent products (Haartveit *et al*., 2004). Relatively long lead times are understood as the time it takes for the forest to mature. Risks in raw material supply are understood as storms, illegal felling, disease and other general risks to forests. A high amount of consequent products means that the timber and pulpwood can be developed to products in vastly different types, sizes, colors. Each of these dimensions means that the end product is different, while the inputs remain the same.

According to Haartveit *et al.* (2004) there are two popular methods of mapping a supply chain. The two methods are the "structural mapping method" and the "lead time method". The first focuses on material flow in the chain (starting from raw materials to the end product). The second focuses on lead time mapping (starting from the product, mapped by time spent in production). Haartveit *et al.* (2004) concluded that the structural mapping method is more effective in describing forestry supply chains, because of the high amount of consequent products, which makes it complicated to illustrate it in lead time mapping. The result of the "structural mapping method" is illustrated in Figure 1.

Within the structural mapping method the relationships are described by good flows. The different good flow types in supply chains are illustrated in Appendix 1. These different kinds of relationship types are used to explain why the focus on the forestry companies within the forestry supply chain. This is further discussed in the methodology.

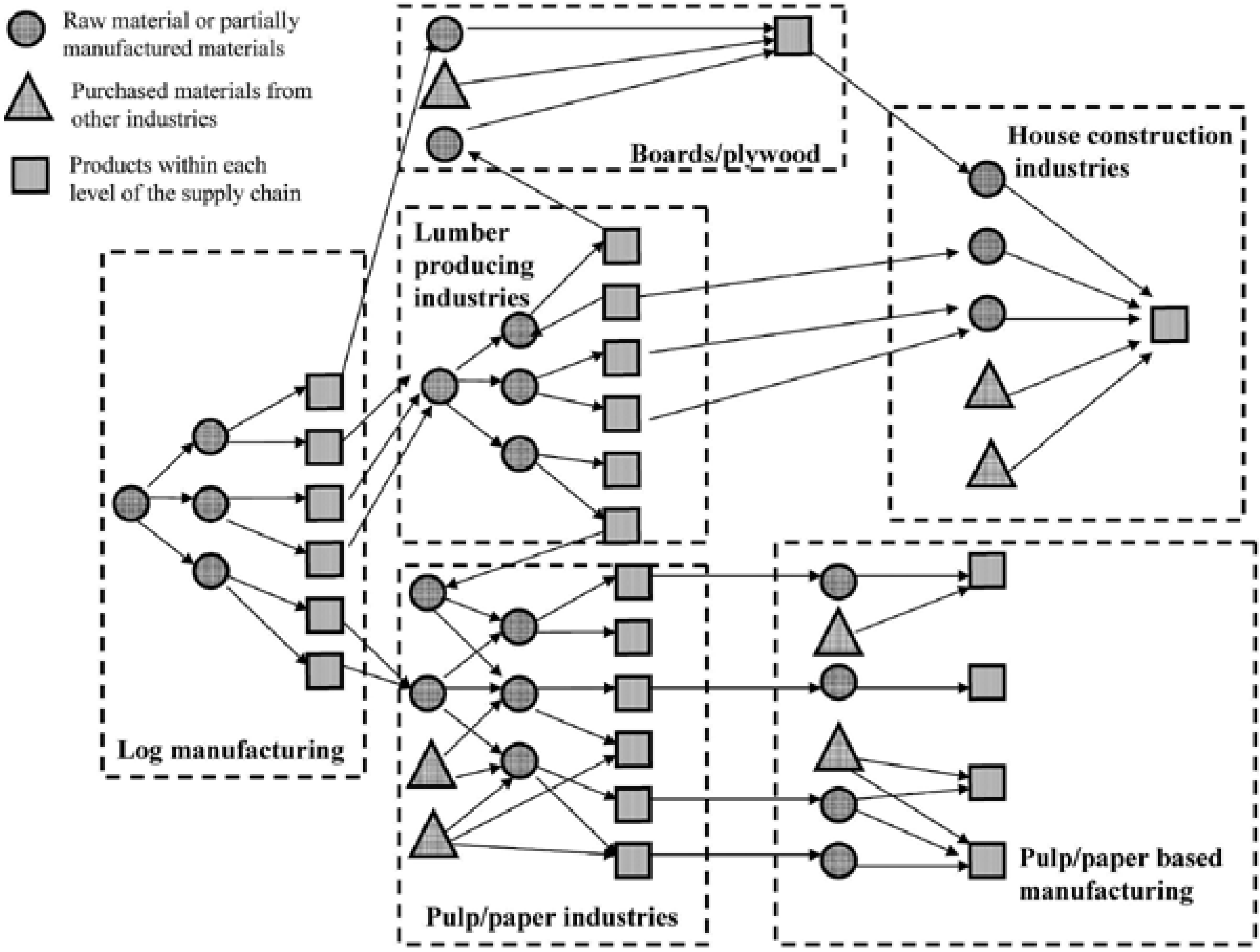

Figure 1 -Generalized representation of material flows and relationships in forestry industry supply chains (intermediaries are excluded to reduce complexity); Created by Haartveit et al. (2004).

The result of Haartveit, *et al.*, (2004), can be seen in Figure 1 – an illustration of the structure of the forestry supply chain. The increasing number of consequent goods can be well observed by many V-type material flows. In order to make a better illustration the intermediaries are not included, as it would drastically increase complexity, thus reducing the clarity of the representation (Haartveit, *et al.*, 2004).

The intermediaries that are not represented in Figure 1 should not be ignored. An example of the intermediaries is seedling production, forest work, transportation and insurance, but can also include other actors (Sinclair, 1992). To sum up – the forestry supply chain consists of log manufacturing (which can also be described as forest owners), the intermediaries (transport, cutting, etc.), processing (for pulp and paper, for lumber and for burning (energy)), which leads to the final product that is then be sold to an intermediary, and then to the final customer (Sinclair, 1992).

During *status quo*, when there are no storms effects, within the supply chain, decisions of individual actors are often based on cost minimizations – therefore it is possible to maximize the total profits of the supply chain through coordination, information sharing and setting of correct incentives (Chopra & Meindl, 2013). These individual decisions are mostly in the form of optimal solution of sub-problems, such as minimum roadside, mill-site costs or transportation costs (Haartveit, *et al.*, 2004). An additional characteristic which is important in understanding the forestry supply chain is that it can be described as driven by pull factors – the forest owner is motivated by push factors, but the rest of the chain respond to actual demand (Sinclair, 1992; Chopra & Meindl, 2013).

2.2 Effects of Storms

To understand the impacts of storms, it is first necessary to shortly describe storm mechanics, and there afterwards describe the effects that storms have in general on forestry supply chains. The example of storm "Gudrun" will be used to illustrate shocks. It should be noted that storm "Gudrun" was more severe than the storm that took place in 2013.

A storm in this case, is caused by changes in atmospheric pressure. This change of pressure leads to wind currents which have changing characteristics, such as changing speed, direction and frequency. Storms can be damaging when the instantaneous wind load is strong enough to exceed a limit which breaks the structural integrity of wood (Brunet, 2013). It should be noted that it differs for different species of trees (*ibid.*). Thus for assessment of how damaging a storm is, one should not pay as much attention to the mean wind speed, but to how turbulent the wind is and what is its' maximum speed (Peltola *et al.*, 2013) (Brunet, 2013) (Birot & Gollier, 2001). Also wind gusts affect different areas with different intensity, for example forest edges, hills, varying tree species, or forests with varying height of trees (Brunet, 2013). This means that proper forest management has significant effects on forest susceptibility to storms (Schuck & Schelhaas, 2013).

When storms do hit, there are significant changes that are automatically forced on the supply chain. Forestry companies have spent significant effort to develop extensive models and plans that deal with logistics and forestry work – after a storm these plans are made obsolete (Broman *et al.*, 2009). Broman *et al.* (2009) helped develop a model to optimize transportation after storm Gudrun in 2005 based on four variables - harvesting capacity, transportation capacity, storage costs and demand of logs. They state that transportation is the most constraining factor after storms. A additional issue that a storms initially forces to resolve is information acquiring – amounts of wind felled volumes, harvesting capacities at different sites, transportation capacity, demand from customers (mills) and storage issues (*ibid.*). These issues correspond to the possible cost increases defined by Chopra and Meindl (2013), which are discussed in the next chapter.

According to Broman *et al.*, (2009) after storm Gudrun the main issues that forestry companies had to deal with were storage and transportation. With storage it was possible to find "creative" solutions, such as using lakes and abandoned airfields. It should be noted that timber, if stored properly and watered regularly, can be stored between two to three years. If timber is not collected quick enough, then it creates losses as quality drops in processing, which affects the price of the timber. The most cost effective method for collection is to use harvesters and forwarders, and while there was a shortage of these, this was made up by employing them from other regions, that is why it was not an issue. Broman *et al.* (2009) state that transportation was a more difficult issue to solve because of its increased complexity. Logs had to be transported from different areas to different storage points, and afterwards to different mills, with the possibility of other modes of transportation such as rail or boat, being used in the middle. To get the immense volumes of logs to the right places, transporters from different parts of Sweden as well as other countries were employed as additional labor.

To sum up this chapter - Schuck and Schelhaas (2013) note that forest management practices have a huge impact on forest susceptibility of storms. They define storms as “highly stochastic and relatively rare events”, which means that time-series data analysis does not work well in forecasting these events (Schuck & Schelhaas, 2013). When a storms does strike the industries that are most affected are the forest owners, the forestry companies, the transporters and the providers of storage (Broman *et al*. 2009; Hanewinkel & Peyron, 2013). Extreme leanness and efficiency can lead to increased vulnerability within firms and supply chains (Kleindorfer & Saad, 2005). These different degrees of susceptibility and efficiency, with an introduced shock from a storm lead to cost increases.

2.3 Costs in the Supply Chain

When researching costs within a supply chain it is important to outline that the costs that are the focus of the research are “abnormal” or “additional”. This means that costs, which the supply chain experiences regardless of shocks, are not taken in to account. Within this subheading two costs types are discussed, as well as a theory supply chain processes.

The first types of costs are direct costs. These are additional expenses that the chain is forced to experience to continue operations (Christopher, 1998). Chopra and Meindl (2013) list the possible direct costs:

- **Manufacturing costs** – to adapt to variability, the manufacturing equipment has to be able to work with both higher and lower frequencies. This applied to harvesting and processing. This means that technology needs to have higher capacity, and sometimes, be run below capacity;
- **Inventory costs** – because of the shocks, different amounts of inventories will be held to continue operations. This increases inventory costs - as more physical space is needed for the inventory, or the opposite - space which is reserved for inventories remains unused.
- **Transportation costs** – shocks can change the amount of goods transported, or transportation distance. Additionally it can be necessary to hire extra transport capacity or the opposite – have transport capacity which is not used.
- **Replenishment lead time** – because of the shocks, companies tend to restock less often and hold higher inventories. This increases replenishment lead time which makes scheduling the next time to restock more difficult.
- **Labor costs** – in order manage the shocks, overtime might be used. Shocks can increase or decrease the planned amount of labor, thus resulting in either excess capacity or lack of it.
- **Relationships across the supply chain** – during a shock when the supply chain is less coordinated there exists a tendency to put the blame on other parts of the supply chain, thus stressing the relationships between adjacent actors.

- **Product availability** – shocks make it harder to supply all of the customers simultaneously, thus as a consequence, the amount of different products can be decreased in order to cope.

The second type of costs that can occur is best described as coordination costs. While coordination costs can result in direct costs, as described above, these costs are theoretically avoidable by coordinating between actors more efficiently. Miss-coordination can happen if different parts of the chain work separately and have different objectives (Chopra & Meindl, 2013). According to Chopra and Meindl (2013) the causes for a lack of coordination are: local optimization; sales incentives; forecasting based on orders and not customer demand; lack of information sharing; price fluctuations. The results of a lack of coordination can often be observed as the "bullwhip" effect. A bullwhip effect is defined as: "when the variability of demand orders in the supply chain is amplified as it is moved up the supply chain. Distorted information from one end of a supply chain to the other can lead to tremendous inefficiencies (Whang *et al.*, 1997).

Another important factor that should be noted is whether the supply chain is driven by "push" or "pull" processes. A pull process is defined as "being initiated by a customer's order (a reactive process)" and a push process is defined as "being initiated as anticipation of customer orders (a speculative/proactive process)" (Chopra & Meindl, 2013). The main difference between two is the knowledge of customer demand for the good. Different actors in the same supply chain can be driven by different processes. This is an important addition in understand the position of individual actors in a chain.

3 Method

The method which is chosen to answer the research questions should be based on methods that are used in the research field (Yin, 2013). Basing upon other the methods used by other researchers is thus considered as a safe approach to tackle the problem. In order to answer the three research questions, first it is necessary to map a supply chain. The method of structural mapping is chosen from the paper by Haartveit *et al.* (2004). The illustration from figure two is used as a basis to describe forestry supply chains. Additionally the same authors use a descriptive case-study approach to each supply chain (Haartveit *et al.*, 2004). This approach is supported by Hanewinkel and Peyron (2013), who state that "*A storm leads to a sequence of impacts within the forest/wood sector, which can be qualitatively described, but for which a quantitative evaluation of the economic impact is often hard to make*." Thus a case-study approach is chosen. This implies an inductive approach to solving the problem and generalizing the conclusions

This method is based on the approach used by Haartveit *et al.* (2004), where the authors map forestry supply chains using semi-structured interviews. Such semi-structured interviews are preferred as actors in different parts of the supply chain have knowledge about different functions, and possibly have different experiences dealing with the fallout from storms. Interviews in general are a notable source of information in case studies (Robson, 2011). The approach can be classified as a multiple case-study approach (Yin, 2013). Single cases studies are riskier, and are only suggested when going in depth of very specific issues, thus a multiple case study is preferable as it avoids sample dependence. Having multiple points of view can give additional insight in to the problem (*ibid.*). It should be noted that fully structured interviews are not preferred because they would have to be differentiated for each actor in the chain, which would require considerably more input and thus result in fewer interviews done. Additionally this would lead to an increase of the risk that the results are sample dependent.

The semi-structure interviews are conducted using an interview guide which can be found in Appendix 2. The interview guide has four main topics that are based on the literature review:

- **Map of the supply chain** – This area of the interview guide is based on Haartveit, *et al.* (2004) and the structural mapping method. It checks for relationships between actors in the supply chain and also the amount of different actors that are adjacent, as well as the main activities. The questions add to understanding the structural map of the supply chain, in case actors that are not mentioned in the literature play a significant role.
- **Storms and their effects** – In the paper by Broman *et al.*, (2009) it is noted that a focus should be put on storage and transportation expenses. The questions about damaged wood and capacity change are based on Hanewinkel and Peyron (2013). The questions on coordination during storms are based on Birot and Gollier (2001). Additionally variable usage in capacity can be in indicator of the bullwhip effect based on Whang *et al.* (1997) and Chopra and Meindl (2013).
- **Costs** - This part focuses on costs in the supply chain as described by Chopra and Meindl (2013). Additional questions are included to understand the extent or importance of the costs relative to each other. Also these same questions address the issue of push and pull factors.
- **Reaction** - This is a more general part and includes issues that are previously not covered - such as possible actions taken, usage of forecasting and collaboration. This is based on Chopra and Meindl (2013) as possible solutions to bad coordination.

3.1 Answering the Research Questions

To answer the research questions three actors from Sweden's forestry supply chains are selected – "Svenska Cellulosa Aktiebolaget" (henceforth referred to as SCA); Norrskog; Södra. According to Broman *et al.*, (2009) these are forestry companies who deal with the fallout of storms. Forestry companies are selected because within the supply chain they function as a V type of supplier and as an A type of customer (according to Appendix 1), thus they are bottlenecks – which makes it easier to take them as a basis for a supply chain. Additionally these organizations hold positions in their respective supply chains that force them to deal with fallout from storms (Broman *et al.*, 2009). The selection of these three forestry companies is based on data availability – the available contacts at the time, and on the responsiveness of the companies' representatives. Semi-structured interviews are then conducted with the people in key management positions, and afterwards actors from other functional units within the chain are interviewed using the snowballing method – by getting contact information from the initial interviewee. The contacts in the different points of the supply chain are forest owners, producers of seedlings, managers of logistics, mill and plant managers. These interviews serve as the main source of data. By understanding the different points of view from the actors it is possible to gain an understanding of which costs increase and why, which allows answering the first research question:" What costs do storms increase for forestry supply chains?".

A total of 10 interviews are conducted with people who work at different parts of the chain. A list of all interviewees and their contact information can be found in Appendix 3. The storms which are used as a reference point in the interviews are the storms of 2013 described in the introduction. In the results and analysis part of the work when referring to storms, it is generally understood as the storms that affected the organizations within 2013. Due to the massive influence of storm Gudrun which struck Sweden in 2005, it is also mentioned as a reference point in the interviews (Swedish Meteorological and Hydrological Institute, 2011). In text storm Gudrun will be explicitly referenced. Otherwise in general text storms from 2013 are the subject.

To answer the second research question "What actions are taken within the forestry supply chain to minimize the costs from storms?" the interviews include questions on reaction by different actors in the supply chain. These actions are explained as relative to a scenario where the supply chain is not affected by a storm. These questions include actions taken by all of the parts of the supply chain. The restrictions to the length of the researched part of the supply chain are described in detailed under the subheading "3.2 Limitations".

To answer the third research question "Which parts of the supply chain profit in the short run from shocks caused by storms?" questions are included in the interview guide. Because the different actors are able to identify the costs and price changes, the actors should be aware if adjacent actors gain or lose from storms. Financial reports are not used because of multiple issues, which are addressed under the subheading "3.2 Limitations".

Because of the difference in size of the companies, different amounts of interviews are conducted within each of the three supply chains. The interviews are conducted in person as well as via telephone, depending on the time availability of the person, as well as geographical distance. The interviews are conducted in a similar structure for all persons, while focusing in on the parts where the person had more experience and also depending on which positions that person would hold. The interviewee received the information on the topics beforehand in order to be able to prepare answers. The interviews are recorded, while the interviewee is assured that in case sensitive material is brought up then it is possible to not answer a question. In case after the interview there is a need to clarify an issue or a question needed looking in to, it is done over e-mail.

3.1.1 Data Quality and Assurance

When interviews are used as a main source of data, the quality of those interviews is of utmost importance to getting results (Robson, 2011; Yin, 2013). The three sources of data quality for this research are experience, transparency and comparability. The study bases on these three reasons as the pillars to be sure of the quality of work.

As stated before – interviews are the main source of data. These interviews within forestry supply chains happen with individuals who had recently experienced working with fallout from storms. Because these are not randomly selected, and are specifically related to working with storm shocks, means that the information is relevant and current. This should be sufficient to assure internal validity in terms observing a "cause" and an "effect" and there relations (Shadish et al., 2002). This is a significant determinant for internal validity (Yin, 2013). Regarding external validity (Shadish et al., 2002) there are different components of the that can be generalized to different extents. The extent of which these different can be generalizes are based on Robson's (2011) notion that three degrees of generalization are to be taken in to account - industry wise, country wise and to other research field.

The interviews are based on the notion of transparency – which is a critical component of for any research (Robson, 2011). All of the participants are informed and had to agree to the possibility that their statements could be published. The list of interviewees and their contacts can be found in Appendix 3. Transcripts are done after every interview, and used in when looking at specific topics. This gives additional reliability to the interviews, in the form of recalling information. As such recording information is a part of a technique to establish reliability (Yin, 2011).

The third basis of reliability is the basis on multiple cases. By analyzing three supply chains there is a decrease on sample dependence, which is a risk in all research (Shadish et al., 2002). These three supply chains are competitors, and operate similarly – the activities taken within one of the cases would not impact the others, thus it can be considered that they are not interdependent.

The three pillars – experience of interviewees, transparency and multiple cases – assure that the research is internally valid (Shadish et al., 2002). By interviewing persons who are experienced the fallouts of storms, the action and cost observations have a causal link, thus the study has temporal precedence and covariation. By emphasizing transparency and analyzing multiple supply chains, it is possible to establish, that other alternative explanations, which do not appear in the case, are not viable. This establishes nonspuriousness, which in turn means the study is internally valid (*ibid.*). Lastly basing the method on previous studies, and adjusting it based on different framework suggestions (Robson, 2011; Yin, 2013) ensures that the study has construct validity (Westen & Rosenthal, 2003).

3.1.2 Ethical Considerations

There are three main considerations that should be taken into account when using interviews as a part of the research method - confidentiality, informed consent and consequences for the interviewee (Kvale, 1996). All three aspects are taken into account within this thesis. All 10 of the interviewees are informed beforehand, and also during the start of the interview what it will be about and what it will be used for, thus ensuring informed consent. Confidentiality is taken into account by informing the interviewees that the results of the interviews will be made public, and thus any information that is confidential could be omitted. No interviewee used this option. Lastly, the consequences for the interviewee – negative consequences can happen if the interviewee presents negative information on their peers within the supply chain or the company itself. Firstly, this is partially addressed by having the interview questions formulated in such a way as to emphasize a general situation with storms (taking the storms of 2013 as an example). This avoids pinpointing individuals within the chain. Secondly the risk that the individual might have negative possible consequences regarding relationships within the organization he/she is working for is not fully avoided. No such information was received at the interviews.

According to Robson (2011), informed consent with transparency can lead to diminished data quality. This is can lead to interviewees withholding information that could put them in a negative setting. Robson (2011) states that it is of key importance that ethical considerations come first before the quality of data. For this reason the study is done with having the interviewees and their public contact information listed in Appendix 3. Thus the accountability is preferred to data quality.

3.1.3 Case Profiles

The three supply chains that are researched are based around forestry organizations that forest owners sell their timber to. As stated before this is because they are the key actors that deal with storm fallout (Broman *et al.*, 2009). The three organizations are SCA, Södra and Norrskog.

"Svenska Cellulosa Aktiebolaget" or SCA is hygiene and forest product company (SCA, 2015). It is owned by various different stockholders, as its stocks are sold on Stockholm's Stock Exchange – NASDAQ OMX Nordic. It has around 46 100 employees worldwide. For this specific case only a part of SCA's activities are looked at – specifically activities in Sweden's region of Medelpad, Ångermanland, Norrbotten, Västerbotten and Jämtland (*ibid.*). Within these regions SCA is a forest owner and additionally it works with the independent forest owners of the region in buying timber and pulp wood. SCA owns a paper mill, a pulp mill, two paperboard mills and works in five saw mills (Henrik Sakari, 2015). This means that SCA owns large parts of the supply chain with regards to Figure 1 – from parts of the log manufacturing, to pulp as well as paper manufacturing and processing, to distribution. The sales of SCA's products are conducted in more than 100 countries around the world. The company experienced storm damage during the end of 2013, when Hilde and Ivar caused 3 million and 7 million m^3 of damage respectively. Out of the 10 million m^3 of damaged timber 4 million m^3 were on SCA's forests (*ibid.*).

Södra is an economic association of more than 50 000 forest owners in Southern Sweden, who own more than half of all privately owned forest land in the region. Södra is based on maximizing the profitability for the forest owners by providing services such as consulting, and processing of raw materials (Södra, 2014). The association owns 3 pulp mills, 12 saw mills and employs 3 500 people. For this specific case the interviews are conducted with the part of Södra that operates in the South of Sweden – namely around Växjö, Ljungby, Långasjö, Ronneby, Broby and Höör. Within these regions Södra operates in the part of the supply chain the works with processing the logs and pulp (see Figure 2), and selling the product to manufacturers (Calle Nordqvist, 2015). The products are then sold to the industries which are willing to pay the most – the biggest markets being Sweden and Europe. Södra was affected by storms Simone and Sven in late 2013, which resulted in 1 to 1.5 million m^3 of timber being damaged on the lands of Södra's members (*ibid.*).

Norrskog operates similarly to Södra - it is a Swedish economic association of around 13 000 forest owners in Jämtland, Medelpad, Ångermanland and South Lappland. The principles of operation are to maximize the profit for its members by giving consultations, assisting in sales, and owning mills. It employs around 300 people, making it the smallest of the three organizations within this research (Norrskog, 2015). It owns 3 sawmills and 2 timber processing mills within the region. Norrskog works with its own forest owners as well as working with independent forest owners in the regions, thus being competition to SCA. The products are then sold to the industry of Sweden and Europe. Similarly to SCA, the storms that affected Norrskog – being Hilde and Ivar, which at the end of 2013 caused around 1.5 million m^3 of timber being damaged (Olof Falkstrom, 2015).

3.2 Limitations

There are three main limitations to the chosen method and an additional consideration that is taken into account. The three limitations are with regards to using the interview method, set boundaries of the supply chain, and with the generalizability of the conclusions. The additional consideration that is taken in to account is using financial reports as an additional data source.

The method of using interviews has fundamental weaknesses with regards to multiple aspects. Firstly the "interviewer" effect should be noted. Because the interviewee is representing his/her company or work, it is likely that the information can be manipulated in the favor of creating a good image for the interviewee. This might drastically affect the answers regarding possible improvements, or in case mistakes were made in the process of dealing with the fallout. This is taken in to account when forming the interview guide, so that the questions are formulated in a more indirect way as "what were the lessons learnt from the storm?" and "How was forecasting adjusted?". An additional weakness of the interview method is that the questions are formulated for the period of late 2013 (and in some cases for early 2014) – this means that some time has passed since the events have occurred. The interviewee might be since, but significant details might be forgotten over time. Thus there is risk that significant details might be omitted.

The second limitation to using the selected method is the set boarders of the supply chain. There are many actors that are involved in the forestry supply chain and the number increases when discussing the effects of storms. The limits of the mapped supply chain in this case are starting from the forest owner and ending with the processor or timber, including as many intermediaries as possible. The chosen limits are similar to those set by Haartveit *et al.* (2004), where such actors as storms insurers or governmental agencies are not looked at more closely. The reason for not researching past processors is due to restrictions of time as well as a more limited impact from storms.

The third limit is the generalizability of the conclusions. The three supply chains that are taken might not be a good representative of the general population. Because the actors in these supply chains are more responsive, it might correlate with the chain being more “efficient” or might have other unobserved characteristics in common that affect the results. Additionally the governance and laws of the state apply to many aspects within the supply chain (further elaborated on in the analysis), which means that the conclusions are limited to Sweden. As Robson (2011) points out it is highly important to take three factors in to account – generalization industry wise, country wise and generalization to other research field. The conclusions take into account these three possible factors.

Regarding usage of financial reports of companies – the information from annual reports is used as a source of information before the interview. It should be stressed that annual reports are reviewed for backing up the statements made by company representatives, but are omitted from contributing to the results because of data aggregation. It is not possible to determine the costs of specific activities, mentioned in the interviews, from the companies' reports due to this data aggregation and, due to contracts being activity based, and not time based. This means that a yearly perspective does not accurately represent the actual activities. Storm fallout can also be cleared over a course of multiple years. For this very same reason annual reports are not used to answer the third research question on actor profitability.

4 Results

This chapter provides insight in to how forestry activities are conducted, what do the supply chains look like, what are the similarities and differences between the three cases, and what are the costs incurred by the supply chains from storms. A model is developed to help to explain the relationships between actors in the supply chain. At the end of the chapter the most significant cost increases are outlined. The information within this chapter provides a basis upon which the analysis is conducted and the research questions are answered.

4.1 The process

In order to provide an insight into the whole forestry supply chain, a model is developed to help the reader understand the whole process and the subsequent analysis. The model tries to incorporate all of the involved actors that play a role in the construction of the end product. The resulting model differs slightly from the model proposed by Haartveit *et al.* (2004), as certain actors within that model are not given appropriate weight and are left out, while other actors are aggregated to simplify the model.

4.1.1 Illustration of the Forestry Supply Chain

In the literature review the work of Haartveit *et al*. (2004) outlined the forestry supply chain by using structural mapping. This model, as seen in Figure 1, ignored multiple intermediaries in order to reduce complexity, as well as to better illustrate it. Some of these intermediaries are of importance to understanding the effects regarding to storms. For this reason I introduce a simple model in Figure 2 which reduces the complexity in terms of number of actors (compared to Haartveit *et al.* (2004)) while at the same time illustrating the parts of the chain that have not been shown before.

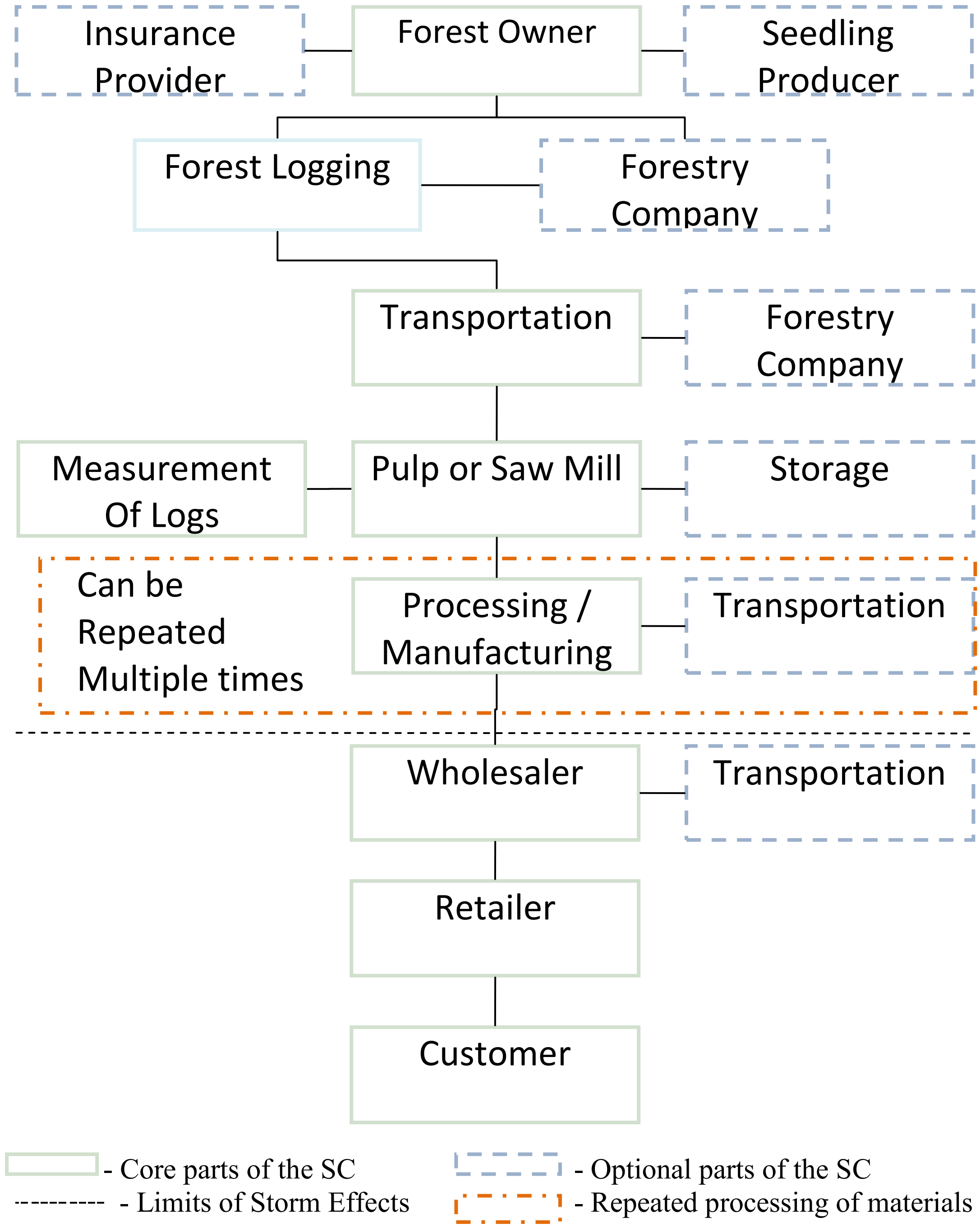

Figure 2 – Illustration of the Forestry Supply Chain and its different parts; Separation between core parts and optional parts; Created by Author.

The model in Figure 2 simplifies the forestry supply chain, by illustrating it from the point of view of a single forest owner. It is based on the model proposed by Haartveit *et al.* (2004). The difference is in grouping several of the proposed actors together. It should be noted that different parts are meant to be independent actors or companies, but can sometimes be incorporated in to a single actor, similar as in the definition of supply chain management. For example it is possible that the forest owner offsets the risk of storms by buying insurance form an insurance provider – or he/she can take the risk of storms themselves thus removing the need of the actor in the chain. Similarly the forest owner in the chain can own the transportation or felling/harvesting machinery.

The model is different from the model proposed by Haartveit *et al.* (2004), as it excludes the divergence of a single product in to multiple products – for example trees grown by a single forestry owner can be used to produce timber of different dimensions and different kinds of pulp – thus making this model more understandable for the reader. Additionally this model includes parts of the chain that were omitted for reasons of simplifying it – namely the measurement of logs, insurance providers, seedling producers, forest loggers (part of log production), storage and transportations companies. These actors are included because of their significance in working with fallout from storms. The purpose of this model is to make it easier to understand the supply chain relative to the highly branched model proposed by Haartveit *et al.* (2004).

4.1.2 Activities in the Supply Chain

The activities in the supply chain which cannot be avoided are defined as core activities. The activities that are complementary or are often done by other actors in the chain are defined as optional parts of the supply chain. This distinction is necessary to understand that there are cases where independent forest owner do some of the activities that at other times are done by the forestry company.

1. **Forest owners, insurance providers, seedling producers**

According to Lars Bergman (2015), an independent forest owner, and Henrik Sakari (2015), from SCA, there are different kinds of forest owners. They vary depending on how much of the onsite work is done. Some forest owners take up the risk of fire and storms upon themselves, while others buy insurance from insurance providers. Similarly – some of the forests are regrown naturally, with the seeds from the nearby forest stand, while other forest owners choose to buy seedlings from seedling providers, and plant them. There are some forest owners who have their own harvesters and forwarders, but this accounts for less than 1% of all forest owners (pers.com., Sakari, 2015). Because this number is relatively small, forestry logging can be considered as being a different part of the chain, which is done separately from the forest owner.

2. **Forest logging and forest companies**

After a forest is in a condition that is fit for felling, the forest owner can contract a company that deals with forest felling and try to do everything independently from a forestry company or he/she can sign a contract with a forestry company that will arrange the details of particular forest – sales, transportation and felling (pers.com., Nordqvist, 2015; pers.com., Sakari, 2015; pers.com., Henckel, 2015). The forest owner can effectively replace the forestry company with their own activities, but he/she is less efficient in doing so. The work required in dealing with individual forest stands is more systematic and effective for forestry companies that specifically deal with such concerns (pers.com., Nordqvist, 2015). Contracts with the forest owners are made for a period of time – the forest company arranges to have the forest felled within 3 to 5 years and pays the forest owner after the felling (pers.com., Nordqvist, 2015; pers.com., Sakari, 2015; pers.com., Falkeström, 2015). After the forest is felled the logs are stored by the roadside to be picked up by the transporters.

3. Transportation

The next step after the timber or pulp wood is felled and placed by the roadside is to transport it to the mill for measuring. It should be noted that in all cases transportation is a service that all parties outsourced. SCA, Norsskog and Södra outsource most of the transportations to smaller local companies (pers.com., Nordqvist, 2015; pers.com., Sakari, 2015; pers.com., Henckel, 2015).

4. Measurement and mills

Measuring takes place in the mill before storage, and processing. The timber measurement association works as an auditor that approves that a certain amount of timber and pulp wood is felled and is of a certain quality. It also gathers data so that there would be information available on a country level with regards to felling. According to Swedish law, all timber that is felled must be measured by these certified agencies (pers.com., Blixt, 2015; pers.com., Oscarsson, 2015; pers.com., Huittinen, 2015). After the measurements are taken, the logs are stored near the saw or pulp mill for processing. Sometimes the logs are stored, and sold from one organization to another – in the end it is still processed at one or another mill. In the mills the logs are stored and sorted in piles with specific machinery. The logs are watered with on-site machinery to maintain their quality and avoid fungus and bark beetles (pers.com., Oscarson, 2015). The storage of logs has been optimized throughout time, which means that the storage space has been decreased to lower costs, and coordination on how much timber is felled has been increasing (*ibid.*). Currently a mill can sustain itself for around one week without receiving new shipments of raw material (pers.com., Huittinen, 2015). Regarding timber there are many different dimensions that the timber is cut in. This has to do with width and thickness (typical examples are 16mm x100mm; 50mm x100mm). The same applies to pulpwood – there are different kinds of mixtures pulpwood can be made into, while not as varying as timber products. This is best illustrated in Figure 1 where there is great divergence from a single product (timber or pulpwood) to many different products. Afterwards the timber is dried and graded, while the paste is stored. When enough similar types of processed materials are in storage, they are packaged with local machinery and then sent for further processing (pers.com., Oscarson, 2015).

5. Further processing, manufacturing and transportation and sales

From the mills the materials can then be taken to different processors, such as paper mills, furniture producers, building material producers, etc. (pers.com., Huittinen, 2015). This is where the traceability within the supply chains gets complicated, as the materials at this point are sold all across the world – with Norrskog selling their products to 20 different countries, Södra to more than a 150, and SCA to even more than that (pers.com., Nordqvist, 2015; pers.com., Sakari, 2015; pers.com., Henckel, 2015). As is explained within the next subheading – storms have little effect at this point, in terms of supplying the chain with material. Also there are no interviews done past the point of processing within the supply chain.

4.2 Effects of Storms on the Supply Chain

In order to illustrate how storms affect supply chains, the previous chapter was used to show how the chain operates in *status quo*. This chapter will address the supply chain in similar order, starting from the beginning of the chain, and will focus on how storms disrupt the supply chain. This chapter will mention what actions are taken to reduce the impacts of storms – a fuller description on actions taken is found within the next chapter.

1. **Forest owners, insurance providers, seedling producers**

When a storm hits, the forest owner is the first to feel the effects. If the owner is not a part of a forest owner association, or does not have an existing contract for felling, all the fallout has to be dealt with by him/herself. Contract for felling are usually made for 3 to 5 years and during this time the company deals with the storm risk, which also includes the costs of replanting after the forest is cleared (pers.com., Andersson, 2015). The forest companies get in contact with all of the members who could be affected and ask if they need help in harvesting or with advice (pers.com., Nordqvist, 2015). Afterwards more precise information is gathered on precisely how many storm-felled trees are there and a plan is made on how and when it will be harvested. If the damaged volumes are small then it doesn't pay off to call in a harvester. Thus a forest owner might choose to take care of the storm-felled timber themselves. For the ones that decided to do it themselves a contract is made for the delivery of the timber at a certain time, place and amount. It should be noted that the storm damage varies from case to case. According to Ville Huittinen (2015), the variation can start from a loss of 10% in the value and can go up to 60% of the value for affected forests.

Even if the owner is a part of a forest owner association, if there is less than 100 m^3 then the forest owner has to pay extra to help collect it (pers.com., Nordqvist, 2015). The law in Sweden states that spruce timber and pulp has to be brought to the mills before the end of June; otherwise it must remain in its place until next year, when it can be picked up after winter. This means there is a time limit on when it can be collected. One of the bigger costs is when the timber just lays in the forest for a year, because it is badly stored- and thus it gets moldy, as well as infested with bark beetles which lower the timbers quality (pers.com., Oscarson, 2015). The cost of having the logs lying around far outweighs the extra costs of the operations, because afterwards it cannot be sold as a fresh product (pers.com.,Oscarson, 2015). Mainly all of these costs fall on the forest owner (pers.com., Henckel, 2015). It should be noted that usually forest owners want to harvest more than is just storm-felled, but this is not preferable to the forest companies, as there is already a lot of available timber, thus negotiations happen (pers.com., Nordqvist, 2015). If there is a valid reason why standing volumes need to be cut, a separate contract for felled timber and standing timber is made (*ibid.*). Contracts with other forest owners who do not have storm felled logs are put on hold, and the forest company forbids its members to cut existing trees (pers.com., Falkeström, 2015).

2. **Forest logging and forest companies**

Because contracts at some parts are put on hold forest working teams with forest machinery have to be moved around. Teams from other regions that are not affected by the storm are generally a source of additional labor and machinery that is required (pers.com., Nordqvist, 2015; pers.com., Sakari, 2015; pers.com., Henckel, 2015). As stated before – logging can happen all year around, but storm felled logs have to be picked up until the end of

June, which can cause quality issues for the logs. While quality issues are a part of the costs, they are relatively small compared to other costs (pers.com., Huittinen, 2015). The losses during storms come from harvesting and forwarding because trees are felled over large concentrated area, which increases the needed time to gather the timber, fuel costs and depreciation (pers.com., Henckel, 2015). Most of the forests that are storm-felled are old forests and are close to final felling (pers.com., Sakari, 2015). It takes ~15% more time to harvest a standing forest compared to a wind felled forest (*ibid*.). Generally working in forests that are storm-felled lowers efficiency up to 50% of the working machinery and personal because the storm-felled trees are located over bigger area (pers.com., Falkstrom, 2015).This means that the harvesters have to spend more time driving to a point and back. This is why extra capacity is needed after storms (pers.com., Söderström, 2015). Most forest owners are insured for storm damage, and it covers the costs of harvesting and forwarding to the road (pers.com., Falkeström, 2015). Broken logs can cause losses, because the machinery has to pick up multiple pieces which otherwise would have been a single log. While the pieces are smaller there had been no losses for the mills because of it (*ibid.*).

3. Transportation

Trucks have to be instructed to transport the trees to new destinations because the forest companies look for new markets of pulpwood and timber by selling it to other sawmills in other areas (pers.com., Falkeström, 2015) This is done because there are generally more logs than the mills can handle. At this point it is possible that trains or ships are hired to transport the logs to a new destination (pers.com., Sakari, 2015). Another possible action by the forest companies is to communicate with the governmental agencies, to temporarily change restrictive laws (pers.com., Sakari, 2015). There are the regulations that state the amount that can be loaded in the trucks and the amount of hours a driver can drive per day. For a limited time these restrictions can be reduced. Also it is possible that incentives are put in places to promote weekend driving to increase the capacity of transportation, which is not done during *status quo* times (*ibid.*).

4. Measurement and mills

While the forestry teams relocate and start working there is a short period of time when there is a strong decrease of logs supplied to the mills. Depending on each mill individually, the average amount that a can continue working on the material that is in storage is one week (pers.com., Huittinen, 2015). Afterwards there is a very big increase in the amount of logs that need to be measured (pers.com., Nordqvist, 2015). In this case the measurement agency can choose to speed up the process, by having the measurers evaluate all of the wood of a truck in a single go (this is generally done for pulpwood, but not for timber), thus increasing the speed of measuring. There is no change in quality of the wood from the perspective of the State Measuring Agencies (pers.com., Oscarson, 2015).

The amount of timber supplied to pulp mills and sawmills drops slightly while machinery relocates. Afterwards there is a large surplus of timber and pulpwood (even with it being exported to other mills in other regions) (pers.com., Oscarson, 2015). Thus storage is mayor issue (pers.com., Sakari, 2015). Additional holding facilities are rented or underwater storage is used, and additional machines are hired to stack the timber in higher piles than before (pers.com., Oscarson, 2015). It should be noted that these extra costs of the driving, storage, and labor are passed on to the forest owner, who sold the timber (pers.com., Henckel, 2015; pers.com.,Sakari, 2015). The timber and pulpwood that is processed loses very little value when comparing storm-felled and regular felled timber (pers.com., Oscarson, 2015). This also means that the processing costs for the mills change very little (pers.com., Nordqvist, 2015). The extra costs for the mills are for machinery to water the logs, to make the log piles higher, extra storage, and slightly more fuel and labor costs due to distances to different storage places (*ibid.*). If measured per m^3 these costs are relatively small.

Before a storm, mills use their capacity to the fullest (pers.com., Sakari, 2015). Some of the timber that is processed is imported from other forest owners or other regions. After a storm the mills focus on the available timber in that specific region. Thus saw mills are operating at maximum speed all the time, thus there is no extra output after storms (pers.com., Nordqvist, 2015). If there is change in output, it generally decreases (pers.com., Blixt, 2015).

5. **Further processing, manufacturing, transportation and sales**

After the timber and pulpwood is processed in the mills, it is transported for further processing. Because the output of the mills has not changed, the transportation expenses remain the same (pers.com., Blixt, 2015). The most crucial point is to plan the change point where whole trees are switched with storm-felled trees, so that the mills do not run out of wood (pers.com., Nordqvist, 2015). Additionally there is a need to coordinate the harvesting and transportation teams, but other than there is no further impact that goes outside processing (pers.com., Sakari, 2015). Because there is a lot of wood on the market, the price of it goes down – thus it becomes easy to supply mills with raw materials, and it becomes good for the economy if the short run (pers.com., Sakari, 2015). This price decrease is for raw materials, while the price for processed materials is affected very little. Otherwise further processing costs do not change (pers.com., Nordqvist, 2015). By the time the product is made and is sold to wholesalers the effect that a storm have on forests are not noticeable. This means that all of the processing and manufacturing actors in the chain have absorbed the shock completely (pers.com., Nordqvist, 2015).

4.3 Similarities and Differences of Cases

As described in the previous chapter – the impact of a storm is particularly tough on the start of the forestry supply chain. This chapter will outline the reactions of each of the forestry companies. The reactions are very similar in many ways, with small distinctions. The reaction of each of the forestry companies is described, with a summary of the similar and different approaches at the end of the chapter.

4.3.1 Norrskog

After a storm hits, there are two things that are initially done. Firstly a coordinating group is set up within the company – which is responsible for timing all of the activities, pricing the services and gathering information (pers.com., Falkeström, 2015). The second thing that is done – contact is established with all of the members of the organization to check if anybody needs immediate assistance or consultation (pers.com., Henckel, 2015). Afterwards there are a number of activities that the group implements:

- Existing contracts with forest owners are put on hold, to free up machinery and limit the amount of timber and pulpwood that is sent to the mills (pers.com., Falkeström, 2015);

- Regional forest officers are contacted to gather information on how much storm-felled timber is there on the fields. These officers continuously report the amount and species at a given location (pers.com., Henckel, 2015);
- To gather more information some areas can be surveyed via planes or helicopters, while other areas are surveyed with the help of the forest owner (pers.com., Bergman, 2015);
- The members are forbidden to cut trees in their properties, as there would be limited capacity to work with that timber or pulpwood. This is an important point, as forest owners tend to want to cut trees in spars locations after storms – thus some negotiation is necessary (pers.com., Falkeström, 2015).

After information is gathered on the amounts of storm-felled timber, and there is a rough general idea of approximately how much storm-felled wood is there. Then other activities can be implemented:

- Contact other saw mills in different regions and gather information, on possibilities of selling raw materials (*ibid.*);
- Forest working teams with machinery from other regions are coordinated to assist in harvesting and transporting (*ibid.*);
- Extra contractors are taken in to assist in harvesting and transporting. These contractors are also coordinated from the same group that is set up to deal with the storms fallout (pers.com., Falkeström, 2015; pers.com., Henckel, 2015);
- Extra storage space is leased to store logs (pers.com., Falkeström, 2015; pers.com., Henckel, 2015);
- Special machinery is hired to stack logs in higher piles at the existing storage space (pers.com., Oscarson, 2015);
- The mills would start working every second Saturday (*ibid.*);
- New contracts are made with the forest owners on the harvesting of the logs (pers.com., Falkeström, 2015);
- The group would meet up every second week to discuss and share newest information on how much storm-felled logs are on the field, the capacity of the machinery, and transportation (pers.com., Falkeström, 2015; pers.com., Oscarson, 2015);

The only long run solution on how to improve dealing storm fallout is by educating the forest owners on what to do after storm (pers.com., Henckel, 2015). Proper forest management is necessary so that the forests are resistant to storm impacts. Thus a possible solution is to create a manual for forest owners – on being active in nursing the forests, putting the right action at the right time to get maximum value (pers.com., Falkeström, 2015).

4.3.2. SCA

The first thing that is done - a reaction group is established. This group meets once every week and shares information on capacity and information from the field. A plan is made for the activities for the coming week until the next meeting. The activities that are done:

- The forests are surveyed by a survey team. To get a general idea of the degree of damage the forests are surveyed by planes and helicopters (pers.com., Bergman, 2015);

- Capacity is planned in terms of harvesting, transporting, mill processing capabilities and storage. The information on these capabilities is updated every week (pers.com., Sakari, 2015);
- Extra attention is given to the "change point" where whole trees are switched with windfall trees, so that the mills do not run out of logs (*ibid.*);
- Additional teams that work with transportation and forest work are hired from other regions or other sources. These teams are then coordinated by the group that meets once a week (*ibid.*);
- Imports of wood from other regions are discontinued (*ibid.*);
- Extra storing facilities are rented, as well as extra machinery that allows for higher stockpiling of logs (*ibid.*);
- Renegotiations of agreements with independent forest owners who have contracts with SCA (*ibid.*);
- Negotiations with governmental agencies are done to increase the allowed truck driving hours per day and the allowed load of a single truck (*ibid.*);
- Create incentives for voluntary weekend driving (*ibid.*).

Because SCA is a company, not a forest owner association, it does not have to spend as much time in creating contracts and getting consent with regards to working on their own land. There is still a sizeable amount of contract with independent local forest owners. As for possible future improvements - thinning practices and planting practices can be improved by consulting with forest owners. That is the limit of possible actions to improve forest susceptibility to storms (pers.com., Sakari, 2015).

4.3.3. Södra

The sequence of actions that is taken by Södra is similar to that of Norrskog and SCA. A group is set up whose responsibility is to deal with the fallout of the storm. There are two things that are initially done. Firstly they get in contact with all of the members who might be affected and ask if they need help in the form of consulting, or harvesting. Secondly they gather information on what kind and how many of logs are there (pers.com., Nordqvist, 2015). This is done by contacting forest owners as well as having regional officers survey the forests. Afterwards a reaction plan is made with calculations of how much timber and pulp can be produced from the forests and how much can be processed by the plants. According to Calle Nordqvist (2015) and Johan Blixt (2015) the things that Södra can do is as follows:

- Contracts with forest owners are put on hold;
- Contact other saw mills in different regions and gather information, on possibilities of selling raw materials;
- Forest working teams and transportation trucks are moved from other regions to work with storms affected forests. If necessary additional teams can be hired form other sources.
- Extra storage space is leased to store logs;
- Special machinery is hired to stack logs in higher piles at the existing storage spaces;
- Negotiations happen with the forest owners as they want Södra to harvest more logs than is just the storm-felled ones as some areas will be left very spars. Forest owners are asked to wait until the all of the storm-felled logs are processed.

- Meetings take place every week, where information on capacity, inventory and harvested logs is shared. Every week a plan is made for the next week, when information is shared again, and the plan is updated.

According to Calle Nordqvist (2015) long run improvement can be done, by improving forest management practices and educating forest owners. If forests are managed properly, they are more resistant to wind damage as well as give higher yields, and are thus more profitable.

An aspect that has to be taken in to account is that Södra is a market price setter in the region that it operates in. This means that the organization is careful in changing the prices that it buys and sells logs for. The price setting is dependent on the degree of damage as well as the markets for processed timber and pulp products (pers.com., Nordqvist, 2015).

4.3.4 Similarities and Differences

All three of the supply chains, with regards to storm management are highly dependent on the forestry companies. The three cases can be compared in two different ways. The first one is similarity in organization – how the forestry companies compare to each other in terms of size and activates. The second is in terms of what is similar in the reaction to how they handle the fallout of storms.

Table 1 – Organizational similarities between Södra, Norrskog and SCA.

	Södra	**Norrskog**	**SCA**
Relationship with forest owners	Forest owner economic association	Forest owner economic association	Forest owner / Company that buys logs from independent forest owners
Total activities in Supply Chain	Forestry, consulting, primary processing	Forestry, consulting, primary processing	Forest ownership, forestry, primary processing, secondary processing
Number of pulp and saw mills owned	12 saw mills 3 pulp mills	3 Sawmills 2 Processing plants	Works with 5 saw mills (owns 4) 1 Paper mill 1 Pulp mill 2 paper board mills
Mechanization	Harvesters and forwarders	Harvesters and forwarders	Harvesters and forwarders
Transportation	Outsourced	Outsourced	Outsourced
Forest work	Outsourced	Outsourced	Mostly outsourced/ some owned harvester and forwarders
Contract length with forest owners	5 years	3-5 years	3 years

The reactions that the three organizations had to storms are similar to a high degree. Within all three of the organizations a reaction group is established, that deals with the fallout. This group then takes a series of actions that are centered on information gathering, capacity increasing, and negotiation. These are:

- Information is gathered and shared in weekly meetings. Information from the field is gathered by planes / helicopters and by survey teams who report the amount and species of storm-felled logs. Information on capacity of mills, transportation, harvesters and forwarders is gathered and shared.
- Capacity is increased by moving forestry teams and transportation from other regions (within the same organization), as well as by hiring external forestry teams. Extra storage capacity is rented. Machinery that allows more storage within existing facilities is rented.
- Preventive actions are taken by negotiating with forest owners – to change contracts and to avoid more timber being cut. Timber is sold to other organizations, so that it does not lose quality from being in storage for too long. Negotiation happens with the government to relax some of the laws that restrict truck loads, driving hours and harvesting storm felled logs after end of June.

It should be noted that the differences are minor. It is not mentioned during the interviews that Södra uses planes or helicopters for information gathering. The frequency of meetings differs – once a week for Södra and SCA; once in two weeks for Norrskog. Apart from these small differences the actions taken are different only in scope – otherwise they are identical.

5 Analysis and Discussion

In this chapter the results of the interviews are analyzed and discussed. The chapter is divided into four parts – one to each respective research question, and one to the generalizability of the results. Due to limited literature on the subject it is not possible to establish an expected result to compare to. This leads the analysis and the discussion being merged in to a single chapter. The start of each subchapter analyses the results on the particular research question, and ends with the statements that are available from the limited literature.

As a reminder to the reader - the aim of this paper is to describe the costs or benefits and taken actions after storms within the forestry supply chain, in order to cover the gap in the academic literature. This aim is covered by the three research questions, where the first one is about costs, the second one is on actions, and the third one is on benefactors of storms.

5.1 First Research Questions

Research Question 1: What costs do storms increase for forestry supply chains?

As concluded from the interviews there are two cost types that are increased – the cost in log quality, and the costs of activities. As noted by Tommy Oscarson (2015): "The cost of having logs lying around far outweighs the costs of the operations, because afterwards the logs cannot be sold as fresh products". Thus the forest companies take up activities to minimize the costs of bark beetles, mold and rot decreasing the quality of logs. The activities that forest companies take up are harvesting and processing the storm-felled timber before the loss of quality is noticeable. If managed correctly there are very small and limiter losses of quality from storm felled timber after storms (pers.com., Huittinen, 2015). The activities that become more costly in descending order are:

- Harvesting (manufacturing) costs – Because of the decreased efficiency of harvesters and forwarders on the field, this is the biggest cost increase in the supply chain. The efficiency of harvesting decreases by 30% to 50% depending on the specifics of the forest stand (pers.com., Falkstrom, 2015);
- Inventory costs – storing the logs in additional terminals increases inventory costs. Storage in these additional terminals is more costly compared to storing them in the mill storage, as the distance to the mill is greater, thus there is decreasing efficiency (pers.com., Blixt, 2015). It should be noted that storage involves watering the logs, so that to maintain the quality for mills;
- Transportation and labor costs – the cost increases in labor and transportation are generally small if calculated per m^3. This is because the additional labor and transportation services that are brought in and hired replace the existing labor and transport providers. The cost increases come from having to hire additional labor which is generally more costly than existing providers, thus the costs increase slightly (pers.com., Nordqvist, 2015; pers.com., Sakari, 2015). It should be noted that the efficiency of transportation and labor is addressed in manufacturing and inventory costs.

The other costs that are noted by Chopra and Meindl (2013) - replenishment lead time, relationships across the supply chain, product availability are unaffected. Because the mills keep working at full capacity, just as before, replenishment lead time and product availability are unchanged. Relationships across the supply chain largely remain unchanged (pers.com., Nordqvist, 2015). Because all parties are interested in maintaining a long-term relationship, there are generally little problems in negotiations (pers.com., Bergman, 2015). Regarding cost of quality of timber – they strongly depend on how well the fallout from the storm is managed. Processing costs for mills remain unchanged, but the quality of output depends on the quality of raw materials. If properly managed the quality loss of timber is negligible (pers.com., Huittinen, 2015). If the storm fallout is not properly managed then the costs of quality could be higher, but this has not been the case with regards to storm in 2013.

An important factor which should be regarded in costs is that the biggest part is born by the forest owners. These costs are experienced through the decreased price that the forest owners have to sell their logs for. Because the forest owner takes the hit for the decreased efficiency of harvesting, 90% to 95% of the total losses of the chain fall on the forest owners, or insurers (pers.com., Henckel, 2015). The additional costs that are experienced by the rest of the chain are with regards to storage, slightly increased labor and transportation costs, as well as possible quality losses – these are small compared to the losses born by forest owners (pers.com., Nordqvist, 2015).

When discussing the nominal size of the costs, the individual situations are not generalizable. Every storm is unique – there is no unique manual to follow, thus the costs in nominal terms can differ wildly for each specific situation (pers.com., Nordqvist, 2015). Every extra unit of storm felled logs increases costs non-linearly based on location and degree of damage, thus the discussed numbers are not relevant for future estimates, and would only serve as an illustration of the moment (pers.com., Sakari, 2015).

Regarding the literature on the subject of costs – the different possible costs discussed by Chopra and Meindl (2013) were relevant to different degrees. The cost increases of transport, labor, inventory and manufacturing (harvesting and processing) are highly relevant to the case, and crucial to making the interview structure. The cost points of product availability and replenishment lead time were not relevant in terms of being a source for costs in the supply chain. Product availability – in terms of how many different kinds of products are available - is completely unaffected. The cost point of "relationships across the chain" is highly relevant when discussing the renegotiation of existing contracts between forestry companies and forest owners. Such type of costs are not observed in chain, because the involved parties are oriented towards long-term relationships (pers.com., Bergman, 2015; pers.com., Nordqvist, 2015), it should reminded that the interviews happened with consent on transparency. According to Robson (2011) transparency can affect results, by having the interviewees avoiding to say anything negative about other parties. This should be taken in to account when evaluating the results.

An additional cost that is mentioned by Chopra and Meindl, as well as many other sources – is the bullwhip effect. This occurs when the supply chain in uncoordinated and information in not properly shared (Chopra & Meindl, 2013; Whang *et al*., 1997). This is not observed to be an issue that the forestry supply chain had to deal with before or after the storm. This is because the output of mills is stable regardless of storms (pers.com., Huittinen, 2015; pers.com., Oscarsson, 2015). This means that in the supply chain after the mills, the coordination is simpler and more predictable. Meanwhile the actors in the supply chain before the mill are working with minimizing storage costs before storms, and minimizing quality loss costs after storms. In both cases the bullwhip effect is not observed.

Regarding quality losses to products – from the literature review according to Hanewinkel and Peyron (2013) the main losses from storms are from the reduced market value of logs “whose mechanical properties have been damaged”. This is found to be partially true. As this can be a very big costs for the supply chain, but that does not mean it necessarily is. To quote Ville Huittinen (2015):”If storm fallout is properly managed the quality loss of logs is negligible”. This statement from Hanewinkel and Peyron (2013) is true to the extent that part of the supply chain refocuses on minimizing losses from possible quality loss. This refocus is mentioned by Broman *et al.* (2009). In the work of Broman *et al.* (2009) transportation is noted as the most complex and constraining issue. While transportation costs do increase slightly, the losses from it per m^3 are not as noticeable as from harvesting. This could be because losses from logistics can be influenced by management decisions, while losses from harvesting cannot be influenced.

5.2 Second Research Questions

Research Question 2: What actions are taken within the forestry supply chain to minimize the costs from storms?

To restate the point made by Tommy Oscarson (2015): “The cost of having logs lying around far outweighs the costs of the operations, because afterwards the logs cannot be sold as fresh products”. This means that the forestry companies’ act in a way to minimize the cost associated with loss of quality of logs. A similarity in all three cases is that a working group is created within the organization that would deal with the fallout of storms. The activities taken by these companies would then reduce the impact for the rest of the forestry supply chain. The actions that are taken by within the forestry supply chain are as follow:

- Existing contracts with forest owners are renegotiated. Contracts for clearing a forest stand are made for a period of 3 to 5 years (with some exceptions that are faster), and after a storm, to free up capacity, it is more costly in the long run to work on standing forests than on storm felled ones (pers.com., Nordqvist, 2015; pers.com., Sakari, 2015; pers.com., Henckel, 2015). Thus negotiations happen with the contracted forest owners to put off the arrangement;
- Labor and transport capacity is increased. This is done by bringing in forest workers and trucks that work in other regions, as well as employing other transportation methods such as railways and seaways (pers.com., Söderström, 2015). Firstly internal resources are “moved around” and afterwards external sources are used to make up for decreased capacity (*ibid.*);
- Additional terminals to store storm-felled logs are rented in all cases. This is because the existing mills are equipped to store raw materials so that the mill could process them in around one week (pers.com., Huittinen, 2015);
- Machinery for improving storage efficiency in existing storage space is rented (pers.com., Blixt, 2015; pers.com., Huittinen , 2015; pers.com., Oscarsson, 2015).
- Logs are sold to other mills. Depending on the market prices of logs and transportation costs, logs are sold to other mills. Alternatively this would increase storage costs, to maintain the quality of the logs until the existing mill could process the logs (pers.com., Blixt, 2015; pers.com., Huittinen, 2015; pers.com., Oscarsson, 2015);
- Negotiations are done with governmental agencies on restrictions. There are multiple restricts that limit the efficiency of the supply chain. These are the restrictions on the

driving capacity of trucks, the allowed driving hours of truck drivers as well as the restriction that all storm-felled timber has to left lying in the forest after the end of June until next year. The restriction on truck driving, both hours and capacity, were relaxed for month after the storms in 2013. The restriction on lying forests were relaxed after Storm Gudrun in 2005 (Swedish Meteorological and Hydrological Institute, 2011; pers.com., Nordqvist, 2015).

It should be noted that the choice of activities that are implemented depend on each specific storm. The activities listed above are the ones that were implemented after the storms of late 2013. For different storms, circumstances might differ, and some of the aforementioned activities would not be implemented (pers.com., Nordqvist, 2015; pers.com., Sakari, 2015; pers.com., Henckel, 2015).

As an additional actor whose activities are worth mentioning is the government of Sweden influences the process through regulations. Examples of this are the regulations regarding collection of storm felled timber and limited driving hours for truck drivers. This means that these results are limited to Sweden, as different countries can have different regulations. Otherwise the government's role in the supply chain is minuscule.

Some of the activities are mentioned in the literature by Broman *et al.* (2009). The activities that are mentioned are information gathering after storms, capacity building in terms of forestry work, transportation, storage and sales of logs to other mills. The activities that are not mentioned are renegotiation of contracts, machinery for increasing storage efficiency, and negotiations with governmental agencies. The process of how storms are generally managed has not been explicitly documented. For this reason the author proposes a model in Figure 3 to explain the process.

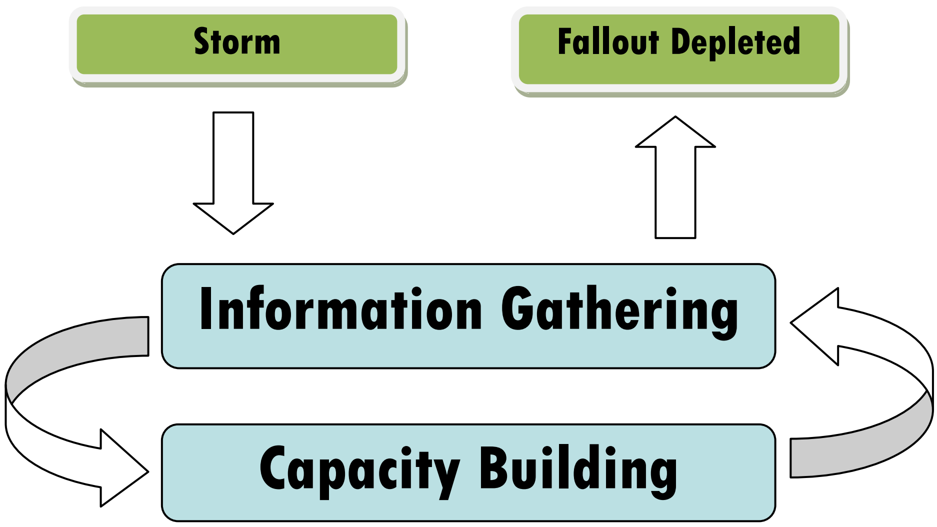

Figure 3 – Illustration of the storm fallout management process;

The proposed model shown in Figure 3 is a simple explanation of how storms are managed. It is based on the information gathered from the interviews. This is described more in detail under heading 5.4 Generalizations The activities that are done within capacity building are described in chapter 5.1 "Analysis" under the 2nd research question.

The actions described in Figure 3 happen in all three cases. All three supply chains started to work with the fallout by forming a managing group which works by continuously collecting information and then using it to adjust capacity. This is done until all of the fallout is managed and the arrangements for its usage are made. The specific actions that are taken are described at the start of this subchapter. The model is necessary to fill the gap of lack of literature on how fallout from storms is managed. The model is also generalizable to forestry management chains further than Sweden because it omits the specific actions taken, and just focuses on how forestry companies deal with storm fallout. More is discussed in subchapter 5.4 Generalizability.

5.3 Third Research Questions

Research Question 3: Which parts of the supply chain profit in the short run from shocks caused by storms?

During the interviews with different parts of the supply chain all of the interviewees stated that there are no parties who profit from storms in a way that would be significant. This applies to both, the short-run and the long-run. The losses are outlined under the first research question – there are parts of the chain the benefit in some form, while not making increased profits. The contracted forestry workers and transportation companies, while not making any increased profit, have a guaranteed flow of work for a significant amount of time (pers.com., Henckel, 2015). The biggest benefactor of storms, while not gaining profit on it, is the forestry industry which uses processed wood products (pers.com., Sakari, 2015). After a storm there is an implicit guarantee that there will be a steady surplus of processed wood products, thus the manufacturers have a more predictable source (pers.com., Falkeström, 2015). Lastly it should be noted that while none of the parties in the supply chain profit from the shock to the supply chain, the economy as whole gains, as all of the activities to mitigate storm damage, listed under the second research question, increase GDP (pers.com., Sakari, 2015).

To sum up with a quote from Henrik Sakari (2015): “There are no winners from a storm, but some are bigger losers than other. The forest owner gets less, the insurer loses, and the harvesting becomes more costly. With all of the wood on the market the price goes down – thus it becomes easy to supply the industry and it becomes good for the economy”.

Regarding the third research question on possible profits in parts of the supply chain, it is now safe to say that no part of the supply chain profits from storm. The brief possibility mentioned by Hanewinkel and Peyron (2013) that forest loggers or nurseries profit from storms has been proven untrue. Forest loggers gain in terms of stability of work, as the shock from the storm guarantees work for a significant amount of time – while no noteworthy costs increases have been reported by any of the interviewees. Seedling producers pointed out that there is lag of 1 to 2 years between a storm felling a tree and time when that forest stand is replanted (pers.com., Andersson, 2015). This leads to increased short-term demand after those 1 to 2 years, but it is done on the account of that same stand being felled at a later time – meaning that the produced seedlings that were meant for regular felled forest stands now go to storm felled forest stands (*ibid.*). This can also be confirmed by the reaction groups that work with storm felled timber – the seedling producers are not a part of the group that get information and it is pointed out that they do not need to be (pers.com., Andersson, 2015; pers.com., Sakari, 2015).

Another theory that helps explain the activities in supply chain is the notion of push and pull. Defined in Chopra and Meindl (2013) these can be distinguished by either predicting customer demand or by reacting to it. According to Tommy Oscarson and Olof Falkeström (2015), during *status quo* the forestry supply chain has a pull position. Mills work at full output and the stock of logs near mills is necessary only as precaution. The shock created by storm forces the forestry supply chain to take a push position.

5.4 Generalization

This subchapter addresses the generalization and the external validity of the conclusions. This is done to thoroughly address the different parts that can be generalized to a different extent. As noted by Robson (2011) there are three degrees of generalization that should be taken in to account - industry wise, country wise and to other research field.

External validity is an important factor in to determine to what extent the results can be expected to be the same in different situations (Shadish et al., 2002). The process of working with fallout from storms is impacted by multiple factors that could be specific to Sweden, such as price and availability of different services, demand for processed timber and the role of the government. These limitations apply to apply to all specific taken actions, cost distributions and possible profits. This means that the results of this work can be generalized only to the forestry supply chains, as no other supply chains are analyzed, and only to Sweden.

An exception to this rule is the model illustrated in Figure 3. This model is simplified to illustrate the continuous process of working the fallout of storms. Because it leaves out specifics and only describes the general actions of the process, this model can be generalized to any forestry supply chain that would choose work with the fallout from storms. The country limitation does not apply only to this model.

6 Conclusions

This chapter concludes the research done in this paper. This includes briefly describing the methodology, the answers to the research questions, achievement of the aim and suggestions for further studies.

Storms are a significant impact on forestry supply chains. In the end of 2013, Sweden is hit by numerous storms that caused damage to forests. Because the forestry supply chains reaction to storms, has not well documented in academic literature, this provided a good opportunity to research the reaction of the forestry supply chain. Case studies of three forestry supply chain are done and interviews are made with people in key positions in different parts of the chain. The most significant part of the chain, that deals with the shocks of storms are the forestry companies, who have been the main source of data. The forestry supply chain involves forest owners, forest workers who do felling and thinning, transportation, forestry companies, pulp and saw mills, secondary processors in the end retailers. The shock is absorbed by the forest owners and the forestry companies. The pulp and saw mills deal with extra storage, but the output does not change notably – thus after the secondary processors the impact of storms is generally not noticeable.

Research Question 1: What costs do storms increase for forestry supply chains?

The shock from a storm creates a tradeoff for the forest owner and forestry company – the storm-felled logs lose quality if they are not harvested after the storms. Harvesting the storm-felled logs is less efficient than harvesting fresh logs because it is more time consuming and not as concentrated, thus more costly. The costs of quality loss far outweigh the costs of reduced efficiency of harvesting, thus there is adjustment to work with storm-felled timber. The main costs, which the storms increase, are harvesting costs, because of reduced efficiency, inventory costs, because storm-felled logs have to be stored, and slight increases to labor and transportation costs. These increased costs come from the activities to minimize the possible losses from quality, and these activities are related to increasing capacity to work with storm-felled logs.

Research Question 2: What actions are taken within the forestry supply chain to minimize the costs from storms?

The forestry companies are the main actors in dealing with the storm-felled logs. In the three cases that are looked at all of these activities are present, while in slightly different extents. The reaction of the forestry companies starts by establishing a working group that would deal with the fallout of the storm. This group would then gather data on the species and amount of specific logs at specific areas. This would be done by either survey teams on the ground or by aerial surveillance. Information is continuously gathered as the storm-felled logs are harvested. There are a number of actions that the forestry companies can take, mainly capacity building and negotiating. Capacity building refers to hiring additional working teams, harvesters, inventory and machinery, while negotiating refers to selling the logs to other mills, postponing existing contracts with forest owners, and communicating with governmental agencies on capacity restrictions.

Research Question 3: Which parts of the supply chain profit in the short run from shocks caused by storms?

It is concluded that no part of the chain profits from the shock created by a storm. However there are some actors in the chain that benefit. Firstly the forestry workers and transporters who are hired as extra capacity gain certainty of employment until the fallout of the storm has been gathered. Secondly the industries that rely on processed wood products have an implicit guarantee that there will not be a shortage of raw materials. Lastly, due to increased economic activity a countries GDP increases. The losses are taken by the forest owners and insurance companies because of the reduced price of logs.

There are three main contributions of this paper to the academic literature. Firstly it is the list of activities taken in the forestry supply chains in Sweden in order to minimize cost and a description of the costs. Secondly it is the map of the Swedish forestry supply chain illustrated in Figure 2 – it is based on the work of Haartveit et al. (2004), and uses the same method, while being a simplified in order to better show the effects of storms. Lastly it is the framework of dealing with the fallout from storms illustrated in Figure 3. It shows the approach that the forestry companies used. These three contributions are the key elements in achieving the aim of this paper.

The aim of this paper is to describe the costs (or benefits) and taken actions after storms within the forestry supply chain, in order to cover the gap in academic literature. The aforementioned conclusions are drawn from the three cases of supply chain. The aim has been achieved to the extent that the conclusions are generalizable within Sweden, with the exception of the model which describes the continuous process of working the fallout (Figure 2).

7 Epilogue

During the interview process of research multiple issues reoccurred that are unrelated to the main body of research. These issues might be of interest for future studies and / or inquiry. These issues are related to climate change, forecasting, hiring and long term impacts.

Questions regarding climate change are brought up at the end of some interviews after the topic of general improvement from forestry management. An argument that is pointed out by Sverker Henckel (2015) that forest structures are changing noticeably quicker than the environment. This is evident by changing forestry management practices in some regions (was not specified in which regions) – which leads to an inquiry that is not found often in the literature: ”How are management practices changing?”.

A point that is made by multiple interviewees is that long-term forecasting is not practiced in the industry precisely because of natural disasters. According to Henrik Sakari, 2015 and Olof Falkeström this is due to reasons of low predictability and because there are no tools that would help protect a forest even if it is known that a storm would hit a specific area. This is best summed up by a quote from Calle Nordqvist (2015): “We just assume that there are storms every other year”. This leads to a question which should be answered within a completely different field – can anything be done to prevent storm damage to a forest, even with accurate forecasts?

Outsourcing is common practice in the industry – as can be seen by the three forestry companies. While transportation is easily outsourced because of competition and easy adjustment, forestry worked is less flexible. This issue could be seen as a minor suggestion to all of the forestry companies for future improvement. While none of the three cases had problems with outsourcing forestry work, the way additional forestry work is found is through industry knowledge of the right people at the right place. If there is an unsystematic way of solving these issues, it leads to risk. If the employees change within the forestry company, a chance exists that somebody without such industry contacts would have to solve the same problem. The solution from such an employee might take more time or additional expenses, thus leading to losses. Therefore the suggestion is to have more systematic way of hiring external contractors.

Interviewees from all three forestry companies noted that as a long term improvement the only thing that can be done in better and more educated forest management – to do the right thing at the right time. In the last ten years, since storm Gudrun, there has also been increased awareness of storms in forestry management (pers.com., Henckel, 2015). All of this means that the field of forestry management adjusting, while the academic literature on the subject is slowly catching up. Lastly a thank you should be said to all of the participants in this research for educating the author with respect to forestry management as well as for the insight in to the unpredictable.

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Personal messages

Andersson, Jörgen
Chief of Norrplant
Phone interview, (2015-04-02)

Bergman, Lars
Independent forest owner
Phone interview, (2015-04-15)

Blixt, Johan
Platschef, Södra Timber Långasjö
Phone interview, (2015-03-30)

Falkeström, Olof
Norrskog Skogschef
Phone interview, (2015-03-26)

Henckel, Sverker
Norrskog, Skogsrådgivare Medelpad Östra
Phone interview, (2015-04-16)

Huittinen, Ville
SCA Timber, Råvaruchef
Phone interview, (2015-04-29)

Nordqvist, Calle
Södra, Regionchef
Personal interview, (2015-03-11)

Oscarsson, Tommy
Norrskog, Östavall Millmanager
Phone interview, (2015-04-08)

Sakari, Henrik
SCA, Kundförsörjningschef
Personal interview, (2015-03-26)

Söderström, Olov
Norrskog, Virkeschef
Phone interview, (2015-04-02)

Appendix 1: Types of material flows

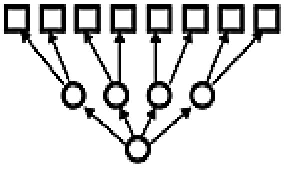
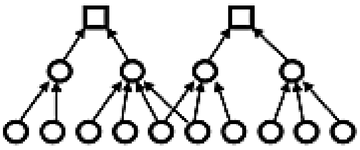
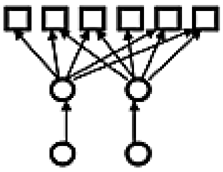
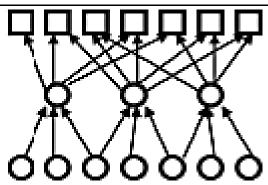
Material Flow Illustration	Material Flow Type	Description	Examples
	V-type (Mattsson, 1999) (Ferguson & MacBeth, 1994) (Burbidge, 1994)	Diverging flows involve partitioning or splitting the raw material into a number of products.	The breakdown operation in lumber production
	A-type (Mattsson, 1999) (Ferguson & MacBeth, 1994) (Burbidge, 1994)	Converging flows refer to situations where several raw materials end up in significantly lesser amounts of end products	Assembly operations in general: - Assembly of computers - Assembly of furniture
	T-type (Mattsson, 1999) (Ferguson & MacBeth, 1994)	The T-type is where a small number of raw materials end up as a larger number of end products. The number of converging points increases as focus is moved downstream in the supply chain.	The paper industry utilizes only a few ingredients, but a large number of paper qualities and types can be produced.
	X-type (Mattsson, 1999)	The x-type is characterized by a large number of raw materials that converge into lesser number of parts or modules that can be combined into a multitude of end products.	Use of modules makes it possible to create a multitude of products from a moderate number of parts: - Automotive industry - Manufacturing of kitchen cabinets
	I-type (Mattsson, 1999) (Ferguson & MacBeth, 1994) (Burbidge, 1994)	The I-type has one raw material that ends up as one final product. Typically, this is true for separation processes, or processes where the raw materials is shaped into a product.	Lumber manufacturing.

Figure 1. Types of material flows and their characteristics. Created by Haartveit et al. (2004)

Appendix 2 - Semi structured interview plan

Topics:

1. Map of the supply chain
2. Storms and their effects
3. Costs
4. Reaction (information sharing, extra capacity, etc.)

The interviewee is reminded that they can refuse to answer if the answer involves trade or competitive secrets. Recording is done for personal use. The final version will be sent for approval. Start with personal questions – position, experience and current events.

At the end – ask if I have missed any important factors in understanding how storms affected the company in 2013. In the end ask for contacts regarding the other parts of the supply chain.

1. **Map of the supply chain**

What is your role in the supply chain? (What do you do; what are you responsible for?)

Could you outline the full supply chain of your organization? What part of the supply chain is owned by your organization, and what part is owned by others?

What activities are outsourced? (Logging, transportation, etc.)

How are goods transported within the supply chain? (Ask again later after storms)

From what activities does your organizations revenue come? (Log sales; lumber sales; real estate; retail; pulp/paper sales; etc.)

What kind of raw materials and services does the organization buy?

How many companies are you buying your supplies from? (How many companies are before you in the supply chain?)

How much % of all sales is to the largest customer? (Not needed to disclose who the customer is)

2. **Storms and their effects**

Within 2013 and 2014, was the company affected by storms?

How did the company react? What actions were taken?

What activities do the storms force the organization to do?

What was done with the damaged timber? (How was it arranged? How was it handled?)

Does the degree of damage differ? How?

How did the storm affect operations? (Were some things postponed/ hurried?)

How do storms affect existing contracts? (How does the company deal with felling contracts for the period?)

How was capacity affected at different points in the supply chain?

Did the company have extra capacity before the storm? (In terms of available workforce, technology for felling and transportation, etc.)

What actions were taken to improve capacity at chokepoints during storms?

3. **Costs**

How did coordination happen during and after the storm? (What was the chain of actions how the organization reacts?)

How did each of these costs change because of the storms:

- Manufacturing cost (costs of harvesting; processing timber)
- Inventory costs (holding more inventory)
- Transportation costs (because surplus needs to be maintained)
- Labor costs (were more people hired?)

Could you explain the reasons for these cost changes?

How did the relationships with other companies change?

How did the delivery times change?

Were the previously agree upon orders delivered?

Does any part of the supply chain benefit from storms? (If yes, how?)

4. **Reaction**

Does collaboration happen with other organizations in the supply chain during storms? (If yes, how?)

In your personal opinion, how would sharing information on the damages of storms change relationships and costs in the supply chain? (This question is asked if not previously answered)

How does forecasting happen?

How was forecasting adjusted after the storms?

Were there any lessons learnt / preparation made for the future, after the storm?

How did you receive the information about the storm? How predictable are storms?

What did your organization do "good" (well) and what could have been done better with regards to working with the consequences of a storm?

Appendix 3 – Interviewee list

Name	Description	Contact information
Jörgen Andersson	Chief of Norrplant - supplies seedlings to SCA and Norrskog	jorgen.andersson.skog@sca.com 060-59 41 72
Lars Bergman	Independent forest owner who has experienced storms in his forests	-
Johan Blixt	Platschef, Södra Timber Långasjö	0471-509 27
Olof Falkeström	Norrskog, Skogschef,	olof.falkestrom@norrskog.se 0612-71 87 81
Sverker Henckel	Norrskog, Skogsrådgivare Medelpad Östra	Sverker.henckel@norrskog.se 060-16 72 80
Ville Huittinen	SCA Timber, Råvaruchef	070 398 59 02
Calle Nordqvist	Södra, Regionchef, Södra Skogs region syd	calle.nordqvist@sodra.com 0454-59 801
Tommy Oscarsson	Norrskog, Östavall Millmanager	tommy.oscarsson@norrskog.se 0690-524 08
Henrik Sakari	SCA, Kundförsörjningschef	henrik.sakari@sca.com 060-19 32 10
Olov Söderström	Norrskog, Virkeschef	olov.soderstrom@norrskog.se 0612-71 87 70

The contact information of all the interviewees is listed above. The contact information is taken from public sources. Private contact information is not disclosed because of ethical considerations described in chapter 3.3. The contact information of Lars Bergman is not given as per request – to confirm interview status please contact Henrik Sakari from SCA.