Swedish University of Agricultural Sciences
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The Swedish Forest Industries' View on the Future Market Potential of Nanocellulose

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Abstract

General concerns about environmental issues may mean that the demand for bio-based products will increase. Opportunities that arise on markets, together with the declining demand for newsprint, may trigger firms in the Swedish forest industry to increase their development of new products. One product that has received a lot of attention during recent years (and is a contender) is nanocellulose.

The purpose of this master thesis was to examine the Swedish forest industry's view on the market potential of nanocellulose. For many forest based firms standard newsprint have been of utmost importance. However, due to the rise of digital media it is commonly acknowledged that the consumption of standard newsprint may have peaked. New product development is of importance when markets change and uncertainty on markets arises. Maybe, nanocellulose could be the answer to several problems.

Qualitative interviews with eleven respondents from relevant Swedish forest firms have been conducted during the period Mars to May 2014. Specific questions the thesis tried to answers were:

- What are the factors that could make wood-based nanocellulose a successful commercial concept?
- What are the factors that hinder wood-based nanocellulose from becoming a successful commercial concept?
- In what stage of the value-chain should the implementation commence?

During the conducted interviews it has been emphasized that the right combination of business model and product area is of importance for a successful commercial concept. At the same time the process ability of nanocellulose has to increase.

Judging by the conducted interviews, areas of use and required volumes will determine which actors that may pursue a commercialization of nanocellulose. There is still a lot of work to be done and at the moment some forest firms are unsure if they should commence the commercialization - this because the current situation of nanocellulose is quite unsure. Demand is uncertain, and there are still technological issues to be solved before nanocellulose can reach the great potential it carries.

Still, most of the approached respondents believe that nanocellulose will find its place on a market within 5-10 years. Nanocellulose is considered a fantastic material and the main push factors for a successful commercialization are its characteristics. However, no real demand from the customers' point of view has been made visible. If the right business model could be connected to the right product nanocellulose will surely be successful. Maybe, it is too early to determine how big the market potential of nanocellulose is. Nonetheless, what can be said is that nanocellulose carries great potential.

Keywords: *Nanocellulose, innovations, strategy, resources, alliances*

Sammanfattning

En ökad oro avseende miljöfrågor kan leda till att efterfrågan för biobaserade produkter ökar. Tillsammans med en dalande efterfrågan på tidningspapper kan de eventuella möjligheterna som uppstår på marknader vara incitament till företag inom den svenska skogsindustrin att öka sin utveckling av nya produkter. En produkt som under den senaste tiden fått mycket uppmärksamhet är nanocellulosa, kanske kan svaret på några av skogsbolagens problem just vara nanocellulosa.

Syftet med detta examensarbete var att undersöka den svenska skogsindustrins syn på nanocellulosans marknadspotential. För många företag verksamma inom den svenska skogsindustrin har tidningspapper länge varit en viktig inkomstkälla. På grund av ökad efterfråga på digital media är det allmänt känt att konsumtionen av tidningspapper kraftigt har minskat. När marknader förändras och är osäkra är produktutveckling av betydelse.

Under perioden mars till maj 2014 har elva kvalitativa intervjuer med respondenter från relevanta företag inom den svenska skogsindustrin genomförts. Frågor som har ställts och svar som har getts har använts för att besvara tre specifika frågor:

- Vilka är de faktorer som kan göra träbaserad nanocellulosa till ett framgångsrikt kommersiellt koncept?
- Vilka är de faktorer som hindrar den träbaserade nanocellulosan från att bli ett framgångsrikt koncept?
- I vilket skede av värdekedjan bör en implementering av nanocellulosan påbörjas?

Enligt de flesta respondenterna kommer kommersialiseringen av nanocellulosa vara användnings- och volymberoende. I nuläget inverkar många faktorer negativt på företagens vilja att driva kommersialiseringen framåt. Den främsta faktorn är en osäker efterfråga på nanocellulosa, det finns också tekniska frågor som måste lösas innan nanocellulosan kan nå dess potentiella höjder. Många respondenter tror däremot att nanocellulosan kommer att hitta sin plats på en marknad inom fem till tio år.

Nanocellulosa anses vara ett fantastiskt material och det som talar för en framgångrik kommersialisering är materialets egenskaper. Om rätt affärsmodell kan kopplas till rätt produkt kommer nanocellulosan lyckas, men kanske är det för tidigt att avgöra hur stor marknadspotentialen är. En sak är säker, även om mycket arbete återstår bär nanocellulosan på mycket potential.

Nyckelord: *Nanocellulosa, innovationer, strategi, resurser, allianser*

Preface

A long period of studies is over. The last two years at the master programme studying Forest Industrial Economics at the Swedish University of Agricultural Sciences have been most fulfilling. I will cherish the memories from our study trip to China and I will remember the free coffee (something many students dream of) with delight. It is now time to plunge into the world of work.

I would like to thank my supervisors Tom Lindström (Innventia AB) and Torbjörn Andersson (SLU), you have been very helpful throughout this process. I would also like to thank all of the respondents that participated in this study. Without your input there would not have been a thesis, thank you for your time! Finally, I would like thank my family, friends and girlfriend for all of your support.

Tack!
Thank you!
Danke schön!
Merci beaucoup!
Gracias!
谢谢!

"I realized the more fun I had, the more relaxed I was working, the better I worked"
Bill Murray

/Johan Eklund

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1 Introduction

The first chapter describes the background, the purpose and the delimitations of this master thesis. In the background a brief description of possible future opportunities will be presented. Later, a summary of the background will lead to a description of the problem, i.e. what the thesis pursue to answer. The description serves as the basis for the purpose of the thesis.

1.1 Background

"*A world without oil would quickly become a world without all of the products made from petroleum that we have come to know, love and depend upon. The list of essentials that we'd soon be doing without is prodigious: virtually all plastics, paints, medicines, hospital machines that go "bleep," Barbie dolls, ballpoint pens, breast implants, golf balls etc*." (Hallet & Wright 2011)

The quote originates from an article in the Washington Post (2011). The authors of the article *"Imagining a world without oil"* describe a scenario where the world stands without oil. Due to the resource's central role in the present society the current situation may imply that the ways we live by may drastically change in the future. Oil is a finite resource which means that its central role in everyday life is likely to be reduced. (Hallet & Wright 2011)

"Peak-oil" became a widely recognized term during the second half of the 20th century. The problematic scenario can be describe as a theoretical point where maximum oil production is reached, after that point there is a decrease in production – i.e. the production decreases because extraction of oil becomes more expensive while demand does not change. Whether the theory and all statements about it are correct is a hard question to answer. However, supply of oil is difficult to predict and it is challenging to measure the availability of a resource that is not visible. Oil itself may never stop to exists, but global companies may come to shift their usage of resources due to an increased global environmental friendly demand. (Murphy 2011)

Oystein Noreng, a professor in petroleum economics at the BI Norwegian Business School, has criticized the theory. Noreng contradict the knowledge that availability of oil is likely to decrease in the near future. The professor suggests that there are areas where oil has not been exploited due to current technologies. If petroleum companies develop their technologies oil extraction and production can increase. Noreng also declared that the price mechanism behind oil trade has worked well through the years - high oil prices weakens demand and encourage investment in energy conservation and new construction. According to Noreng, the price mechanism prevents a possible economic and social disaster. (Noreng 2012)

Even if the theory concerning "peak-oil" proves to be false, there are still a lot of incentives for organizations to search for more sustainable alternatives. Environmental concerns have increased during recent years and the increasingly common saying "*we borrow the planet from our children*" is a statement that requires responsibility. The Great Pacific Garbage Patch is a bad example of that work and a testament to (our) lack of responsibility and the environmental downside of oil production. The environmental issue consists of marine debris in the North Pacific Ocean, the debris are litter that end up in seas, oceans and other large bodies of water affecting wildlife negatively (National Geographic 2014). In the Great Pacific Garbage Patch, a single square kilometer can contain up to 750 000 bits of plastic. The debris threatens plankton and algae communities which in turn can mean that the entire ocean food chain may change. It has also been proven that debris can be linked to a decrease in carbon storage (ibid.).

Our generation has a responsibility when it comes to taking care of our planet in order for other generations to thrive. In a newsletter from the Swedish Forest Industries Federation (Skogsindustrierna) CEO Carina Håkansson stated that the forest industry should strive to be the engine towards a bio-based society (Håkansson 2013). According to Håkansson the industry, as a whole, has to take many small steps in order to reach that stated goal. One long-term goal for the forest industry was therefore a vision of replacing products manufactured by fossil resources with products based on renewable resources (ibid.).

An example of an organization who is working with innovations is Innventia AB – a world leading research institute. Innventia search for new technological solutions and new products derived on raw material from the forest (Innventia 2014a). One specific material that has received a lot of attention during recent years is nanocellulose. Nanocellulose (described below) may become an important factor in the forest industries long-term goal - starting the transition towards a bio-based society.

1.2 Nanocellulose

There is a variety of potential applications for nanocellulose. For example, research has shown that nanocellulose can be used as a reinforcing agent in paper with high filler content (e.g. making the paper stronger and lighter). Other uses may be surface sizing and coating, e.g. as a barrier material (to oxygen, water vapor, fat/oil) in food packaging (Innventia 2014b). Besides applications connected to forest industries there is potential of nanocellulose becoming a reinforcer in bio-plastics, light weighting in products enabling lighter transports, additive in food, bendable batteries, thin displays and screens. It has also been shown that techniques for re-constructing body parts (Chalmers 2009) and nano-paper filters to remove viruses (RISI 2014) are under development.

As described above, there is a lot of potential connected to the term nanocellulose. However, the term nanocellulose can mean different things. There are three types of nanocellulose described in *"Nanocelluloses: A new Family of Nature-Based Materials"* (Klemm et al 2011), and also in Mikael Ankerfors' dissertation -*"Microfibrillated cellulose: Energy-efficient preparation techniques and key properties"* (Ankerfors 2012). The three types of nanocellulose are presented in Table 1 below.

Table 1. Three types of nanocellulose; adapted from Klemm et al. 2011 and Ankerfors 2012

Type of nanocellulose	Related terms	Typical sources	Formation & dimensions
Microfibrillated cellulose (MFC)	Microfibrillated cellulose, cellulose nanofibrills, **nanofibrillated cellulose (NFC),** nanofibrillar cellulose, and microfibirls.	**Wood**, sugar beets, potatoes, hemp, and flax.	Delamination of wood pulp by mechanical pressure preceding and/or following chemical or enzymatic treatments. Diameter: 5-6 nm Length: several μm
Nanocrystalline cellulose (NCC)	Cellulose nanocrystals, crystallites, whiskers and rod-like cellulose microcrystals	**Wood**, cotton, hemp, flax, wheat straw, mulberry bark, ramie, tunicin and cellululose from algae and bacteria	Acid hydrolysis of cellulose from many sources Diameter: 5-70 nm. Length: 100-250 nm (from plant celluloses); 100 nm-several πm (from cellulose of tunicates,

			algae and bacteria)
Bacterial nanocellulose (BNC)	Bacterial cellulose, microbial cellulose, and bio-cellulose	Low-molecular sugars and alcohols	Bacterial synthesis Diameter: 20-100 nm (various nanofibre networks)

1.2.1 Nanocellulose retrieved from wood-based fibers

Nanocellulose is most commonly produced from wood (Klemm et al. 2011). By thorough homogenization of pulp using a high-pressure homogenizer nanocellulose can be collected from the cell wall (Klemm et al. 2011; Ankerfors et al 2013). Mainly, sulfite pulp is used for the production due to the fact that it is considered quite easy to delaminate. However, nanocellulose derives from the cell wall of cellulose and when it is obtained it consists as a highly viscous gel with only a few percent of solid content (Innventia 2014b). When cellulose has gone through the homogenization process the microfibrills (or nanofibrills) have a length in the micro size range and a diameter in the nano size range (ibid.).

This type of nanocellulose was first discovered in the 1980s. At that time, the amount of energy required (approx. 30 000 kWh/tonne) to delaminate fibers was significant and the associated high energy costs were considered to be too high for commercial exploitation of nanocellulose (Innventia 2014b). However, subsequent research and development (which resulted in various pretreatment methods of fiber) now means that the energy required to produce nanocellulose has been reduced by up to 98 percent (approx. 500 kWh/tonne) (Innventia 2014; Klemm et al 2011; Ankerfors 2012). Therefore, the fundamental research question of this thesis is whether nanocellulose is now commercially viable?

Innventia AB is working on a number of scale-up issues related to manufacturing, processing and applications of nanocellulose. The challenges connected to nanocellulose have been described being coating technologies, drying and re-dispersion and processing at high consistency (Innventia 2013).

1.3 Problem

For established forestry firms, nanocellulose can be a potential new product to their product portfolios. Newsprint has been a key product in such portfolios – for many forestry based firms it has been of utmost importance. However, the consumption of standard newsprint may have peaked due to the rise of digital media. Therefore, many (if not all), forecasts indicate falling demand for standard newsprint. In Figure 1, the drop of significance for newspapers' current format is described. From the picture it can be interpreted that many may stop reading their news from a paper version in a near future. Thus, many Swedish forestry firms need to find alternative income streams as the market demand for newsprint decreases. Furthermore, Skogsindustrierna (2013) have also expressed a wish that the forest industry should be a driving force in the transition towards a bio-based society. Both require the forestry industry to innovate.

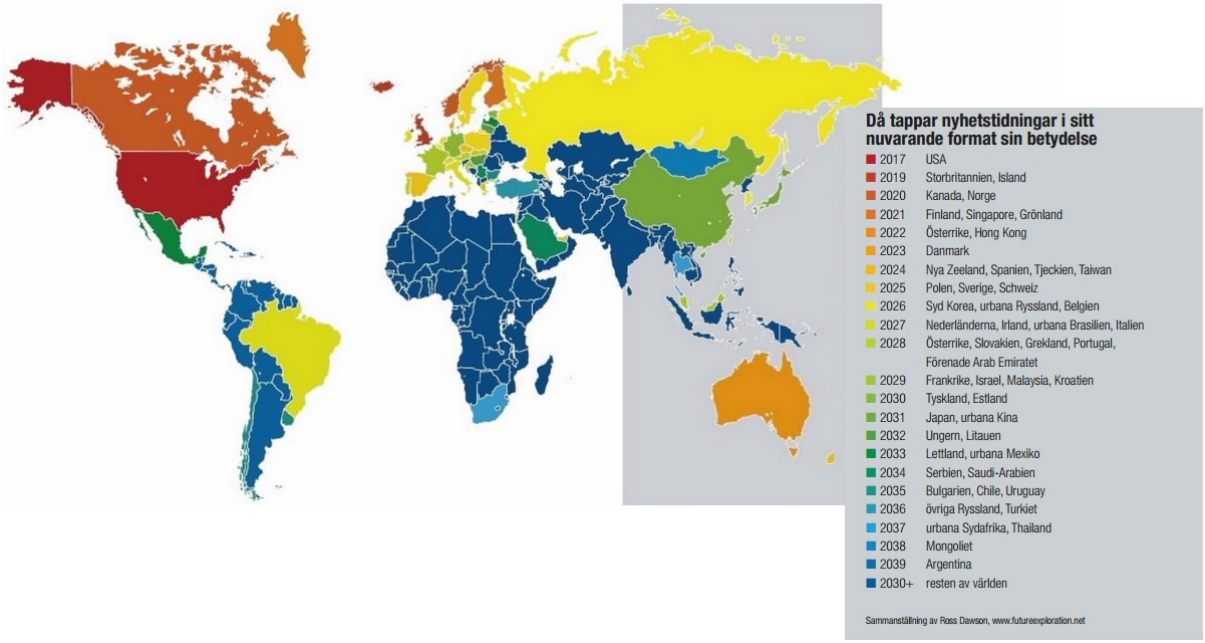

Figure 1. When newspapers loses significance in their current state (i.e. the paper version) (SPCI 2013).

However, there are concerns about the low rate of innovation in the forest industry, which is often attributed to its conservative culture. Changing this culture and developing new nanocellulose-based products is therefore a challenge to actors in the forest industry. Nevertheless, actors that have relied on standard newsprint may be driven to change when demand for newspaper decreases. New product development is of importance when markets change and uncertainty on markets arises. Maybe, the answer to several problems can be nanocellulose. Perhaps the decrease in demand in newsprint will be a wakeup call?

This possible drive, together with recent development that substantially reduced the production costs of nanocellulose may be a source of innovation (Drucker 2006) – especially given the noteworthy potential and the areas of usage for nanocellulose. However, at the moment, it is scientists who are excited (buzzing) over the prospect that a wide implementation soon may occur. Still, how is it that a material with such potential has not yet found its place on a market? How should firms use nanocellulose to target Skogsindustriernas long-term goal "*we should be the engine towards a bio-based society*". One important question that arises is: does nanocellulose hold a high market potential? Why has the commercialization of nanocellulose not yet succeeded given the potential and the hype? Nanocellulose can be procured from wood – i.e. forest companies may have the right resources to produce large quantities in a sustainable way. If markets and applications for nanocellulose can be found, new possibilities for increased profitability may arise.

Based on these issues this master thesis is concerned with assessing the perspectives of the Swedish forest industry concerning the market potential of nanocellulose. Fundamental research questions are: Do the Swedish forest industries believe that the commercialization of nanocellulose should be commenced from the industry or by someone else? Which role will nanocellulose play in the future of the Swedish forest industry? Nanocellulose is a possible important ingredient to the long term goal of a bio-based society. However, are the forest industries willing to support and pursue the development and commercialization of nanocellulose?

1.4 Purpose

The research purpose is to assess the perspectives of the Swedish forestry industry concerning the commercial potential of nanocellulose-based products for their firms.

Specific questions, from the Swedish forest industry's point of view, that this study pursues are:

- What are the factors that could make wood-based nanocellulose a successful commercial concept?
- What are the factors that hinder wood-based nanocellulose from becoming a successful commercial concept?
- In what stage of the value-chain should the implementation commence?

1.5 Delimitations

As described in Table 1 "nanocellulose", or microfibrillated cellulose (MFC), can also be referred to as nanofibrillated cellulose (NFC) (Klemm et al. 2011; Ankerfors 2012). This thesis will focus on the issues of nanofibrillated cellulose (NFC). Nanofibrillated cellulose (NFC) and microfibrillated cellulose (MFC) will not be separated because, as shown in Table 1, the two names describe the same thing - in Sweden there is as saying: *"A loved child has many names"*, the same can be said for nanocellulose. Nanocrystalline cellulose (NCC) can also be of interest for the forest industries. However, most focus on and development of nanocrystalline cellulose can be found "on the other side of the pond". Therefore, when the term nanocellulose is used in this thesis it refers to nanofibrillated cellulose (NFC) retrieved from wood-based fibers.

When the phrase Swedish forest/forestry industry/company/actor/firm is used it will be referred to companies working with pulp- and paper. The whole Swedish forest industry is very large, actors who are (mostly) working with sawn wood are not considered as stakeholders to nanocellulose.

1.6 Previous Research

Throughout this study a lot of effort has been put into the issue of finding reports concerning the market potential of nanocellulose. Results from the search engine Google and the database Web of Science have proven to be scarce. Most of the reports found through google have all been relevant and interesting from a thesis' point of view. However, the amount that has to be paid in order to read these reports has been far too great for the author. It has also been made clear that these reports are products produced by companies who intend to make profit from them, which makes it difficult to interpret results because the reports may be biased. Instead of biased market reports, focus has been put on previous conducted research from the department of forest product and also an agenda from Innventia.

"Kraftsamling kring nya processer for biobaserade material – En strategisk forsknings- och innovationsagenda" (English: *Mobilization on new processes for bio-based materials – A strategic research and innovation agenda*) is a summary of an agenda work whose primary goal has been to create cross-sector initiatives on bio-based material – from existing ventures into full-scale processes and new value chains (Lindström 2013). Identifying value chains that have both technical and market potential were the main purpose of the agenda work. The agenda believed that the Swedish forest industry can increase its profitability through new value chains. The long term goal of the agenda was to create and increase sustainable

development for a more sustainable community in the future. 17 organizations, including two universities, participated in the preparation of the agenda. Through two workshops (30 participants in the first and 14 participants in the second workshop) the agenda work concluded that two certain areas were of extra interest achieving commercialization and increased use of bio-based materials: "*nanocomposites for transport*" and "*bio-based packaging materials*".

For the automotive industry lightweight bio-based materials are of interest because they could reduce fuel consumption. The workshops also mentioned that nanocellulose was interesting in the issue of strengthening traditional plastics, the usage of nanocellulose could mean that the plastics becomes more stiff with less material usage. The packaging industry, which is a traditional part of the forest-based industry, was emphasized being an important area in order to achieve a large volume transition - from oil-based materials to bio-based materials. The best way to achieve a large transition was considered being producing a number of demonstrations of packaging solutions. If the outcome would turn out to be successful opportunities for trialability on markets could encourage brand managers to try out new packaging solutions. The workshops pointed out that an increased trialability would enable organizations to put more pressure on suppliers in the issue of delivering new solutions which in its turn would increase the pace of innovation. The workshops concluded that demonstrations of new solutions, where meticulous evaluations of relevant aspects have been made, will lead organizations to take the initiative creating the first major commercial venture. (Lindström 2013)

In the agenda all participants agreed that an important issue is to replace plastic and aluminum in packaging with more environmentally friendly and bio-based materials – i.e. it was pointed out that a change is really needed. However, participants highlighted that, in order to succeed, new materials and solutions may not be more expensive than existing materials and that the functionality has to be at a similar level with existing materials. There were some doubts whether trademark owners' and packaging users' interests in bio-based packaging solutions are strong enough for a change to commence – demand is an important factor that must be present in order for there to be market potential in the packaging segment. The agenda also showed that further research and development is required in order to achieve technically viable bio-based packaging materials. (Lindström 2013)

"*New wood based materials – From Lab to Market*" is a master thesis written by Erik Lind (2011) with backup from Innventia and the department of forest products, SLU. The purpose of Linds' thesis was to examine and find factors that are needed for a successful implementation of a new product on a market, i.e. "from lab to market". By interviewing experts from relevant industries (packaging, furniture and vehicle) and experts on material and material introduction Lind was able to create a picture of how new materials derived from the forest can become competitive on certain markets. Lind interviewed 13 experts from different industries.

Lind showcased examples of new wood based materials at each interview, all of the participants agreed that characteristics provided from the forest were beneficial. The most appreciated factor with wood-based material was its renewability. Linds' study showed that in order to be successful with new materials the forest industries need to obtain additional skills and/or partners. Linds' conclusion was that new materials must be cheaper than current alternatives, no participant were interested in paying more for a material derived from the forest.

In the study Lind emphasizes that the demand for renewable materials are growing and that an increasing popularity among environmental friendly alternatives can be discerned. However, the participants of the study declared that if an environmental aspect adds extra costs the likeliness of an implementation will be low - but what about an increased retail price for a better product? Lind also emphasized that besides the cost factor the technical functionality is of main concern when organizations prioritize characteristics of new materials.

"The Innovation Process: From Renewable Material to Product" is a master thesis written by Christian Nielsen (2013). This master thesis was also written at SLU department of forest products with Innventia as initiator and case host. Similar to Lind, Nielsen aimed to highlight factors that affect the forest industry's ability to successfully innovate renewable products based on wood. The study focused on a renewable material called durapulp which is a cellulose-based pulp that contains an admixture of bio plastic material which gives the pulp good durability. Nielsen chose to study an innovation that had been successful or was assumed to succeed.

Nielsens' study was conducted as a case study and interesting respondents were approached through "snowball-sampling". Nielsen conducted eight interviews with respondents considered valuable for the study. In general it was considered that the opportunities for micro-loans should be increased. According to some respondents entrepreneurs need increased options for micro-loans to facilitate creation of prototypes, implementation of tests and the patenting of innovations. The most important conclusion of the thesis was that contacts, transparency and information exchange are essential for the success of material innovation. It was also highlighted that "gatekeepers" that possess the willingness to share their networks are important for an innovation project because right contacts can be linked together. The study concluded that when the right connections between the right actors have been found autonomous project teams should be created in order to utilize the actors' experiences and skills. Nielsen emphasized some lessons learned and practical conclusions of how an innovation process is best driven forward.

2 Theoretical frame of reference

In this chapter, a theoretical framework is presented based on a literature review. The framework will later be used for an analysis of the results given from conducted interviews. A summary of the theoretical model together with reflections on chosen theoretical framework will be presented at the end of the chapter.

2.1 Invention versus innovation

The process for producing the type of nanocellulose this master thesis highlights were developed during the 80's. Thus, wood-based nanocellulose is not a novelty. However, techniques for producing the material have been improved. An innovation occurs if someone improves on or makes a significant contribution to an existing product, process or service, whereas an invention is the creation of a product or introduction of a process for the first time (Trott 2012). It can be said that this thesis will somewhat focus on the innovation of the invention nanocellulose.

> *"There are, of course, innovations that spring from a flash of genius. Most innovations, however, especially the successful ones, results from a conscious, purposeful search for innovation opportunities, which are found only in a few situations"*
> – Peter Drucker (1985) (Drucker 2006)

According to Drucker (2006) areas of opportunities for innovation exists within and outside a firm. There are four areas of opportunity within a firm: industry and market changes, process needs, incongruities and unexpected occurrences. The three opportunities that Drucker (2006) describe existing outside the firm are: new knowledge, changes in perceptions and demographic changes. The areas of opportunities may overlap and the potential for innovation lie in more than one at a time – *"together, they account for the great majority of all innovation opportunities"*. (Drucker 2006)

2.2 Diffusion of innovations

"Diffusion of Innovations" is a theory describing how fast an innovation spreads and is received on a market. In theory the innovation process can be illustrated with an S-curve, shown in Figure 2 below. The curve describes how individuals and organizations embrace innovations over time and the slope of the curve shows the velocity of innovation spread. Diffusion can be divided into four phases illustrated in Figure 2. During the first part of diffusion the innovation generally has a slow growth due to few individuals or companies embracing the innovation. Further in time, approximately when 50 percent of a social system has embraced an innovation, there is often a rapid growth phase. The growth phase is then followed by a phase where the diffusion process grows more slowly. The last stage of diffusion is maturity, this stage usually commences when the market is saturated or if a new innovation has been introduced replacing the former innovation. (Rogers 2003)

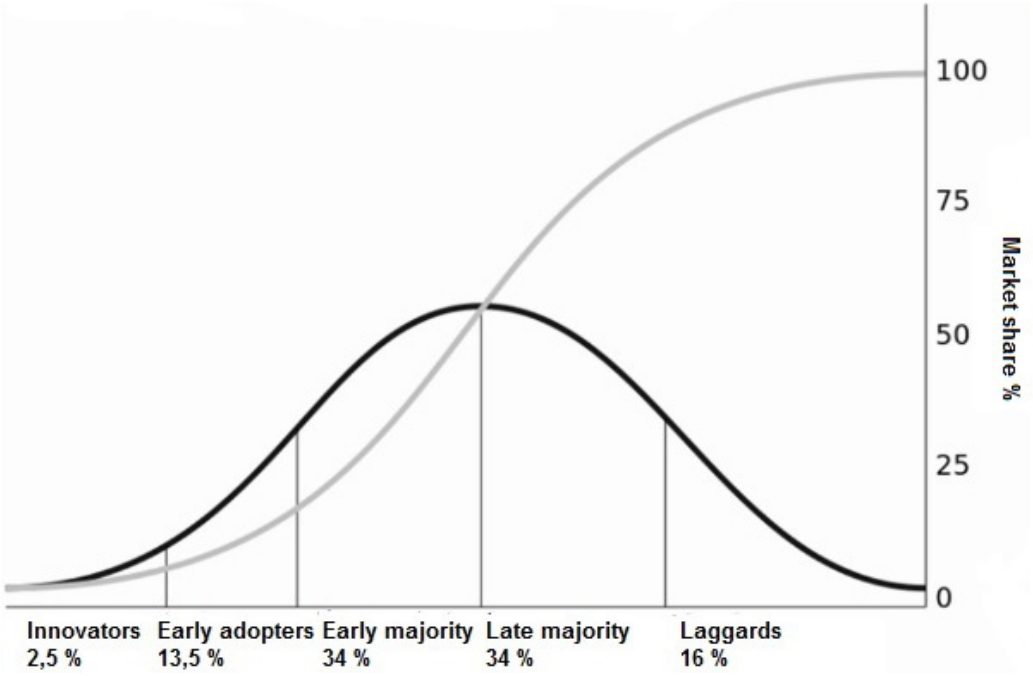

Figure 2. Diffusion of Innovations Rogers' "S-curve" (grey). The rates to which people implement innovations are shown in black. Adapted from Rogers (2003)

There are variations in appearances of slopes in the S-curve. While most innovations have an S-shaped rate of adoption, some diffuse more rapidly than others. Innovations that have a rapid adoption rate show a steep slope in the S-curve. For innovations with slower rate of adoption the slope is more gradual. However, what distinguish an innovation from another are specific properties that affect the rate of adoption. (op.cit)

How organizations and individuals approach and acquire new innovations differ from case to case. Customary, the willingness to embrace innovations is divided into five different groups (Figure 2) where "*innovators*" are the most likely to embrace innovation and "*laggards*" the group who lastly embraces innovation. Attitudes towards innovations depend on demographics, personal attributes, communication behavior and social relationships. (op.cit.)

2.3 Attributes of innovations and their rate of adoption

Some innovations may come into widespread use just a few years after their discovery; other may never enter the market. The characteristics that affect the rate of which an innovation is adopted can predict if an innovation will be successful or not. There are many factors affecting how quickly and efficiently an innovation gets adopted or becomes widely spread. (Rogers 2003)

Rate of adoption is a term which explains the relative time (speed) members of a social system use to get accustomed to new ideas. Generally, rate of adoption is measured by the number of individuals adopting an idea during a specific time period. Variations in adoptions of innovations can be explained by perceived attributes and variables. The attributes affecting an innovations success rate will be explained later in this chapter. The variables behind the rate of adoption are (1) *the type of innovation-decision*, (2) *the nature of communication channels diffusing the innovation at various states in the innovation-decision process*, (3) *the nature of the social system in which the innovation is diffusing*, and (4) *the extent of change agents' promotion efforts in diffusing the innovation*. (Roger 2003)

Rogers (2003) has identified five attributes that explains an innovations rate of adoption: relative advantage, compatibility, complexity, trialability and observability. Below, the five attributes are described.

2.3.1 Relative Advantage

If an innovation is considered (or perceived) as being better than a previous idea the innovation has a relative advantage over the idea it supersedes. Relative advantage can be measured in economic terms but social prestige, convenience and satisfaction are important factors also affecting the adoption. What type of relative advantage an innovation reaches depends on the nature of the specific innovation. How adopters perceive specific innovations is important and some characteristics are more significant than others. Factors affecting adopters are: initial cost, technological advantage, cost reduction and social status. During time, an innovation's relative advantage changes because characteristics of innovations change. Rogers (2003) argues that *"measuring the perceived characteristics of an innovation cross-sectionally at one point in time may provide only a partial picture of the relationship of such characteristics to an innovation's rate of adoption"*. (Rogers 2003)

2.3.2 Compatibility

How well an innovation corresponds to established values, experiences and needs of the potential users can be described as the innovations compatibility. If an idea does not correspond to a social system's values and norms it will be adopted more slowly. Adoption of incompatible innovations must often be preceded by adoptions of new values which is a slow process. (Roger 2003)

2.3.3 Complexity

An important barrier to adoption is complexity. Innovations that are perceived as difficult to use and understand can be described as complex. Complexity is the degree to which adopters understand an innovation. Some innovations are understood quickly by social systems, other more complex innovations require additional knowledge from their adopters. The more complex an innovation is, the longer the rate of adoption. (Rogers 2003)

2.3.4 Trialability

Whether an innovation can be experimented with in a limited scale affect how quickly it can be spread. An innovation that can be tested in split format is usually adopted faster than innovations where experimenting is not possible. Trialability decreases uncertainty because the innovation can be put to test by the adopter. When customers can create their own picture wide knowledge of the novelty can be reached. (Rogers 2003).

2.3.5 Observability

If positive results of an innovation can be made visible the chance for a wide adoption increases. Observability stimulates discussion of innovations; individuals often tend to ask early adopters of their opinion concerning certain innovations. (Rogers 2003)

2.4 The innovation-decision process

Getting an innovation from cradle to market takes effort, actors on the market need knowledge of innovations in order to decide if they are suitable or not. The *"Innovation-Decision Process"* (illustrated in Figure 3) is a model that contains five stages where each stage consists of different actions and choices. The five stages in the model are: knowledge, persuasion, decision, implementation and the confirmation stage. During the process, systems (or individuals) evaluate and decide if an incorporation of an innovation is promising or not.

When dealing with evaluations and decisions a degree of uncertainty is present, especially if an innovation is being evaluated. According to Rogers (2003) decision making of innovations consists of a distinctive aspect, namely *"the perceived newness of an innovation and the uncertainty associated with the newness".* (Rogers 2003)

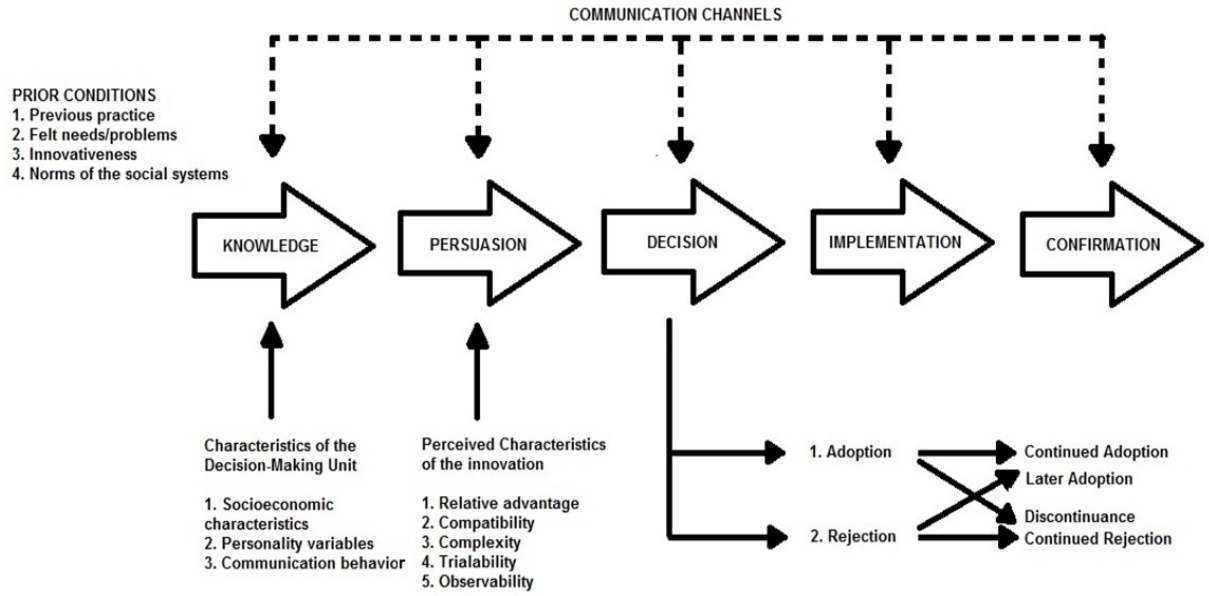

Figure 3. The innovation-decision process adapted from Rogers (2003).

When decision-making units are exposed to an innovation and understands the functions of the innovation knowledge occurs. In the persuasion stage decision-making units that have gained knowledge of an innovation develop an attitude towards the innovation; attitudes can either be positive or negative. Activities that choose to reject or adopt an innovation take place in the decision stage and when an innovation is considered useable it will enter the implementation stage. The last stage, confirmation, occurs when individuals seek approval on the decision that has been made. If there are conflicting opinions about the innovation, previous decisions might be reversed. (op.cit)

2.5 Defining the organization's strategic direction

Organizations who seek out to formulate a technological innovation strategy often begin with assessing their current position, after the assessment organizations form and define a strategic direction for the future (Schilling 2008). When planning a technological innovation strategy organizations evaluate their threats, opportunities, key strengths and weaknesses. What the firm's competencies are and how their capabilities and key resources can act as platforms for sustainable competitive advantage are important questions to ask. In the long term, does the organization need to acquire or develop new resources or competencies in order to gain sustainable competitive advantage? (ibid.)

"A coherent technological innovation strategy both leverages and enhances the firm's existing competitive position, and it provides direction for the future development of the firm" (Schilling 2008). An accurate evaluation and appraisal of the organization's current situation is important when formulating a correct technological innovation strategy. Organizations' must have a well-articulated strategic intent that articulates the firm's ambitions. Also, organizations must create a clear picture of which existing resources and capabilities that can be used and of which resources, competencies and capabilities that needs to be acquired. To

cohesively leverage all resources into a unified vision creating inimitable competitive advantage is an important ability for organizations. (op.cit)

There are many tools that can be used to assess an organization's position on a market. One of the most commonly used analyzing-tools is Porter's five-force model that analyzes an industry's attractiveness. Another well-known tool is Ansoff's model of strategic behavior which explains the significance of manager's perceptions of the environment. The analyzing-tools support the assessment of an organization's internal and external environment.

2.5.1 Porter's five-force model

By analyzing the five forces the attractiveness of an industry and the threats and opportunities connected to it can be identified (Schilling 2008). In practice the analyzing-tool is used to assess an organization's external environment, the model can also view the profitability of an industry (Grant 2010). Porter's five-force model can be used to pinpoint what differentiates one organization from others based on external forces. The five forces presented in Porter's five-force model are: (1) the degree of existing rivalry, (2) threat of potential entrants, (3) bargaining power of suppliers, (4) bargaining power of buyers and (5) threat of substitutes (Schilling 2008; Grant 2010). Below, the forces are presented in

Figure 4.

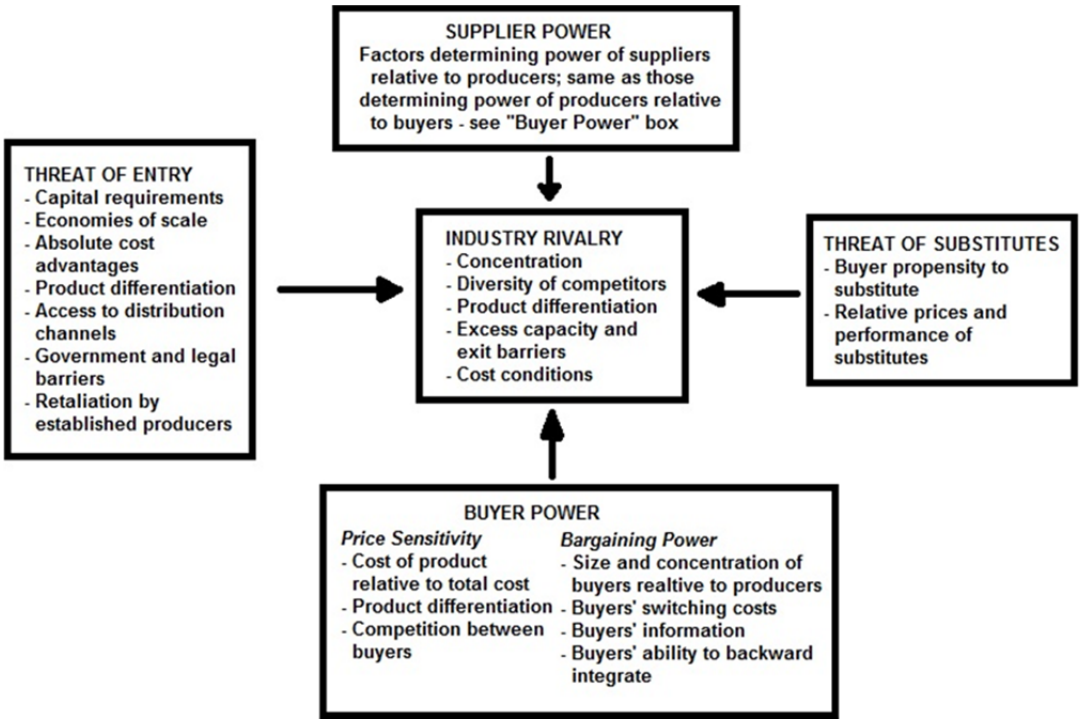

Figure 4. Porter's five-force model. Adapted from Grant (2010) The degree of existing rivalry

<u>The degree of existing rivalry</u>

The nature of rivalry will often be shaped by the relative size and number of competitors, i.e. the concentration of competitive companies on a market. Generally, if an industry contains several organizations of the same size the industry will be competitive. Other factors that influence the degree of rivalry is the degree of diversity among competitors and their differentiation. If organizations in an industry are highly differentiated from each other the degree of rivalry will be low, this due to their products appealing to different market segments. When industries and markets are declining the degree of rivalry can be affected by organizations' reluctance to abandon the industry due to high exit barriers. High exit barriers

can be: emotional attachment to the industry, high fixed capital investments – i.e. *"cost or commitments that make it difficult for firms to abandon an industry"* (Schilling 2008; Grant 2010)

Threat of potential entrants

This force is affected by the height of entry barriers and the degree of an industry's attractiveness. Entry barriers are conditions that hinder market entry. Conditions typically influencing entry barriers are: brand loyalty, large start-up costs, government regulations etc. One specific entry barrier is the issue of gaining access to distributors and suppliers, especially in an industry where options are scarce and where specific resources play important roles. An industry's growth and profitability may be attractive to new entrants. However, most entry barriers will deter some entrants. (Schilling 2008; Grant 2010)

Bargaining power of suppliers

Schilling (2008) describes bargaining power of suppliers in the following way: *"the degree to which the firm relies on one or a few suppliers will influence its ability to negotiate good terms"*. Few suppliers on a market means few options for buying decision and in turn low leverage over the supplier, i.e. negotiating prices, delivery schedules etc. will be advantageous for the suppliers. In addition to the number of suppliers the purchasing amount from buyers is relevant for the bargaining power of suppliers The relationship between the buyer and the supplier determine which party who has the greatest bargaining power. (Schilling 2008; Grant 2010)

Bargaining power of buyers

"Many of the same factors that influence the bargaining power of suppliers have an analogous role with the bargaining power of buyers" (Schilling 2008). The bargaining power of buyers is influenced by the amount of customers that a specific organization has. If an organization has numerous customers the bargaining power of buyers can be considered low because the organization can turn to several options. If an organization on the other hand only has a few customers the bargaining power of buyers can be considered high. (Schilling 2008; Grant 2010)

Threat of substitutes

Services or products not considered competitors are substitutes that fulfill the same needs for customers. There is a greater threat of substitution if there are more potential substitutes whose functions are practically the same to an organization's service or product. The relative price of substitutes is also a factor that shapes the threat of substitutes. How the industry is defined can help answer the question of how a competitor and a substitute are distinguished. (Schilling 2008; Grant 2010)

As earlier mentioned, the five forces can be used to pinpoint what differentiates one organization from others based on external forces. Porter has also acknowledged the role of complements, i.e. *"products that enhance the usefulness or desirability of a good"*. For example, apps in your iPhone can be considered as complements (Schilling 2008). Factors that influence the opportunities and threats posed by the industry are price, quality and availability of complements. Different questions to ask when considering the issue of complements: are complements key to the industry? Are complements differentially available in comparison with rivalry products? The complements offer certain value, who captures it? (Schilling 2008)

2.5.2 Ansoff's model of strategic behavior

One key concept in strategy is to understand organizations' environments. Many organizations may have the same potential information as other competing firms. While some organizations fail to grasp obvious signals of change, others can anticipate emerging opportunities. Manager's capabilities to retrieve and interpret information from the environment influence the development of sustainable strategies. According to Ansoff (1979) the significance of a manager's perceptions of the environment can be explained by distinguishing environmental information into categories: the organization's future prospects and its immediate financial results. Below, Frankelius (2002) simplified version of Ansoff's (1979) model of strategic behavior is described (Figure 5). (Hugosson & McCluskey 2008)

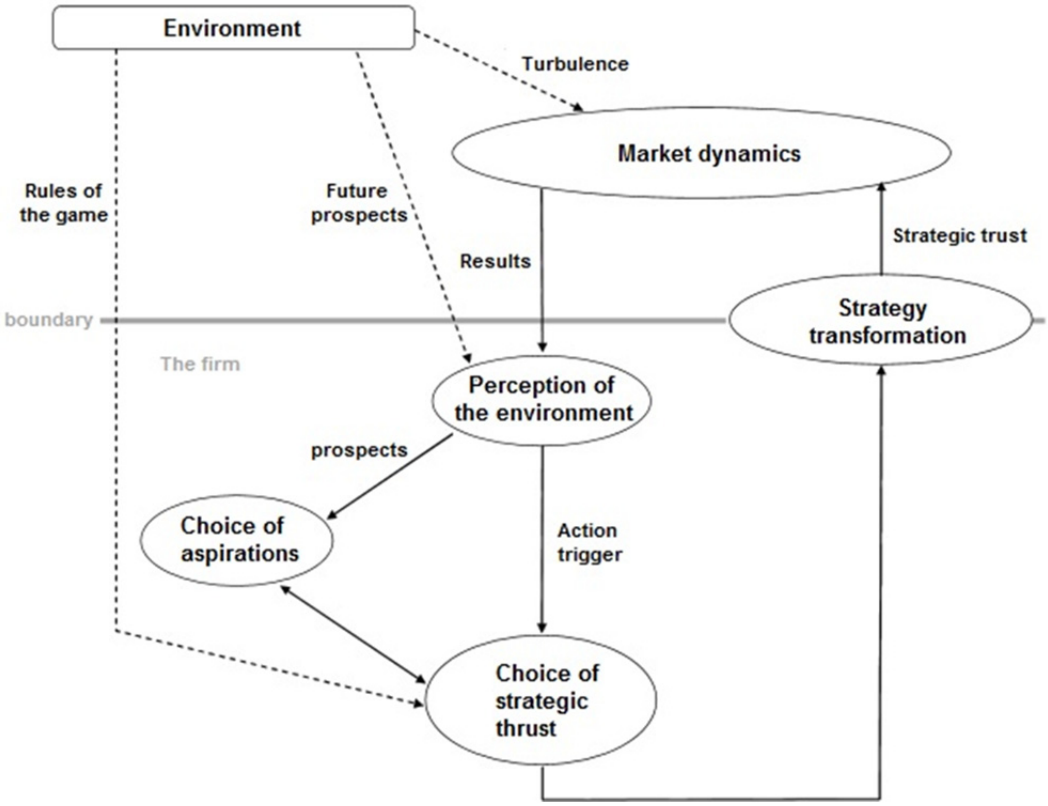

Figure 5. Frankelius simplified overview of Ansoff's model of strategic behavior. Adapted from Hugosson & McCluskey (2008)

When environmental turbulence is not grasped by managers, the organization's perception of the environment is too narrow. The phenomenon is called myopic management and can lead to organizations missing out on opportunities - because their strategic response to an environmental change may have been too late. It is important that managers can detect turbulent signals in the environment. The best way to detect signals is gathering information. Information later influences manager's perceptions on future prospects and strategies. According to Ansoff, organizations are in tune with their environment when the scope of a firm's perceptions matches the environmental turbulence. Organizations are described as foresight-full when their scope exceeds current environmental turbulence levels. (Hugosson & McCluskey 2008)

Changes in the general environment often pressure managers to take action. "Triggers" initiate internal processes which commences considerations on strategic behavior. The considerations lead to different strategic thrusts. Ansoff argues that strategic thrust is a process which weighs

complex interdependencies to the goals of financial performance and the choice of strategic thrust. The final selection of strategic thrust manifests itself as a strategy transformation – a change in the organization's internal resource configuration, or external linkages with the outside environment (or both). What affect the organizations' interaction with the market are patterns of business behaviors (the thrust) in strategy transformations. The patterns of business behavior intercept emerging market dynamics, managerial perceptions, future financial results etc. (Hugosson & McCluskey 2008)

Hugosson & McCluskey (2008) emphasized that a key concern with Anoff's model is *"the necessity of ensuring the emergence of new strategic thrusts is well-timed with the moment that environmental turbulence impacts the firm's market dynamics"*. The development of new strategies and their timeliness are dependent on the organization's culture and managerial capability – both factors have a significant impact on the development. (Hugosson & McCluskey 2008)

2.6 The resource-based view of the firm

Decisions regarding differentiation and considerations about product portfolio or market positioning are decisions drawn from an organizations new product strategy. The new product strategy is connected to the firms' competitive strategy (Trott 2012). Necessary for carrying out organizational goals is determining long-term goals and objectives, by taking action and allocating important resources the goals can be carried out. Innovative activities are often based on strategic decisions concerning which markets to serve and how.

"*Strategy is concerned with matching a firm's resources and capabilities to the opportunities that arise in the external environment"* (Grant 2010)

Grant (2010) describes that the general role of strategy is to provide a vision and identity to an organization. The strategic intent of the strategy is to determine how the organization should employ its resources. To fulfill the organization's vision the resources have to be employed in the correct environment. During recent years emphasis on strategy has shifted from the identification of profit opportunities to the role of resources and capabilities of the firm - the reason why is an increasingly unstable industrial environment. Grant (2010) argues that "*it has become increasingly apparent that competitive advantage rather than industry attractiveness is the primary source of superior profitability"*.

According to Grant (2010) the resource-based view of the firm emphasizes the uniqueness of each organization on a specific market or in a certain industry. Grant argues that *"a closer look at Porter's five forces framework suggests that industry attractiveness derives ultimately from the ownership of resources"*. The resource-based view suggests that organizations should not be doing the same as others, instead the key to profitability is exploiting differences. In order to establish competitive advantage an organization must formulate and implement a strategy that exploits the firm's unique strengths.

Productive assets owned by the organization are resources, what the organization can achieve with the resources are its capabilities. It is important to distinguish capabilities and resources from each other because individual resources do not offer competitive advantage by themselves – resources must work together in order to create organizational capability. According to Grant (2010) capability is the essence of superior performance. Resources, organizational capabilities, industry key success factors, strategy and competitive advantage can be linked together (Figure 6).

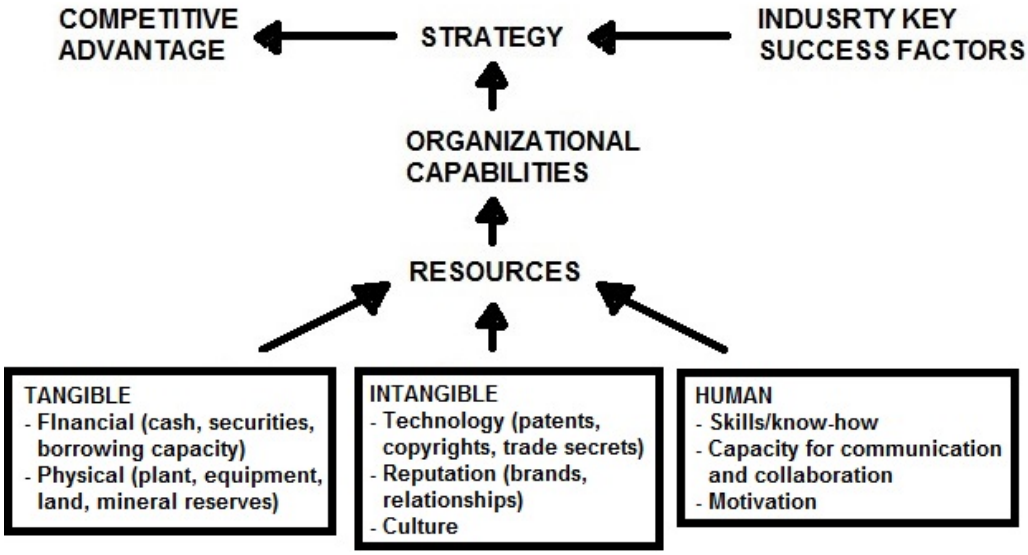

Figure 6. The links among resources, capabilities and competitive advantage. Adapted from Grant (2010)

Resources are connected to three principal types of resource: tangible, intangible and human. Tangible resources (physical assets and financial resources) are valued in an organizations financial statement and are easiest to identify and evaluate. Intangible resources (brand names, trademarks, reputation and technology) are often considered more valuable than tangible resources because they cannot be seen in financial statements. Human resources are the effort and expertise offered by the organization's employees. By combining resources organizations can create organizational capabilities which in turn can lead to competitive advantage. Identifying key resources and capabilities is of utmost importance. (Grant 2010)

2.7 Strategic alliances and collaborative new product development

Powell et al. (1996) argues that when an industry's knowledge base is expanding, complex and its sources of expertise widely dispersed the central point of innovation will be found in networks of learning, not in individual organizations (Powell et al. 1996). Alliances have become an important issue in competitive strategies (Schilling 2008; Trott 2012). By combining efforts and resources in common goals organizations can create *"competitive weapons"* through strategic alliances (ibid.). In order to gain competitive advantage many organizations are involving suppliers early in their development and design processes (Ragatz et al 2001). The involvement from suppliers can range from full responsibilities to simple consultations.

Monczka et al. (1998) emphasizes that a close relationship between buyer and supplier may offer strategic, technical and financial advantages, especially concerning vertical integration and market transactions. Negative impacts on cost results have been identified when technology uncertainties have appeared in relationships. However, there is evidence that certain elements of supplier integration can lead to significant improvements in cycle time, quality and cost objectives (Ragatz et al 2001). Still, in the start-up phases of strategic alliances barriers occur (Kelly et al 2002). Collaborative alliances are not always successful and barriers affecting the success rate of the alliances can be: communication problems, roles and responsibility problems, operational problems and cultural differences. Solutions to problems that affect alliances negatively are: specific partner and people selection, learning and relationship building, communication building, reconciliation of cultural differences, ongoing relationship management, constructive interaction and negotiation. Relationship

issues may imply devastating effects on strategic alliances, it is important to not underestimate the relationship factor.

Strategic alliances require that: benefits among parties are shared, the actors are independent towards each other and that they participate in key strategic areas (technology, markets, products, etc.) (Monczka et al 1998). Monczka et al. (1998) defines strategic supplier alliances in the following way: *"Strategic supplier alliances are long-term, cooperative relationships designed to leverage the strategic and operational capabilities of individual participating companies to achieve significant ongoing benefits to each party. These alliances continue as long as significant value accrues to both parties. Among the primary benefits of such relationships are enhanced supply chain synchronization, total cost reduction, improved quality and cycle time and a strengthened overall competitive position, which exceeds the contributions possible from other traditional relationships"*. Trott (2012) has a shorter definition which describes the same: *"A strategic alliance is an agreement between two or more partners to share knowledge or resources, which could be beneficial to all parties involved"*.

A strategic alliance is not a simple money exchange, a strategic alliance is beneficial for both (or many) parties because *"it allows large firms to access the subset of expertise and resources that they desire in the smaller firm, while the smaller company is given access to its large partner's massive capital and organizational resources"* (Trott 2012).

2.7.1 Reasons for going solo

Some organizations may avoid, or believe that they should avoid, strategic alliances. Schilling (2008) lists four *"reasons for going solo"*: (1) availability of capabilities, (2) protecting proprietary technologies, (3) controlling technology development and usage, and (4) building and renewing capabilities. If an organization possess all of the necessary resources "in-house" the organization may not want or need an alliance, it may opt to do it alone. Organizations can also be forced to work on their own because no potential partners with relevant capabilities can be found. Organizations may avoid alliances in fear of exposing proprietary technologies or because of the unwillingness to share created technologies. Complete control over development processes and the usage of the results are also reasons why organizations choose to avoid alliances. Last, some organizations may believe that solo development is key to renewing and building capabilities, even when an alliances could save them money and time. Some organizations believe that solo development of a technological innovation is of key because it challenges the organization to develop new skills, resources and market knowledge. (Schilling 2008)

2.7.2 Advantages of collaborating

While some organizations choose not to engage in alliances some do. If used correctly there are huge benefits to gain from alliances. Joining alliances can put pressure on organizations obtaining necessary resources or skills more quickly than from "in-house" development. Alliances are beneficial when an organization lack resources and capabilities to *"transform a body of technological knowledge into a commercial product"* (Schilling 2008). Developing organizational capabilities is a time consuming activity, by entering strategic alliances organizations can get quick access to important complementary assets. Strategic alliances can also increase organizational flexibility which is important on markets where there is technological change. When a change in technology is quick, innovation can become a primary driver of competition because product life cycles shorten. A change in technology can also mean an unstable environment for the organizations in it. By being flexible organizations can avoid being stuck to fixed assets. Collaborations can act as platforms for learning. By

working together, facilitating knowledge between firms, organizations can cooperatively create, transfer and expand their knowledge more quickly. (Schilling 2008)

Strategic alliances are advantageous when sharing risks and costs of projects. Development projects can be expensive and when risks are shared the incentives to commence develops. Last, organizations may work together when a development project would facilitate the creation of a collective standard. Collaboration in the development stage could ensure cooperation in a commercialization stage – crucial for technologies where compatibility and complements are of importance. (Schilling 2008)

Trost (2012) summarizes the reasons for entering a strategic alliance in the following points:

1. Improved access to capital and new business
2. Greater technical critical mass
3. Shared risk and liability
4. Better relationships with strategic partners
5. Technology transfer benefits
6. Reduce R&D costs
7. Use of distribution skills
8. Access to marketing strengths
9. Access to technology
10. Standardization
11. By-product utilization
12. Management skills

2.7.3 Types of collaborative arrangements (strategic alliances)

Strategic alliances can take shape in different kinds of ways. In the literature following ways of collaboration are presented: joint ventures, collaboration (non-joint ventures), licensing, supplier relations, collective research organizations, industry clusters and innovation networks. The different types are presented below.

Joint ventures

A type of alliance that requires significant structure and commitment is a joint venture. This collaboration arrangement involves significant equity investments from partners, therefore a joint venture often results in a new separate entity. The partners in a joint venture are normally shareholders in their created legal entity. Through contracts capital and other resources are committed by each actor involved in the joint venture, the same arrangement is used for profits earned by the joint venture. Joint ventures usually cease when a project is completed. (Schilling 2008; Trott 2012)

Collaboration (non-joint ventures)

When there are no legal contracts binding actors' together arrangements tend to be more flexible. Collaborations (or non-joint ventures) occur frequently in supplier relationships but can also be found in many other different situations. For example, universities often work closely together with local firms on research projects. These types of alliances are often maintained and extended throughout many years. (Trott 2012)

Licensing

The rights to use technologies (copyrights, trademarks, etc.) from other organizations can be obtained through licensing. Licensing is a simple way for organizations to acquire technologies they do not possess. For some organizations (licensors) licensing can be used to reduce costs or gain knowledge, for others (licensees) licensing is a great marketing tool. (Schilling 2008; Trott 2012)

Outsourcing

Outsourcing is a great alternative for organizations that do not possess the resources or capabilities to fully develop technological innovations. Outsourcing enables organizations to focus on their own core competences because they let other firms support areas where the organization itself lacks certain resources and capabilities. (Schilling 2008; Trott 2012)

Supplier relations

Supplier relations are informal alliances where certain actors have established close relationships to their suppliers. The informal alliances are often based on cost-benefit issues from the suppliers' point of view. By creating a close relationship to a customer a supplier can adapt/modify its production and supply-chain and gain lower costs. From the customers' point of view a supplier relationship can mean increased expertise, knowledge, experience and investments in new product development at a lower cost. (Trott 2012)

Collective research organizations

Alliances established in cooperative research development organizations can be seen as collective research organizations. Usually collective research organizations are created through industry or government initiatives. For example, national organization can share R&D expenses via collective research organizations and work together towards increased global competitiveness. (Schilling 2008; Trott 2012)

Industry clusters

In particular regions there are clusters of specific organizations. Hollywood, Bollywood and Silicon Valley are examples of geographically concentrated industry "clusters". What distinguishes industry clusters from innovation networks is geographical closeness between organizations in the specific industries. According to Trott (2012) industry clusters can increase the competitive productivity for the organizations involved in clusters. (Trott 2012)

Innovation networks

There is no specific definition of what an innovation network is. It can be a series of customer-supplier relationships, innovation networks can also be seen as temporary "webs" of loosely connected organizations in which firms unite and discuss a certain business opportunity. Innovation networks often function as strategic partnerships where actors help each other to find solutions for problems or ceasing opportunities. (Trott 2012)

2.8 What separates the winners from the losers

"Product innovation – the development of new and improved products and services – is crucial to the survival and prosperity of the modern corporation" (Cooper 2012). Central to effective new product management is the understanding of why some organizations are better at product innovation than others and why some new products succeed and some do not. Cooper (2012) has listed eight critical success drivers to the question why new products succeed, he has also listed nine critical success drivers to why businesses excel (Table 2):

Table 2. Why new products succeed & why businesses excel (Cooper 2012)

Why New Products Succeed - Eight Critical Success Drivers	Why Businesses Excel - Nine Critical Success Drivers
1. A unique superior product. A differentiated product that delivers unique benefits and a compelling value proposition to the customer or user is the number one driver of new product profitability 2. Building in the voice of the customer. A market-driven and customer focused new product process is critical to success. 3. Doing the homework and front-end loading the project is key to success: Due diligence done before product development gets under ways pays off! 4. Getting sharp and early product and project definition. Avoiding scope creep and unstable specs means higher success rates and faster to market. 5. Spiral development – build, test obtain feedback and revise. Putting something in front of the customer early and often gets the product right. 6. The world product. A global or glocal (global concept, locally tailored) product targeted at international markets is far more profitable than the product designed to meet "one-country" needs. 7. A well-conceived, properly executed launch is central to new product success. A solid marketing plan is at the heart of the launch. 8. Speed counts! There are many executed ways to accelerate development projects but not at the expense of quality of execution.	1. Businesses with superlative performance in new products development have a product innovation and technology strategy to focus the business on the best arenas, and to provide direction for ideation, road-mapping and resource allocation 2. Successful business focus: fewer development projects, better projects, and the right mix of projects. They achieve this by adopting a systematic portfolio management method and by building tough Go/Kill decision points into their new product idea-to-launch system. 3. Leveraging core competencies is vital to success; step-out development projects which take the business into new areas (new markets or technologies) tend to fail. However, collaborative development and open innovation can mitigate some risks here. 4. Projects aimed at attractive markets do better; thus, certain key elements of market attractiveness (market size, growth and the competitive situation) are important project selection criteria. 5. The resource must be in place, there is no free lunch in product innovation. 6. The right organizational structure, design, and teams are major drivers of product innovation success. 7. Business that excel at product innovation have the right climate and culture that supports and fosters innovative activity 8. Top management support does not guarantee success, but it certainly helps. However, many executives get it wrong 9. Companies that follow a multistage, disciplined stage-and-gate idea-to-launch system fare much better than ad hoc approach or no system at all.

What often separates winning products from losing is organizational ability to deliver products with unique benefits and real value to customers. Businesses who succeed to produce and deliver these types of products will most likely become winners. According to Cooper (2012) the key to success are differentiated and superior products. Superior products often have certain characteristics in common, Cooper addresses that winning products boast price/performance characteristics, reduce total costs for the customer and feature good value. Winning products also provide a relative advantage in excellent product quality from the customers' point of view. If customers' needs are not met, a product is not a competitor. A

competitive product can solve problems or offer unique features that other products do not have. Last, but not least, winning products offer benefits that are highly visible and attributes easily perceived as useful. Organizations who can offer better value, important benefits and superior value proposition to their customers are often successful. In a study (from Cooper 2012) it was identified that results from "best performers" were superior on a number of performance metrics: "*new product profitability, meeting sales and profit objectives, time efficiency and on-time performance, and the ability to open up new windows of opportunity"*. (Cooper 2012)

2.9 About the theoretical framework

Since the choice of theories affects the results and analysis of the conducted study, it should be discussed how and why this theory has been selected.

It is often problematic to determine and choose which theories to use in a study's framework. In this study, theories regarding innovation, strategy, alliances and products have been emphasized - each theoretical area consists of a lot of literature. Based on the purpose of the study and the issues connected to the purpose many factors affect the final choice of theories.

Judging by the purpose and the issues of this thesis theories regarding corporate strategies and firms' competitive advantages were seen as central. And since nanocellulose is a material that has gone through substantial development over the years theories on successful products and the diffusion of innovations were considered relevant. However, the question of whether a different focus would have been a better option can be discussed. Still, whether a different approach would have been a better option for the purpose of the study is difficult to evaluate when values and experiences affect what options the researcher considers appropriate. A researcher with other experiences and values would probably have found different alternatives to answers the research questions – alternatives that have not even been considered by the current author.

The literature that has been used for this study originates from writers who come from different countries. The Swedish forest industry is a global industry active in numerous countries around the world. Based on the different cultures each company has to face, the fact that the theories origins from authors who come from different countries do not really matter. Also, many of the theories used are classic and often applied in other studies.

The literature chosen for the theoretical framework is considered appropriate and relevant for the purpose of this study. Shortcomings were observed in Porter's five force model, thus that part was expanded with Ansoff's model of strategic behavior.

3 Methodology

In this chapter the selected methodology for the study is motivated and its application described with respect to the study's purpose.

3.1 Research Methodology

There is various defined research methods that describes and explains how researchers collect/gather data, two of these are broadly characterized as qualitative- and quantitative research. Quantitative methodologies usually include analysis of numerical data while qualitative methodologies are mostly based on the use of words or pictures. However, one specific source of information can be used for both methods, what differentiates the two methodologies from each other are the approaches being used. In a research project both methodologies can be used to illustrate different perspectives of certain issues (Denscombe 2009). According to Kvale & Brinkmann (2010) the difference between the two methodologies is that a qualitative approach allows a more detailed examination of limited material, whereas a quantitative methodology relies on large amounts of data in order to draw statistical conclusions. In a qualitative method the formalization level is low - gaining a deep understanding of the current problem is of more importance to the researcher. The quantitative methodology aims to analyze current problems through high formalization and structuring. (ibid)

3.2 Methodology for data collection

There are several methodologies that can be used to procure information and data that can answer the research questions, for example: existing documents, databases and interviews. The researchers' choice of methodology is often determined on the quest to answer the inquired questions with reference to the information, resources and time available for the study. Collected data can be of both primary and secondary nature. Primary data are gathered by the researcher in order to be used as an evaluator for a certain purpose, while secondary data has been collected by someone else whose purpose would not necessarily have been the same for the collected data. (Kvale & Brinkmann 2010)

Since the strategies of forestry firms with regards to the adoption of nanocellulose production technologies is of essence an interpretation of events, processes and experiences have been made. The choice of a qualitative research approach, based on interviews, has therefore been considered to be appropriate (Silverman 2005).

3.2.1 Selected methodology for this study

Throughout this study a qualitative interview methodology has been adopted in order to view and describe certain approaches from different organizations concerning nanocellulose (Kvale & Brinkmann 2010).

3.3 Selection criteria

Trost (2011) argues that it is important for the researcher to know what the selected population of the study represents, especially when a quantitative study is being commenced. However, in the context of qualitative studies representative samples are of less importance. In qualitative studies, the selection should be heterogeneous within a given frame – or as Trost (2011) puts it "*The sample should preferably be heterogeneous within the given homogeneity"*.

The question of how large a selection sample should be in a quantitative study is easy to answer – the sample has to be relevant to the purpose of the study (Trost 2011). In qualitative studies the size of the sample depends on time, cost and other aspects/circumstances connected to the study. Trost (2011) argues that researchers should limit their selection to a very small number of interviews when commencing qualitative research. Commencing many interviews may be of risk because the collected material can become unmanageable. The researcher can become "buried" in material - this may complicate the assessment of the material collected and can create tunnel vision.

There are two main types of selections (or samplings), probability selections and non-probability selections. Probability selection can be described as a random sampling where each unit has a known probability which is included in the selection. Two sub-types of probability selection are stratified sampling and cluster sampling. In a non-probability sampling the choices of samples are not made randomly, therefore chosen samples cannot be predicted. Different sub-types of non-probability sampling are: strategic, convenience and snowball sampling. In strategic sampling the interviewer select which individuals should be interviewed – common in qualitative studies when a deeper understanding is being sought out. When an interviewer conduct interviews with individuals who are easily available it is called convenience sampling – the selection of interviewees has been made without any significant control over the sample, the interviewees "happened to be available". Snowball sampling can be seen as a chain of events that connect a number of people that can be of interest to a specific study – in the conducted interviews the interviewer ask the interviewee for other suitable candidates. (Bryman 2002; Christensen et al 2010; Trost 2011)

3.4 Selection of interviewees

Trost (2011) acknowledges that there are few practical guidelines in the literature when selecting interviewees. When a deeper understanding of a problem is sought out, the researcher often strategically decide which interviewees are of interest – this is called strategic selection (Christensen et.al 2010). The objective of this study is to examine the Swedish forest companies' views on certain issues related to nanocellulose. Therefore, relevant respondents from relevant companies have been identified in order to create a reliable and valid picture of the issues presented in the purpose section.

3.4.1 Criteria for selection of interviewees

Respondents were found by snowball sampling. Initially business intelligence directors of forestry firms known to be active in nanocellulose research have been approached. They have later recommended some of the respondents approached for this study.

The operational criteria for the selection of respondents for this master thesis were: (1) respondents from forestry firms or firms closely connected to the Swedish forest industry and (2) respondents who are familiar with and possess knowledge of nanocellulose. The main reason why respondents acquainted with issues connected to nanocellulose were chosen is because they are both personally familiar with the nanocellulose field as well as they can provide insight to their firm's opinions on the material.

3.4.2 Interviewees

Below, the interviewees for the study are presented in a manner that presents the order in which the interviews have been implemented, starting with Folke Österberg.

- **Folke Österberg**, SCA. (2014-03-06)
  - Vice President External Research, SCA. Interviewed via telephone.
- **Mikael Hannus**, Stora Enso. (2014-03-10)
  - Vice President, Biorefinery. Interviewed via telephone.
- **Johan Lindgren**, Holmen. (2014-03-12)
  - Manager at Paperboard Development Centre. Interviewed via telephone.
- **Karin Emilsson**, Södra. (2014-03-26)
  - Director of Technology. Interviewed face to face.
- **Katarina Jonasson**, TetraPak. (2014-03-27)
  - Senior Board Specialist. Interviewed via telephone.
- **Geoffrey Daniel**, SLU (2014-04-07)
  Professor Wood Science. Interviewed face to face
- **Ulrika Andreasson**, SCA. (2014-04-10)
  - R&D Specialist, Material Technology and Chemistry. Interviewed via telephone.
- **Kent Malmgren**, SCA. (2014-04-14)
  - Senior R&D Specialist. Department Fibre & Biomass. Interviewed via telephone.
- **Martin Eskilsson**, Holmen. (2014-04-16)
  - Project Manager New Business Development. Interviewed via telephone.
- **Irene Wedin**, Stora Enso.(2014-04-22)
  - Senior Specialist. Interviewed face to face
- **Mikael Ankerfors**, BillerudKorsnäs. (2014-05-07)
  - Project Manager New Business Lab. Interviewed face to face
- **Jon Haag**, BillerudKorsnäs. (2014.05-07)
  - Corporate Innovation Manager. Interviewed face to face.

3.4.3 Interviews

Holme & Solvang (1997) define four main elements that can determine an interviews outcome: themes, scenes, roles and actors. When an interviewee finds it hard or problematic to answer a question, the theme of the interview can be limiting. Themes of interviews give interviewees information about the research objective, whereas scenes include planning, selection of scenery and time for the interview. When an individual conducts several interviews he/she has certain expectations of meeting different interviewees with different personalities, the interviewees also have expectations of the interviewer. These expectations should be taken into consideration in order to create a neutral role between interviewer and interviewee. Commitment and ability from the actors to create a good environment for the interview affect the results of the interview (ibid).

Interviews can be conducted in different ways and there are variations in degree of standardization and structure (Trost 2011). Examples of different interviews are: informal, in depth, focus and qualitative interviews. Interviews conducted with standardized questions containing set response options are considered structured. If response options are open, interviews are considered unstructured or semi structured.

Bryman (2002) describes qualitative interviews as less structured interviews with great flexibility conducted in qualitative research. Quantitative interviews are described as being more structured interviews in quantitative studies. Bryman (2002) distinguishes semi-

structured interviews from unstructured interviews. During semi-structured interviews the interviewer uses a specified questionnaire whereas in an unstructured interview the interviewer has specified themes that the interview will include. In semi-structured interviews a list of both themes and topics can be included, the list mainly supports the interviewer to ensure that all points of essence are covered during the interview. The semi-structured questionnaire insures a relaxed interview with room for dissolute reasoning.

Holme and Solvang (1997) define two distinct variations of qualitative interviews: respondent- and informant interviews. A research's purpose is of key when choosing the right method. In respondent interviews key respondents familiar to the issues of the study are approached. Informants do hold information about the issues but not to the same degree as respondents.

Trost (2011) declares that qualitative interviews provide more comprehensive and complex answers than quantitative methods. Holme & Solvang (1997) stresses that standardized questionnaires should not be used in interviews because it is of importance that the interviewer does not steer interviewees in certain directions – it is important that the interviewees feel that they freely can express their own opinions and expectations. Bryman (2002) emphasizes that interviews conducted via telephone decreases the possibilities to observe body language and reactions to questions.

3.5 Approach for the collection of data

Data for this master's thesis has mostly been collected through personal interviews. Interviews have been conducted face to face or via telephone (when it was convenient for the interviewee or a visit could not be enabled). At first the interviewees were approached via email (Appendix 2). The questionnaire used for the interviews was based on the literature review used for the theoretical framework. In the beginning, relevant respondents were pointed out.

A semi-structured interview has been formulated in order to minimize the interviewer's control over the interviewees, the questionnaire itself has been built on theories linked to organizational strategies for new product development and innovations (Kvale & Brinkmann 2010). Qualitative interviews are characterized by straightforward and simple questions – and by using qualitative interview methods the governance of those interviewed can be minimized (Trost 2011; Holme & Solvang 1997). While questions are of basic character answers from interviewees are often complex and profound. The purpose of qualitative interviews is to obtain nuanced descriptions of various qualitative aspects of the interviewee's thoughts on a certain issue (Kvale & Brinkmann 2010). In this case, qualitative interviews have been conducted in order to obtain nuanced descriptions of the issues presented in the purpose section.

According to Trost (2011) interviews should be recorded for reliability reasons. Trost (2011) and Bryman (2002) suggest that the interviews should be given a thorough listen through. A focused "listen through" can reduce the transcription work by focusing on what is essential for the research itself – leaving out the "jibber jabber" is of essence. Nonetheless, Bryman (2002) discuss a number of problems related to the issue of recording interviews, for example the interviewer or interviewee could be disturbed by knowledge of the recording. Since the material in this thesis can be considered to be of a sensitive business nature, it was decided that it would be inappropriate to record the interviews since it was judged that recording would disturb the respondents. However, respondents interviewed over the telephone agreed to the use of a recording devise. Later, these recorded interviews were thoroughly listened

through and transcribed in detail. By going through the data in detail the researcher can secure that everything of essence is being collected and interpreted.

However, a recording devise was not used during the interviews conducted face to face. Variations in tones from respondents may therefore have been left out - this could mean that the interviewer missed responses of importance. Nonetheless, during interviews notes were taken and nuances noted where possible. Furthermore, immediately after each personal interview, a summary of the conducted interview was written and correlated with the notes.

3.6 Methodology for analyzing interviews

Kvale & Brinkmann (2010) describe five important methods that can be used for analyzing interviews: concentration of sentences, categorization of sentences, narrative structuring, interpretation of meanings and the ad hoc method.

When concentrating sentences the interviews are summarized to a shorter and more concentrated text. Categorizing sentences means that the interviewee's statements are summarized and reduced to a number of categories. Narrative structuring, or structuring of sentences, means that the interview material is concentrated and presented as a coherent story. When interpreting sentences the summarized text often gets a deeper analysis, this may lead to the text getting another meaning than initially expressed by the interviewee. The ad hoc method may contain all of the analyzing methods – i.e. it can be a combination of methods.

3.6.1 Method used for analyzing the conducted interviews

A narrative structuring of the conducted interviews has been made in order to present and concentrate the collected results as a coherent story. The results have later been connected to and analyzed via the theoretical framework.

The importance of a critical view was emphasized by Davidson & Patel (1994). Throughout this study the database "Web of Science" has been used for retrieving articles of use for the theoretical framework. Articles have been selected based on times cited – i.e. articles that have been cited many times have been used. The theoretical framework has also been based on theories that have been presented during the latest two years of master studies – they can be considered relevant for the author's education and thus the master thesis.

3.7 Ethical aspects

Since the current status of nanocellulose technologies are at a pre-commercialization stage, general information about the technology processes can be found in the public domain. Firms in the sector have been open about their general intent to use nano-technologies, the information in this thesis meets ethical requirements in the sense that it does not disclose information that is of a sensitive commercial nature.

Trost (2011) argues that the interviewee should be guaranteed anonymity, both regarding the interview subject as well as what is said during the interview, even if the interviewee allows or encourages the opposite. The views of individuals are not attributed to respondents in the analysis and discussion sections - instead quotes are anonymous. The choice to not present the interviewees as respondents A, B, C.. X is due to the fact that every interviewed respondent were promised anonymity. The choice to not label the respondents has minimized the risk of readers connecting certain answers to certain respondents. Still, labeled respondents could have made the result chapter more structured. However, judging by the collected answers the choice to not label the interviewees will not have a negative effect on presentation of the

results as a whole. The reason for this is to protect the integrity of respondents by ensuring that individual quotations cannot be taken out of their context.

3.8 Reliability, validity and generalizability

To determine how reliable and valid the collected information is, it is important to critically examine the collected information (Bell 2011). Reliability is a measure describing the extent to which an instrument or approach give similar results on different occasions but under similar circumstances. A specific question given different responses by the same interviewee depending on certain situations is not a reliable question (Bell 2011; Trost 2011). When asking for opinions, a lot of factors can affect the interviewee's response – perhaps he/she recently watched a television show that affected their opinion? One may ask whether different interviewers get the same answers by the same interviewees at different times. There are ways to measure reliability: test-retest, alternative formulations and the split-half-method. However, most measurements are only usable when the examiner is commencing a test or trying to build a scale of some sort. Still, if the correlation between responses is high, the degree of reliability can be considered high for the study. In this study, the results demonstrate a high degree of reliability within an interviewee's responses as well as between respondents (any deviances are noted in the results section.)

Validity is a measure of whether a particular issue measures or describes what the researcher wants it to measure or describe. It is a relatively vague definition which makes validity a more complex concept (Bell 2011). Validity is of importance because evidence, outcomes and conclusions provided by research has to be credible and constitute strong support for interpretations being made. (op.cit)

If a question is not reliable, it is neither valid (Bell 2011). However, the degree of validity does not need to be high just because the degree of reliability is. A question asked can be given the same responses at different times – still, it does not measure what it is intended to measure. Measuring validity can prove to be complicated and during short-term projects it is rarely necessary to reflect on the technological perspective of validity measuring. (ibid.) Nonetheless, in this study, it is noted that the interviewees' broadly shared perspectives about the current status of the development of nanocellulose technologies and business (any deviances are noted in the results section). Accordingly, it could be argued that the results are reliable at this period in time.

According to Trost (2011) the ideas of reliability and validity originates from quantitative methodology. Still, qualitative interviews and the collection of data need to be done and collected in a credible, appropriate and relevant way. One problem with qualitative studies, and thus qualitative interviews, is the issue of credibility. The researcher has got to be able to showcase credible sources – the sources are of utmost importance and should be relevant to the formulated problem. It is judged that the respondents above are credible sources in this field.

Generalizability can be described as the issue whether results from one study can apply to other cases than those occurring in the study. This studied did not aim to produce generalizable results.

4 Results & Analysis

This chapter describes the results from the qualitative interviews. These results are presented in the same order as the theoretical framework. By using this structure the analysis of results given from conducted interviews can be facilitated and presented in an understandable way. The chapter then ends with the respondents' views on the issue of replacing fossil-based products with bio-based ones.

4.1 Diffusion of the innovation nanocellulose

The respondents approached for this study were all familiar with nanocellulose and have encountered issues connected to the material on several occasions. Many of the respondents attended the workshop earlier mentioned in the previous research section (1.6 Previous Research), thus their knowledge of nanocellulose can be considered high. However, the same cannot be said for the general public. As earlier mentioned, a commercialization of nanocellulose failed during the 80's mostly due to high production costs. During the interviews it has been acknowledged that there were no large incentives from Swedish forest industries to develop the techniques used to acquire nanocellulose – this because the industries were "*fat and happy*". With the recent rise of digital media the situation is different. Unlike the 80's, the demand for some important forest products has decreased while the need for new product development has increased. However, it has been emphasized that new product development from the forest industries has been "*far too inactive for far too long"*. By using Rogers' "S-curve" assumptions about the diffusion of nanocellulose can be illustrated: namely, the number of actors that are interested in either the innovative use of nanocellulose or improving its production technologies have increased (Figure 7Figure 7).

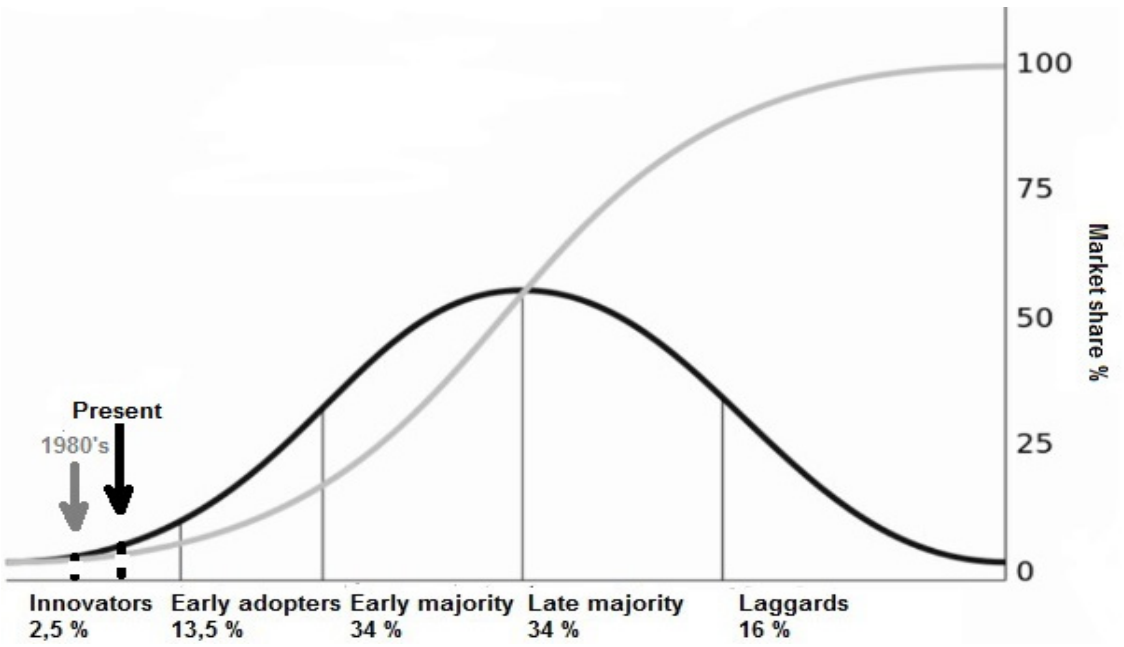

Figure 7. Diffusion of nanocellulose amongst R&D type actors that have a connection to the forestry industries adapted to Rogers' "S-curve" (2003).

Please note that this curve describes general assumptions regarding the market share of an innovation. In this study, assumptions about the market share of nanocellulose have been difficult to address. However, the present market share nanocellulose holds can be considered low. During the interviews, the diffusion process has been described as being at an early stage.

Still, it was considered that the development of nanocellulose has reached further than during the 80's. However, the demand for nanocellulose is uncertain - the uncertainty act negatively on the Swedish forestry firm's incentives to invest in the development of nanocellulose. Nonetheless, there are still several factors that come into play regarding the question of whether nanocellulose will become a successful commercial concept or not.

4.1.1 Rogers' attributes of the innovation

During the interviews, the respondents were asked to state which characteristics of nanocellulose they considered to be competitive and which areas there is still work to be done. They were also asked if nanocellulose holds relative advantage compared to other competing materials, e.g. aluminum and plastic barriers in packaging.

Rogers (2003) describes five attributes that affect an innovations success rate. The following section will focus on attributes and characteristics of nanocellulose described during the conducted interviews. Which attributes and characteristics suggest that nanocellulose will be a successful or unsuccessful commercial concept?

The perceptions of nanocellulose

When asked which characteristics the respondents considered to be nanocellulose strongest, most answered strength and structure. One respondent emphasized that when nanocellulose is implemented in suitable applications, astounding strength and structure properties can be obtained. Strength properties of nanocellulose were highlighted as being of utmost importance throughout the whole thesis process. It was emphasized that different constructions/products/designs can be made lighter, thinner and stronger by replacing existing materials in some products with nanocellulose. Still, several respondents stressed that in order for nanocellulose to become a successful concept it has to be applied in the right products, i.e. in applications where nanocellulose is advantageous and cost neutral compared to competing materials.

An increased trialability was considered important because it could act as eye-opening for potential customers. By demonstrating and proving the advantages of nanocellulose potential customer unsure of the material could be convinced. However, one respondent highlighted the issue of marketing a product that does not exist – *"a product that does not exist should not be sold nor marketed"*. Another interviewee pointed out that the forest industries need to become better at creating market pull while one respondent believed that the industry should focus on what it does best – sell and market existing products.

According to Rogers (2003) trialability affects how quickly an innovation can be spread. Trialability also decreases uncertainty and enables a faster adoption of innovations. The trialability of nanocellulose at its present state is limited, especially for customers. A limited ability to try out and test an innovation affect the uncertainty connected to the innovation negatively. In the case of nanocellulose an increased trialability is important because it can act as eye-opening for uncertain customers.

During the interviews it was emphasized that the forest industries need to become better at communicating and demonstrating the opportunities/possibilities that lie hidden in the woods – i.e. nanocellulose needs to be more exposed to different stakeholders. The observability of nanocellulose cannot be considered high. However, during the thesis process Swedish television had a news feature on nanocellulose (Sveriges Television). Rogers (2003) describe

that observability stimulates the discussion of innovations. If nanocellulose were to reach a wider audience it has to be made visible.

Rogers (2003) declared that an innovation has a relative advantage over an idea it supersedes if it is considered being better than the previous idea. Respondents approached have considered the initial cost of nanocellulose being too high – the cost has to be on the same (if not lower) level as materials it may outcompete (e.g. plastics or aluminum in barrier constructions). It was emphasized that if the material were to be successful it must prove that it contains technological advantage and possesses a higher social status than other options on different markets. From a customer's point of view, it is important that nanocellulose can reduce costs and at the same time offer a higher performance than products presently used in the production. The technological compatibility of nanocellulose needs to increase – however, the fact that it is a bio-degradable material makes it very compatible with an increased will to "*go green*".

"The biggest obstacle for nanocellulose is probably the fact that it is a hopelessly promising technology or material that is constantly beaten by competing materials"

An idea that corresponds to a social system's values and norms will be adapted more quickly than vice versa. This implies that if the technological compatibility can be solved the change for a successful commercialization will be amplified. The picture of nanocellulose's present state that has been created through the interviews shows that there is still a lot of technical development to be done before it can be considered a competitive substitute.

The perceptions of nanocellulose production technologies

A process where nanocellulose would be mixed with pulp before the production process commenced would not be problematic according to some respondents. Still, the process parameters must be improved in order to increase the dry content. This was described as a necessity if the material is to be used as a barrier in packaging. The techniques for coating and applying carton board or other surfaces with films made of nanocellulose was considered being at an immature development stage.

During the interviews respondents highlighted the fact that a lot of attention has been put on the issue of energy consumed when producing nanocellulose while the issue of drying the material has yet to be solved. When dried, respondents believed that nanocellulose loses its amazing properties, a concern shared among some respondents. Most respondents have emphasized that the drying issue is important. Methods of drying have got to be developed so that the bonds between the nanofibrills are not irreversible. This may be a chemistry issue - however, the cost level must be on par with other materials on the market. Still, all respondents believed that the issue can be solved.

Applications of nanocellulose in thermoplastics were highlighted as interesting. However, nanocellulose is hydrophilic whereas thermoplastics are hydrophobic. Compatibility amongst the two materials needs to be increased in order for nanocellulose to be considered as a relevant supplement in thermoplastics. If the issue of compatibility were to be solved additional market opportunities would arise, for example nanocellulose could be used as a reinforcer in composites. From a chemical point of view, the challenge is to make the surface of nanocellulose hydrophobic so that it can blend well with a thermoplastic.

A problem often raised during the interviews was the issue of water. One respondent pointed out that nanocellulose consists of water up to 95 percent, applications where nanocellulose has to be in a dry state may therefore be problematic areas. Some respondents believed that a successful business model with the current properties of nanocellulose is not possible. Transporting nanocellulose in its current state would imply transporting large amounts of water, an issue that the respondents' considered non-feasible due to the large costs the process would generate. However, if the volume of water were to be reduced, transportations of nanocellulose could be carried out more cost efficiently.

4.2 Prerequisites for strategic directions

Strategic issues regarding the specific strategies of a given firm's work naturally proved to be sensitive and so the interviewees answered cautiously about their firm's particular strategies. Some strategic directions were described as general and so this section firstly presents a summary based of respondents' answers about the commercialization of nanocellulose and associated adoption of nanocellulose production technologies in the forestry sector. These are then analyzed using the theoretical framework presented in chapter 2.

4.2.1 Strategic directions

The Swedish forest industry consists of large organizations with capital intensive operations that require economies of scale. According to some of the respondents, it is difficult for large organizations to enter new markets when such markets have small scale needs. Some organizations may build pre-commercial plants but it was emphasized that one of the main issues with nanocellulose is its process ability. The amount of water that nanocellulose contains is a process challenge. Because of the water amount paper and cardboard become "dented" when nanocellulose is used and dried.

When it comes to the issue of scaling up the production of nanocellulose there may be problems in the future. An issue that has been discussed during the interviews is if nanocellulose should be considered a bulk product or not. Some respondents were of the opinion that bulk production enables a greater availability of nanocellulose which in its turn can generate a greater impact on products in different markets. An increased availability would increase the trialability. Taking the step towards an up-scaled production was seen as a riskful due to the present state of the development of nanocellulose. However, one respondent emphasized that small amounts of nanocellulose on the market will hinder a large impact – i.e. small amounts of nanocellulose can be inhibitory. It was highlighted that *"the issue of nanocellulose is a bit like the chicken and the egg"* – meaning: what comes first - demand or production?

The implementation of nanocellulose was considered to be very dependent on what it will be used for and which volumes that is actually required. Initially most of the respondents were of the opinion that the Swedish forest industry may have too large operations and that an additional focus on nanocellulose would be superfluous. The implementation was also considered reliant on demand. Some respondents emphasized that if a market has to be built (from scratch) small actors is a better way to go. If small to medium organizations or enterprises (SME:s) were to take pursuit of the progress a more rapid development would be more likely. What nanocellulose will be used for in the future is also a factor that controls which party who will implement the material on certain markets.

One respondent highlighted that in order for a large organization to take the initiative, something special has to occur (e.g. a high increase in demand) – especially if the produced

volume is in a small scale. If that scenario were to occur large organizations would most likely try to transfer the operations to something else, maybe joint ventures or other collaborations. It was highlighted that if nanocellulose were to be used as a replacement chemical in ordinary production the implementation would have to be done by a large organization - because of the amount that has to be used. An SME does not have the capacity to produce large volumes in an initial state.

One respondent emphasized that if nanocellulose were to be used in carton the implementation should be commenced from the paper-mills. Still, techniques for coating and applying carton with films made of nanocellulose are at an early development stage. It was also stressed that if nanocellulose finds its place on markets unfamiliar to the forest industry, the development should be pursued by other actors. Later, when the demand for nanocellulose potentially has grown, the forest industries can approach organizations in a later stage providing nanocellulose. This because the industry may possess the right resources to produce large amounts of nanocellulose – they do have the raw material but not the equipment.

Organizations that may choose to enter the commercialization stage of nanocellulose need to find the right business model and product area. Finding the right business model and product area was considered being finding the right combination of companies included in the commercialization and that the selected product areas were areas where growth could be enabled without regulatory boundaries. Initially organizations have to focus on the areas that are easier to accomplish, such as - applications for wet based products. However, it was emphasized that some organization has to be the "*initial mover*" – i.e. if an actor "*dare to take the plunge*" others will follow.

4.2.2 The resource based view of the firm

During the interview process it was highlighted that nanocellulose is derived from the same resource the industry is used to work with. One respondent pointed out that there is no need to acquire new resources and believed that a further exploitation of wood properties could enable forest industries to capitalize on the strength properties of nanocellulose.

One interviewee stressed that the biggest obstacle for nanocellulose may be that it is a *"hopelessly promising material/technology often beaten by competing materials"*. The polymer industry is no stranger to nanomaterials, perhaps they are ten years ahead in their development and have applications on the market worth defending. It was pointed out that competing in price and performance is crucial to success. If the price of nanocellulose turns out to be too high and the performance too low there is no chance that it will be a successful concept. In order for nanocellulose to be a successful commercial concept it has to find a place on a market where organizations can avoid having to compromise and lower the price because its characteristics are lower than competitors. One respondent emphasized that companies must ensure that they have to avoid giving up something for their weaknesses, one way to do this is being operative in areas where the strengths of nanocellulose are clearly dominant. The same respondent also said that is unfair to say that nanocellulose will save the Swedish forest industry – the important thing is to find nanocellulose's compelling offer. Another interviewee highlighted that applications made from nanocellulose might become more expensive than fossil-based applications. If this is a fact, organizations that might produce nanocellulose would have to find niches where the usage of nanocellulose could be a viable option from the customers' point of view.

During the interviews it was pointed out that if any of the traditional forest organizations would pursue the development and commence a commercialization, i.e. be the driving force, an implementation could be made relatively easily. The Swedish forest industries already have the right "channels" – they possess the resources, organization and the customers. However, the large Swedish forest industries are not flexible and if there is no demand, why strive towards something that is not profitable?

There are many things to work on. However, all of the approached respondents believe that nanocellulose will find its place on a market within 5-10 years. The main push factors are the characteristics of nanocellulose, it is considered a fantastic material with great potential. Some respondents drew attention to the fact that the newspaper industry is on its knees. The industry is not *"fat and happy"* anymore, and new product- and market areas must be found. Nanocellulose is close at hand because it is derived from wood. The will to "go green" was also emphasized being a factor for success – "peak oil" might soon occur and the fact that nanocellulose is biodegradable is advantageous.

4.2.3 Strategic Alliances & Customer Incentives

Alliances

At present, there is no large production of nanocellulose at any of the Swedish forest industries. Most of the respondents said that in the long run, a large production may commence. However, it is well known that one of the surveyed organizations is working with a pre-commercial plant.

Most organizations (if not all) approached for this study have participated in collaborations with other actors. The extents to which actors have been active in these alliances differ and some organizations have closer relationships with their customers than others. When it comes to the development of nanocellulose most of the approached actors have worked on their own or in collaborations with others and some of the organizations partially own "R&D-companies". In some cases the surveyed organizations have had deliveries of nanocellulose from small external actors. In one case, the deliveries were tried out in the production. But the organization experienced differences in quality of the nanocellulose received and the outcome did not yield any good results. Thus, a lack of a standardized characterization method was emphasized as problematic.

One respondent pictured a future were its organization would not produce nanocellulose in bulk. Instead, the respondent was of the opinion that the company should act at a later stage in the value chain regarding the issue of nanocellulose – i.e. working with value-added products that would contain nanocellulose. It was also pointed out that this may be initiated via an alliance of some sort. In general, alliances were considered important with emphasis on the issue of trialability. It was considered advantageous to have an actor to work with and against. This because alliances were deemed necessary when the development process eventually becomes business.

Some respondents expressed that the issue of nanocellulose at first need a company that produces it in small amounts in appropriate segments. Later, when the demand has grown the production can be increased by larger organizations that hold large amounts of resources - i.e. a slow start followed by an accelerated production due to increased demand. Alliances were considered important/useful for the development of nanocellulose because small and large organizations can gain from each other. It was emphasized that the forest industry hopefully

will start the commercialization, but it was pointed out that it would most likely be commenced in collaborations with other sectors.

Customer Incentives

When the demand for nanocellulose was discussed during the interviews most respondents answered cautiously optimistic. One respondent emphasized that customers demand price and performance. If an organization had a compelling offer where nanocellulose could help a customer to lower their total material usage in products or replace existing applications at a lower price with sustained performance deals could be made. The respondent believed that this was not possible with the present development state of nanocellulose. For every customer who would consider a transition, from existing products to nanocellulose, there would be a conversion cost when systems or products were to be replaced. It must be proven that nanocellulose can deliver better price and performance than other competing products in order for a change to commence. Another respondent stressed that there is a lot of talk, but that the willingness to pay extra for something that is a little bit better is almost non-existent – a problem well associated with new products. It was also emphasized that there may be geographical markets where demand for nanocellulose can be found. The development of nanocellulose and processes that affect the material was considered being at a too early stage for any true appraisal of the potential demand. Respondents were divided on the issue that nanocellulose could generate increased customer value. However, most respondents were of the opinion that usage of nanocellulose could increase the reputation of the organizations brands.

4.2.4 Strategic directions related to the approached companies competitive advantage

According to Porter's five-force model an industry can be seen as competitive if it contains several organizations of the same size. Based on that definition the Swedish forest industry is competitive because it consists of companies that all can be considered as large. However, an organizations' degree of rivalry is also determined on the degree of differentiation amongst competitors on a market. The companies approached for this study are quite differentiated in relationship to each other, some more than others. The companies are situated on markets closely linked together, if not on the same markets.

Due to the size of and the fact that most of the Swedish forest companies are capital intensive, the forest industry can be considered an industry with high exit and entry barriers – especially on the supply side. The threat of potential entrants can be described as low partially dependent on the fact that there are large start-up costs connected to facilities and machines.

Ansoff (1979) argued that one key concept in strategy is to understand the organization's environment. The Swedish forest industry consists of few large organizations that collaborate in different workshops. Thus, most of the organizations share some information with competing firms. One key difference that distinguishes one firm from another is the managers' capabilities to retrieve and interpret information. Throughout the conducted interviews many organizations have emphasized the fact that they have special groups assigned to search for new forest-based products. Hence, incentives from the industry to search for new products and find new areas of profitability are present.

Among firms operating in the forest industry there is an inherent inertia. When changes in the general environment occur "triggers" initiate internal processes towards considerations on strategic behavior. Because of the capital intensive operations and the inertia that characterizes the forest industry strategic changes are hard to initiate. Something "spectacular" has to

happen before changes are implemented to the costly operations. Maybe, the decrease in newsprint is not a sufficient trigger for a change to commence. However, the timeliness and development of new strategies are dependent on the organization's culture and managerial capability (Hugosson & McCluskey 2008). The Swedish forest industry is generally seen as conservative. There is, however, a drive towards being at the forefront of development and many of the responding firms are hopeful when discussing the future of the industry.

According to Grant (2010) and the resource-based view of the firm the key to profitability is exploiting differences – i.e. how should an organization formulate and implement a strategy that exploits the firm's unique strengths? Strategy was earlier described as matching a firm's resources and capabilities to opportunities that arise in the external environment. During the conducted interviews no distinctive strategy that addresses nanocellulose have been made visible. However, all of the approached actors believe that nanocellulose is an interesting material that carries a lot of potential. Due to the fact that nanocellulose is derived from the same resource as the industry is used to work with it can be considered of value. Still, there is doubt concerning which party who will drive the development of nanocellulose further on. It has been expressed that SME's should pursue the commercialization, mainly because of unsure market potential and large capital intensive operations. Grant (2010) highlighted that capability is the essence of superior performance. If the Swedish forest industries do not have the capabilities maybe a pursuit of commercialization should not commence from their side. However, the Swedish forest industries possess the right resources, organization and the customers – i.e. if the demand for nanocellulose would rise the industry would most likely find solutions for earlier mentioned problems.

The central point of innovation will be found in networks of learning (not in individual organizations) when an industry's knowledge base is expanding, complex and its sources of expertise is widely dispersed (Powell et al. 1996). According to Schilling (2008) and Trott (2012) alliances have become an important issue in competitive strategies. All of the approached companies have been part of some sort of alliances, however in different extents. There was some disagreement to how the Swedish forest industries should approach alliances and in which stage of the value chain operations connected to nanocellulose should be commenced. By a close relationship to their customers, companies can gain strategic, technical and financial advantage (Monczka et al 1998). In order for an alliance to become successful the relationships amongst certain actors have got to be beneficial for all parties involved. For the forest industries that are capital intensive an alliance with shared risks and costs can be very useful. Reduced costs and risks can increase the incentives to move outside "*the comfort zone*". Maybe, a collaboration where a large forest company delivers raw material to a SME who develops the process ability of nanocellulose could be a way to increase the speed of commercialization.

Cooper (2012) describes that the survival and prosperity of the modern corporation is dependent on the development of new and improved products and services. Judging by the conducted interviews, the Swedish forest industries investments in research and development are way too scarce. This implies that the amount invested in R&D has to increase. A winning product is often derived from an organizational ability that assimilates a delivery of products with unique benefits and real value. According to Cooper (2012) a winning product is competitive in price/performance, cost reduction, value adding and has a relative advantage in excellent product quality from the customers' point of view. Whether nanocellulose will become a successful and winning product remains to be seen. The question can be answered by continued development of the process ability.

4.3 The issue of replacing fossil-based products with bio-based

During the interviews one specific question was raised related to the issue of "peak-oil" (Appendix 1). The question focused on the issue of investments in research and development (R&D) from forest industries. Should more resources be allocated towards R&D in the future in order to outcompete fossil-based products when demand for bio-based products may rise? Most of the respondents highlighted that this is an issue and that increased investments in R&D are of importance. One respondent emphasized that forest based research and new product development has been far too inactive for far too long. It was pointed out that the industry collectively has to invest more in R&D. But there is however no (and maybe it should not be any) guarantee that the forest industry as a united sector collectively should invest in R&D. Each of the organizations needs to understand that they individually must increase their efforts and not simply "*follow the stream*". One interviewee stressed the fact that if the industry were to replace large newsprint operations within the next ten years much work is needed and the change will require diversification. The respondent was of the opinion that if the industries are active in the same research projects every organization will strive towards pressing prices and hunting costs in razor-sharp competition. It was stressed that organizations must dare to diversify and carry development costs by themselves. Swedish forest companies cannot maintain the present levels of investments – they must look to the future instead of treading water.

Doubt was also raised towards the question of peak oil and to a decreased demand in fossil-based products. It was highlighted that the percentage of oil used in plastic manufacturing relative to recovered oil is very low. In contrary, the sales of plastics stands for a very high percentage of the profits gained from extraction of oil – i.e. the oil industry basically subsidize gasoline by making plastic. The environmental arguments were considered important, but it was emphasized that the forest industry cannot solely rely on them. One respondent argued that it would be difficult to outrank plastics in favor of bio-based products via replacements. Instead, biodegradable alternatives should be introduced in a small scale in an initial phase. The interviewee was of the opinion that replacements do not lead to transitions, products with new and different functions must be presented in order for a transitions to commence.

Sooner or later extraction of oil may reduce. The oil-industry has been the main supplier of ethylene to the plastic-industry for a long time. However, it was emphasized that the plastic-industry are constantly searching for alternative sources to oil. Where the ethylene originates from does not matter do the plastic-industry as long as the industry receives it. Bio-ethylene can be derived from wood and used in the manufacturing of plastics. One respondent stressed that the forest industry need to be on its toes because there are large market shares to gain.

Generally most respondents believed that the Swedish forest industry is moving towards a new era and that the industry is in a changing state. One interviewee pointed out that the industry need to ask itself if it receives logs or "*chemistry sets*" when wood arrives to the industry gate. This because "*given the potential our forest carries basically everything made from oil could be made from wood*". However, lobbyist working for the oil-industry are larger in numbers and a lot of issues concerning transitions of resources are dependent on political decisions – it was emphasized that the forest industry in general have got to be more active in the rooms and behind the closed doors where political decisions are being made.

5 Discussion

This chapter includes a discussion of the results based on the study's purpose and the earlier presented issues. Later, the methodology will be discussed in relation to the results given in order to determine if it was suitable for the conducted study.

5.1 A summary of results connected to the research questions

By summarizing the results from the conducted interviews the research questions can be answered. Below, they are presented and discussed.

5.1.1 Factors that could make wood-based nanocellulose a successful commercial concept

During the interview process it has been detected that all respondents are of the opinion that nanocellulose, at its present state, is not a product in itself. If/when the material is implemented on a market, it will initially function as an application/supplement for a new- or already existing product. It has been emphasized that a commercialization of nanocellulose failed during the 80's mostly due to high production costs. It has also been stressed that the incentives from large forest companies to develop techniques for nanocellulose were very small due to high demand for classic forest-based products.

The rise of digital media is affecting some forest industries negatively, thus an increased focus on new product development is necessary. The need to find new products and the quest to find new opportunities of profitability are factors that could make nanocellulose a successful commercial concept. Still, organizations based in the industry are not known for their innovativeness – i.e. the forest industry is not commonly known for being in the forefront of product development and is generally considered as being a conservative industry.

Most respondents have highlighted that nanocellulose has to be applied in the right products in order for it to become successful on specific markets. With the current state of nanocellulose the material can be advantageous in wet-based products. However, the initial cost has been considered too high compared to the materials it would have to outcompete. In order for nanocellulose to stand a chance against competing applications it has to be at least cost neutral. An area where growth without regulatory barriers could be enabled was seen as promising – this may be wishful thinking considering the amount of standardizations, certifications and the amount of quality- and environmental management systems there are available on different markets. However, the right combination of business model and product area is of importance for a successful commercial concept.

If nanocellulose's properties were to be maintained when dried the opportunity of a successful implementation would increase. Because nanocellulose is considered a fantastic material with great potential the right implementation could become a great success. Still, somebody has to "*dare take the plunge*" in order for others to follow.

5.1.2 Factors that hinder nanocellulose from becoming a successful commercial concept

The fact that nanocellulose contains a lot of water and the problematic issue of drying nanocellulose has been emphasized as hindering. The development of nanocellulose's process ability has to increase in order to enable involvement in different matrices. Methods of drying nanocellulose have been described being at an early development stage. This means that there is still work to be done before nanocellulose could become a successful commercial concept on markets or in products where it has to be in a dry state. The immense water content of nanocellulose has also been described as a factor that hinders transportations of the material.

Due to problematic transportation scenarios, a bulk production with the present development stage of nanocellulose is not feasible because it is not cost efficient.

Nanocellulose has often been described as a material with great potential. Still, the drying processes irreversibly decrease the great properties of nanocellulose. Focus has to be put on the issue of drying nanocellulose – if the issue were to be solved more business opportunities would arise. It has been highlighted that the compatibility of nanocellulose in different products has to be increased. Another hinder that has been presented is the size of the Swedish forest organizations. Some respondents stressed that it is difficult for large organizations to enter new markets, and that their lack of flexibility is problematic when approaching new innovations. However, large forest companies are global and often have great financial capacity. If there is a willingness to approach new markets, the leap is unlikely giant.

There may be problems with scaling up the production process of nanocellulose in a near future due to the present state of nanocellulose's process ability. Respondents have also had different opinions of how nanocellulose should be considered as a product – i.e. is it a product in itself or is it a supplement/application? One respondent described nanocellulose as a *"hopelessly promising material/technology often beaten by competing materials"*. Thus, organizations that will pursue the development of nanocellulose have got to make sure that the material can compete in price and performance. Overall, a demand for nanocellulose is crucial - a lack of demand may be the biggest factor that can hinder a successful commercialization.

5.1.3 In what stage of the value-chain should the implementation commence?

Judging by the conducted interviews, areas of use and required volumes will determine which actors that may pursue a commercialization of nanocellulose. It was emphasized that the Swedish forest companies' operations are too large and that an additional focus on nanocellulose could be superfluous. However, all of the approached respondents hoped that the forest industry will be a driving force in the commercialization. If nanocellulose were to be produced and sold in bulk, the respondents were of the opinion that the forest industry should pursue the development. This because SME's do not possess the resources needed for large operations. On the other hand, if nanocellulose were to be used as applications/supplements it was considered that SME's should pursue the implementation. It was emphasized that if SME:s were to take pursuit of the progress a more rapid development would be more likely- mostly due to their flexibility. An alliance between a large organization and a smaller more flexible firm could generate great results. If the compatibility, trialability and process ability increases nanocellulose's relative advantage will be improved and the chance for a successful commercial concept would be greater than the present.

Based on the theory and the answers given by the respondents an alliance may be the best way to pursue the commercialization of nanocellulose. At present, there is no large production of nanocellulose in any of the Swedish forest firms. Still, most of the respondents emphasized that in the long run a large production may commence. If a joint venture were to be created, where large forest companies deliver raw material to smaller developers, development risks and costs could be shared. A joint venture could perhaps increase the incentives to accelerate the development of nanocellulose.

Overall, the investments in research and development have been considered scarce. It has been made clear that there is a willingness to develop and implement new products, but the organizations capital intensive operations negatively affects the flexibility – a lack of flexibility hinders these intentions. Still, the industry's inherent inertia has to be addressed,

firms' active in the industry need to make sure that they strive towards seizing opportunities that arises – in this case the opportunities connected to wood-based nanocellulose.

5.1.4 Background, current situation and the desired situation

During the conducted research it has been made clear that a commercialization of nanocellulose partially failed during the 80's because there was no need for the industry to find new areas of profitability. The technological struggle, the lack of demand and the undiscovered areas of usages put the development of nanocellulose on hold – especially the commercialization stage. However, the potential of nanocellulose has always been considered high and the research have continued throughout the years. Nowadays, when the demand for newsprint is decreasing and the world is changing in a rapid pace there is as growing need for product development. The "revival" of nanocellulose is a result of the above. Back in the 80's, when nanocellulose first was produced, the energy consumed when producing nanocellulose was considered too high. Due to continued research, the issue of high energy consumption has been solved.

Still, the current situation of nanocellulose is quite unsure. Demand is uncertain, and there are still technological issues to be solved before nanocellulose can reach the great potential it carries. However, the industry has a lot to gain from the situation. By grasping the opportunity and showcasing that a "conservative" industry has the ability to work with "high-tech processes" and that there is new product development present - the attractiveness of the industry can increase. The issue of commercializing nanocellulose is a slow process which the forest firms play a central role in. The observability and trialability of the material need to increase so that stakeholders can test the material and discover the benefits connected to it.

There are still a lot of issues to be solved and the need for continued research remains central. The Swedish forest industry need to invest more in R&D, the industry must also showcase the opportunities that lie hidden in the woods. Maybe, logs that arrive at the industry gates should be seen as both logs and chemistry-sets – this because there is need for further exploration of wood properties. At the same time, the industry need to capitalize on the opportunities that may be presented through increased R&D in order to be profitable in the long run.

Most of the approached respondents believe that nanocellulose will find its place on a market within 5-10 years. Nanocellulose is considered a fantastic material and the main push factors for a successful commercialization are its characteristics. However, no real demand from the customers' point of view has been made visible. Mostly due to the fact that the interviewed respondents approached for this thesis are operating on the supply side. The areas of use described in the beginning of this thesis are large. If the right business model could be connected to the right product nanocellulose will surely be successful. Maybe, it is too early to determine how big the market potential of nanocellulose is. Nevertheless, what can be said is that nanocellulose carries great potential.

5.1.5 Future studies

This thesis has focused on the supply side, i.e. large organizations that have capital intensive operations. An interesting take on this study would be to focus on customers and firms active in areas/markets where nanocellulose has the potential of becoming successful. Increased demand of nanocellulose would surely increase the forest firms' incentives to develop the material and the technologies connected to it.

5.2 Methodology discussion

Because of the purpose for this thesis, a quantitative study was not considered an appropriate approach. At the moment large amount of data that concern the market potential of nanocellulose cannot easily be found. Because of nanocellulose's relatively immature development stage it was considered that a qualitative approach would generate a deeper understanding of the Swedish forest industry's views on issues connected to nanocellulose.

A goal connected to the thesis was to increase the author's own knowledge of how Swedish forest companies view nanocellulose. A qualitative research allows for a more detailed examination of a limited material. In this case the selected methodology can be considered to have worked well because of the results given from the conducted interviews. However, answers given from semi-structured questions can be hard to structure and may be difficult to standardize. There is always risk that the interviewer guides the interviewees, not just by the questions but also through verbal expressions and/or body language in response to the respondents' answers. Still, whether the questions are leading or not is not of importance – the important thing is what the question lead up to and what the interviewer gains from the answers.

A recording devise was not used during the personal interviews. This can be a problem because variations in tones from respondents could have been missed out – it could mean that the interviewer have missed responses of importance or responses that were sensitive. However, after each personal interview a summary of the conducted interview was almost immediately written down. In the case of recorded telephone interviews they have been carefully listened through and thoroughly transcribed - this in order to secure that everything of essence was collected and interpreted.

A natural limitation of qualitative studies is the fact that the work is time consuming. Depending of the time-scale the number of respondents may be limited. However, the sample has to be relevant to the purpose of the study. The sample used for this thesis has been relevant for the purpose of this study.

5.2.1 Reliability, validity of this study

Reliability is a measure describing the extent to which an instrument or approach give similar results on different occasions but under similar circumstances. If the correlation between responses is high in a study it can be considered reliable. In this case most of the respondents' answers to the questions have been quite similar. However, there have been some differences in answers to certain questions. The measure of reliability is based on the notion that reality is constant which enables the possibilities to repeat attempts. Still, it is impossible to freeze a social environment – this means that the measure of reliability is not completely reliable in terms of qualitative interviews. Still, general questions have been answered similarly which suggests a high degree of reliability. If there is any doubt concerning the questions asked, please check the questionnaire (Appendix 1).

Validity is a measure of whether a particular issue measures or describes what the researcher wants it to describe – a very vague definition. Based on the respondents approached for this study the conducted research can be considered valid. Because the approached respondents all have encountered issues connected to nanocellulose and are working with research related questions the answers given can be considered valid.

6 Conclusion

In the last chapter of this thesis the conclusion of the conducted study are presented

A commercialization of nanocellulose failed during the 80's mostly due to high production costs and lack of incentives from the forest firms. The rise of digital media has had a negative effect on the demand for newsprint. This has increased the need for new product development. Nanocellulose is a material that carries a lot of potential and the fact that it can be produced from wood make it very interesting from the forest industries' point of view. However, there is still a lot of work to be done and at the moment some forest firms are unsure if they should commence the commercialization.

Conclusions that can be drawn from the conducted study are:

- Due to the decrease in demand for "classic forest-based" products, incentives from forest companies to focus on new product development are increasing.
- Nanocellulose is not considered a product in itself, nanocellulose will initially be used as an application/supplement in existing or new products.
- Nanocellulose has to be applied in products where it can be advantageous, at the same time the initial cost must be on par with other alternatives.
- The right combination of business model and product area is of importance for a successful commercial concept.
- The immense water content and the fact that nanocellulose is highly hydrophilic have been emphasized as problematic – the process ability has to increase.
- Methods of drying nanocellulose need further development – solutions to the drying problem may create additional business opportunities.
- There is uncertainty to the question of which actor that will be the driving force to a commercialization of nanocellulose. The question is dependent on what it will be used for and in which volumes.
- The demand for nanocellulose is uncertain, but the will to "go-green" is increasing.
- Nanocellulose carries a lot of potential. However, forest industries are not fully willing to "*take the plunge*" because the risks are too great and the market potential too uncertain.

During the thesis process it has also been emphasized that the forest industries should invest more in research and development. It has been stressed that the industry need to ask itself how it should perceive the wood that arrives at the factory gates – logs, or "*chemistry sets*"? The companies approached for this study are all willing to support the long term goal of a bio-based society. Nevertheless, it has come to a point where everyone is willing to participate at the party but no one is willing to buy the ingredients needed for baking the cake - mainly because the guests' preferences are uncertain.

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Appendices

Appendix 1. Questionnaire for the conducted interviews

Frågeguide för de semi-strukturerade intervjuerna
(*Questionnaire for the semi-structured interviews****)***
Intervjuerna genomförs enligt en kvalitativ semi-strukturerad metodik.
(The interviews have been conducted via a qualitative semi-structured methodology)
Intervjuerna har utförts muntligt, om en intervju inte kunnat möjliggöras genom personlig kontakt har den skett via telefon.
(The interviews were conducted orally, if an interview could not be made possible through personal contact it was conducted via telephone)

Följande frågor är tänkta att användas som ett diskussionsunderlag. Frågorna utgör den strukturerade delen i de semi-strukturerade intervjuerna, men intervjuerna är mer tänkta att föras som en dialog där de tidigare uppställda frågorna verkar som vägledande. Detta för att inga viktiga punkter ska utelämnas.
(The following questions were ment to function as a basis for discussion. The questions represent the structured part of the semi-structured interviews, but the interviews were carried out as dialogues. The questions were used as guidance, this to ensure that no important points could be left out)

Introduktion
(Introduction)
Intervjuaren presenterar sig själv och vad uppsatsen skall gå ut på.
(The interviewer presents him/herself and the purpose of the thesis)
Förklaring av examensarbetets syfte, och anledningen till varför detta genomförs.
(The purpose and the reason to why the research is carried is then explained)
Vem det utförs för (Innventia).
(For whom this thesis is conducted (Innventia))
Vad frågeställningen är (Arbetet handlar kortfattat om nanocellulosa och dess förväntade marknadspotential: affärsmöjligheter, strategiska aspekter och kundrelationer)
(What the thesis pursues to answer(In short, the thesis focuses on nanocellulose and the issues of business opportunities, strategic aspects, customer relationships and market potential connected to the material)
Resultatet behandlas anonymt vad avser enskilda svar.
(The results given from the interviews are treated anonymously regarding individual responses)
Frågar om inspelning med diktafon är okej.
(Asks if recording with a Dictaphone is okay)
Ett referat kommer att mailas i efterhand för verifiering och ev. uppföljning
(A summary will be emailed afterwards for verification and possible monitoring)

Den intervjuade
(The interviewee)
Namn:
(Name)

Arbete/position:
(Work/position)
Utbildning:
(Education)
Arbetserfarenhet:
(Work experience)
Hur länge har du arbetat för nuvarande arbetsgivare:
(How long have you worked for your current employer)
Specifika projekt?
(Some specific projects?)
Vad har du för kompetensområden?
(What are your areas of expertise?)

Nanocellulosa – produkt och produktion
(Nanocellulose – product and production)

- **Erfarenhet av nanocellulosa?**
  (Experience of nanocellulose?)
- **Vilka är, enligt er, nanocellulosans bästa respektive sämsta produktegenskaper?**
  (What are, in your opinion, the best and worst product attributes of nanocellulose?)
- **Sett från er synvinkel, vilka är nanocellulosans kännetecken, prestanda och specifikationer?**
  (From your point of view, which are nanocellulose characteristics, performance and specifications?)
- **Hur har utvecklingsarbetet med nanocellulosa sett ut på ert företag? Vad är bäst: Att skogsindustrierna samarbetar i utvecklingsarbetet eller att ni kör på egen hand?**
  (How has the development of nanocellulose been commenced at your firm? What is better: collaborative development or to run your on show?)
- **Hur ser utvecklingspotentialen ut?**
  (How does the development potential look like?)
- **Om problem, vilka hinder har ni stött på?**
  (Have you encountered obstacles in the development process?)
- **Hur pass tekniskt komplex är nanocellulosan att utveckla?**
  (How technologically complex is nanocellulose to develop?)
- **Ur ett tekniskt perspektiv, tror ni att nanocellulosans kompatibilitet (förenlighet med befintliga system och processer) är en viktig parameter vid införandet av nanocellulosa?**
  (From a technical perspective, do you think compatibility (with existing systems and processes) is an important parameter to the indtroduction of nanocellulose?)
- **Hur viktig är kompatibiliteten?**
  (How important is the compatibility?)
- **Vilka möjliga applikationer av nanocellulosa skulle vara relevanta för ert företag?**
  (Which possible applications of nanocellulose would be relevant for your firm?)

- **Skulle ett införande öka graden av komplexitet i ert företag – d.v.s. nya processer, utbildningar, produktionstekniska aspekter?**
  (Would the implementation of nanocellulose increase the level of complexity in your firm – i.e. educate staff for new processes, new technical aspects etc?)
- **Har ni någon form av produktion idag? Hur ser kostnadsbilden ut, om man jämför med andra typer av applikationer?**
  (Do you have any current production of nanocellulose? The cost of producing compared to other types of applications?)
- **Om ingen produktion, varför inte? Skulle det vara mer relevant att köpa in nanocellulosa? Prototyper? Pilotanläggningar? Tester (prestanda och kvalitet)?**
  (If no production, why not? Would it be more relevant to procure nanocellulose from another source? What about prototypes, pilot plants, tests etc?)
- **Om produktion, har en marknadsföringsprocess inletts?**
  (If the firm is producing nanocellulose – has a marketing process been initiated?)

Potentiella kunder & marknader
(Potential customers & markets)

- **Skulle nanocellulosan kunna inkorporeras i nuvarande produkter? Vilka applikationer används i nuvarande produkter?**
  (Is it possible that nanocellulose could be incorporated into existing products? What applications are used in your current products?)
- **Vilka konkurrensfördelar/nackdelar skulle applikationer av nanocellulosa kunna innebära för era produkter?**
  (What competitive avantages/disadvantages would applications of nanocellulose bring to your products?)
- **Finns det tydliga incitament från andra aktörer i er värdekedja att implementera nanocellulosa?**
  (Are there clear incentives from other actors in your value chain leading to an implementation of nanocellulose?)
- **Vad säger lagstiftningen? Finns det några incitament eller hinder där? (skatter, regleringar)**
  (Are there any statutory obstacles?)
- **Ser ni några fördelar med att naoncellulosa är nedbrytbar och härstammar från skogen?**
  (Do you see any advantages in the fact that nanocellulose is biodegradable and derived from the forest?)
- **Tror ni att kunder är benägna att betala ett högre pris för produkter baserade på nanocellulosa?**
  (Do you believe that customers are likely to pay a higher price for products based on nanocellulose?)
- **Hur ser efterfrågan ut?**
  (What is the demand for nanocellulose?)

- **Jämfört med andra applikationer på marknaden, vilka är/skulle kunna vara fördelarna med nanocellulosa?**
  (Compared to other applications on the market, which are/or could be the advantages (or benefits) with nanocellulose?)
- **Kan nanocellulosa erbjuda lösningar som inte är möjliga med befintliga produkter på marknaden?**
  (Can nanocellulose offer solutions that are unique to market X?)
- **Hur kan kundvärdet ökas med hjälp av nanocellulosa?**
  (How can the customer value be increased with the help from nanocellulose?)
- **För ni dialoger med kunder?**
  (Are you currently having dialogues with customers concerning the future of nanocellulose?)
- **Samarbeten? Har det förekommit några samarbeten med externa aktörer genom åren?**
  (Collaborations? Have there been any collaborations with other actors throughout the years?)
- **Kan applikationer av nanocellulosa enkelt prövas på marknaden? I produktionslinjen?**
  (Can applications of nanocellulose easily be tested on the market or in the production line?)
- **Spelar slutkunderna en stor roll vid en eventuell implementering av nanocellulosa? Hur då? I vilken Utsträckning?**
  (How large is the role that end customers play when it comes to a possible implementation of nanocellulose?)
- **Hur skulle ni beskriva målmarknaden för nanocellulosa?**
  (How would you describe the target market for nanocellulose?)
- **Har ni utvecklat någon specifik strategi för nanocellulosans marknadsroll? Försäljningsstrategi? Marknadsstrategi? Utvecklar ni någon specifik strategi för produktlansering/marknadsföring?**
  (Have you developed a specific strategy for the market role that nanocellulose may come to play? Sales strategy? Market strategy? Are you developing a specific strategy for the product launch/marketing?)
- **Hur mycket arbete läggs det ned på att analysera: produktionen, kundbehoven och konkurrenssituationerna gällande nanocellulosa?**
  (How much effort is put into analyzing: the production, the customer needs and the competitive situation regarding nanocellulose?)
- **Vilka är de viktigaste strategiska aspekterna? Tillverka och sälja? Köpa in och använda?**
  (What are the key strategic aspects? Produce and sell vs. Purchase ad use?)
- **Hur ser kostnadsbilden ut för utvecklingen av applikationer baserade på nanocellulosa?**

(How high/low is the cost for the development of applications based on nanocellulose?)

- **Hur ser tillverkningskostnaderna ut? Låga eller höga?**
  (How do the manufacturing costs look like? Low or high compared to other competing materials?)
- **Framtida försäljningsvolym? Beroende på vilka faktorer?**
  (Potential future sales? Factors of importance?)
- **Pågår det några beräkningar på framtida vinster baserade på nanocellulosa?**
  (Have any estimates been made on future earnings nanocellulose could generate?)

- **Plast som härstammar från oljan (oljan kanske försvinner) och dess inverkan på miljön (Great Pacific Garbage Patch bl.a.) - bör skogsindustrierna försöka satsa mer pengar på forskning och utveckling för att i framtiden vara beredda att konkurrera ut sådana produkter när efterfrågan stiger? Finns det ett brett mål med att kunna tillgodogöra kunder med miljövänliga och nedbrytbara alternativ? Till vilket pris?**
  (Plastic that is derived from oil (which may disappear) and its impact on the environment (Great Pacific Garbage Patch, among other things) – do you believe that the forestry industries need/should spend more money on research and development in order to outcompete products made from plastics when the demands for biodegradable products are rising? Are you striving towards being able to give customers eco-friendly and biodegradable alternatives? At what price?)

- **Skulle en introduktion av nanocellulosa kunna påverka ert varumärke i hög utsträckning? Positivt eller negativt?**
  (Would the introduction of nanocellulose influence your brand to a great extent? Positive or negative?)

Slutligen

- **Vilka är de faktorer som skulle kunna göra träbaserad nanocellulosa till ett framgångsrikt kommersiellt koncept?**
  (What are the factors that could make wood-based nanocellulose a successful commercial concept?)
- **Vilka är de faktorer som hindrar den träbaserade nanocellulosan från att bli ett framgångsrikt koncept?**
  (What are the factors that hinder wood-based nanocellulose from becoming a successful commercial concept?)
- **I vilket skede av värdekedjan bör en implementering av nanocellulosan påbörjas?**
  (In what stage of the value-chain should the implementation commence?)

Tack för er medverkan!

Appendix 2. Mail to respondents in Swedish

Hej X!

Mitt namn är Johan Eklund och jag studerar vid institutionen för skogens produkter på SLU i Uppsala. Under vårterminen skriver jag mitt examensarbete inom masterprogrammet i skogsindustriell ekonomi. Arbetet handlar kortfattat om nanocellulosa och dess förväntade marknadspotential: affärsmöjligheter, strategiska aspekter och kundsamarbeten. Till min hjälp har jag två handledare: Torbjörn Andersson (SLU) och Tom Lindström (Innventia AB)

Examensarbetet ska bygga på ett antal kvalitativa intervjuer och jag skulle gärna vilja träffa dig för en intervju. Om ett personligt möte inte skulle vara möjligt så undrar jag om det istället går att genomföra en telefonintervju. Jag förstår att Du är en upptagen person som inte har obegränsat med tid, men jag skulle uppskatta Ditt deltagande i studien. Hur ser ditt schema ut? Finns det någon öppning i Mars eller April? Jag är anpassningsbar gällande datum för intervju.

Intervjun i sig bör inte ta mer än cirka 45-60 minuter

Exempel på frågor:

- Vilka är de faktorer som skulle kunna göra nanocellulosa till ett framgångsrikt koncept?
- Vilka är de faktorer som hindrar nanocellulosan från att bli ett framgångsrikt koncept?
- Om implementering av nanocellulosa; i vilket steg av värdekedjan bör detta initieras sett från ert perspektiv?

Ser fram emot Ditt svar!

Med vänliga hälsningar

/Johan Eklund

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