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# Managing supply uncertainty in supply chain planning

A white fish case study


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# Problem description

This thesis is concerned with supply uncertainties and supply chain planning at a Norwegian white fish processor. The aim is to: (1) explore the characteristics of supply uncertainty and its impact on supply chain planning processes and; (2) use this insight to propose how the supply chain planning process can be designed to mitigate supply uncertainty.

# Preface

This is a master's thesis written at the department of Industrial Economics and Technology Management at NTNU (Norwegian University of Science and Technology) during the spring of 2018. The thesis is a compulsory, written assignment in the course IØ3911 Master's Thesis in Global Manufacturing Management and amounts for 30 credits.

The thesis is viewed as a contribution to a three-year, multidisciplinary research project called iProcess, administered by SINTEF Ocean with several R&D partners such as NTNU, Nofima and Lerøy Norway Seafoods. The research project aims to develop innovative and flexible processing solutions to reduce waste in the Norwegian food industry and is divided into four work packages. This report constitutes a contribution to Work Package 4, where the goal is to develop information flow management solutions to support decision making for the food processor to maximize resource efficiency and profitability.

We are very thankful for all the helpful and constructive feedback and encouragement we have received from our supervisor, prof. Heidi Carin Dreyer. We also want to thank her for giving us the opportunity to participate in writing a research paper derived from this thesis for the 2018 EurOMA conference. We are also grateful to Lerøy Norway Seafoods who provided us the opportunity to learn more about the Norwegian white fish industry and their challenges.

*Trondheim, 8 June 2018*

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# Abstract

This thesis investigates the impact of supply uncertainty on tactical supply chain planning processes. It focuses on identifying sources of supply uncertainty in a white fish processor's planning environment, and establishes a severity ranked list of these uncertainties. Based on the most severe uncertainties, the thesis aims at proposing measures in the supply chain planning process which can be taken to mitigate the impact of supply uncertainty. The proposal takes the form of a planning process design, and can give white fish processors improved ability to increase capacity utilization, service levels and ultimately enhance the supply-demand balance. The thesis includes two research questions (presented below) which guided the research, each with two research objectives linked to it:

- *Research question 1:* How does supply uncertainty impact tactical supply chain planning?
- *Research question 2:* How can the tactical supply chain planning process be designed to mitigate the impact of supply uncertainties?

To date, there is no comprehensive review concerning the role and impact of supply uncertainty on the supply chain planning process, and how the planning process can adapt in the face of supply uncertainty. A systematic literature review and an exploratory single-case study are therefore conducted to theoretically and empirically explore how the tactical planning process is impacted by supply uncertainties. The case company is a Norwegian white fish processor and is chosen for its uniqueness, and the unit of analysis is the case company's tactical supply chain planning process.

Processors in the Norwegian white fish industry have experienced decreasing profitability, despite their immerse role as value creator and main employer in coastal communities. Several studies have drawn attention to the variability in raw material availability when trying to explain the negative trends in the industry. Supply uncertainties are often assured against in other industries by hedging inventory, sourcing from multiple suppliers or increasing capacity. However, in food supply chains and the white fish industry in particular, uncertainties must be mitigated against differently due to the seasonal and perishable nature of foods.

From the supply chain planning literature it was concluded that sales and operations planning (S&OP) was a recognized framework dealing with the tactical supply chain planning process, and the process parameters of importance was found as inputs, structure & processes and outcomes. The supply chain uncertainty literature suggested four sources of supply uncertainty: inherent characteristics, supplier related uncertainty, supply chain uncertainty and external uncertainty. These findings allowed for the development of a four-phase analyzing framework which purpose is to establish the impact of uncertainty on tactical supply chain planning processes. The framework therefore played a central role in answering research question 1.

Through semi-structured interviews it was identified 11 supply uncertainties, of which four were supplier related uncertainties. The most severe supply uncertainty was related to the case company's raw material forecast. Some critical characteristics of the tactical supply chain planning process was found to be high planning frequencies, disparate plans (made in separate spreadsheets), limited use of measurements and low integration with suppliers. The empirical data also showed an absence of supply chain analytics.

The thesis proposes a design of the tactical supply chain planning process that takes into account the most severe supply uncertainties. The design suggests integrating the suppliers in planning to reduce supplier related uncertainties. It also emphasize the need for an increased focus on information availability, mainly through more sophisticated IT systems and supply chain analytics, which could play an important role in reducing uncertainty related to accuracy of forecasts and plans.

# Sammendrag

Denne oppgaven undersøker hvordan usikkerhet i forsyning påvirker verdikjedeplanlegging. Oppgaven identifiserer kilder til usikkerhet hos en produsent av hvitfisk, og forsøker å rangere usikkerhetene etter deres alvorlighetsgrad. Basert på denne rangeringen blir det foreslått hvordan en verdikjedeplanleggingsprosess kan utformes for å dempe konsekvensen av usikkerhetene. En slik utforming kan gi produsenter av hvitfisk bedre evne til å balansere tilbud og etterspørsel. Denne oppgaven tar for seg to forskningsspørsmål (presentert under), hvor hvert spørsmål har to forskningsmål knyttet til seg.

- *Forskningsspørsmål 1:* Hvordan blir taktisk verdikjedeplanlegging påvirket av usikkerhet i forsyning?
- *Forskningsspørsmål 2:* Hvordan kan den taktiske planleggingsprosessen i en verdikjede utformes slik at den demper konsekvensen av usikkerhet i forsyning?

Per dags dato tilbyr ikke litteraturen en grundig utredning om hvordan usikkerheter kan påvirke planleggingsprosesser i verdikjeder, ei heller hvordan disse prosessene kan tilpasses med hensikt på usikkerhet i forsyning. Denne oppgaven gjennomfører derfor en systematisk litteraturstudie og en utforskende casestudie for å, både teoretisk og empirisk, utforske hvordan den taktiske planleggingsprosessen i verdikjeder blir påvirket av usikkerhet i forsyning. Casebedriften er en norsk produsent av hvitfisk og ble valgt på grunn av dens særpreg, og analyseenheten er casebedriftens taktiske planleggingsprosess.

Norske produsenter av hvitfisk har i senere år opplevd nedgang i lønnsomhet, på tross av deres sentrale rolle i verdiskaping og sysselsetting hos kystsamfunn. Flere studier trekker frem den betydelige variasjonen i råvaretilgjengelighet når de prøver å forklare denne negative trenden som foregår i hvitfiskindustrien. I andre industrier med usikkerhet i forsyning benyttes blant annet lagerhold, multiple sourcing eller fleksibilitet i kapasitet som metoder for å takle usikkerhet i forsyning. Men for verdikjeder som leverer matvarer, blant annet hvitfiskindustrien, så er det behov for andre metoder som tar høyde for holdbarheten og sesongvariasjonene som matvarene innehar.

Ut i fra den eksisterende litteraturen om planlegging i verdikjeder ble det konkludert med at sales and operations planning (S&OP) var et passende rammeverk for å beskrive den taktiske planleggingsprosessen for verdikjeder, og de viktigste prosessparametrene ble funnet til å være inputs, struktur & prosess og utfall. Litteraturen om usikkerhet i verdikjeder foreslår at det finnes fire kilder til usikkerhet i forsyning: iboende karakteristika, leverandørrelaterte usikkerheter, kjederelaterte usikkerheter og eksterne usikkerheter. På bakgrunn av disse funnene ble det utledet et analytisk rammeverk bestående av fire faser. Rammeverkets formål er fastslå hvilken konsekvens usikkerhet i forsyning har på taktiske verdikjedeplanleggingsprosesser, og spiller således en sentral rolle i besvarelsen av forskningsspørsmål 1.

Ved å gjennomføre semistrukturerte intervju ble det identifisert 11 ulike usikkerheter i planleggingsprosessen til casebedriften, hvorav fire var leverandørrelaterte usikkerheter. Den mest alvorlige usikkerheten ble funnet til å være relatert til casebedriftens råvareprognose. Videre avdekket analysen at de mest kritiske karakteristika til casebedriftens taktiske planleggingsprosess var en høy planleggingsfrekvensen, uensartede planer (opprettet i separate regneark), lite bruk av målinger og lite integrasjon med leverandører. Den empiriske dataen viste også at det var lite bruk av avanserte verktøy og metoder som analyserte verdikjeden i casebedriften.

Avslutningsvis, presenteres det et forslag til hvordan en hvitfisk produsent kan utforme en taktisk planleggingsprosess som tar tilstrekkelig høyde for de mest alvorlige usikkerhetene i forsyning. Forslaget anbefaler blant annet å inkludere leverandører i planleggingen slik at leverandørrelaterte usikkerheter kan reduseres. Forslaget påpeker også hvordan mer informasjontilgjengelighet og mer avanserte IT-systemer kan øke kvaliteten til prognoser og fremme koordinasjonen mellom aktører i forsyningskjeden.

# Abbreviations

| | |
|---|---|
| **BOM** | Bill of materials |
| **CAQDAS** | Computer-aided qualitative data analysis software |
| **CMM** | Collaborative materials management |
| **ERP** | Enterprise resource planning |
| **FTE** | Full-time equivalent |
| **HORECA** | Hotel, restaurant and catering |
| **ICT** | Information and communications technology |
| **IQF** | Individually quick frozen |
| **IT** | Information technology |
| **LNS** | Lerøy Norway Seafoods |
| **MPS** | Master production schedule |
| **SKU** | Stock keeping unit |
| **SCM** | Supply chain management |
| **SCMM** | Supply chain materials management |
| **SCMP** | Supply chain master planning |
| **SCP** | Supply chain planning |
| **SCRM** | Supply chain risk management |
| **S&OP** | Sales and operations planning |
| **WIP** | Work-in-process |

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# Chapter 1

# Introduction

This thesis is concerned with supply uncertainty and supply chain planning in a white fish supply chain. It seeks to categorize the sources of uncertainties, assess their severity and determine how they affect the tactical supply chain planning process. The focus of the report is on the Norwegian white fish industry and it proposes how a white fish processor can incorporate the effects of supply uncertainty in the design of the tactical supply chain planning process.

The first chapter of this thesis starts by presenting some of the practical challenges and related concepts that motivated this research, followed by an outline of the research questions and objectives to provide a clear focus. The chapter concludes with an outline of the structure of the thesis.

## 1.1 Background and problem statement

Firms no longer act as isolated entities, but are increasingly seen as a part of a supply chain. Consequently, they are more involved with other firms to achieve better linkages and coordination between the processes of suppliers, manufacturers and customers. Rather than single firms competing against single firms, we now see more and more competition between supply chains (Christopher, 2016). Increased international competition, shorter product life cycles, more demanding customers, and increased vulnerability have resulted in new complexities and concerns for supply chains (Jüttner et al., 2003; Chen & Paulraj, 2004; Christopher, 2016). In response to the changing competitive environment, the concept of supply chain management (SCM) emerged (see Oliver & Weber (1982)) and has quickly become one of the most important management philosophies (Stadtler, 2005; Stadtler & Kilger, 2008; Asgari et al., 2016)).

A supply chain typically comprises a network of materials, information, financial and services processing flows with the characteristics of supply, manufacturing and demand (Chen & Paulraj, 2004). Prescriptions of SCM emphasize the need for managerial ability to integrate and coordinate these flows both internally within the company and externally between companies, in order to deliver value at minimum cost to customers while satisfying requirements of other stakeholders (Lambert et al., 1998; van der Vorst & Beulens, 2002; Christopher, 2016; Isaksen et al., 2016). Those that succeed in doing so can gain competitive advantage (Wilding, 1998; Peidro et al., 2009).

A major obstacle to integrate and coordinate flows within a supply chain is that of uncertainty (Davis, 1993; Wilding, 1998). In essence, uncertainty exists because future outcome is unknown, and develops from incomplete knowledge, variability or lack of information processing capabilities (Barros et al., 2013). In their paper, van der Vorst & Beulens (2002) consider uncertainty in supply chains to be situations in which a decision-maker is unsure about best course of action. The growing dependence between supply chain members increases the need for up-to-date information in decision-making processes. When information is lacking or incomplete, the uncertainty is amplified as it moves through interdependent supply chain members (Flynn et al., 2016). In relation to demand order information, this phenomenon has become known as the bullwhip effect (Lee et al., 1997). It illustrates the detrimental effects of uncertainty in supply chains; demand order variabilities are amplified as the orders are transmitted upstream in the supply chain (Mason-Jones & Towill, 1997), leading to either a lack of or excess inventory. It also demonstrates the need for supply chain members to address the issue of uncertainty related to misalignment of goals. As put by Flynn et al. (2016): "...differentiated goals cause supply chain members to myopically order quantities that are locally optimal, without considering the effect on other supply chain members" (p. 9). Therefore, it is argued that the presence of uncertainty in supply chains leads to overreactions, second guessing, mistrust, and noisy or incomplete information flows (Childerhouse & Towill, 2004; Gosling et al., 2013), which in turn induce higher costs and decreased capacity utilization in more demanding processes. Ultimately, supply chain uncertainty can lead to lost sales due to shortages in supply or under-forecasting, or to unsold stock due to over-ordering or failure in delivering products on time in the market (Barros et al., 2013).

A relevant example of a supply chain with higher levels of uncertainty, both upstream (raw material input) and downstream (customer orders) is food supply chains. The characteristics of food supply chains differ from that of others; the seasonal and perishable nature of the products lead to risk of imbalances in demand and supply (van der Vorst et al., 1998; Aramyan et al., 2007). Other characteristics of food supply chains include price, demand and quality variability, which makes the supply chain more complex and challenging to manage than other supply chains (Ahumada & Villalobos, 2009). Given the volatile environment in which food supply chains reside, Fleischmann et al. (2015) argue that dealing with uncertainty becomes particularly important when creating plans. To this end, supply chain planning (SCP) is a common method and one of the building blocks in SCM (Stadtler, 2005). SCP aims to mitigate uncertainty through coordinating and integrating key business processes from raw materials procurement, production, distribution and sales, and by balancing demand and supply (Jonsson & Holmström, 2016; Stadtler, 2005). As such, SCP addresses the predictability of future outcomes in supply chain processes, and is particularly important in planning environments with long-term uncertainty (Gupta & Maranas, 2003). In contrast to day-to-day variability from processing variations, rushed orders/cancellations and equipment failure, where event management is more important, planning environments with long-term uncertainty struggle to predict internal and external long-term changes.

As conveyed by Gosling et al. (2013); "there is a clear need to effectively anticipate, identify, classify, and assess supply chain uncertainty" (p. 102). An increasing amount of research exists on identifying and managing supply chain uncertainties in SCM (Wilding, 1998; van der Vorst & Beulens, 2002; Childerhouse & Towill, 2004). Uncertainties can be classified according to where they originate from (Simangunsong et al., 2012). External uncertainty, demand uncertainty (bullwhip effect), control uncertainty and supply uncertainty are some examples of sources of uncertainty. Recent studies have highlighted the negative impact of supply uncertainty on supply chain performance in food industries such as inefficient production capacity utilization, risk and cost of over- and under-stocking, unreliable availability of materials and poor service level (van der Vorst, 2000; van der Vorst & Beulens, 2002; Nyamah et al., 2017). However, to date, little research is dedicated to investigating the role and impact of supply uncertainty on the SCP process (Ivert et al., 2015), and how the planning process in food industries can adapt to supply uncertainty. While most studies addressing SCP and uncertainty concentrate on demand uncertainty, inadequate attention has been aimed at supply uncertainty. Snyder & Shen (2006) found in their study of multi-echelon supply chains that if firms do not plan for uncertainty, the cost under a given level of supply uncertainty is in fact greater than that under the equivalent level of demand uncertainty.

## 1.2 Research questions and objectives

Against this background, there seems to be a need for research that addresses the impact of supply uncertainty on SCP. In addition, as the above challenges show, there is an opportunity to design tactical SCP processes that can better mitigate the impact of supply uncertainty. A design of this nature can give companies improved ability to maximize capacity utilization, increase service levels and ultimately achieve a supply-demand balance. This thesis therefore aims at solving this problem, and two central research questions are formulated to guide the research:

- **Research question 1:** *How does supply uncertainty impact tactical supply chain planning?*
- **Research question 2:** *How can a tactical supply chain planning process be designed to mitigate the impact of supply uncertainty?*

To answer these two questions, there is a need to make an accurate description of the research objectives. These serve to guide the activities of the research and are linked with each research questions. This thesis incorporates four research objectives, where the first two are linked with RQ 1 and the remaining two are linked with RQ 2. Table 1.1 provides an overview:

Table 1.1: The thesis' research objectives

| Objective | Description | RQ adressed |
|---|---|---|
| 1 | Map a tactical supply chain planning process | RQ1 |
| 2 | Identify, categorize and evaluate supply uncertainties in a planning environment | |
| 3 | Identify planning methods for coping with or reducing supply uncertainty | RQ2 |
| 4 | Design a tactical supply chain planning process accounting for supply uncertainty | |

Based on the above problem description, the purpose of this thesis is: (1) to explore the characteristics of supply uncertainty and its impact on SCP and; (2) use this insight to propose how the SCP process can be designed to mitigate supply uncertainty. To further define the research area, the next section outlines the scope of research.

## 1.3 Scope of research

The two main subject domains in this thesis are supply chain uncertainty and SCP. Supply chain uncertainty entails any uncertainty that is present in a supply chain process (Simangunsong et al., 2012). By investigating the meaning of uncertainty, it is in this report asserted that supply chain uncertainty is closely interlinked with the field of supply chain risk. Thus, the concept of risk is also relevant to the scope of this thesis. As the context of this study is concerned with perishables and food supply chains, the most interesting source of uncertainty is supply uncertainty. A narrow scope allows for a study of greater depth, and the thesis is therefore mostly interested in supply uncertainties.

As already established, in planning environments where long-term uncertainties are present, SCP is particularly relevant. Planning has several levels, but in SCP the tactical aspects concern the coordination of demand and supply on a medium- to long-term time horizon (Fleischmann et al., 2015), involving inbound, operations and outbound stages in the supply chain (Stadtler, 2005). A recognized framework for tactical SCP is sales and operations planning (S&OP), which is a cross-functional process aimed at coordinating demand and supply planning (Ivert et al., 2015). It will later in this report be shown that balancing demand and supply at the aggregate level is the basis of S&OP and that it is not concerned with operational details about products, customer or orders (Yurt et al., 2010). In this thesis' scope, S&OP is referred to as tactical SCP, and vice versa. Figure 1.1 depicts the scope of the thesis.

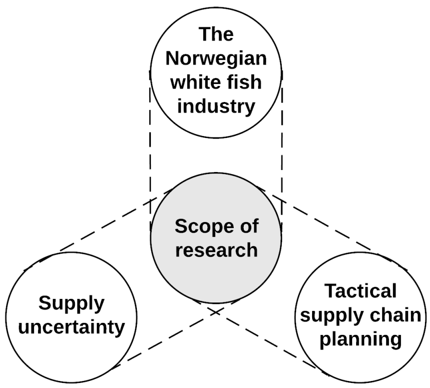


Figure 1.1: Scope of thesis

Given these two subject domains, it was decided to contextualize their inherent challenges and use a case study methodology to answer the research questions. The context in which the case is investigated in is the Norwegian white fish industry. A white fish processor is chosen as case company. This choice is embedded in a food supply chain, bounded by the perishable and seasonal nature of the fish. Further, the white fish processor is subject to significant supply uncertainty, making effective SCP a real challenge. Investigating the planning environment in which the white fish processor operates will provide deep insight into how supply uncertainty impact SCP, addressing RQ1. Moreover, by identifying measures that can be taken to cope with or reduce the impact of supply uncertainty through empirical and theoretical reviews, the thesis can propose a design for a tactical SCP process which sufficiently accounts for supply uncertainty, addressing RQ2. Thus, the scope of the research is defined and the motivation is founded in the need to contextualize the research issue.

## 1.4 Thesis outline

Table 1.2: Report structure

| Chapter | Content |
|---|---|
| Chapter 1: *Introduction* | Included the background and purpose of the report. Some key concepts were briefly explained and the main problem area was introduced to explain the relevance of the report. Research questions and objectives were presented, before the scope of the report was presented to set the outline. |
| Chapter 2: *The Norwegian white fish industry* | The chapter describes the Norwegian white fish industry and highlights the most relevant characteristics and challenges. |
| Chapter 3: *Methodology* | The choice of research method is explained and justified in this chapter. Presents the literature review protocol and case study protocol. Includes a rigorous review of the data collection methods. |
| Chapter 4: *Literature review* | The chapter includes a systematic literature review on supply chain uncertainty and SCP. Reviews existing theoretical frameworks in SCP and different ways of categorizing supply chain uncertainty. A four-phase analyzing framework is suggested. |
| Chapter 5: *Case study analysis* | Introduces the case company, its position in the white fish industry and other relevant data from the case study. The empirical findings are analyzed and seen in relation to the theoretical constructs presented in chapter 4. |
| Chapter 6: *Discussion* | First answers RQ 1 and highlights the most relevant findings from the case study analysis. The chapter then discusses and proposes a design of the tactical planning process (RQ 2). |
| Chapter 7: *Conclusion* | Summarizes the key findings, outcomes and the limitations of the thesis. Outlines the contribution and potential future research. |

# Chapter 2

# The Norwegian white fish industry

Since the context of this thesis is the Norwegian white fish industry, it is necessary to introduce the characteristics of the industry. This chapter presents the relevant aspects of the industry which are of interest to the thesis' research area. The chapter will first describe the current trends of white fish industry actors and some key figures. This is followed by a presentation of the much discussed governmental regulations and how they affect the industry. The chapter then breaks down the white fish supply chain into three stages and highlights the most relevant and important features with each stage. To summarize the chapter, it discusses the challenges that have been uncovered.

## 2.1 Background

Throughout the Norwegian history, many people have had fishing as their livelihood. It has been the very basis for life and culture in coastal communities, and many of them are still dependent on marine resources. Fisheries and aquaculture are growing sectors in Norway and export earnings have soon quadrupled in size since the start of the 2000s. Per 2017, Norwegian fishing businesses exported products for 94,5 billion NOK to over 140 countries. From the total exported volume, approximately 70 % is sold to EU-countries, and the largest markets (in NOK) are Poland, France and Denmark (Iversen et al., 2016; Norges sjømatråd, 2017). The Norwegian seafood industry is also growing, and contributed with 93,8 billion NOK to the Norwegian gross domestic product in 2017 (Kvistad, 2018). Despite the fisheries' importance in coastal communities the recurring problems such as poor profitability, declining number of facilities and full-time equivalents (FTE) have received much focus recently. In the past 20 years, Norwegian wild fisheries have been subject to a continuous downturn. In 1995, the number of operating processors in the industry was approximately 710. Correspondingly, in 2014 that number had decreased to 425, accounting to a 40 % decrease over a 20-year period (Nyrud & Bendiksen, 2017). The wild fisheries can be decomposed in five sectors; white fish, fish meal/oil, pelagic, salmon and shellfish.

Since the focus of this thesis is on the white fish industry, this will be the fishery of focus for the remainder of the thesis. The white fish industry mainly handles cod, saithe and haddock and comprises firms that produce conventional products such as clipfish, salted or dried fish, and firms that produces fresh and/or frozen fillets (Otterlei, 2014). Per 2017, Norwegian white fish processors exported products for approximately 15 billion NOK (Norges sjømatråd, 2017). In 2014, the industry consisted of about 220 processors dispersed along the coast with approximately 3300 FTEs in total (Tveterås, 2014). The majority of processors and core of activity is located north of the county Sogn and Fjordane. The white fish industry has seen the same decrease rate in number of firms as with the fishing industry in general, with 364 firms in 1995 (Bendiksen, 2009). The decrease has several reasons, and Bendiksen (2009) explains that many processors have had to deal with overcapacity in the market, stiff competition from Chinese companies, and more demanding customers. Another challenge white fish processors are faced with is a rigid regulatory system. This will be elaborated on the following section.

## 2.2 Governmental regulations

The Norwegian Directorate of Fisheries plays an important role in the fish industry. Its responsibility is to promote a sustainable management of marine resources and the marine environment. In that lies exercising of administrative authority through a regulatory framework (Directorate of Fisheries, 2017). There generally exists three laws or obligations regulating the actors in the fishing industry: the participants' act, the marine resource act and the delivery obligation. The participants' act strictly regulates ownership of fishing vessels, and determines who has the right to take part in fisheries activities. This regulation prohibits most actors to vertically integrate, but dispensations are given by the Ministry of Fisheries and Coastal Affairs to support sustainable and economic activity in rural communities (Ottesen & Grønhaug, 2003).

The marine resources act is another influential law, because it lays the basis for the quota system. The quotas are catch limits that indicates the types and volumes of fish each vessel is allowed to catch. They are set annually by the government on the basis of scientific advice on the stock status. Moreover, the stock status is affected by biological factors. The variations in annual quotas are therefore often large (Ottesen & Grønhaug, 2003), making the quota system a significant source to raw material uncertainty. Lately, however, the Ministry of Trade, Industry and Fisheries has increased the emphasis on stability in quotas, but it still remains a direct challenge for white fish processors. The Ministry has also expressed that they wish to promote long term investment strategies and industrial development, but the consideration of a sustainable management of resources is always of highest priority (Ministry of Fisheries, 1998).

The delivery obligation was introduced in the fishing industry to secure a steady flow of raw material, promote profitability and to support year-round operations for the processing plants to secure employment for the coastal communities. The law obligates trawlers to offer 80 % of the cod and 60 % of the haddock they catch to designated facilities. If the beneficiaries do not want to buy the lot, the trawler has to offer the catch to other potential buyers in the region. In addition to the obligation to deliver, the processing plant buying the catch is obligated to process 70% of the purchased cod (activity obligation). If there are no buyers of the offered catch, the trawlers are free to sell it in the open market where processors can buy the lot without the obligations of processing it. Norges Råfisklag estimates that over 90% of the fish caught by trawlers are sold during the third round (i.e., in the open market) (Ministry of Trade, Industry and Fisheries, 2016).

Activity obligations are used to secure production at certain facilities and link vessels and plants together. It ensures that industrial activities and ownership of the vessel remain one unit that cannot be changed without permission from the government. The activity obligation prevents closure of processing plants and makes it impossible for trawlers to catch fish and sell the catch to low cost countries for production. There is however, only one company, Havfisk ASA, that is imposed the activity obligation, concerning the processing plants in Stamsund, Melbu, Hammerfest, Storbukt, Kjøllefjord and Båtsfjord (Ministry of Trade, Industry and Fisheries, 2016).

As these obligations demonstrate, the fishing industry is to a large extent controlled and influenced by the government. The laws exist to ensure sustainable growth and both industrial and social development. Still, many companies question the expediency of the obligations and argues that they leave very little room for strategic maneuvering, much because of the prohibition to vertically/horizontally integrate (Iversen et al., 2016). They also argue that the regulatory system is based on old ideas and needs renewal to match a changing environment.

## 2.3 Auctions and sales associations

As of today, there are six sales associations operating in the wild-caught fish marketplace in Norway. Each sales association undertake a management function, and are responsible for organizing and arranging the sale of fish, and setting minimum prices for fish auctions (Svorken et al., 2006). Each association has set their own sales regulations and minimum prices (which are normally negotiated three times a year) to ensure that the auctions are carried out fairly and transparently. The minimum prices are also a safeguard for sellers against normal stock price reactions on big volumes in a short period of time (Svorken et al., 2006). The auctions are either organized manually or electronically, and the catch is sold to the highest bidder. The table shows the 6 sales organizations that are active in Norway today.

Table 2.1: Sales organizations

| Sales associations | Trade area |
|---|---|
| *Norges Sildesalgslag* | Trades pelagic fish for the whole country |
| *Norges Råfisklag* | From the Russian border to Nordmøre |
| *Surofi* | Sunnmøre and Romsdal |
| *Vest-Norges Fiskesalgslag* | Sogn og Fjordane and Hordaland |
| *Rogaland Fiskesalgslag* | Rogaland |
| *Skagerrakfisk* | From Rogaland to the Swedish border |

## 2.4 The supply chain

Principally, the fish supply chain can be split into three sequential nodes: harvest, processing and sales & marketing. Each node is described in the following section. Figure 2.1 illustrates the Norwegian white fish supply chain from catching to consuming, comprising both national and international processing/production and sales. Dry stockfish, salted fish and frozen raw material constitute the largest categories of white fish which are shipped out of Norway without further processing (Iversen et al., 2016). Over time, the supply chain has consolidated and now consists of fewer nodes between fishing vessels and the consumer. Whereas fish earlier could go from processor to exporter through importer and retailer and out to the supermarkets, the products are now traded more directly between processors and supermarkets (Tveterås, 2014).

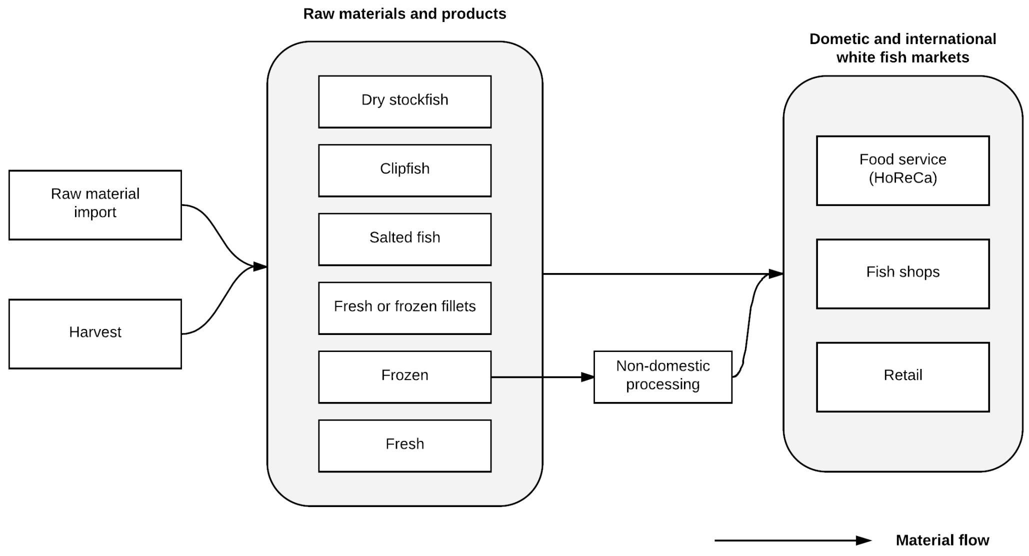


Figure 2.1: The Norwegian white fish supply chain, adopted from Tveterås (2014)

## Harvest

Fish is a biological product, and has characteristics making it more complex compared to other types of raw materials, such as oil and metal. The supply of fish is to a large extent determined by the productivity of the fish stock (i.e., the biomass) (Hart & Reynolds, 2002). The abundance of fish stocks are mainly driven by two factors: the recruitment of young fish, and mortality. The Norwegian fishing industry is therefore characterized by a high degree of seasonality. This is depicted in figure 2.2, which illustrates the average monthly volume of cod landings in Norway between the years 2002 and 2011. The diagram shows that roughly 50 % of the annual volume is landed between January and April. Spawning migration in the spring and feeding migration in the winter draws the fish closer to the coast, resulting in good catch rates for minimum cost (e.g., reduced fuel consumption) for the fishermen (Iversen et al., 2016). Norwegian fisheries are known for the "Skreifiske" which takes place outside of Lofoten and Vesterålen from January to April. For fishers partaking in different types of fisheries, the seasonal peaks for white fish are beneficial, because it allows them to participate in other fisheries when the season is low for white fish. Nevertheless, it is the processing plants that ultimately suffer from the seasonality of the landings.

For catching fish, there exist various methods and equipment employed by fishermen. Modern industrialized fisheries have become very effective and so have the different vessels, and in general one can distinguish between seagoing vessels and coastal vessels.

Seagoing vessels are usually equipped for longer trips and are consequently able to catch more fish during each trip. Although they can carry more fish, they are usually compelled to freeze the fish in order to avoid decay. Coastal vessels are smaller in size, and normally delivers fresh fish daily to the processing plants (Thakur, 2017). Because of their size they are not able to go far from the coast, and therefore mostly operate during the season peaks when the fish has drawn closer to the shore.

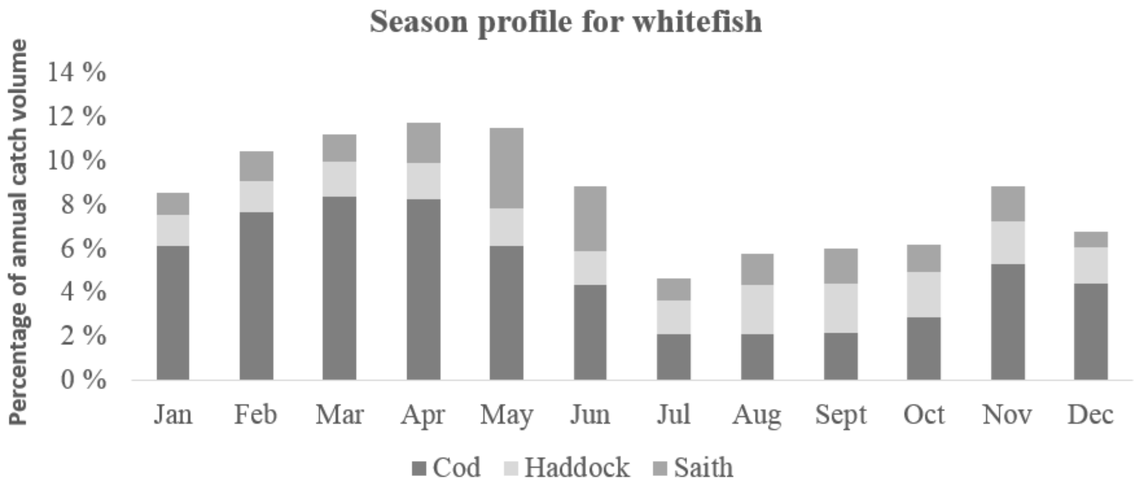


Figure 2.2: Average monthly landings of white fish in Norway in the period between 2002 and 2011. *Source: Norwegian Directorate of Fisheries (2017)*

As figure 2.3 illustrates, the annual landings of white fish in Norway fluctuates significantly. In the sample period (2004-2016), the lowest volume amounted to approximately 500 000 tonnes, while the highest volume (2014) was 720 000 tonnes. The catch volumes do to a large extent reflect the annual quotas as well. This coincide well with what was presented in section 2.2 about the Marine Resources Act, and how the quota system causes fluctuations at an aggregated level. All things considered, it is the interplay between biology, markets and technology that causes the fluctuations in raw material supply.

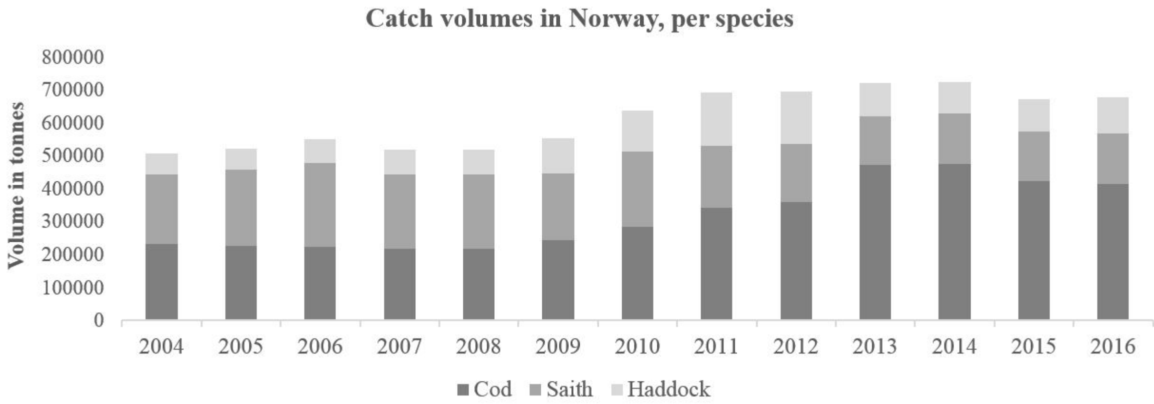


Figure 2.3: Annual catch volumes of white fish in Norway in the years 2004-2016. *Source: Statistics Norway (2017)*

## Processing

As touched upon in chapter 1, many Norwegian processing plants suffer from low profitability. The main reasons behind this is the fierce competition from low-cost countries, excessive capacity for production in relation to demand, and the above mentioned challenging characteristics with the fish itself.

In short, one can divide the production of white fish end-products into two parts: high-quality and low-quality. The former comprises products such as fresh fillets, which normally are processed to fresh consumer-packaged products in coastal countries, such as Norway. The latter comprises low-end semi-processed products which are shipped to low-cost countries for further processing. This production uses frozen raw material and thus produces consumer-products with lower quality but lower production cost. Both fresh and frozen products are then distributed out to supermarkets. In 2017, 69 % of the total Norwegian export volume comprised unprocessed fish. For the white fish industry alone, the corresponding number was 47 % (Norges sjømatråd, 2017).

## Sales and marketing

Norwegian white fish processors (and seafood producers in general) have in recent years been faced with stiff competition from countries with low labor costs, primarily China. Many of these processors have responded to the competition by seeking a differentiation strategy. By offering fresh fillets of premium quality some companies are able to obtain a high sales price which covers some of the high production cost and are consequently able to generate positive results (Henriksen, 2013). In a study conducted by Nilssen et al. (2014), it was proposed that Norwegian processing companies that focused more on fresh production seemed to outperform those that focused mostly on frozen production. Norwegian seafood producers have the advantage of close proximity to fresh raw material. However, a major challenge related to pursuing a fresh fish strategy is obviously the seasonality of the supply, lack of raw material, and the perishability inherent in fresh products. Even more, some of the fresh fish that is landed is of too low quality to be used in fresh fillet production.

## Challenges

This chapter has presented the Norwegian white fish industry and some of the most central features of it. By doing this, several important challenges have become clear. Below are these challenges summarized:

- The regulatory framework leaves little room for strategic maneuvering, and thus limits the availability of sufficient coping strategies.
- The quota system causes fluctuations in annual catch volumes of fish, which makes it challenging for processing firms to make long-term plans
- Seasonality (monthly fluctuations) caused by biological aspects - significant peak in winter months, low in summer months.
- White fish processors are facing tough competition from low-cost countries, forcing many companies to pursue a differentiation strategy.
- White fish is perishable in its nature, making it difficult to pursue a fresh fish (differentiation) strategy.

These challenges will be of significance when the thesis later analyzes how a supply chain planning process can be designed to mitigate supply uncertainty. It is here also important to address these challenges and how the planning process can be affected by these challenges. This matter will be given focus in the case study analysis (chapter 5) and discussion (chapter 6.

# Chapter 3

# Methodology

The aim of this chapter is to outline the methodological approach taken to explore and answer the report's research questions. First, the research strategy and design chosen to answer the research questions are thoroughly justified and explained in order to obtain a reliable and valid result. Second, the literature and case study protocol are introduced. The protocols present the entire set of procedures involved for ensuring a rigorous collection of data.

## 3.1 Research strategy and design

Research on supply uncertainty, and more broadly supply chain (risk) management, is traditionally dealt with by methods from operations research (Bakhrankova et al., 2014). Optimization under uncertainty, or robust/stochastic optimization, targets to find reliable solutions that remain feasible in the presence of uncertainty (Mitra et al., 2009). In a similar vein, decision-making is often managed with a quantitative approach (Anderson et al., 2016). A decision maker may resort to mathematical modelling if the problem is new, complex, repetitive and of importance (e.g., a great deal of money is involved) (Anderson et al., 2016). In food supply chains, these problems are definitely present and they tend to include uncertain, uncontrollable inputs (Hosseini et al., 2014). Borodin et al. (2016) reviewed 50 articles concerned with stochastic and robust programming modelling dedicated to cope with supply chain uncertainty. This shows the wide accumulation of quantitative models in the field of SCM. In this thesis, both quantitative and qualitative methods were considered as research strategies, but in order to explore how supply uncertainty affects tactical SCP processes, a qualitative approach seemed more appropriate. This was mostly due to not having a well-defined decision making situation with a clearly defined problem, leading to difficulties in formulating a mathematical problem (Semini, 2011). In addition, the thesis seeks to describe how processes are designed when subject to supply uncertainty, which a qualitative approach is well-suited for. Qualitative data is typically defined as anything that is not in a numerical form (Bryman, 2016). Qualitative research is therefore great for exploratory purposes, and can provide researchers with deep and rich information not possible to discover with quantitative data alone. Along the same lines, Voss et al. (2002) argue that qualitative understanding is crucial in order to explain quantitative findings and to construct theories based on those findings. Taking this into consideration, this report undertakes a qualitative research strategy to investigate how supply uncertainty affects SCP processes.

The research design guides the collection and analysis of data, and the choice of research design reflects decisions about the priority given to a range of dimensions of the research process (Bryman, 2016). When outlining the study, several research designs were considered. The longitudinal design was immediately discarded due to the length of the process (Bryman, 2016). A cross-sectional or survey design was also considered. However, this research design was inappropriate due to not having a well defined context and variables at the outset of the study, which is a requirement for survey designs (Forza, 2009). Taking a more exploratory perspective, the case study design was considered as the most appropriate design in order to answer the research questions (Zainal, 2007), and it was decided that the study should employ a single-case design concerned with the white fish industry. When selecting cases, it is preferable to choose extreme cases where the process of interest is transparently observable (Eisenhardt, 1989). The white fish industry is considered to be an applicable case due to its high exposure to supply uncertainty. Preferably, a multi-case study should have been applied to ensure generalizability of the findings (Voss et al., 2002), but limitations in terms of time, as well as participating in the iProcess research project made this impossible. However, the advantage of single-case studies is that they provide a greater depth than multi-case studies (Voss et al., 2002). As argued by Tellis (1997), a case study must be linked to a theoretical framework. Therefore, to find and develop appropriate frameworks from the body of knowledge on SCP and supply uncertainty, it was decided to conduct a systematic literature review. To ensure that the chosen methods were followed accordingly, protocols for the literature review and the case study were made. The protocols are described in detail below.

## 3.2 Literature review protocol

Formulating research questions that are suitable for a topic requires preparation. One way of doing so is to review the literature on the topic that is going to be researched (Yin, 1994). Petticrew & Roberts (2006) identify eight different forms of reviews: systematic, narrative, conceptual, rapid, realistic, critical, expert and state-of-the-art. To capture the body of knowledge of the topic, as well as creating a theoretical framework for the case study, this report follows a systematic approach outlined by Denyer & Tranfield (2009). This way, it can be ensured that the approach taken for dealing with the topic is replicable, scientific and transparent. A systematic literature review "...locates existing studies, selects and evaluates contributions, analyses and synthesizes data" (Denyer & Tranfield, 2009, p. 671), and then provides an audit trail and justification of the reviewer's procedures, decisions and conclusions (Cook et al., 1997). A systematic review differ from traditional reviews in the sense that it produces an unbiased, reliable and precise presentation of evidence. It does so by documenting the research strategy used, step by step, so that the reader can access its completeness (Kitchenham, 2004). To achieve a complete and comprehensive review, this report will adopt a five-step process illustrated in figure 3.1.

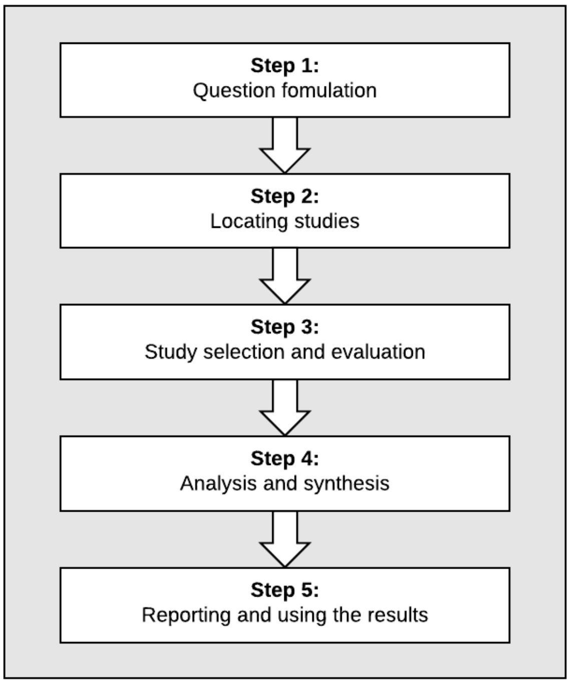


Figure 3.1: Systematic literature review approach adopted from Denyer & Tranfield (2009)

### 3.2.1 Question formulation

To establish focus and give guidance in choosing which studies to include and exclude in the review, the first step in the systematic review is to define research questions (Denyer & Tranfield, 2009). The research questions were formulated through identifying challenges in the white fish industry and counseling from supervisors. Based on the aforementioned challenges in the white industry, this thesis attempts to investigate how supply uncertainty affects tactical SCP processes, as well as exploring how such planning should be designed in order to mitigate uncertainty.

### 3.2.2 Locating studies

The next step concerns determining which databases that are suitable and relevant for the research (Denyer & Tranfield, 2009). Two databases with high coverage of the topics were selected: *Web of Knowledge* and *Scopus*. Both databases cover the majority of journals of interest within the field of social sciences.

To capture specific topics, one can create comprehensive search strings by linking relevant terms with the use of boolean operators (OR/AND). In addition, by using an asterisk symbol (*) the search engine will return any word that starts with the root of the word truncated by the asterisk (e.g., uncertain* will return uncertainty, uncertainties and uncertain). Proximity operators were also used. Scopus offers two proximity operators: *preceding* (pre/n) which declares that the first word must be no more than (n) words apart from the second word; and *within* (w/n) where the order of the words does not matter. For example, "supply PRE/2 management" returns both supply chain management and supply chain risk management. Web of Knowledge provides the proximity operator *NEAR* which is similar to the *within* function in Scopus.

When searching in bibliographical databases there are different search types, deciding on where in the articles the search string should be applied. The standard option in most search engines is to search in the article's title, abstract and keywords, and this option was used in this literature review to limit the amount of hits. Searches were performed on February 7$^{th}$ 2018 and resulted in 1166 papers. The search strings and number of hits are presented in table 3.1.

Table 3.1: Search strings

| Database | Search string | Application of search string in database |
|---|---|---|
| Web of Knowledge | ((supply NEAR/2 chain NEAR/1 uncert*) OR (supply NEAR/2 chain NEAR/1 risk*) AND (planning OR "supply chain planning" OR "supply-chain planning") AND ("medium term" OR "medium-term" OR tactical OR "mid-term" OR "mid term")) | The search resulted in 316 papers. |
| Scopus | ((supply PRE/2 chain PRE/1 uncert* ) OR (supply PRE/2 chain PRE/1 risk*)) AND (planning OR SCP OR "supply chain planning" OR "supply-chain planning") AND ("medium term" OR "medium-term" OR tactical OR "mid-term" OR "mid term") | The search resulted in 850 papers. |

### 3.2.3 Study selection and evaluation

In the selection and evaluation process one will be assessing the literature sample and choose literature based on the relevance in addressing the research questions (Denyer & Tranfield, 2009).

The results from the literature search were downloaded into an EndNote library that included the papers' title, author, year, journal and abstract. The selection process was conducted in four phases, in which both authors of this thesis individually assessed the papers. Based on the phase's criterion it was decided on whether to reject or include papers for further assessment. After each phase, the selected papers were merged into a new EndNote library. In the first phase, duplicates were removed, before assessing the titles. Although excluding articles based on keywords or titles can seriously threat the validity of the synthesis (Thomé et al., 2016), 986 papers were removed in this phase. The papers that were rejected were mostly concerned with a specific planning problem such as vehicle routing, lot sizing, and optimizing of production lines that were thought to have little relevance to the scope of the research. In the second phase, the remaining papers were assessed through reading the abstract and confirming that the inclusion of the studies met the search criteria (Thomé et al., 2016). This phase ended with the removal of 73 papers. The third phase was concerned with validation of the papers' importance and required a full-text review. This phase led to the exclusion of 38 papers. Lastly, a snowball phase (Kitchenham, 2004) included 20 papers, resulting in a total sample of 33 papers for revision.

Kitchenham (2004) argues that to increase the extent of the study selection, it is recommended to undertake some manual work to find relevant studies. This can include searching in the reference lists of the studies found in the primary search, seeking information and advice from experts in the field, or searching in relevant journals, grey literature (work in progress), conference proceedings (Kitchenham, 2004), or from personal knowledge (Greenhalgh & Peacock, 2005). Reference tracking was proved to be the most efficient search method for identifying systematic reviews published in obscure journals (Greenhalgh & Peacock, 2005). In this report, multiple relevant articles were found in the reference lists of studies from the primary search. In addition, Chopra & Meindl (2016), Christopher (2016) and Jacobs et al. (2011), books on SCM and planning & control, were included in the literature review as supporting material. The literature selection process in its entirety is illustrated in figure 3.2, and the studies included in the literature review are presented in table 3.2.

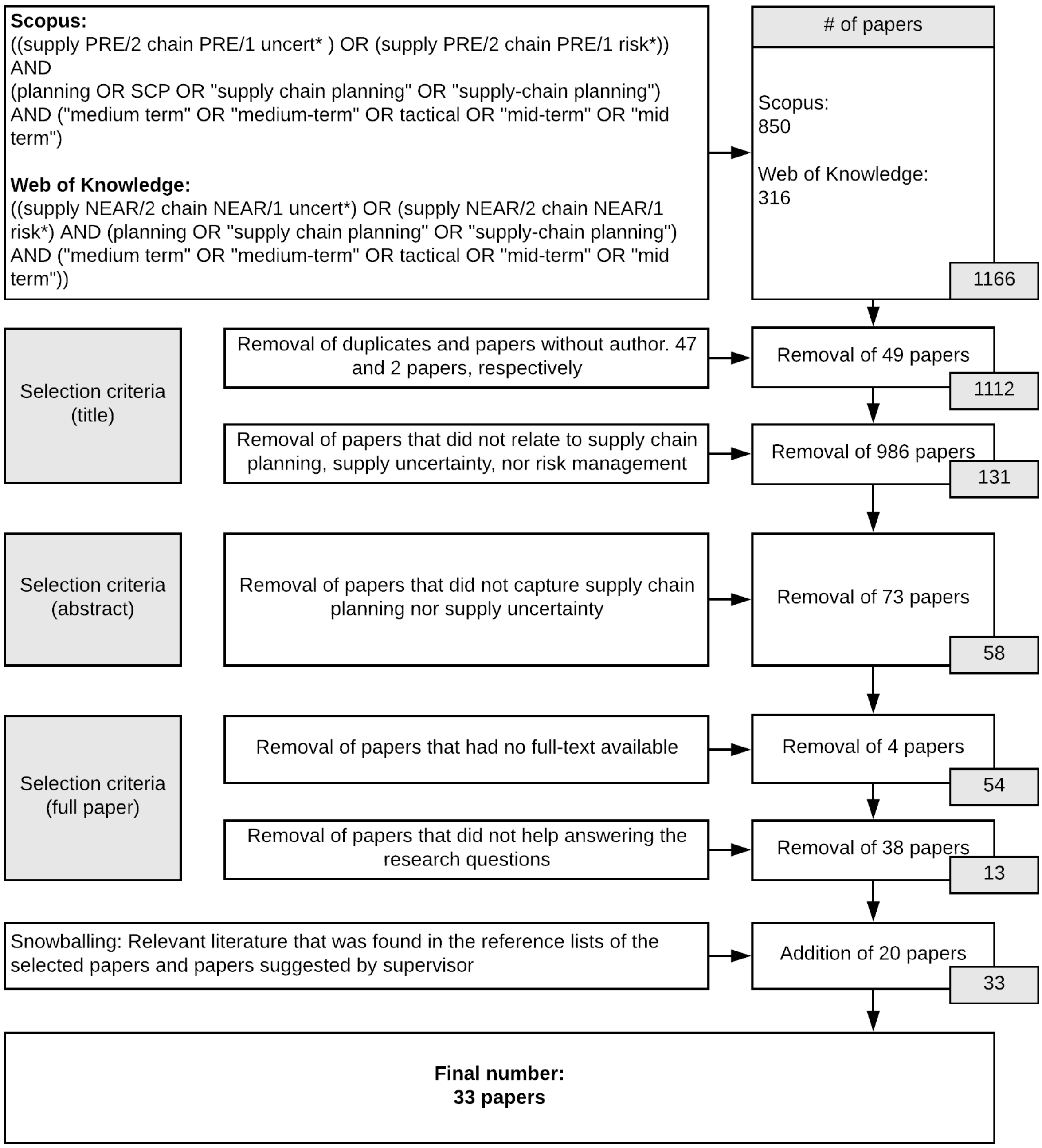


Figure 3.2: Literature selection process

Table 3.2: Papers included in the systematic literature review

| Article | Reference |
|---|---|
| **Supply chain management** | |
| Supply chain management 1982–2015: a review | Asgari et al. (2016) |
| Supply Chain Management under uncertain supply | Dreyer & Grønhaug (2012) |
| **Supply chain risk management** | |
| A critical analysis of supply chain risk management content: a structured literature review | Prakash et al. (2017) |
| A literature review on risk sources and resilience factors in agri-food supply chains | Zhao et al. (2017) |
| Building the Resilient Supply Chain | Christopher & Peck (2004) |
| On uncertainty in supply chain risk management | Vilko et al. (2014) |
| Propagation of risks and their impact on performance in fresh food retail | Srivastava et al. (2015) |
| Robust and resilient strategies for managing supply disruptions in an agribusiness supply chain | Behzadi et al. (2017) |
| Supply chain risk management: outlining an agenda for future research | Jüttner et al. (2003) |
| **Supply chain planning** | |
| A framework for collaborative planning and state-of-the-art | Stadtler (2009) |
| Advanced Planning | Fleischmann et al. (2015) |
| Centralised supply chain master planning employing advanced planning systems | Rudberg & Thulin (2009) |
| Coordinating material and information flows with supply chain planning | Kaipia (2009) |
| Future of supply chain planning: closing the gaps between practice and promise | Jonsson & Holmström (2016) |
| Impact of the integration of tactical supply chain planning determinants on performance | Okongwu et al. (2016) |
| Information sharing for sales and operations planning: Contextualized solutions and mechanisms | Kaipia et al. (2017) |
| Managing demand uncertainty in supply chain planning | Gupta & Maranas (2003) |
| Quantitative models for supply chain planning under uncertainty: a review | Peidro et al. (2009) |
| Sales and operations planning: A research synthesis | Thomé et al. (2012) |
| Sales and operations planning in the process industry: A literature review | Noroozi & Wikner (2017) |
| Sales and operations planning: an exploratory study and framework | Grimson & Pyke (2007) |
| Sales and operations planning: responding to the needs of industrial food producers | Ivert et al. (2015) |
| Stochastic optimization of operational production planning for fisheries | Bakhrankova et al. (2014) |
| Supply chain planning in the German automotive industry | Meyr (2004) |
| Uncertainty and Production Planning | Graves (2011) |
| **Uncertainty** | |
| Application of stochastic programming to reduce uncertainty in quality-based supply planning of slaughterhouses | Rijpkema et al. (2016) |
| Conceptual Framework for Managing Uncertainty in a Collaborative Agri-Food Supply Chain Context | Esteso et al. (2017) |
| Identifying and Categorizing the Sources of Uncertainty in Construction Supply Chains | Gosling et al. (2013) |
| Identifying sources of uncertainty to generate supply chain redesign strategies | van der Vorst & Beulens (2002) |
| On Theory in Supply Chain Uncertainty and its implications for Supply Chain Integration | Flynn et al. (2016) |
| Shrinking the supply chain uncertainty circle | Mason-Jones & Towill (1998) |
| Supply Uncertainty in Food Processing Supply Chain: Sources and Coping Strategies | Chaudhuri et al. (2014) |
| Supply-chain uncertainty: a review and theoretical foundation for future research | Simangunsong et al. (2012) |

### 3.2.4 Analysis and synthesis

The aim of a synthesis is to recast information from individual studies into a new or different arrangement, providing the reader with knowledge that is not apparent from reading the studies in isolation (Denyer & Tranfield, 2009; Bryman, 2016). However, as mentioned in the outset of this chapter, the goal of the systematic literature review is to provide a framework for the case study, rather than extending the literature with a systematic literature on the topics of SCP and supply uncertainty.

In the coding process of the articles, NVivo, a computer-aided qualitative data analysis software (CAQDAS) was used. Bryman (2016) argues that such software simplifies the task of coding and retrieving, facilitating better data analysis. The first stage in the coding process was to import the selected papers into a project file and define the parent node structure (SCP and uncertainty). When reading through an article in NVivo one can mark text and assign it to a node. Due to the university not having an add-on license, it was not possible for the authors to work on the project file simultaneously. Therefore, two project files were used for coding and merged. Sub-nodes were created when appropriate, and by the end of the coding there were over 90 nodes in a structure of four levels. In parallel of the coding process, the authors wrote summaries of the articles, describing the essence of the paper, methodology and the main findings. These proved to be useful resources when constructing the literature review.

In the process of synthesizing the literature, the node structure (NVivo) was used for creating a new arrangement of literature. For SCP, it became clear that S&OP was a recognized framework that dealt with mid-term planning, attempting to balance supply and demand. It was also evident that the categorizations of the sources of uncertainty were mainly inspired by van der Vorst & Beulens (2002). It was therefore decided that their framework was going to be the starting point of the uncertainty section. When analyzing the articles, it was put focus on information that was concerning supply uncertainty and the sources from where they occur. When the information was extracted, it was attempted to relate it to the framework by van der Vorst & Beulens (2002). Drawing on the analysis of the papers, the literature review proposes a four-phase analyzing framework for establishing the impact of supply uncertainty on tactical SCP processes.

## 3.3 Case study protocol

Bryman (2016) states that case study research is concerned with complexity and particular nature of the case being considered, and that the emphasis of the study is to intensively examine the setting. Yin (1994) defines a case study as a strategy to investigate an empirical topic by following a set of specified procedures, and argues that it is a good way to develop knowledge in areas where theory is scarce. Case studies are especially useful when one wants to understand a real-life phenomenon in depth, but such understanding requires contextual conditions (Yin, 2009). An important feature with the case study inquiry is that it benefits from prior developed theoretical propositions to guide data collection and data analysis (Yin, 2009). Case studies are also particular strong for answering *how* and *why* questions, and for in-depth exploration of phenomena (Yin, 2009). The research questions addressed in this report are of an exploratory nature, and as such the case study is an appropriate method for this report. McCutcheon & Meredith (1993) says that in order to develop the clearest possible picture of the phenomenon in focus, a case study usually involves gathering a considerable amount of data from within the organization. This data may come from primary sources such as observations, interviews of key persons, or secondary sources such as documents and records. The case study evidence sources used in this thesis will later be presented.

Furthermore, Yin (2009) suggests different rationale for case selections. One of them is selecting a case because it forms a representative or typical case, serving as an example of a wider group of cases. Another rationale, and the one given in this report, is the extreme or unique case. In that lies selecting a case when not many similar cases are available (Yin, 2009). By presenting the case study findings, it will be demonstrated how and why the case company can be considered as a unique case.

### 3.3.1 Unit of analysis

One important step in designing a case study research is defining the unit of analysis (Yin, 2009). By defining the unit of analysis in a case study, one spells out what the *case* is. Common units of analysis include individuals, groups, organizations or communities. They can also comprise less concrete and more abstract units such as relationships, projects, processes or even decisions (Yin, 2009). The unit of analysis in the case study of this report is the SCP process of the case company. As advocated by Yin (2009), it is important to define the boundaries of the unit and clarify its role in the case study. In this report, the role of the SCP process involves planning in the mid-term time-horizon, cross-functional structure, and alignment of strategic and operational decisions. SCP is particularly important in planning environments with long-term uncertainty, and hence the case company's SCP process is of particular interest.

### 3.3.2 Data collection

Collecting case study evidence is commonly done through one or more of these six sources: documentation, archival records, interviews, direct observations, participant observations and physical artifacts (Yin, 2009). The main sources of data for this report's case study are *semi-structured interviews* and *documentation*. In addition, one site visit and two workshops were carried out. See table 3.3 for an overview of the data sources used in the case study.

Table 3.3: Data sources of case study

| **Data source** | **Data object** | **Quantity** |
|---|---|---|
| *Semi-structured interviews* | Central planner | 5 |
| | White fish processing team manager | 3 |
| | Business analyst | 1 |
| *Documentation* | Pre-study report from SINTEF | 1 |
| | Specialization project | 1 |
| | Previous master's theses from a related research project | 2 |
| | Annual report of case company | 1 |
| *Site visits* | One of the case company's plants | 1 |
| *Workshop* | Case company | 2 |

### Semi-structured interviews

Interviews are common means of collecting data for case studies (McCutcheon & Meredith, 1993). There exists a range of different forms of interviews. The most common one is structured interviews or standardized interviews, which is preferred when the goal is to reduce error due to variation in the asking of questions (Bryman, 2016). Another common interview form is semi-structured interviews. Semi-structured interviews refer to an interview form where the interviewer has a series of predefined questions in a general form (an interview guide) but is able to vary the sequence of questions. The questions are typically more general in frame of reference compared to that of a structured interview, and gives the interviewer latitude to ask further questions in response to answers (Bryman, 2016). In a semi-structured interview, the interviewee can talk rather freely, but the interviewer can set a path for chosen topics and has the opportunity to ask followup questions (Bryman, 2016; Kallio et al., 2016). This allows the interviewing researcher to discuss the relevance of the questions and gain valuable guidance about the wording and the arrangement of the questions (Bariball & While, 1994). To gain sufficient understanding of the case company's SCP process, semi-structured interviews were conducted. The interview form was preferred since it gave the opportunity to prepare questions ahead of the interview, but also allowed the respondent to provide the interviewers with insight in the most convenient way. A framework developed by Kvale (2007) was applied to ensure correct focus and a rigorous interview process. The framework suggests seven steps in an interview investigation. Each step will in the following be described in relation to the interview process of this study.

Table 3.4: The interview process, adopted from Kvale (2007)

| **Step** | **Description** |
|---|---|
| *Thematizing* | A case study protocol guided the interview process, and provided the topics of interest. |
| *Designing* | The initial interviews were planned with the researchers of the research project. After establishing contact with the case company, subsequent interviews did not need as much planning as the first ones. |
| *Interviewing* | An interview guide was actively used for the individual interviews. The interviews were mostly conducted through Skype, and each session lasted from 15 - 90 minutes. |
| *Transcribing* | All interviews were tape recorded and subsequently transcribed. The results of the transcribed interviews led to a large amount of data. NVivo was used to organize and systematize the data. |
| *Analyzing* | By using NVivo to analyze the interviews, case stories were written with emphasis on the SCP process and supply uncertainty. |
| *Verifying* | Reliability and validity of interpretations in the form of texts and figures were checked against the interview objects. The findings were also discussed among other researchers in the research project to ensure validity. |
| *Reporting* | The results are reported in this thesis. |

## Documentation

The authors, along with the other researchers engaged in the research project, were granted access to a SharePoint-site. The site contained classified documents from both the iProcess and Qualifish project (a completed research project in which the case company participated). Formal studies, pre-study reports and other relevant documentation generated through the projects were available through the site. In line with the reasoning of Yin (2009), documentation in the case study became an important tool for corroborating evidence from other sources. The value of these documents became apparent when searching for case company-specific information, as many of the documents were research related to the case company. Along with data from the SharePoint-site, the annual reports of the case company were also used.

A common criticism of using documentation as source to case study data is that the documents usually are written for some specific purpose other than that of the case study being done (Yin, 2009). This can make it difficult for the researcher to use the case study evidence without encountering some degree of bias. This issue was taken into consideration, and the interviews were actively used to corroborate data from the other documents. It is assumed that the reliability and internal validity of the interviews are of higher degree than the documents as they are primary data while most of the documents constitute secondary data.

### 3.3.3 Case study tactics to increase research quality

Yin (2009) presents four tests relevant for judging the quality of a research design. There exist several tactics for dealing with the tests. Table 3.5 summarizes the different measures, or tactics taken to fulfill the criteria for a good-quality case study.

Table 3.5: Tactics to increase the quality of the case study design. Adapted from Yin (2009)

| Criteria | Definition | Case study tactic used |
|---|---|---|
| *Construct validity* | Identifying correct operational measures for the studied concepts | Using multiple sources of evidence: documentation in the form of formal studies, theses and other relevant reports. A series of semi-structured interview with key positions in case company. |
| *Internal validity* | The degree to which a causal conclusion based on a study is warranted | Pattern matching: comparing empirically based relationships with a predicted, theoretical scheme. |
| *External validity* | Establishing the domain to which a study's findings can be generalized | Use of theory in single-case study and selecting a representative case |
| *Reliability* | Demonstrating that the operations of a study can be repeated with the same results | Use of case study protocol in which detailed reporting of assumptions are done. Developed a case study database (SharePoint site) with case study evidence |

### 3.3.4 Analyzing the data

When applying the frameworks, the main method for analyzing the case evidence in this report is pattern matching. Principally, pattern matching attempts to determine the 'fit' between theoretical ideal and the case evidence. In other words, examining the relationship between the ideal and the real (Bryman, 2016). The expected pattern in this study refers to supply uncertainties and how the literature deals with them in the context of SCP literature. By empirically examining if the same supply uncertainties apply in the case company's context, and how the planning process is conducted, one can establish the observed pattern, and thus determine the degree to which the observed pattern corresponds to the expected pattern.

### 3.3.5 Criticism of the case study design

Criticism of the case study research design is that the findings derived from it often are not generalizeable. However, external validity is not always aimed at (Bryman, 2016). Below are listed some common prejudices against case studies, according to Yin (2009):

- **Lack of rigor:** Biased views and sloppy work are common pitfalls inherent in case studies. Also, the lack of a clear procedure can make these studies challenging to conduct for new beginners.
- **Provide little basis for generalization:** It can be difficult to draw general conclusions on the basis of the case study results.
- **Lengthy and time-consuming:** Case studies tend to take too long and may result in massive, unreadable documents.

The single-case study does indeed incorporate these weaknesses, and Yin (2009) argues that multiple-case designs can provide more analytic benefits through replication logic and ultimately increase the (external) validity of the research. Single-case studies involves putting ”all your eggs in one basket” and are consequently more vulnerable. In the words of Yin (2009): “If you do use single-case design, you should be prepared to make an extremely strong argument in justifying your choice for the case” (p. 62). The time and resources available for the authors of this report limited the possibility to conduct a multiple-case study, but they do acknowledge the potential strengths of such a study design.

In addition to these generic weaknesses of the case study design, this report faces some other sources of error. As it was discussed, using documentation as source of evidence can offer some degree of bias. Several documents used in this case study were theses or reports conducted by other researchers, i.e., secondary analyses. Even though it offers the prospect of good-quality data for a limited time and resource effort, it may lack accuracy or even be outdated.

# Chapter 4

# Literature review

This chapter reviews the body of knowledge from the topics of SCP and supply uncertainty. Firstly, this chapter will describe the concept of SCP, before digging into planning activities and S&OP. Secondly, the chapter will provide an overview of the term supply chain uncertainty. The chapter then takes a deep dive into the sources of supply uncertainty that is evident in the literature, before presenting measures that can be taken in planning processes to mitigate uncertainty. Lastly, a four-phase framework for analyzing the impact of supply uncertainty on tactical SCP processes is proposed.

## 4.1 Supply chain planning

The increasing competitive pressures in the global marketplace, in addition to advances in information technology, have brought attention to SCP in most manufacturing firms (Gupta & Maranas, 2003). The notion of supply chain competition rather than competition between individual firms (Christopher, 2016) has led firms to align operations and supply chain partners with the business strategy (Jonsson & Holmström, 2016). With this view, firms are attempting to improve organizational performance and securing competitive advantages for the chain as a whole (Okongwu et al., 2016). Moreover, by employing cross-functional collaboration and administrating the supply- and demand-facing activities, mismatches can be minimized, resulting in greater customer value (Oliva & Watson, 2011). However, as argued by Noroozi & Wikner (2017), in order to achieve a balance of supply and demand it is essential to integrate people from different areas, both within and outside the company, also known as vertical and horizontal integration. A common definition of SCP is given by Gupta & Maranas (2003): "... the coordination and integration of key business activities undertaken by an enterprise, from the procurement of raw materials to the distribution of the final products to the customer" (p. 1219).

While many authors emphasize the importance of SCP, the study from Jonsson & Holmström (2016) showed that SCP in practice often fails to capture the promised benefits. In an attempt to close this gap and make SCP implementable, the article proposes a research agenda for increasing the practicability of SCP. Moreover, there has been discussed the level of planning and information sharing in regards to flexibility, and Kaipia (2009) presents a matrix showing an increased need for planning, if the execution flexibility in the processes is low.

### 4.1.1 Planning

In order to grasp the concept of SCP, one must understand the basics of planning. In the context of supply chains there are continuously decisions that have to be made, and planning is as such a valuable tool for preparing for the most important decisions (Fleischmann et al., 2015). Examples of decisions that are planned for include: what product mix should be sold, when and how much should be produced, and what raw material is needed. The answer to such questions usually leads to the formulation of sales forecasts, production and procurement plans. To increase the ability to create plans that are effective and reflect reality, there has in recent times been a focus on two aspects of planning: integral planning of the entire supply chain and; planning where true optimization is the goal (Fleischmann et al., 2015). However, due to the complex environment most companies have to cope with, decisions are often made in a hierarchical way (Rudberg & Thulin, 2009). As put by (Fleischmann et al., 2015): "the hierarchical planning is a compromise between practicability and the consideration of the interdependencies between the planning tasks" (p. 74). Instead of solving a monolithic or sequential planning problem, hierarchical planning decomposes the total planning process into planning modules (Graves, 2011) that are conducted by different functions within the company. The planning modules are also categorized by different time horizons, and will be explained in the subsequent section.

#### Time horizons and level of aggregation

The planning levels are usually categorized as long-term, mid-term or short term (also referred to as strategic, tactical and operational), where the length of the time horizon is the deciding factor (Gupta & Maranas, 2003; Rudberg & Thulin, 2009; Okongwu et al., 2016). The length of the planning levels vary within industries, depending on the complexity and the life cycle of the product (Okongwu et al., 2016), but the most common time frames with a description of the decisions are shown in table 4.1.

Table 4.1: Planning horizons

| Horizon | Length | Supply chain decisions |
|---|---|---|
| Long-term | 5-10 years (Fleischmann et al., 2015; Gupta & Maranas, 2003) | Decisions on plant location; investments in production networks (Gupta & Maranas, 2003); materials program; physical distribution structure; and strategic sales planning (Fleischmann et al., 2015). |
| Mid-term | 6-24 months (Fleischmann et al., 2015), 12-24 months (Gupta & Maranas, 2003; Peidro et al., 2009) | Outlines the need for raw materials, which suppliers to use (Rudberg & Thulin, 2009; Peidro et al., 2009) and the plans are usually concerned with multiple production sites (Gupta & Maranas, 2003). |
| Short-term | Few days - three months (Fleischmann et al., 2015), 1-2 weeks (Gupta & Maranas, 2003) | Operational planning often comprise exact sequencing (Gupta & Maranas, 2003), lot sizes, assigning loads etc. (Peidro et al., 2009). |

The organizational hierarchy often resembles the planning process where the top management makes the strategic decisions and the operational decisions are made at the job floor (Graves, 2011). The decisions and plans made at the strategic level are made far in advance, and detailed information is therefore not available. For mid- and long-term planning it is difficult to estimate long-range sales figures for each individual item, and therefore the plans are often made at an aggregated level. This means that the object of planning usually is product family. A product family comprises products sharing the same characteristics (Fleischmann et al., 2015). The closer a planning level is to the actual planning object (e.g., product family, stock keeping unit (SKU)) the greater the degree of detail and shorter the planning horizon will be (Stadtler, 2009). The decisions made at the higher levels dictate and set constraints for the decisions further down the hierarchy (Rudberg & Thulin, 2009). The plans are pushed through and disaggregated in the hierarchy until the lowest level is reached where detailed decisions and plans are implemented and executed (Meyr, 2004; Rudberg & Thulin, 2009). Furthermore, Fleischmann et al. (2015) argue that the whole supply chain network can be divided into internal supply chains for each actor in the network where the planning tasks are assigned to the functions procurement, production, distribution or sales. Jointly, the planning horizons and the supply chain functions make up the supply chain matrix as presented in figure 4.1. The matrix illustrates typical tasks that are present in most supply chain types at what stage and function, and the flow of materials and information (Fleischmann et al., 2015).

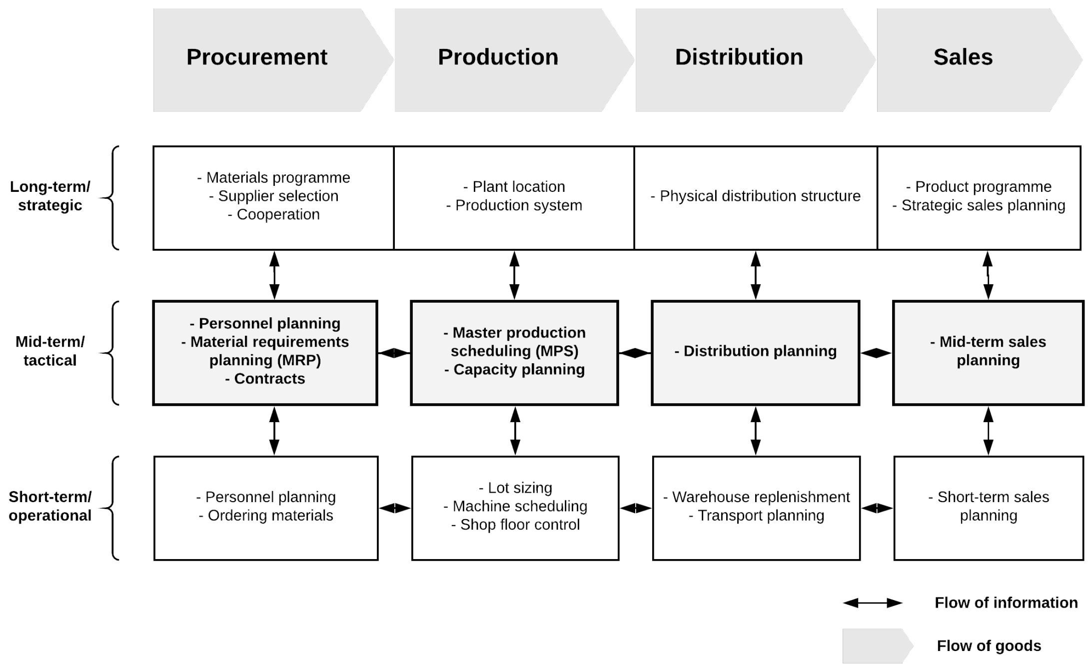


Figure 4.1: The supply chain matrix (Fleischmann et al., 2015, p. 77)

Since this thesis is interested in the tactical aspect with planning (see emphasis in figure 4.1), the functions and the planning activities that are involved at this planning level will be described in detail below.

### Sales

The sales process is responsible for determining the demand forecasts and order figures (Fleischmann et al., 2015). The demand forecasts form the basis for all planning within the supply chain (Chopra & Meindl, 2016, p. 221). Sales planning at the mid-term level involves forecasting potential sales for product groups (aggregation) at a weekly or monthly basis and is used as input to the master production scheduling (MPS) (Fleischmann et al., 2015). Aggregate planning has a significant impact on supply chain performance, and Chopra & Meindl (2016) argue that good aggregate planning is carried out in collaboration with both suppliers and customers.

**Distribution**

The distribution process is responsible for connecting the production site to the customers. Based on the sales forecasts, the distribution planning comprises the activities of planning the transport between warehouses as well as determining the safety stock. The plan deals with weekly or monthly time buckets and has to minimize the aggregated costs of holding inventory and transportation (Fleischmann et al., 2015).

**Production**

On a mid-term level, typical tasks include MPS and capacity planning. The objective of MPS and capacity planning is to utilize the available production capacity in a cost efficient manner. MPS is concerned with product families and critical materials (bottlenecks) and considers seasonal fluctuations of demand and the utilization of overtime. In order to minimize costs, the planner has to balance the cost of capacity with the cost of (seasonal) inventory. If multiple production facilities are used, the transportation cost between the locations has to be included in the objective function (Fleischmann et al., 2015).

**Procurement**

Procurement involves all activities of providing resources to production. As the capacity planning does not go in detail on the different production stages, the personnel planning involves a detailed overview of the personnel capacity and the utilization of it. If there is need for additional capacity, external or part-time workers can be used (Fleischmann et al., 2015). As discussed, MPS is concerned with finished products and bottlenecks. Material requirements planning (MRP) considers the bill of materials (BOM) and decides when raw material or components are needed to ensure desired service levels. Using weekly or monthly time buckets, the lot sizes and lead times have to be taken into consideration (Fleischmann et al., 2015). The output of MRP can be used to set up basic agreements with key suppliers. These contracts set the price, quantity, and other conditions for the materials to be delivered during the next planning horizon (Fleischmann et al., 2015).

### 4.1.2 Tactical supply chain planning

SCP concerns the activities that focus on evaluating demand for material and capacity, while also undertaking the process of formulating plans and schedules to create a balance between demand and supply (Kaipia, 2009). Jonsson & Holmström (2016) identified four broad categories of SCP practice: S&OP, supply chain master planning (SCMP), supply chain materials management (SCMM), and collaborative materials management (CMM). While S&OP and SCMP deal with mid-term planning aspects, SCMM and CMM focus primarily on the operational aspects of planning. SCMP seeks to synchronize the flow of materials across the supply chain, thus balancing demand and capacity. The main inputs to SCMP are demand data and network constraints in terms of capacity and dependencies between the processes. The result of the SCMP process is a common supply chain plan for inventory, materials requirements, procurement, production and distribution (Rudberg & Thulin, 2009). S&OP on the other hand attempts to balance supply and demand at an aggregated level through integration and coordination of procurement, production, distribution and sales (Fleischmann et al., 2015). Considering how capacity constraints vary due to the supply uncertainty that is present in the food industry, SCMP as a planning method could be appropriate. However, as argued in (Hull, 2005), food supply chains often handle perishable products that cannot be stored while awaiting orders, and are therefore characterized as supply driven. This issue is addressed in S&OP since it aims at balancing demand and supply by integrating sales with operations. Therefore, S&OP seems like a better tool for analyzing the case company. The next section will give an introduction to the topic of S&OP.

**Sales and operations planning**

In order to integrate the plans that are discussed in previous sections, firms employ S&OP (Noroozi & Wikner, 2017). The integration of the plans is done through intensive, mainly horizontal, bi-directional information exchange between the functions in a supply chain (Fleischmann et al., 2015). In addition to integrate the various plans, S&OP can be described as a mid-term cross-functional process aimed at coordinating demand and supply planning (Thomé et al., 2012; Jonsson & Holmström, 2016; Fleischmann et al., 2015). Moreover, the S&OP process ensures that plans from the various business functions align well and that they support the strategic business plan (Ivert et al., 2015; Thomé et al., 2012). The S&OP process can chiefly be broken down into five steps as shown in table 4.2 (Jacobs et al., 2011).

Table 4.2: The five stages of S&OP, adapted from Jacobs et al. (2011, p. 123–124)

| Stage | Activities |
|---|---|
| **1** | *Run the sales forecasting reports:* This stage comprises the activities of updating information that is needed for planning. For instance, such information can be actual sales, production or inventories. Furthermore, the updated information is distributed to the appropriate people. |
| **2** | *Demand planning:* This stage is concerned with the generation of new sales forecasts based on the information that was received in the first stage. |
| **3** | *Supply planning phase:* This stage is concerned with capacity planning. The updated sales forecasts are compared with the current supply and capacity plans, and necessary modifications are made. |
| **4** | *Pre-S&OP meeting:* The purpose of this meeting is to make decisions regarding the balance of demand and supply, resolve problems of differences, identify areas that cannot be resolved to be discussed in the S&OP meeting, develop alternative courses of action, and set the agenda of the S&OP meeting. |
| **5** | *Executive S&OP meeting:* This meeting involves executives in the business and has the purpose of making decisions on the S&OP plan for each product family; authorization of the spending for changes in production and procurement; relate the collective impact of the dollarized version of the product grouping sales and operations plans to the overall business plan; make decisions in areas that the pre-SOP team could not agree; and to review customer service and business performance. |

Thomé et al. (2012) synthesized the literature on S&OP, and developed a S&OP framework shown in figure 4.2. The framework considers four central elements: context, input, structure and processes, and outcomes. Ivert et al. (2015) performed a multiple case study on S&OP in the food production industry and adopted the framework by Thomé et al. (2012). Seeing the five stages of S&OP (Jacobs et al., 2011) in relation to the framework from Thomé et al. (2012), one can discuss that these stages are embedded in both the input and the structure & processes elements. In order to further understand the S&OP framework, the following describes each of the different elements in detail.

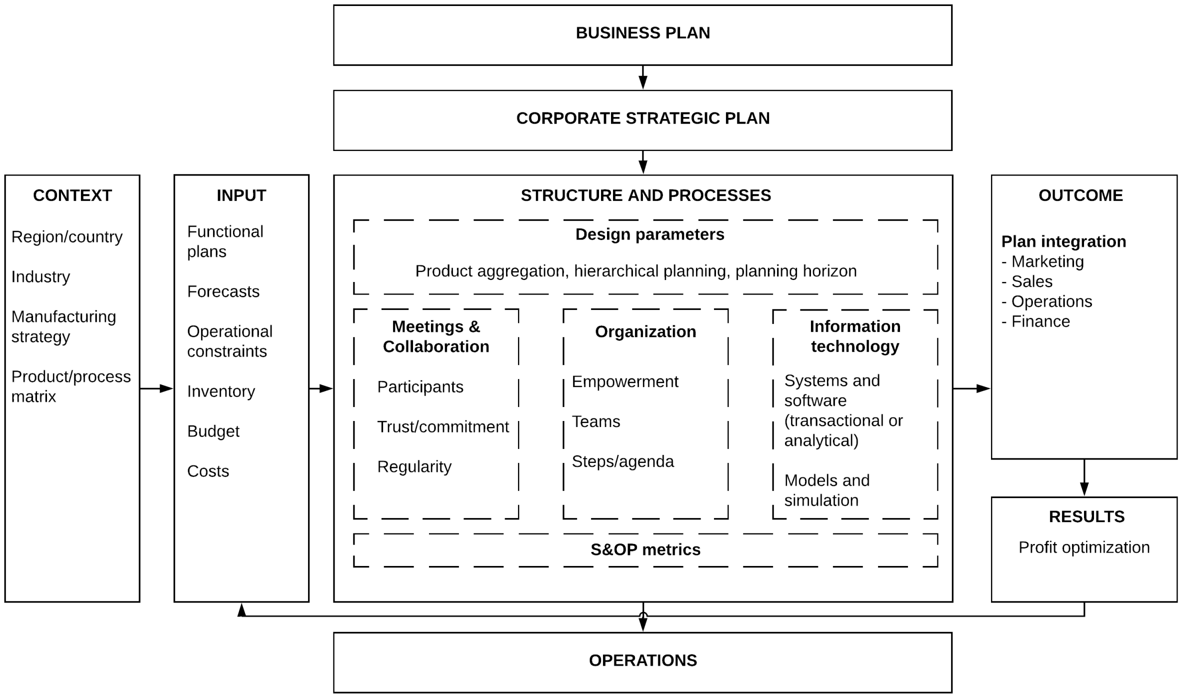


Figure 4.2: The S&OP framework, adapted from Ivert et al. (2015, p.281) and Thomé et al. (2012, p.5)

**Context**: S&OP is not a one size fits all, and the context, or more specifically the company's operating environment influences how the planning process should be conducted (Noroozi & Wikner, 2017; Ivert et al., 2015; Thomé et al., 2012). For instance, where the company is located or which industry they are operating in have consequences for how the S&OP should be designed. In addition, the firm's manufacturing strategy and the product-process matrix developed by Hayes & Wheelwright (1979) were also regarded as context variables in the literature. However, Grimson & Pyke (2007) found no evidence of the product-process matrix being a descriptor of S&OP. Ivert et al. (2015) argued that demand and supply uncertainties were context variables in the food industry. Other variables that were highlighted by Thomé et al. (2012) include hierarchical planning, planning horizon and product aggregation. These, along with planning object were in Ivert et al. (2015) embedded in the structure and processes element, classifying them as design parameters.

**Input**: Inputs in the S&OP process can according to Ivert et al. (2015) be divided into three groups: separated plans (e.g. demand, sales, production, procurement and capacity plans), constraints (production capacity, supplier constraints and financial restrictions) and goals.

**Structure and processes:** The structure and process element includes: meetings and collaboration, organization, information technology, and S&OP metrics (Thomé et al., 2012). The integrative framework from Grimson & Pyke (2007) also comprises these four elements. They do however include S&OP plan integration, which other authors view as the outcome of the process.

**Outcomes**: The preceding activities and processes lead to an outcome, which usually involves integration of the plans that were inputs in the process (Thomé et al., 2012). While Ivert et al. (2015) found that in food supply chains this outcome most commonly is related to integration of production plans, Thomé et al. (2012) suggested that the desired outcome is to integrate the plans from all functions that are present in the supply chain matrix (figure 4.1).

### Integration of the S&OP process

There exist other S&OP frameworks that have been derived from literature reviews. Noroozi & Wikner (2017) conducted a systematic literature review on S&OP in process industries. Although inspired by the framework from Thomé et al. (2012), the proposed framework (see Noroozi & Wikner (2017)) aims to focus on the integration of the S&OP planning processes. The paper identified that S&OP processes were vertical integrated with the strategic plan, business plan, financial plan, as well as strategic and operational planning. Further, horizontal integration with S&OP included both inter- and intra-organizational activities (Noroozi & Wikner, 2017). They also emphasized the importance of dealing with risks in the S&OP process, citing several authors saying that the best-in-class companies integrate scenario and risk management in the S&OP process. Furthermore, Grimson & Pyke (2007) developed a framework for S&OP which assesses the integration maturity of S&OP processes. Its main purpose is to help managers understand how effective their S&OP processes are and how their firm can improve their processes in order to advance to a higher maturity stage. The framework is presented in table 4.3, and consists of the five dimensions across five stages. When assessing a firm's S&OP process, one can use the framework to establish the maturity level of each dimension in the S&OP process. After this assessment, the framework can then be used to establish needs for improvement in order to advance to a higher maturity level.

Table 4.3: S&OP integration framework. Adapted from Grimson & Pyke (2007)

| | **Stage 1** *No S&OP processes* | **Stage 2** *Reactive* | **Stage 3** *Standard* | **Stage 4** *Advanced* | **Stage 5** *Proactive* |
|---|---|---|---|---|---|
| Meetings & collaboration | Silo culture | Discussed at top level | Staff pre-meetings | Supplier and customer data incorporated | Event driven meetings |
| | No meetings | Focus on financial goals | Executive S&OP meetings | Suppliers and customers participate in parts of meetings | Real-time access to external data |
| | No collaboration | | Some supplier/customer data | | |
| Organization | No S&OP organization | No formal S&OP function | S&OP function is part of other position | Formal S&OP team | S&OP is understood as a tool for optimizing profit |
| | | Components of S&OP are in other positions | | Executive participation | |
| Measurements | No measurements | Measure how well operations meets sales plan | Stage 2 plus: | Stage 3 plus: | Stage 4 plus: |
| | | | Sales measured on forecast accuracy | New product introduction | Company profitability |
| | | | | S&OP effectiveness | |
| Information technology | Individual managers keep own spreadsheets | Many spreadsheets | Centralized information | Batch process | Integrate S&OP optimization software |
| | No consolidation of information | Some consolidation, but done manually | Revenue or operations planning software | Revenue and operations optimization link to ERP | Full interface with ERP, accounting, forecasting |
| | | | | S&OP workbench | Real-time solver |
| S&OP plan integration | No formal planning | Sales plan driven operations | Some plan integration | Plans highly integrated | Seamless integration of plans |
| | Operations attempts to meet incoming orders | Top-down process | Sequential process in one direction | Concurrent and collaborative process | Process focuses on profit optimization for whole company |
| | | Capacity utilization dynamics ignored | Bottom up plans tempered by business goals | Constraints applied in both directions | |

## 4.2 Supply chain uncertainty

When planning for a supply chain, one of the main challenges is dealing with uncertainty (Fleischmann et al., 2015). Uncertainties are usually expressed in terms of scenarios or questions such as: what should be produced at what time, what and how much will my customers order, are my suppliers able to deliver what I want? Uncertainty affecting supply chain processes and operations is seen as a major obstacle to deliver customer value (Mason-Jones & Towill, 1998; van der Vorst & Beulens, 2002; Gosling et al., 2013). Gupta & Maranas (2003) argue that underestimating uncertainty and its impact leads to poor planning decisions. They exemplify this:

> One of the key sources of uncertainty in any production-distribution system is the product demand. Failure to account for significant demand fluctuations could either lead to unsatisfied customer demand translating to loss of market share or excessively high inventory holding costs (Petkov & Maranas, 1997), both highly undesirable scenarios in the current market settings where the profit margins are extremely tight (p. 1220).

Seeing the development of these highly demanding market settings, there has been an increasing amount of research devoted to the field of supply chain uncertainty. Early works from Davis (1993) and Fisher (1997) were among the first to explicitly consider uncertainty as a supply chain problem. In recent years, the interest has increased and the focus has centered around categorizing (sources of) uncertainty and effective strategies to cope with or reduce their impact on supply chain processes. Categorization of uncertainties are usually descriptive tools and can allow researchers to provide exhaustive arrays of types of uncertainty (Bailey, 1994). They can also facilitate study of relationships between the different sources. The existing categorization from the reviewed literature will be discussed in subsequent sections along with how these can be aligned with redesign strategies focused on planning performance improvement.

### 4.2.1 Supply chain uncertainty and risk

Before elaborating on the concept of supply chain uncertainty and classifications, it is necessary to discuss the slightly confusing and interchangeable use of the terms risk and uncertainty in practice. A closely related field of interest to supply chain uncertainty is that of supply chain risk. The issue of supply chain risk has developed from increasing globalization, complexity and vulnerability of supply chains (Jüttner et al., 2003), as well as the threat of disruptions across the chain (Asgari et al., 2016). In order to mitigate the negative impact and consequences caused by these risks, an increasing amount of research on supply chain risk management has been undertaken. But what distinguishes this research from that on supply chain uncertainty? Jüttner et al. (2003) review the area of supply chain risk management, and define (supply chain) risk as: "the variation in the distribution of possible supply chain outcomes, their likelihood, and their subjective values" (p. 200), but still emphasize that distinguishing between risk and uncertainty is not important. On the other hand, Prakash et al. (2017) argue that there is a significant difference in that risk has some quantifiable measure for future events, whereas uncertainty does not. A standard formula for quantifying risk is:

$$\text{Risk} = P(\text{Loss}) \text{ x } I(\text{Loss})$$

where risk is defined as the probability (P) of loss and its impact (I) (Mitchell, 1995). The formula indicates the perception of risk of being something that generates a negative outcome (Christopher & Peck, 2004). Therefore, one can distinguish risk from uncertainty in that risk is only associated with negative outcome, whereas stated by Ritchie & Brindley (2007): "uncertainty relates to the situation in which there is a total absence of information or awareness of a potential event occurrence, irrespective of whether the outcome is positive or negative" (p. 1399). As such, the concept of supply chain uncertainty can be seen as more broad, and can encompass any uncertainties (both negative and positive) and risks that may occur throughout a supply chain. This aligns well with the findings from Simangunsong et al. (2012), and the more detailed definition of supply chain uncertainty provided by van der Vorst & Beulens (2002):

> Supply chain uncertainty refers to decision making situations in the supply chain in which the decision maker does not know definitely what to decide as he is indistinct about the objectives; lacks information about (or understanding of) the supply chain or its environment; lacks information processing capacities; is unable to accurately predict the impact of possible control actions on supply chain behavior; or, lacks effective control actions (non-controllability) (p. 413).

The distinction between uncertainty and risk is indeed blurry. However, in light of the assertion made by Jüttner et al. (2003), this report does not deem it important, nor necessary to distinguish between the two terms. Studies associated with supply chain risk and supply chain uncertainty are therefore equally relevant to this report.

### 4.2.2 Classifying supply chain uncertainty

Gosling et al. (2013) argue that to manage uncertainties, one should recognize their many sources that shape the perception of threats and opportunities. The academic literature reveals a range of different ways to identify uncertainties and to classify them into different sources or types. Over the years of research the classification models have gradually become more complex. One of the more simple and acknowledged classifications is found in the early article of Davis (1993), which suggests three sources of uncertainty, namely: suppliers, manufacturing and customers. Mason-Jones & Towill (1998) build on the work of Davis (1993) and present the uncertainty circle model. The conceptual model includes the above mentioned sources (rephrased to supply side, manufacturing process and demand side), but adds a fourth source of uncertainty: control systems. The article also explains how the supply chain uncertainty circle can be shrunk via the use of lean principles and transparent availability of undistorted market information. In subsequent years the uncertainty model has matured and been refined by various authors. It is worth noting that studies adopting the uncertainty circle model often take the liberty of replacing the term uncertainty with risk (see Christopher & Peck (2004) and Christopher (2016)). This illustrates the perceived close correlation between the two terms. Jüttner et al. (2003) classified risk sources into environmental, network related and organizational risk, and Christopher & Peck (2004) later placed the sources of uncertainty derived from the uncertainty circle model into those sources identified by Jüttner et al. (2003), thus giving these three categories and five subcategories:

- Internal to the firm *(organizational risk)*
  - **Process:** Risk related to the resilience of the manufacturing processes.
  - **Control:** Risk arising from the application or misapplication of internal control systems.
- External to the firm but internal to the supply chain network *(network related risk)*
  - **Demand:** Risk related to the demand volatility and the bullwhip effect.
  - **Supply:** Risk related to potential disruptions in supply caused by suppliers.
- External to the network
  - **Environmental:** Risk related to external forces (e.g. socio-political, economical, technological or natural events)

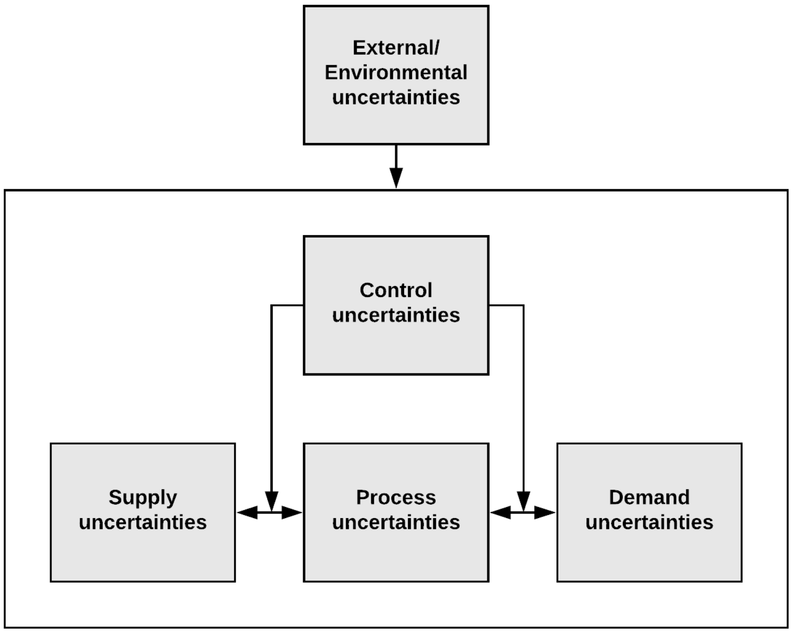


Figure 4.3: Types of uncertainty, adapted from Christopher & Peck (2004, p. 5) and Mason-Jones & Towill (1998, p. 17)

Mason-Jones & Towill (1998), Christopher (2016) and Esteso et al. (2017) all agree that the different sources of uncertainty cannot be seen in isolation, and one should therefore evaluate the strength of the relationship between them to fully understand the effect of them. Hence, the double-headed arrows between the sources in the figure.

Gosling et al. (2013) based their work on the uncertainty circle model, but in harmony with both Jüttner et al. (2003) and Christopher & Peck (2004), they added external uncertainties as a fifth source. The authors used these five sources to create an uncertainty profile for five engineer-to-order projects, and later established the relative importance of the uncertainties. Graves (2011) discussed supply chain uncertainty and how it is handled in production planning, and found that most production planning systems do not explicitly account for uncertainties. Similar to the above presented studies, Graves (2011) proposed sources of uncertainty to be external and internal supply processes, but offered nuance with another source: demand forecast. All production plans rely on demand forecasts, and as such it was argued that this was the largest single source of uncertainty.

Other contributions to classifications of uncertainties is not necessarily concerned with where uncertainties arise from (i.e. sources of uncertainties), but *how* they arise. For instance, the conceptual paper of Vilko et al. (2014) assessed the nature of uncertainties in supply chains, and proposed a framework which categorizes uncertainties in more detail than previous studies. The starting point for their framework, originally developed by Knight (1921) was "Knightian uncertainty", which refers to immeasurable risks that cannot be expressed in objective values. Further, they argue that although describing sources of uncertainty is relevant it does not explicitly describe the type of uncertainty, and thus propose that uncertainty can be examined through the lenses of substantive and procedural uncertainty. Substantive uncertainty derives from the lack of complete information that is necessary to make accurate decisions, while procedural uncertainty is related to the lack of a decision maker's cognitive capabilities and ability to interpret the relevant information, even when available. This concept coincides well with the very definition of supply chain uncertainty from van der Vorst & Beulens (2002) presented earlier in this chapter in that it is linked to a decision maker's lack of information (substantive) and/or information processing capacities (procedural).

Gupta & Maranas (2003) presented in their article on SCP in the presence of demand uncertainty a categorization of uncertainty based on the time frame over which the uncertainties can affect a system. Short-term uncertainties are associated with day-to-day variations, cancelled or rushed orders, equipment failure, etc. Long-term uncertainties are variations in raw material or final product price, seasonal fluctuations and production rate changes occurring over longer time periods.

Instead of describing sources of uncertainty, Flynn et al. (2016) focused on the *types of uncertainty* and proposed these three types based on their level of aggregation:

- **Micro-level uncertainty:** relates to the variability of inputs to the technical core of a supply chain and the operational variation of uncertainty, and arises in repetitive processes in low-complexity task environments.
- **Meso-level uncertainty:** arises in from differentiated supply chain members, who may hold back information and exercise opportunistic behaviour.
- **Macro-level uncertainty:** relates to high impact low probability events. Macro-level supply chain uncertainty is associated with a complex and dynamic context in which situations are ambiguous and ill-constructed, such as when customer demand suddenly shifts or when an organization encounters a natural disaster.

Lastly, studies from van der Vorst et al. (1998), van der Vorst & Beulens (2002) and Chaudhuri et al. (2014) are contributions to context specific and empirical research. van der Vorst et al. (1998) identified four main clusters of sources of uncertainty in food supply chains: order forecast horizon, input data, administrative and decision process, and inherent characteristics. Deduced from literature and practical experience, the authors suggest that each cluster includes a series of different elements such as information lead time (order forecast horizon uncertainty), information availability (input data uncertainty), human behaviour (administrative and decision process uncertainty), etc. A case study demonstrated the positive effect of reducing or eliminating uncertainties in supply decision processes. van der Vorst & Beulens (2002) identify five sources of uncertainty: chain configuration, infrastructure and facilities; order forecast horizon; information technology (IT) complexity; human behaviour; and inherent characteristics. Chaudhuri et al. (2014) also suggest inherent characteristics as a source of uncertainty. In food supply chains, these characteristics refer to "built-in" features of the supplied products such as perishability, inverted BOM structure and seasonal availability. Chaudhuri et al. (2014) elaborated on the study of van der Vorst & Beulens (2002) and added another source of uncertainty, supplier related uncertainties. The next section will go deeper into these two studies, as they are explicitly concerned with supply uncertainty, which is the main focus of this report.

### 4.2.3 Supply uncertainty

Supply uncertainty, as described earlier, is related to potential disruptions in supply caused by suppliers. Gosling et al. (2013) argue that supply uncertainty results from poor performance from suppliers, including the various products, and services provided by suppliers. Long and variable lead times would be typical evidence of this category. Some authors claim that supply side uncertainties are essentially equivalent to demand side uncertainty except for that they are associated with potential upstream disturbances in flow rather than downstream (Christopher & Peck, 2004). However, Vilko et al. (2014) found that supply side uncertainties should be considered to include much more complex issues than demand side uncertainty, requiring more attention and effort to manage correctly.

In order to further operationalize supply uncertainties, van der Vorst & Beulens (2002) and Chaudhuri et al. (2014) identify four dimensions of which uncertainties can be expressed along: supply quantity, supply quality, supply cost (raw material price) and supply lead time (see figure 4.4). In that sense, supply uncertainties can be multidimensional, as illustrated by Chaudhuri et al. (2014) who present typical examples from the fishing industry:

- **Supply quantity:** The fishing industry is exposed to high levels of uncertainty in available quantity of supplies. Year to year, and months for different years can differ.
- **Supply quality:** Quality is depending on periods of the year and biological factors. It is temperature sensitive and the quality degradation depends on microbial

growth.

- **Supply lead time:** Lead times are dependent on weather conditions and availability of fish.
- **Supply price:** The raw material price is affected by external factors (market trends) and results in a total cost uncertainty.

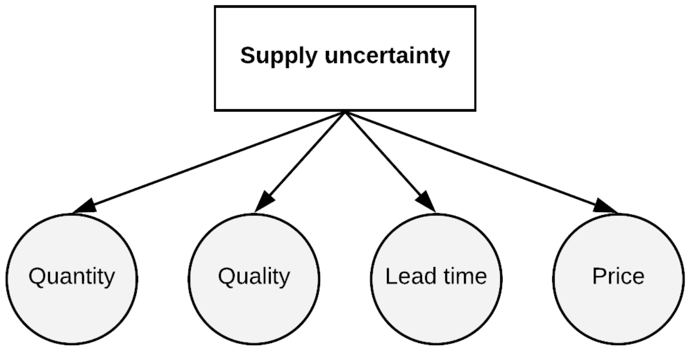


Figure 4.4: Supply uncertainties as defined by van der Vorst & Beulens (2002) and Chaudhuri et al. (2014)

### 4.2.4 Sources of supply uncertainty

The previous subsection was concerned with different classifications of supply chain uncertainty, where most classifications were concerned with the sources of supply chain uncertainty. In order to obtain a sufficient overview of supply uncertainties, it is necessary to identify sources, or sub-sources, of supply uncertainty. Although relevant literature is limited, van der Vorst & Beulens (2002) and Chaudhuri et al. (2014) are central studies in this review. Here, the sources are divided into *inherent characteristics* of the supplied product, *supply chain related uncertainties*, *supplier related uncertainties* and *external uncertainties*. Each of the four sub-sources will in the following be described in detail. Figure 4.5 illustrates the uncertainty circle model presented earlier with focus on supply uncertainty and its four sub-sources.

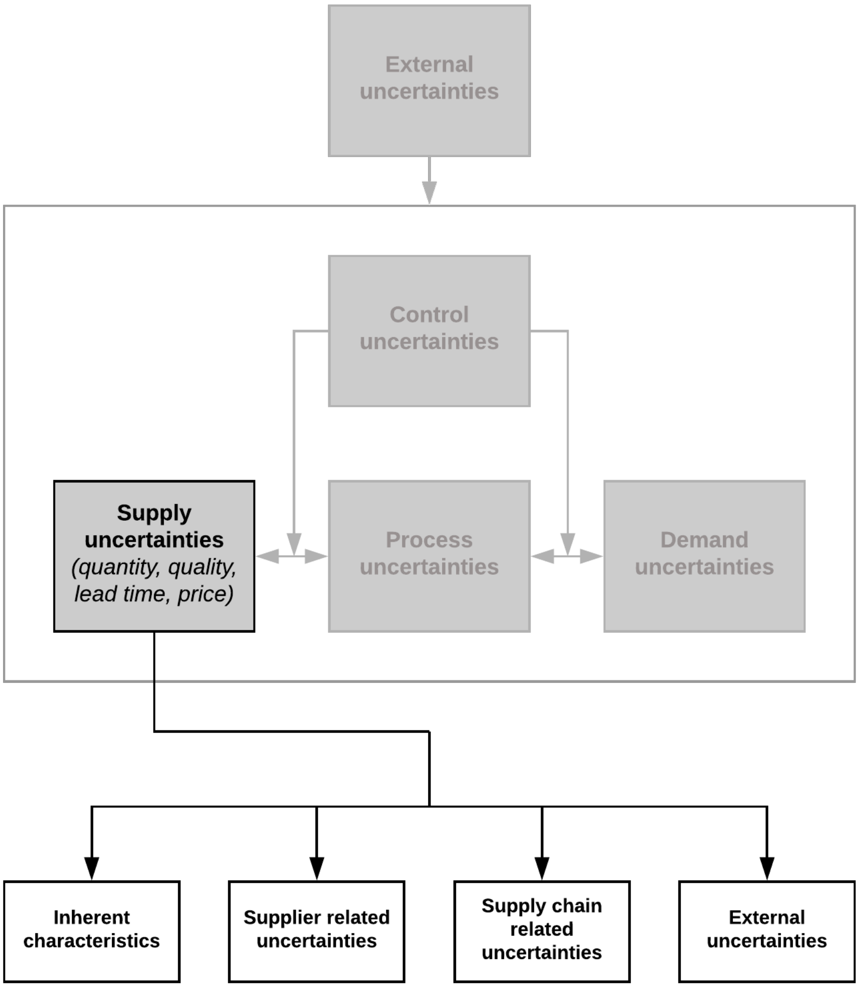


Figure 4.5: Supply uncertainty and its sub-sources. Adapted from figure 4.3.

### Inherent characteristics

Inherent characteristics of the raw material include those characteristics that are built-in in the nature of the supplied product (van der Vorst & Beulens, 2002). This ultimately leads to uncertainty in decision processes. Some examples are seasonality, variation of the yield/harvest, perishability and the impact of weather (van der Vorst & Beulens, 2002; Behzadi et al., 2017). In the food industry, and especially in the fish processing industry, other features of the raw material that cause uncertainty are the variability in species in the catch (Bakhrankova et al., 2014), and the inverted BOM structure (Chaudhuri et al., 2014), where a commodity is processed into multiple finished products (Hull, 2005)

Seasonality results in unbalanced supply and demand cycles (Behzadi et al., 2017). That there will be fluctuations caused by the inherent characteristics is usually predictable (van der Vorst & Beulens, 2002), but the amount of fluctuation is unknown, leading to uncertainty regarding the quantity and quality that a processor can acquire (Chaudhuri et al., 2014; Bakhrankova et al., 2014). Again, as many of the sources of uncertainty are connected, this will cause uncertainty in the next stage of the supply chain. To exemplify, when a fish processing facility is producing different products, the size and weight of the fish decide where it will be produced, and which products that can be produced (Chaudhuri et al., 2014). This induces uncertainty in the production planning process.

In food supply chains, sources of uncertainty are mostly related to inherent characteristics of the products (Esteso et al., 2017). The perishability affects the shelf life, and deterioration rate (Bakhrankova et al., 2014). The former obviously vary, depending if the product is frozen or fresh, and the latter sets constraints to production regarding when it should be processed. Other characteristics Esteso et al. (2017) mention include lack of homogeneity, which means that there are different sizes, species and coloring due to handling. Agri-cultural products also have the risks of contracting diseases and pests (Behzadi et al., 2017; Esteso et al., 2017). Lastly, Zhao et al. (2017) mention antibiotic resistance as a major source of supply risk in agri-food supply chains.

**Supply chain related uncertainties**

Uncertainty that relates to characteristic features of the supply chain can be divided into four elements: chain configuration; chain control structure; chain information structure and chain organization; and governance structure (van der Vorst & Beulens, 2002). These uncertainties can result in disturbances in the system's performance.

With regards to supply uncertainty, supply chain configuration can result in low flexibility in capacities (van der Vorst & Beulens, 2002). The number of suppliers and their location can affect the quantity, quality and lead time of the delivery in both a positive and negative manner (Chaudhuri et al., 2014). Chain control structure relates to administrative processes and decision policies which can create uncertainty. Increased process time of administrative processes and information flows creates uncertainty in supplier lead time (Chaudhuri et al., 2014). Supply chain information system relates to the accuracy and set of data that are being transferred within the supply chain. In a supply context, this can for instance be information on the quality and quantity that the supplier is able to deliver (Chaudhuri et al., 2014; Srivastava et al., 2015; Rijpkema et al., 2016). It is also argued that for supply-driven chains, information is often not shared to prevent low prices if the supplier has difficulties in selling the goods. Due to these tendencies, uncertainty in supply prices increases (Chaudhuri et al., 2014). With a growing number of legislative measures in different countries, the ability to retrieve product history increases the importance of traceability in supply chain (Srivastava et al., 2015; Zhao et al., 2017). Lastly, supply chain organization and governance structure involve problems like misjudgments by the decision maker (van der Vorst & Beulens, 2002). For a food processor, this can include commitments and contracts that can secure the needed quantity and quality. However, poor contracts are often obligating them to buy the whole supply of raw material, regardless of the quantity, quality, and in some cases even the type of product (Srivastava et al., 2015; Chaudhuri et al., 2014).

**Supplier related uncertainties**

Supplier related sources comprise uncertainties regarding capacity and quality that are caused by the supplier's processes and organization. The capacity of the supplier can be constrained by the equipment, either as a consequence of poor maintenance or the supplier is not chasing new improved technology to increase the capacity (Chaudhuri et al., 2014). In terms of quality, the supplier can face trouble of delivering the desired quality due to lack of training in quality principles or techniques, or similarly as with the capacity that equipment can produce lower quality if not maintained (Chaudhuri et al., 2014). The timing of raw material supply may be uncertain if the supplier is unable to meet promised due dates over longer periods (Simangunsong et al., 2012), resulting in an overall lead time uncertainty.

**External uncertainties**

External sources of uncertainty originate from factors outside the supply chain, and are outside a company's direct area of control. These may take the form of changes in markets conditions, technology, competitors or governmental regulations (van der Vorst & Beulens, 2002; Srivastava et al., 2015). A good example of this kind of uncertainty is in the governmental subsidies that Norwegian farmers are heavily reliant on. If policies are changed, the income of farmers are at risk, making this an external uncertainty. Christopher & Peck (2004) and Jüttner et al. (2003) use the term environmental instead of external, and add extreme weather, earthquakes, or other natural disasters to the list of potential environmental/external uncertainties. Studies also emphasize the risks of socio-political (protests or terrorist attacks) and unethical issues (Zhao et al., 2017). Esteso et al. (2017) found in their study of uncertainty in agri-food supply chains three central sources to environmental uncertainty: weather and land conditions, governmental regulations, and pests and diseases. The latter is regarded with the risk of agri-food products being contaminated by pests and biotic hazards such as viruses or bacteria.

## 4.3 Planning under uncertainty

Graves (2011) mentions that most systems for production planning presume that the supply and production processes are exactly as prescribed by the planning parameters and that the demand forecast predicts the actual demand with a 100 % accuracy. However, as the reviewed literature has revealed, integrating uncertainty is of high importance, and failing to account for uncertainty in planning models will make them inferior to the ones that do (Peidro et al., 2009). Snyder & Shen (2006) investigate the differences between supply and demand uncertainty using a multi-echelon simulation model, and demonstrate the importance of planning for supply uncertainty:

> We demonstrate that the cost of unreliability is greater under supply uncertainty than under demand uncertainty, in the sense that, if the firm fails to plan for uncertainty, the cost under a given level of supply uncertainty is greater than that under the equivalent level of demand uncertainty. This suggests that planning for supply uncertainty is crucial (p. 43).

Graves (2011) discuss several ways firms try to reduce uncertainty in the production planning process. When predicting future demand long into the future there will always be inaccuracies in the forecasts. Firms therefore tend to renew the plan when moving onto the next period with new and updated information. However, one consequence of re-planning is that it induces additional uncertainty in the form of schedule churn. The reasoning behind this is that every time a new plan is introduced, a new MPS has to be generated. Updating the MPS can result in new detailed schedules where due dates for some production jobs and replenishment orders are accelerated, while others are delayed (Graves, 2011). Firms therefore set time fences and freeze periods that are to put into action. Fleischmann et al. (2015) refer to this method as planning on a rolling horizon. Moreover, Fleischmann et al. (2015) claim that a more efficient way of updating plans is event-driven planning. Instead of drawing up new plans in regular intervals, a new plan is made in case of an unexpected event. However, this procedure requires all planning data e.g., stock levels, capacity and sales orders to be continuously updated, ensuring that the data is available at any arbitrary event time.

Other ways traditional planning systems are addressing uncertainty include the use of safety stocks, backlog management and flexible capacity (Graves, 2011). Although safety stocks is not directly addressed by planners it does reduce the need for re-planning through providing access to raw materials in situations where there are disruptions in the supply source. If the manufacturer has sufficient market power, the firm can incorporate uncertainty in their backlog management routines, such as deciding on varying the delivery or service times quoted to customers (Graves, 2011). Along with flexible capacity, other types of flexibility are mentioned in the literature. Flexibility can be broadly categorized as new product flexibility, mix flexibility, or volume flexibility (Chopra & Meindl, 2016). New product flexibility refers to a firm's ability to quickly introduce new products to the market. Mix flexibility refers to the ability to produce a variety of products within a short period of time, and is critical in environments where there are uncertainty regarding raw material (Chopra & Meindl, 2016; Dreyer & Grønhaug, 2012; Chaudhuri et al., 2014). Volume flexibility refers to a firm's ability to operate profitably at different levels of output (Chopra & Meindl, 2016). In industries that face seasonality and large volume variations, there is a need for flexible capacity planning, e.g. temporary workers that can work during high season (Dreyer & Grønhaug, 2012).

When there are variations in supply, Kaipia et al. (2017) suggest that it may be beneficial to include suppliers in the planning process. To this end, collaborative S&OP is a popular method which first and foremost is effective for shortening lead times when demand is uncertain (Kaipia et al., 2017). Moreover, in order to achieve a balance of supply and demand it is essential to integrate functions from different areas, both within and outside the company (Noroozi & Wikner, 2017). Supply chain collaboration is proposed as a strategy to cope with uncertainty (Esteso et al., 2017; Zhao et al., 2017). However, efficient collaborations require all actors in the supply chain to share information and synchronize decisions. In addition, there must be incentives to collaborate, meaning that all members should benefit from the collaboration (Esteso et al., 2017). From a case study at a white fish processor, Bakhrankova et al. (2014) describe how a fish processing plant receives daily catch reports from their fishing trawler, and say this is vital for an effective production planning under supply uncertainty. Above all, in the S&OP literature information sharing seems to be considered as the main strategy for coping with uncertainty. It ultimately increases visibility of potential threats, making it easier to act to the forthcoming uncertainties (Christopher, 2016; Grimson & Pyke, 2007), as well as giving planners increased ability to create high accuracy forecasts (Kaipia et al., 2017). van der Vorst & Beulens (2002) highlight the role information and communications technology (ICT) solutions can have in sharing of information. They suggest that companies should establish an information exchange infrastructure in the supply chain on demand, supply, inventory or work-in-process (WIP). By having a common database and a standardized coding, one can increase the speed of the information flow and share up-to-date data in real-time (van der Vorst & Beulens, 2002). These measures facilitate the event-driven planning process advocated by Fleischmann et al. (2015), which requires information availability at any arbitrary event time.

This chapter has reviewed literature on tactical SCP (S&OP) and the field of supply chain uncertainty. The above section has attempted to weave together the findings from the two themes and highlighted measures that sales and operations planners take to account for uncertainty. Table 4.4 summarizes these measures.

Table 4.4: Summary of planning measures in the presence of uncertainty

| **Measures** | **Reference** |
| --- | --- |
| Rolling horizon planning | Graves (2011); Fleischmann et al. (2015) |
| Event driven planning | Fleischmann et al. (2015) |
| Flexible planning | Dreyer & Grønhaug (2012); Chaudhuri et al. (2014); Chopra & Meindl (2013); van der Vorst & Beulens (2002) |
| Flexible capacity | Graves (2011); Dreyer & Grønhaug (2012) |
| Information sharing between supply chain actors | Esteso et al. (2017); Bakhrankova et al. (2014); Chaudhuri et al. (2014); Grimson & Pyke (2007); Kaipia et al. (2017); van der Vorst & Beulens (2002) |
| Integrate suppliers in planning processes (collaborative S&OP) | Noroozi & Wikner (2017); Kaipia et al. (2017) |

## 4.4 Analyzing framework

Based on the literature review, the framework in figure 4.6 is proposed. The framework describes how an analysis process can be conducted in order to establish the impact of supply uncertainties on tactical SCP processes. The first phase is concerned with understanding how the SCP process is conducted in the company that is to be analyzed. Through a mapping of the process, critical stages in the process can be pinpointed. In the second phase, the process is to identify uncertainties and their respective sources in the planning environment. Through a categorization of supply uncertainties, one can better investigate relationships between the uncertainties, as well as being a precursor for developing appropriate management strategies (Simangunsong et al., 2012). The third phase in the process addresses the consequence of the uncertainties, preferably in terms of what parts of the supply chain it affects. The forth phase is concerned with establishing the impact of uncertainties on SCP processes. Inspired by Thomé et al. (2012) and Ivert et al. (2015), it seeks to find, first, which planning decisions and activities (i.e., the structure and process of S&OP process) that are triggered by the consequence, and second, which planning inputs that are affected by the consequence.

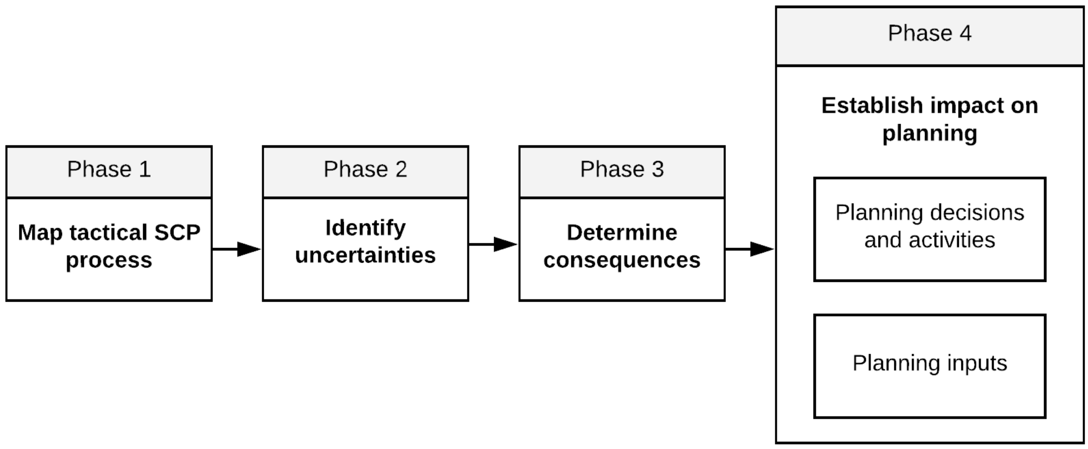


Figure 4.6: Analyzing framework

The framework will be applied, step-wise, in the case study analysis which is presented in the next chapter. Although particularly useful in this thesis, the framework can serve useful also for analyzing other planning environments impacted by uncertainties. The uncertainty in focus of this thesis' analysis is supply uncertainty, but the framework may also be suitable for establishing the impact of other uncertainties (e.g., demand, control, process uncertainty).

# Chapter 5

# Case study analysis

This chapter presents the case company and applies the four-phase analyzing framework from the literature. First, the empirical background and findings are introduced. Second, the tactical planning process of the case company is described and analyzed using theoretical frameworks. Third, the uncertainties that affect the case company's SCP process is identified and categorized by their sources. Last, the uncertainties are quantified and the impact of supply uncertainties on the tactical SCP process is established.

## 5.1 Lerøy Norway Seafoods

Lerøy Norway Seafoods (LNS) is one of Europe's biggest seafood provider (Lerøy Norway Seafoods, 2017). The company's primary business is processing wild caught white fish and currently operates 11 production facilities, eight in Northern Norway and three in Denmark. The three biggest ones in Norway - Båtsfjord, Stamsund and Melbu - handle both fresh and frozen types of fish, while the rest are smaller facilities mostly focused around production of fresh fish products. The product offering includes fillets, loins, portions and tail pieces of cod, haddock and saithe. The company also handles some salted fish as well as king and snow crab. In 2016, the company employed around 730 people (Lerøy Seafood Group ASA, 2017).

As of 2018, the case company constitutes a subsidiary of the bigger corporate Lerøy Seafood Group ASA, following their acquisition in October 2016. The case company represents approximately 10 % of the Group's total revenue (Lerøy Seafood Group ASA, 2017). The acquisition was in line with Lerøy Seafood Group's strategy to become a fully integrated supplier of seafood. Along with the acquisition of LNS, the Group also integrated with Havfisk ASA, the largest trawling operator in the Norwegian white fish industry. Havfisk currently owns ten trawlers and has license rights granting them 10 % of the Norwegian cod quota. As of 2016, Havfisk had 367 employees. Havfisk also owns five white fish processing plants (Stamsund, Melbu, Kjøllefjord, Hammerfest and Båtsfjord), which it leases out to LNS on long-term contracts.

### 5.1.1 Harvest

The harvest stage involves sourcing raw material from four different sources: *Havfisk ASA*, *external sourcing*, *internal transshipments of raw material*, and *capture-based aquaculture*. In off-season or when there are shortages of raw materials, LNS sources from Havfisk. Complying with the delivery obligation presented in section 2.2, Havfisk is obligated to deliver a majority of its catch to LNS's processing plants, and in 2018, they have a contract on delivery of 8500 tonnes. However, due to processing obligations (see chapter 2), LNS does not purchase catches if they have not planned production of cod. Havfisk's three subsidiaries, Nordland Havfiske, Finnmark Havfiske and Hammerfest Industrifiske, own and operate 10 trawlers in total. Five of these are fresh fish trawlers, four are frozen fish trawlers and one is a fresh fish trawler with freezing capability.

External sourcing involves purchasing raw material from external actors such as coastal or seagoing (trawlers) vessels and from businesses solely buying fish and reselling it to make profit. In contrast to coastal and seagoing vessels, LNS can purchase parts of the catch that is offered from these businesses. From the total purchased volume, approximately 70 % is supplied from coastal vessels. The raw material consists mainly of cod, saithe and haddock, but also some red king crab. In peak-season the fish is primarily delivered fresh by coastal vessels, on the same day it is caught. As for seagoing vessels, which are mostly used during low season, it takes up to 5-6 days before the fish is landed at the processor, usually frozen. On average, LNS receives raw material from approximately 30 trawlers during a week.

Besides sourcing from Havfisk and external actors, LNS also manages internal transshipments of raw materials between processing plants. This is a way of maximizing capacity and utilizing the specialization of each processing plant. Some plants focus on fresh production while other focus more on frozen. This affects the need for different raw material at the different plants. Plans and decisions regarding transshipments are made by the central planner of the company. Lastly, a relatively new method for sourcing is live storage or so-called capture-based aquaculture. By keeping fish alive in tanks after it is caught, processors can process the fish when quality or market conditions are advantageous. In 2017, LNS sourced 500 tonnes from live storage.

Figure 5.1 reveals to the reader that in 2017, 50 % of the total purchased raw material was purchased in the months January-April. This is a common distribution of volume, and revisiting figure 2.3 presented in chapter 2 shows a clear similarity between LNS' volume distribution and that of the whole industry.

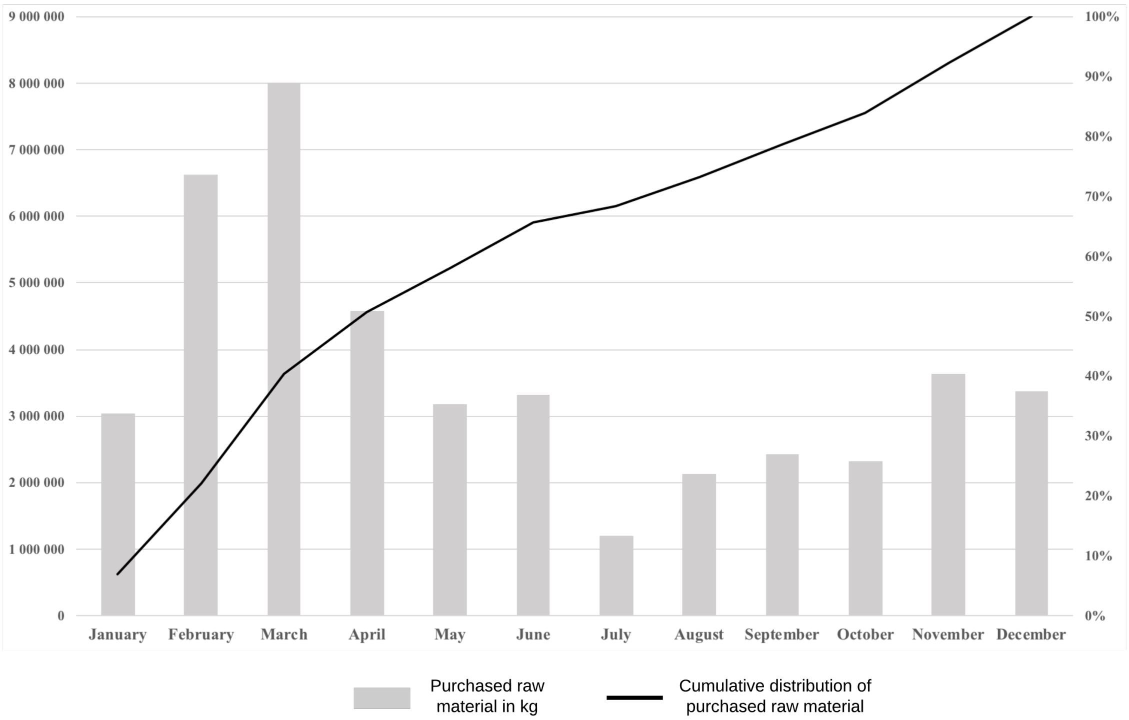


Figure 5.1: Total purchased raw material in 2017 for each month for LNS.

The quality, quantity and species of fish landed each day is uncertain. In order to comply with the delivery obligation, all fish landed at the respective locations must go through buying stations before being further processed. Here, the fish is weighed and quality checked. Based on this assessment a contract note is created. The note is used for paying the fishermen and for creating a catch certificate which is communicated to the Norwegian Fishermen's Sales Organization (see Norges Råfisklag in section 2.3). As of today, LNS manages four buying stations in Nordland, two in Troms and six in Finnmark. Below is a figure presenting the buying stations and their location along the northern Norwegian coast:

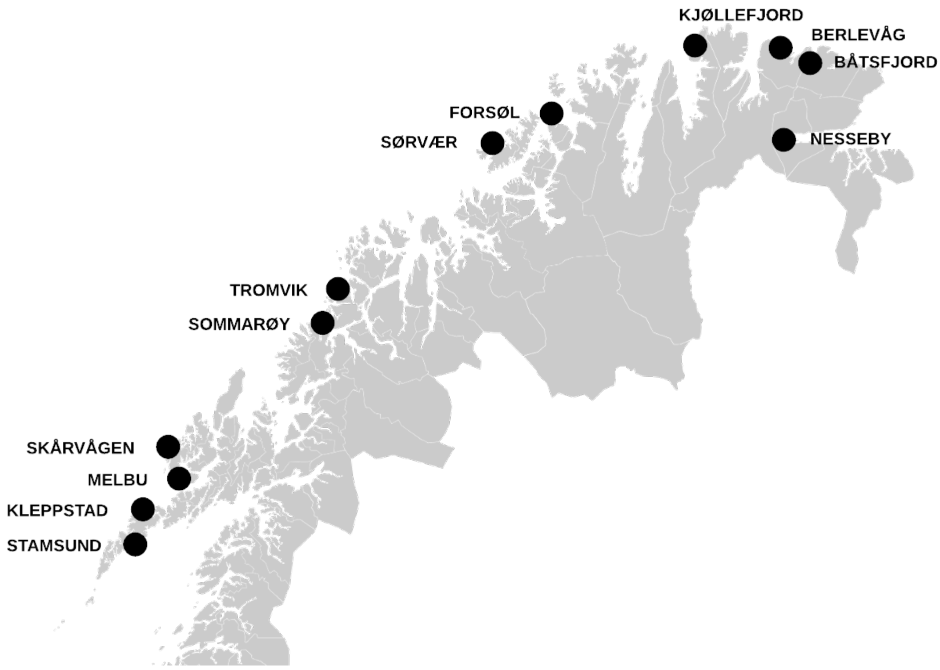

Figure 5.2: LNS' buying stations.

The quality of the catch is largely affected by how it is handled on-board the fishing vessels. Correct on-board handling of the fish is therefore important to improve profitability for the fishing crew and the processor. The purchased raw materials are quality checked upon reception and then classified into three quality categories in accordance with the criteria presented in table 5.1. Quality 1 represents raw material of high quality and implies full flexibility with respect to production. Quality 2 and Quality 3 represent raw material of lower quality and have limited application. Raw material of unsatisfactory quality is subject to special measures to determine the further cause of action. The quality of the catch is registered in a database that is linked to each vessel. On the basis of this, LNS know, or can expect a certain quality from the different vessels. Prior to this, LNS attempted to price catches based on the quality of the raw material. This was not well received by the fishers, and today the case company instead pays a minimum price and offers a premium price if the catch is of excellent quality.

Table 5.1: Raw material quality

| Quality 1 | Quality 2 | Quality 3 |
|---|---|---|
| Sufficiently bled and with a nice, white belly | Sufficiently bled, no blood in the belly | Poorly bled, visible remnants of blood in the flesh |
| No discoloration | Some discoloring | Discolored belly and flesh |
| Straight cut with correct length | Straight-line cut | Uneven cut with incorrect length |
| All guts removed | Some remnants of guts | Clear remnants of guts |
| Temperature at 2 degrees Celsius | Temperature between 2 and 4 degrees Celsius | Temperature above 4 degrees Celsius |

As of today, there exist limited sharing of information between the fishing vessels and the processing plant. In general, the information exchange between the vessel and the processor happens after the fishing vessel has landed its catch. Thakur (2017) argues in her report that if the processor could acquire quality data (e.g. type and size of fish) and other relevant information in advance it would significantly increase the efficiency and quality of the processor's decision making. It would, for instance, make it easier to determine what proportion of the catch that could be used for fresh production. Daily catch reports could provide an overview of the type, quality and quantity of the incoming raw material. This would help the processor to create production plans earlier, which in turn facilitates earlier decision making at the sales department. A pilot project that is currently running is an app that allows the coastal vessels to see the estimated queue time for delivery. In order to enter queue, the vessels have to register the size of the catch in kg. This way, the processor has an expectation of the quantity.

### 5.1.2 Processing

The processing stage involves activities necessary to convert raw material into finished products. It starts with fish decapitation, which is either done in the processing plant or on board the fishing vessel. Before it enters the filleting machine, the fish is graded and weighed. The grading process is done visually and the quality of raw material is assessed through examining the fish's temperature, shininess of skin and degree of discoloration (see table 5.1). Before the material flow is split into frozen and fresh, the raw material is manually trimmed. Depending on the assessed quality of the raw material, a decision has to made on whether the product is to be processed as fresh fish or to be frozen. Raw material with the highest quality is used for fresh products such as loins, tails or fillets, while poor quality fish is sold as frozen fish blocks, fillets or tails. LNS' value chain can be seen in its entirety in appendix A.

Today, the rough-cut capacity plans are generated by a central function. Prior to this, each facility had its own designated planner, and took only its own operations into consideration when planning. With today's system the local management is only responsible for detailed planning.

### 5.1.3 Sales and marketing

The demand for seafood products worldwide is increasing. In addition, consumers have become more willing to pay a premium price for high quality seafood products. LNS has a range of different products based on customer requirements, and has consequently built several acknowledged brands in the European market. With an increased focus on quality, the company has reduced its production of frozen products, and from 2014 to 2015 they increased the percentage of fresh products in their portfolio from 30 % to 37 %. The company has engaged in collaborative arrangements with actors from the Norwegian retail sector and consequently developed several new value-added products. There seems to be a trend towards product diversification strategies among seafood suppliers. As shown in chapter 2, Nilssen et al. (2014) found that processing firms delivering fresh products can fetch higher prices than those delivering frozen. In line with this, LNS tries to maximize the proportion of fresh products in the production.

The sales procedure at LNS can chiefly be decomposed into two segments; frozen products and fresh products. The former involves receiving sales plans from retailers or other customers which indicate the expected demand. These plans initiate long-term contracts which state when the processor is to produce which products (product mix) and of what quantity. Production related to these contracts can therefore be regarded as made-to-order. LNS also produces frozen products to stock (made-to-stock) which is used as a buffer for contracts and for serving other incoming orders. The case company has a number of so-called "fish-cuts" throughout Europe, which are processing facilities in the end market. These facilities handle large volumes of LNS' raw material and process it to final products customized for the respective end market. For fresh products, the sales procedure is somewhat different. Holding inventory is practically impossible due to the perishability of these products, meaning that orders have to be in place before production is initiated. The sales procedure for fresh products is therefore characterized by ad-hoc and day-to-day decisions with a short planning horizon.

Following the merger with Lerøy, a new organization unit named the white fish processing team was established. Prior to the merger, Lerøy Seafood Group only sold red fish, and had limited experience with selling white fish. To reap benefits from synergy effects, the white fish processing team aims to integrate sales and production by, among other things, educating sales personnel to sell white fish. The main challenge here is to be able to not only sell the most popular parts of the fish but also co-products such as tails, blocks and portions. By doing this, the utilization of each kg of fish is maximized, increasing the overall profit.

LNS' products are distributed through the Lerøy Seafood Group system out to retailers and HORECA-customers, both nationally and internationally. The company's customer base utilizes different forms of contracts. Some are more informal than others, but after the merger with Lerøy Seafood Group, the corporate has expressed a preference for formal, long-term contracts. These contracts are usually fixed to a certain volume in a given period (from 1 month up to 5 years). For some customers, a so-called gentleman's agreement is set up. These deals are normally arranged through phone or email, and entail far less degree of formality. This contract form is usually applied in the spot market. Dulsrud (2001) denotes a spot market as a market contract (usually short term and discrete) designed to facilitate economically efficient transactions. The discreteness of the contract implies that neither party commits to each other after the transaction is completed. These contracts contribute to nearly 50 % of the total sales revenue.

As of today, most contracts do not include penalties if LNS fail to deliver on time. As a compensation, the company may reduce the price on the next batch of products to favor the customer in other ways. However, some customer contracts include monetary compensation on failed deliveries.

## 5.2 The planning process

The first phase of the analyzing framework derived from the literature review was concerned with mapping the tactical SCP process. This is attempted in the following, and figure 5.3 outlines the central steps which are subsequently explained in detail. After describing the process, the integration maturity of the processes will be assessed to provide an exhaustive mapping of the tactical SCP process.

The tactical planning process at the case company is in principle governed by a central function, and disaggregated into detailed operational plans which are assigned to each plant. The first stage in the tactical planning process is to create a raw material plan, which is made for the whole succeeding year. The plan is developed during the autumn the year before, starting in August and is finished by the end of November. The plan starts with a forecast which is based on past years' raw material supply information, constraints such as catch quotas, expectations of the fleet structure and predicted fish migration pattern. The raw material plan is continuously updated throughout the following planning period as more and richer information is made available. Moving further into the planning horizon, the planning process is divided into two sub-processes; one for frozen products and one for fresh products.

**Frozen products:** Planning for frozen end products is characterized by a mid-term horizon. Freezing the fish slows down the deterioration process and therefore facilitates stock holding. As explained in section 5.1.3, retailers normally submit sales plans to the processor as well as requesting certain products for campaigns. These plans and requests are then transmitted to the production function which decides whether to accept or reject the requests. At this stage it is also determined how many and which new contracts the processor can enter without risking the ability to fulfill existing commitments. These decisions translate into aggregated production, sales and procurement plans (typically covering 1-3 months) which are continuously updated and coordinated as more information becomes available. Production plans for frozen products are assigned to plants with freezing capabilities. Operational tasks such as job scheduling and sequencing are the responsibility of each plant manager, and continuous updates are given to the central function to ensure balance.

**Fresh products:** For fresh products, planning often takes a more operational approach and has a shorter planning horizon. Due to limited possibilities of stock holding, variations in supply and other uncertain aspects, fresh production is generally bounded by the raw material availability. The raw material plan is used as starting point for subsequent plans, but because of the inherent uncertainty in mid-term decisions the plans for fresh products usually covers weekly time buckets. The day-to-day planning involves absorbing as much information from all possible communication channels. As the head of the white fish processing team explained the management of fresh products:

> There is so much information flowing, often in unorganized forms, through dialogues with customers, phone calls, WhatsApp chats... You have to try and extract the necessary information for making good decisions and just accept the dynamics and sporadic tendencies in the fresh market.

The information flow is mostly regarded with raw material availability and sales information such as customer requests. Plant information in terms of capacities, machine breakdowns or order progression is also essential when planning for fresh production.

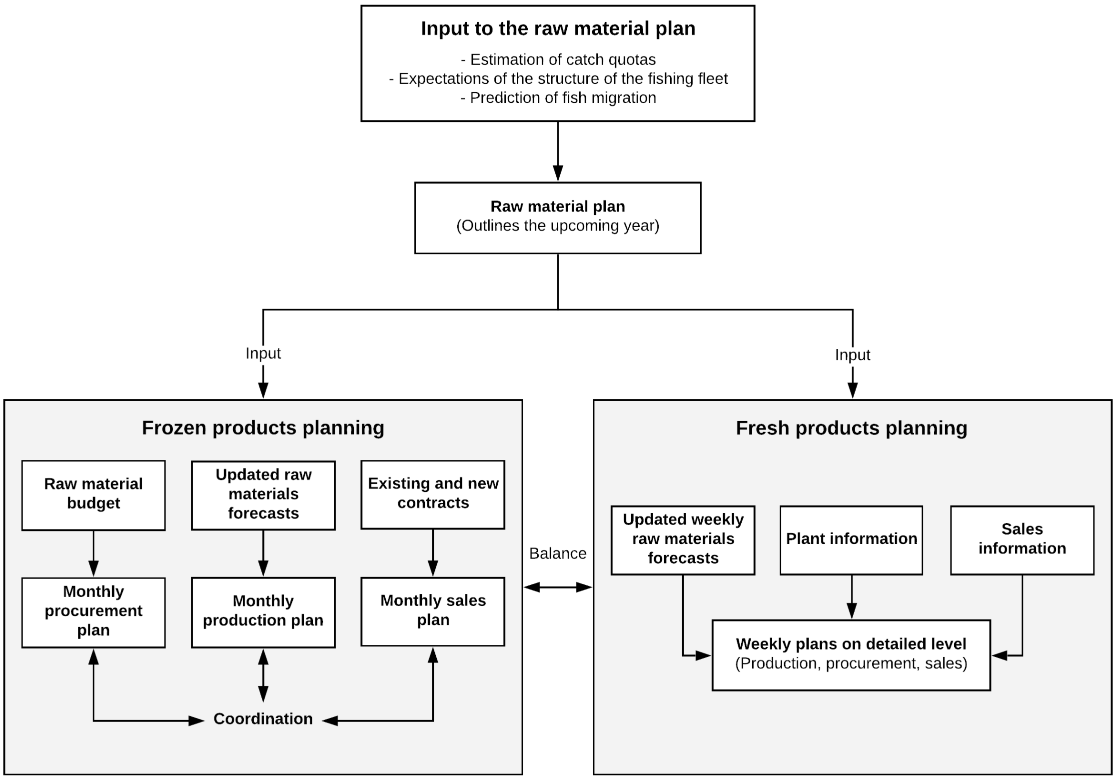


Figure 5.3: The tactical planning process at LNS

### 5.2.1 Sales and operations planning process

As found in the literature review, S&OP was determined to be an appropriate tool for analyzing the tactical SCP process. In order to further analyze LNS' planning process, the S&OP framework by Thomé et al. (2012) has been applied. Following the reasoning in Ivert et al. (2015), design parameters are moved from context to the structure and processes element. Figure 5.4 presents the data in the S&OP framework, and the subsequent sections describe each of the elements.

### Context

As discussed in chapter 2, LNS has to comply with governmental regulations such as activity obligations, delivery obligations from the trawlers and quotas for the fishing vessels. In addition, supply uncertainty leading to variations in supply volume, quality, lead times and fluctuating prices are defining the operational environment.

## Input

As already explained, the inputs to the raw material forecast are historical supply information and regulations. Inputs to frozen products planning include existing customer contracts, customer requests, contract status and planned campaigns. Moreover, the fresh production planning serves as an input to the frozen product planning as LNS is attempting to have a high capacity utilization. Weekly forecasts are made on Thursdays and Fridays the preceding week and use weather forecasts and marine traffic reports as input. Important inputs on inventory levels, expected quantity of incoming material, and operational constraints are received from plants and buying stations. Further, requests from the sales department, current contract status, as well as other relevant customer information are input to the planning process.

## Structure and processes

**Design parameters**
The planning horizon vary, ranging from one week to one year, depending on whether it concerns planning of frozen or fresh products. The SCP frequency is weekly, and the planning object mostly concerns product families. However, in the first stage of the planning process, the raw material forecast involves only fish species, i.e., cod, saithe, haddock and skrei. In the subsequent stages, the planning is more detailed and done at product family level; fillets, loins, tails, portions, block products and mince. These product families are further divided into different segments as the plan evolves: fresh, frozen, individually quick frozen (IQF), vacuum and skin-pack. The current product range consists of around 1150 SKUs.

**Meetings and collaboration**
Before deciding on an operating plan for the planning period, the central planner arrange meetings with several departments within the firm. These meetings are described below.

*Meeting with retailers:* In the outset of the planning process, the biggest retailers are invited to participate in the planning process where their planned campaigns are incorporated in the plans.

*Meeting with buying stations:* There are three weekly phone meetings between the central planner and representatives from each of the 13 buying stations. Here, they discuss current inventory levels of raw material and expectations of incoming raw material quantity in the next days. They also discuss some short-term plans and their current status.

*Meeting with plant managers:* This meeting is also held three times a week. Here, the central planner receives information from each facility regarding:

- Finished goods inventory level
- Expectations for production volumes (in pallets of which products)
- Expectations for raw material input
- Which customer contracts they aim at fulfilling with the planned production

The central planner provides the plant managers with instructions and guidelines for prioritized products and orders. Representatives from the sales department also attend these meetings.

*Meeting with sales:* Every Tuesday, the central planner hosts a meeting with the sales department and the white fish processing team. Here they discuss the raw material situation, and which products that should be pushed out to the market.

*Prioritizing meeting:* This weekly meeting involves the central planner, the white fish processing team manager and the managers from the different divisions (fresh, frozen, value-added products, and distribution). The purpose of the meeting is to decide on whether they should prioritize frozen or fresh production. They also discusses trends in the market and the current raw material situation. They decide on which product mix to run that yield the best prices. The meeting is also an arena for sharing information and knowledge to coordinate functions.

**Organization**

At LNS, the S&OP function is incorporated in the roles of the central planner and the white fish processing team. The central planner is responsible for production and procurement planning. The plans are distributed to the plants, where they are made into detailed plans and executed. To better align sales with operations, the white fish processing team serves as a link between the sales department and the central planner. Together, the team and the central planner attempt to integrate plans.

**Information technology**

*Microsoft Teams* is a communication application which is used to coordinate sales and operations at LNS. Here, contracts and prices are discussed between the central planner and the sales department. The central planner reviews requests from the sales team, discusses and decides if the price and volume are acceptable with the white fish processing team, and then communicates back and forth to agree on contracts.

*WhatsApp* is used by the central planner and the sales department for coordinating decisions and to discuss occurring issues.

*Microsoft Excel* is used for creating plans for production, procurement and internal transshipments.

*Maritech Seafood Software* is an enterprise resource planning (ERP) system used for finished products inventory management. Through Maritech, the central planner receives customer orders and have access to sales plans.

*PowerBI* is a data visualization tool which provides planners visual presentation of data. The tool gathers data from other systems (Excel, Maritech and Innova) and generates reports and dashboards. These are often used when communicating with customers, sales, production or other functions in the company.

**Planning objective and metrics**

The overall planning objective is to optimize production, procurement and sales. This is done through coordinating decisions between these functions, balancing supply and demand, as well as maximizing capacity utilization. Additionally, the planning attempts to achieve a network-wide optimization, taking advantage of the geographical dispersion of the organization. The metrics that measure the performance of the planning process are delivery rates and service levels. Another common metric for measuring planning performance is forecast accuracy (Ivert et al., 2015). However, this is not measured at the case company.

## Outcome

The outcome of the planning process is plan integration of procurement, production and sales. Additional outcomes from the planning process include:

- Plans for production volumes and production mixes
- Guidelines for the sales department
- Decisions on allocating raw materials and resources
- Decisions on laying off plants if incoming raw material quantity is not sufficient.

To conclude the analysis of the S&OP processes, it has been established that LNS uses a short planning horizon and a high planning frequency. Moreover, the planning object changes from specie to product family as the tactical planning process progresses. To achieve plan integration, the central planner and the white fish processing team

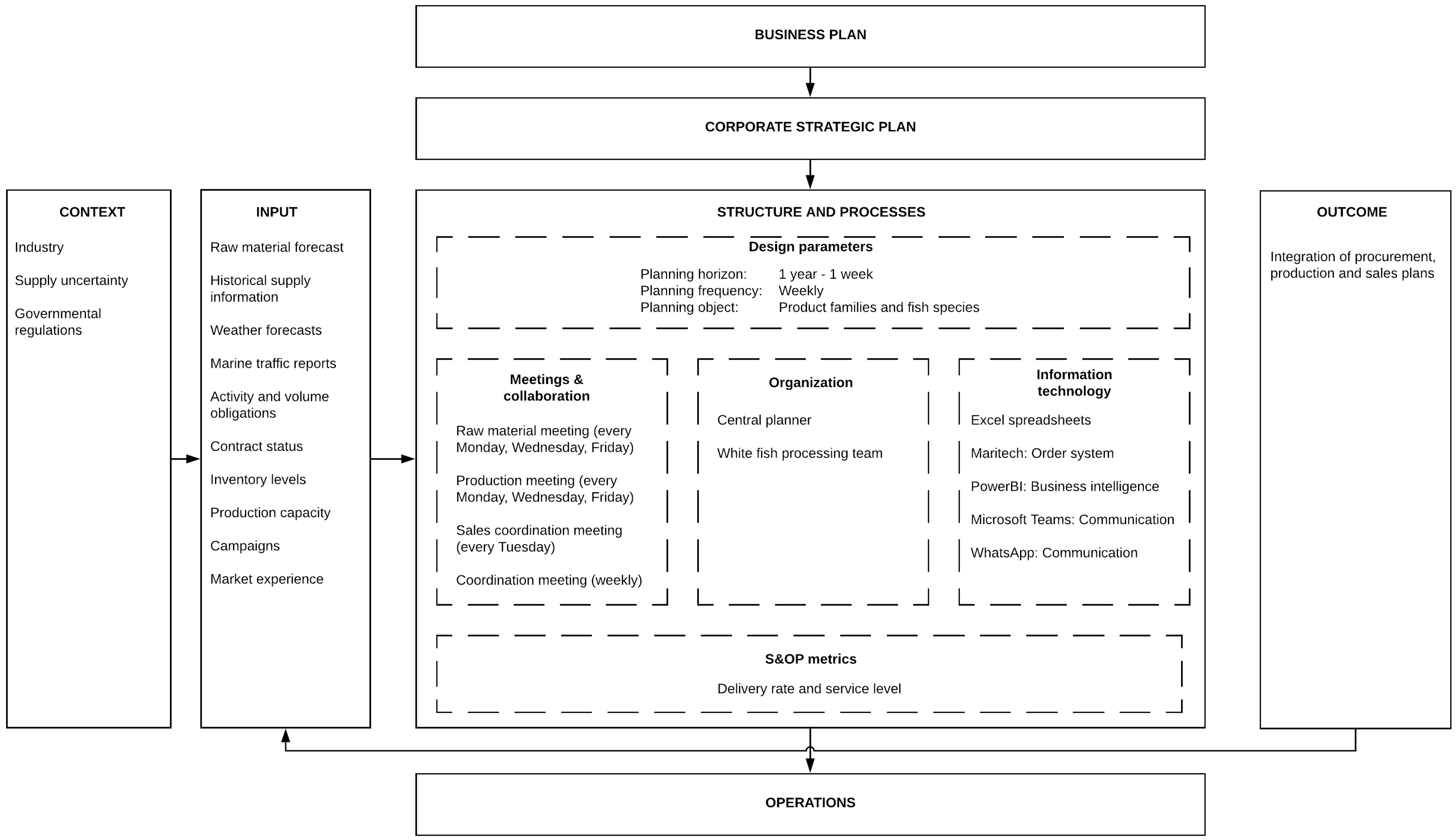


Figure 5.4: S&OP for LNS. Adopted from Thomé et al. (2012) and Ivert et al. (2015)

participate in several meetings to acquire input data and critical information from several departments. Inputs to the process consist of both external and internal data. External data include weather forecasts, marine traffic, governmental regulations and customer data. Internal data comprises inventory levels, capacity and contract status. Even though the planning seeks to balance supply and demand, there are limited measurements to ensure that the planning process contributes to this.

### 5.2.2 Maturity of the S&OP processes

As found by Flynn et al. (2016), uncertainty is inversely associated with supplier, internal and customer integration. S&OP seeks to balance supply and demand through integration of functions, both within and outside the firm (Noroozi & Wikner, 2017). Therefore, it was attempted to establish the integration maturity of the S&OP processes at LNS using the integrative framework by Grimson & Pyke (2007). To recap from the literature, the framework consists of five dimensions across five stages. Evaluating each S&OP process, one can determine in which maturity stage the processes are located. The analysis is shown in table 5.5, and the arguments for the processes' placements are presented below.

**Meetings and collaboration:** Meetings that are held in the activity of balancing supply and demand have a clear agenda, as mentioned in the previous sections. The meetings consist of sharing information, giving important inputs to the planning process. Sales plans from some retailers are also incorporated in the plans, hence this process can be evaluated as a 3-4 stage maturity process.

**Organization:** Presently, the S&OP function is part of other positions. As already presented, the central planner and the white fish processing team have S&OP activities incorporated in their positions. Together they attempt to coordinate supply and demand. Thereby, it is suggested that the organization process has a third stage maturity in terms of integration.

**Measurements:** As discussed in the analysis of the S&OP process, sales use delivery rate and service level as metrics. These measures suggest that there is a measure of how well operations meet the sales plan, and is defined as a second stage maturity.

**Information technology:** Procurement and production plans made in separate spreadsheets, but are consolidated through an Excel dashboard. The sales plan however must accessed through Maritech, which is done manually. Communication and sharing of information are done through several channels such as Microsoft Teams and WhatsApp. Optimization software is not used in the planning process. A dedicated software facilitating efficient and automatic information sharing is also non-existent. Therefore, the level of integration of the information technology process has to be positioned between the second and third stage.

**Plan integration:** Considering that the central planner is responsible for procurement, production and internal transshipment these plans are highly integrated. As discussed in the previous sections, meetings with sales, and the role of the white fish processing team result in some integration between sales and operations. Due to the sales department not being fully integrated, this process has to be categorized as stage 3.

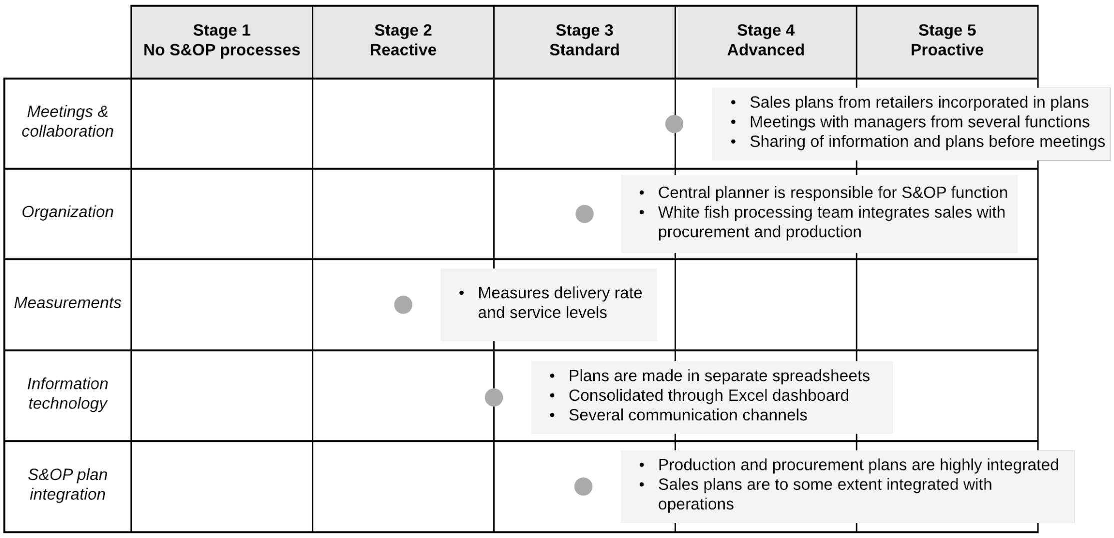


Figure 5.5: The level of integration of LNS's S&OP processes. Adapted from Grimson & Pyke (2007)

## 5.3 Supply uncertainties

Through interviews with the central planner at LNS, insight into uncertainties affecting SCP was acquired. In the following, each identified supply uncertainty (labelled with U1-U11, as further defined in table 5.2) will first be described in detail. It is put particular emphasis on formulating how each uncertainty can affect or is affecting the planning. Further, theory presented earlier is applied and it is attempted to classify each uncertainty into supply uncertainty sources as specified by van der Vorst & Beulens (2002) and Chaudhuri et al. (2014). Lastly, for each uncertainty, the probability and potential impact is evaluated which allows for a severity ranked list (see table 5.4).

Table 5.2: Supply uncertainties identified for LNS

| Label | Uncertainties identified for case company |
|---|---|
| *U1* | Poor raw material quality |
| *U2* | Lack of information from suppliers |
| *U3* | Suppliers fail to deliver contracted volume |
| *U4* | Inclement weather conditions |
| *U5* | Change in catch quotas |
| *U6* | Expensive raw material |
| *U7* | Fishers sell fish to competitors |
| *U8* | Fish migration |
| *U9* | Late delivery of catch (time) |
| *U10* | Raw material quality is not preserved by fishers |
| *U11* | Under/over estimation of raw material |

#### Poor raw material quality *(U1)*

The deterioration process of the fish starts immediately after it is caught, and factors such as temperature, size and fat content of the fish affect the deterioration rate (Hart & Reynolds, 2002). The quality of the fish is therefore a significant uncertainty for processors. Poor quality limits the range of possible end products and ultimately leads to lower sales prices.

#### Lack of information from suppliers *(U2)*

Information from suppliers mainly concerns information on the quantity, quality, size and specie of the catch. Getting this information in advance is crucial for production planning, as it to a large extent determines which end-products that can be produced. This again is used to coordinate sales and marketing. If this information is not available in advance, decisions in production must be delayed until the catch is delivered, which in turn delays decision further downstream.

**Suppliers fail to deliver contracted volume *(U3)***
One of LNS' most important supplier is Havfisk, who stands for approximately 30% (8 500 tonnes) of LNS raw material input over a year. Havfisk usually delivers during the start the of year (January, partly February) and after the high-season ends in June. Failing to deliver can have severe consequences for LNS. However, it is hard to hold Havfisk accountable for such a risk as the supplier is bounded by factors that it cannot affect (seasonality, governmental regulations, fish migration).

**Inclement weather conditions *(U4)***
Inclement weather conditions usually involves the formation of polar lows or other weather phenomena preventing fishers to go out on fishing trips. Polar lows typically form over the sea in polar areas and affect mostly the coastal fishing fleet which is vulnerable to strong winds and heavy rainfalls. Longer duration and higher frequencies of polar lows have higher impact on the fishing fleet. Forecasting weather conditions, and in particular polar lows, is usually a very difficult task. In extreme cases where fishing boats have to stay inactive over longer periods, LNS risks having insufficient volume of raw materials for planned production.

**Change in catch quotas *(U5)***
Catch quotas, given in weight and time period, is annually fixed. Reduction or increase in catch quotas means reduced or increased (respectively) raw material input for the case company. This has consequences for how much they are able to produce and ultimately sell to their customers. In 2018, the catch quota was reduced with 12% of that from 2017. In addition to affecting LNS' raw material volume it also affects the raw material price. Less volume implies higher purchase prices. The following year's quotas are announced in the end of the preceding year. Plans and customer contracts must therefore be reviewed and revised after the announcement.

**Expensive raw material *(U6)***
This uncertainty has been more present in 2018, given the reduction in catch quotas. LNS has knowingly purchased raw material above break-even to adhere to market contracts. In fact, if a buying station rejects too many sellers (i.e., fishermen), the sellers eventually establish relationships with other buyers who are offering them the price they want. Neatly put by the central planner: "with no raw material you have no opportunities, with expensive raw material you have at least the opportunity to put pressure on the market."

**Fishers sell fish to competitors *(U7)***

In accordance with the previous uncertainty; if fishermen establish relationships with other buyers (i.e., competitors), LNS risk losing access to raw material. Therefore, each of LNS' buying station must be price competitive and offer the fishing fleet fair prices for the landings. LNS and competitors do not only compete on price, but also on providing extra services and amenities.

**Fish migration *(U8)***

The majority of Norwegian-Atlantic cod is found in the Barents Sea. When the breeding time hits in December and January, the cod migrates to the Norwegian coast. The main spawning areas are Lofoten and Vesterålen, however, in recent years the fish has migrated further north. This generates longer lead times as fishing vessels have to make longer trips in order to reach the fish.

**Late delivery of catch (time) *(U9)***

If fishing vessels arrive too late at the facility, the case company may not be able to put the raw material into production before the next day. This has consequences for the quality since the deterioration rate of the fish is very high. For fresh production, every hour counts. In terms of planning, these situation can be mitigated with plans for flexible overtime production.

**Raw material quality is not preserved by fishers *(U10)***

As the raw material quality is contingent on the on-board handling, LNS carefully monitors the quality each vessel delivers. Fishing tools, methods and effort affect the quality of the fish caught by fishermen. Over time, LNS has become acquainted with fishers and their fishing methods, which provide them with indications on who is able to deliver what. Based on this knowledge they can control the source of raw material supply and pick and choose fishers who delivers the desired quantity, quality and specie. As mentioned earlier, the quality of the raw material determines which end-products that can be produced.

**Under/over estimation of raw material *(U11)***

Raw material forecasts are essentially never correct and are always over or under estimated. If LNS receives raw material over estimation, they could lack production capacity and consequently be forced to sell the raw material with a calculated loss. If LNS has too little raw material they risk failing to fulfill customer orders, or even incurring obligation to pay wages to workers even though there is no production. In addition, since the raw material forecast is the reference point for many subordinate plans, any inaccuracies usually require revision of these plans.

### 5.3.1 Categorizing supply uncertainties

**Inherent characteristics**

Inherent characteristics are concerned with the features of the product or the raw material that is handled. In this context, the raw material handled is the fish itself. Fish migration (U8) is therefore categorized as an inherent characteristic causing uncertainty since it is "built-in" the nature (Chaudhuri et al., 2014) of the fish to migrate. Poor raw material quality (U1) also falls into this category. The fish starts deteriorating as soon as it is reeled out of the water. In fact, fish is one of the most perishable foods, and the fish muscle tissues deteriorate faster than that of other animals (Hart & Reynolds, 2002). Although measures can be taken to delay the decay process (temperature control, careful handling, correct bleeding, etc.), the raw material quality is to a larger extent dependent on the inherent characteristics of the fish. Inclement weather conditions (U4) causing temporary halts in raw material input is also identified as an inherent characteristic. Although the weather itself is an external factor to the supply chain, the source of uncertainty is inherent because the fish availability is influenced by the weather.

**Supplier related uncertainties**

Supplier related uncertainties are regarded with the internal processes and the organizational aspects of the supplier. Poor raw material quality (U1) was in the previous paragraph denoted as an inherent characteristic uncertainty. However, poor raw material quality caused by suppliers is here distinguished as an uncertainty alone. As uncertainty related to raw material quality not being preserved by fishers (U10) is concerned with the internal processes of the fisher/supplier, it can therefore be categorized as a supplier related uncertainty. It is also concluded that late delivery of catch (U9) is a consequence of the fishers' own routines and processes, and hence is seen as a supplier related uncertainty. Chaudhuri et al. (2014) mentions that uncertainty in the supplier's capacity is also a supplier related uncertainty. This implies that failing to deliver contracted volume (U3) can be considered as a supplier related uncertainty. Lastly, fishers sell fish to competitors (U7) is also considered to be a supplier related uncertainty seeing that the decision on whom to sell the raw material wholly rests with the supplier itself.

**Supply chain related uncertainties**

In the case company's structural design of the supply chain, uncertainties occur. It is found that lack of information from suppliers (U2) induce uncertainty in SCP. The plans attain low accuracy, and decisions are delayed. Havfisk is vertically integrated with the case company and is therefore administered by the same general manager.

This indicates that the lack of information is caused by limitations in information systems (van der Vorst & Beulens, 2002). Another significant supply uncertainty is estimation of raw material. Under/over estimation of raw material (U11) can have several reasons, and thus be interpreted as originating from several different sources. This demonstrates the multidimensionality of uncertainties, described in chapter 4. Although creating forecasts is a difficult task for the planner, the uncertainty originates from the input to the estimation, which is derived from the supply chain environment. It is therefore argued that supply uncertainty U11 can be categorized as a supply chain related uncertainty.

**External uncertainties**

Recapping the categorization of sources of uncertainty from chapter 4, external uncertainties are those that originate outside the system and relate to changes in product, technology, market, competitors or governmental regulations. As such, change in catch quotas (U5) is here categorized as an external uncertainty since it is governed by external factors. The same reasoning applies for expensive raw material (U6), since the raw material pricing is to a large degree affected by changes in market conditions. Figure 5.6 categorizes and summarizes the supply uncertainties that have been identified in the above analysis.

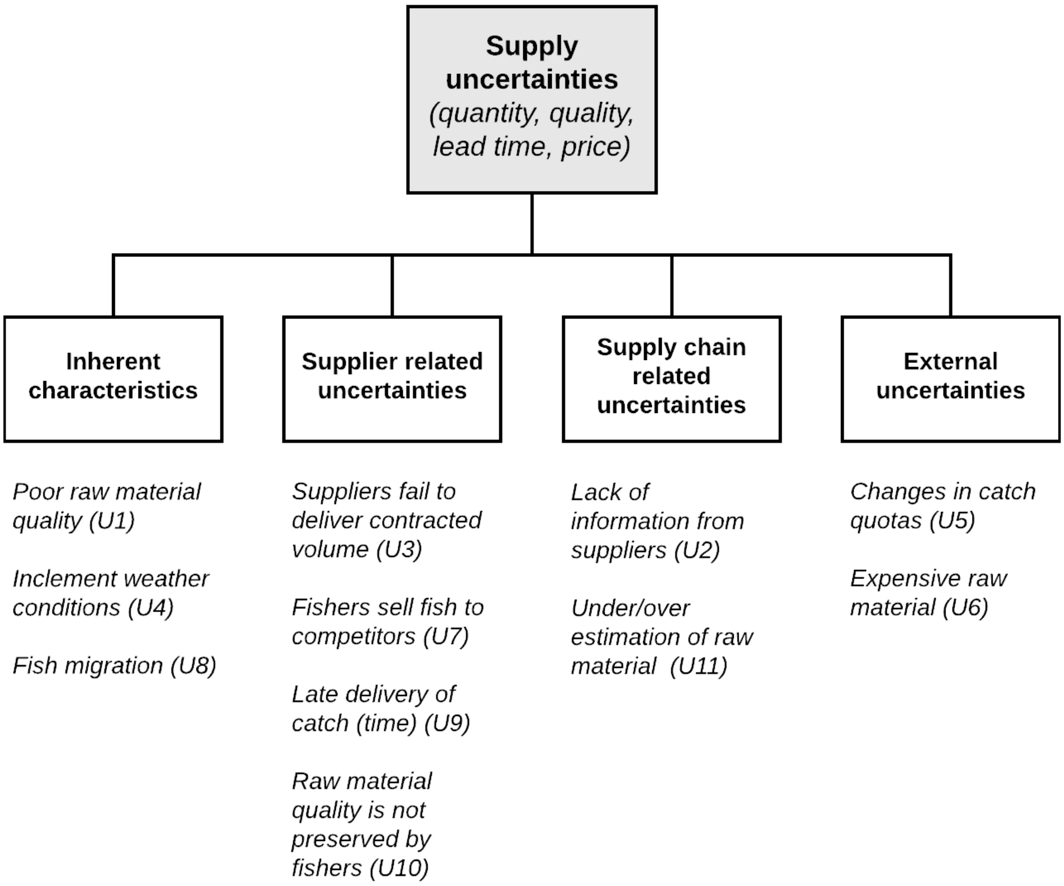


Figure 5.6: Categorization of the supply uncertainties identified for case company

Given this categorization, from here on the report will denote each identified uncertainty with their respective category. U1 therefore becomes $I$-U1, since it is categorized as an uncertainty caused by inherent characteristics. Further, $S$ represents supplier related uncertainties, $C$ represents supply chain related uncertainties, and $E$ external uncertainties. The complete new denotation is shown in the table below:

Table 5.3: Supply uncertainties identified for LNS

| Uncertainties identified for case company | Source | Label |
|---|---|---|
| Poor raw material quality | Inherent characteristics | *I-U1* |
| Inclement weather conditions | Inherent characteristics | *I-U4* |
| Fish migration | Inherent characteristics | *I-U8* |
| Suppliers fail to deliver contracted volume | Supplier related uncertainties | *S-U3* |
| Fishers sell fish to competitors | Supplier related uncertainties | *S-U7* |
| Late delivery of catch (time) | Supplier related uncertainties | *S-U9* |
| Raw material quality is not preserved by fishers | Supplier related uncertainties | *S-U10* |
| Lack of information from suppliers | Supply chain related uncertainties | *C-U2* |
| Under/over estimation of raw material | Supply chain related uncertainties | *C-U11* |
| Change in catch quotas | External uncertainties | *E-U5* |
| Expensive raw material | External uncertainties | *E-U6* |

### 5.3.2 Establishing severity

Establishing severity of supply uncertainties is an important step towards understanding how they affect planning. During the course of a workshop session with the central planner at the case company, the uncertainties presented in the above analysis were assessed. To grasp the seriousness of the uncertainties a scale from 1-5 (with intermediate evaluations) were used to specify the likelihood of occurrence and potential impact of the uncertainty (with respect to planning). The respective values were then multiplied to establish the severity. See appendix B for a description of the criteria for each score. By using a 1-5 scale, possible severity values ranged from 1 to 25. To further classify the supply uncertainties, three separate severity intervals were applied to arrange the uncertainties in different classes:

- *High*: >15
- *Medium*: 10-15
- *Low*: <10

The severity values argued for the development of a ranked list, see table 5.4. The table also indicates the severity-class of the uncertainties.

Table 5.4: Evaluation of supply uncertainties ranked by severity

| Class | Label | Supply uncertainties | Probability | Impact | Severity |
|---|---|---|---|---|---|
| High | *C-U11* | Under/over estimation of raw material | 5 | 4 | 20 |
| | *E-U5* | Changes in catch quotas | 4 | 4 | 16 |
| | *S-U7* | Fishers sell fish to competitors | 4 | 4 | 16 |
| Medium | *I-U4* | Inclement weather conditions | 4 | 3.5 | 14 |
| | *S-U9* | Late delivery of catch (time) | 4.5 | 3 | 13.5 |
| | *E-U6* | Expensive raw material | 3 | 4 | 12 |
| | *I-U8* | Fish migration | 4 | 3 | 12 |
| Low | *I-U1* | Poor raw material quality | 3 | 3 | 9 |
| | *C-U2* | Lack of information from suppliers | 2 | 4 | 8 |
| | *S-U3* | Suppliers fail to deliver contracted volume | 2 | 4 | 8 |
| | *S-U10* | Raw material quality is not preserved by fishers | 2.5 | 3 | 7.5 |

From the categorization of supply uncertainties and the severity ranked list, a number of interesting observations can be made. First and foremost, figure 5.6 shows that the majority of supply uncertainties are supplier related (4 out of 11). 1 out of the 4 uncertainties (*S-U7*) was of high severity. External uncertainties included 2 uncertainties (*E-U5* and *E-U6*), both with a severity score above 10, placing them in the high and medium classes. A supply chain related uncertainty, *under/over estimation of raw material* (C-U11), was found to be the single most severe uncertainty, with a score of 20. The forecast is contingent on a series of uncertain factors, but at the same time incorporated in many of the case company's plans (sales, production, procurement), so that if the estimation turns out to be inaccurate it will bring along critical consequences for the planning function. The second and last supply chain related uncertainty, *lack of information from suppliers* (C-U2), yielded a low severity score. Inherent characteristics are situated in the lower parts of the severity ranked list, and involved merely 2 uncertainties (*I-U8* and *I-U1*). Out of the two, *fish migration* (I-U8) was identified as the most severe. Another severity assessment is presented in table 5.5. It reveals that supplier related uncertainties and inherent characteristics have the highest total severity score with the sum of 45 and 35, respectively. However, looking at the average score for the sources of uncertainty, one may argue that reducing or coping with supply chain related and external uncertainties are more important as these both have an average score of 14.

Table 5.5: Sources of uncertainties

| Source | # of uncertainties | Sum | Average |
|---|---|---|---|
| Inherent characteristics | 3 | 35 | 11.67 |
| Supplier related uncertainty | 4 | 45 | 11.25 |
| Supply chain related uncertainty | 2 | 28 | 14.00 |
| External uncertainty | 2 | 28 | 14.00 |

## 5.4 Analyzing framework application

The two preceding sections have mapped the tactical SCP process of the case company and identified and categorized supply uncertainties that affect the SCP process. These results therefore represent phase 1 and 2 in the analyzing framework. The focus is now shifted to phase 3 and 4, which will see the completion of the framework application. Phase 3 is concerned with determining the consequence of uncertainties, and phase 4 analyzes which planning activities and decisions that are triggered by the consequence, and which planning inputs that are affected. By carrying out all four phases, it will be established the impact of supply uncertainties on the tactical SCP process. This is done in the following. The findings are summarized in table 5.6.

### Results

**Inherent characteristics**

Poor raw material quality (I-U1) is caused by the inherent perishability of the fish biology and causes uncertainty in raw material quality. Low raw material quality leads to low quality end-products, which implies a lower sales price than if the raw material quality was high. In addition to negatively affecting the sales price, the low quality products make LNS unable to fulfill certain orders. To handle this uncertainty, LNS makes changes to the product mix, as well as updating sales plans.

Fish migration (I-U8) is hard to predict and jeopardizes the availability of fish if it migrates differently than expected. The same applies for inclement weather conditions (I-U4). Polar lows can cause harsh weather seemingly out of nowhere, making it impossible for boats to go on fishing trips. In other words, the processor risks having no available raw material for shorter periods which heavily affects the fresh production plans. Important inputs to planning in events of these uncertainties are weather forecasts and plans for procurement, internal distribution and sales. Planning activities that are necessary include personnel planning to coordinate capacity with incoming raw materials, transshipments between plants and updating of sales and procurement plans.

**Supplier related uncertainty**

Out of the four sources of supply uncertainty it was found that supplier related uncertainties had the highest sum of severity. The common features of the identified supplier related uncertainties are that they entail some degree of poor coordination between the fishers and the processor (i.e., the case company), and result in variability in quality and availability of raw materials. Late delivery of catch (S-U9) has consequences for the processor. Quality deterioration of the fish, and delays in production lead to sudden changes of product mix which can negatively affect the profitability.

Fishers not preserving the raw material (S-U10), can be explained as misalignment of goals between the fishers and the processor. Raw material quality of the fish is dependent on catching methods and technology used by the fishers. Receiving poor quality catches limits the processors ability to fulfill customer orders, as well as lower quality products result in lower sales prices. LNS responds to this uncertainty by replacing suppliers if they repetitively fail to deliver high quality catches. If competitors can offer better prices, LNS can risk not receiving raw materials (S-U7). A consequence of having insufficient raw materials is that LNS' can fail to deliver according to contracts. For both this uncertainty and suppliers failing to deliver contracted volume (S-U3), finding alternative supply and internal transshipments are used to coping with these uncertainties.

**Supply chain related uncertainty**

The supply chain related uncertainties are primarily concerned with information aspects; lack of information from suppliers (C-U2) and under/over estimation of raw material (C-U11). The consequence from supply chain uncertainty is low accuracy in plans, making it necessary to have frequent plan revisions. In addition, the central planning function has to make decisions on whether to temporarily lay off workers to balance capacity to raw material input. Moreover, in cases where the raw material price exceed the break-even, customer contracts have to be renegotiated. The input plans that are revised concern procurement, production, internal distribution and sales.

**External uncertainty**

Changes in catch quotas (E-U5) and expensive raw material (E-U6) are uncontrollable supply uncertainties that create problems for the planning process. Changes in quotas occur annually, but the significance of the change is always to some extent uncertain. As the quotas affect the raw material price, the consequence is often that the processor enters customer contracts with a low sales price, potentially missing out on higher sales price if the actual raw material market price turns out to be higher. In situations where raw material prices exceed the break even price (E-U6), the case company may be forced into temporary production stops and/or lay-offs which affects the ability to fulfill customer orders. In events of these uncertainties, important planning decisions have to be made. When the quotas are released, the raw material plan is updated, if the change significantly deviates from the forecast, customer contracts have to be renegotiated. In order to cope with uncertainty from expensive raw material prices, decisions have to be made on whether to stop production or to produce with loss. Production with loss can be chosen in cases where there are contracts that require LNS to compensate customers. The inputs that are necessary for the planning activities and decisions are raw material, procurement, production and sales plans.

Table 5.6: Application of analyzing framework

| Phase 2 | | Phase 3 | Phase 4 | |
|---|---|---|---|---|
| **Source of uncertainty** | **Uncertainty** | **Consequence** | **Planning decisions and activities** | **Planning inputs** |
| *Inherent characteristics* | Poor raw material quality (I-U1) | Unable to fulfill certain customer orders<br>Lower sales price | Change product mix<br>Update sales plan | Production plan<br>Sales plan |
| | Inclement weather conditions (I-U4) | Unavailable supply<br>Increased production costs due to transshipment<br>Unable to fulfill customer orders | Internal transshipment planning<br>Personnel planning | Weather forecasts<br>Internal distribution plan<br>Procurement plan<br>Sales plan |
| | Fish migration (I-U8) | Longer lead times<br>Quality deterioration<br>Increased production costs due to transshipment | Planning of internal transshipment<br>Change input plans | Procurement plan<br>Internal distribution plan |
| *Supplier related* | Suppliers fail to deliver contracted volume (S-U3) | Unable to fulfill customer orders | Find alternative supply<br>Adjust production to available raw materials | Procurement plan<br>Production plan<br>Sales plan |
| | Fishers sell fish to competitors (S-U7) | Lack of raw materials for production<br>Unable to fulfill customer contracts | Planning of internal transshipment<br>Find alternative supply | Procurement plan<br>Internal distribution plan |
| | Late delivery of catch (time) (S-U9) | Delayed production<br>Quality deterioration<br>Lower sales price | Adjust production to available raw material<br>Change product mix | Production plan<br>Sales plan |
| | Raw material quality is not preserved by fishers (S-U10) | Unable to fulfill certain customer orders<br>Lower sales price | Change portfolio of suppliers<br>Change product mix | Supplier ratings<br>Procurement plan<br>Production plan |
| *Supply chain related* | Lack of information from suppliers (C-U2) | Low accuracy in plans | Adjust supply-demand balance | Procurement plan<br>Production plan<br>Sales plan |
| | Under/over estimation of raw material (C-U11) | Price fluctuations<br>Overproduction<br>Excessive production capacity<br>Selling with loss<br>Salary to workers without production<br>Unable to fulfill customer orders | Update raw material plan<br>Renegotiation of customer contracts<br>Decisions on sales price<br>Personnel planning<br>Change product mix | Raw material plan<br>Procurement plan<br>Production plan<br>Sales plan |
| *External* | Changes in catch quotas (E-U5) | Customer contracts with too low sales price<br>Produce with loss<br>Compensation to customer | Renegotiation of contracts<br>Deciding on new contracts<br>Updating raw material plan | Raw material plan<br>Procurement plan<br>Sales plan |
| | Expensive raw material (E-U6) | Unable to fulfill customer orders<br>Produce with loss<br>Compensation to customers | Change product mix<br>Loss vs compensation decision<br>Personnel planning | Production plan<br>Procurement plan<br>Sales plan |

# Chapter 6

# Discussion

This chapter seeks to provide the explanation and interpretation of the findings from the analysis. In order to explain and interpret the findings it is necessary to revisit the report's research questions. This chapter will first discuss RQ1 before addressing RQ2.

## 6.1 RQ 1: The impact of supply uncertainty

**RQ1:** *How does supply uncertainty impact tactical supply chain planning?*

The analysis identified 11 supply uncertainties that impacted the tactical planning process at the case company. The uncertainties were assessed by their severity and further classified into high, medium or low severity. The classification showed that three uncertainties were of high severity, while both the medium and low class included four uncertainties each. As many of the uncertainties are related to inherent features of the fish and governmental regulations, there are reasons to believe that these uncertainties also impact the planning process at other Norwegian white fish processors as well. However, considering that uncertainties can be treated differently in other planning processes, the ranking found here could differ significantly from that of other company's planning process.

By applying theory from van der Vorst & Beulens (2002) and Chaudhuri et al. (2014), the uncertainties were categorized under inherent characteristics, supplier related, supply chain related and external. It was found that supplier related uncertainties represented the largest category with four out of eleven uncertainties. Inherent characteristics resulted in three uncertainties, and both external and supply chain related included two uncertainties each. Determining which source of uncertainty that impacts tactical planning the most can either be done by comparing the sum of each category's severity score, or by taking the average of the severity scores for each category. Examining the current situation at the processor, it is concluded that using the sum of severity is a better measure as it ultimately value the number of uncertainties, and not only the severity of the source. Based on these arguments, the level of impact the different sources of uncertainty have on the tactical planning process can be ranked as: (1) supplier related, (2) inherent characteristics, (3) external and supply chain related with an even score.

Uncertainties appear as variability in supply quantity, supply quality, supply cost and supply lead times, supporting the findings in Chaudhuri et al. (2014). Examples of these variations are: fishers selling to competitors (S-U7), poor raw material quality (I-U1), expensive raw material (E-U6) and late delivery of catches (S-U9). These variations have impact on supply chain performance, where typical consequences were found to be lower sales prices, increased production costs and impaired ability to fulfill customer contracts. Mason-Jones & Towill (1998) states that companies that cope with uncertainty achieve better bottom-line performances. The tactical planning process at the case company absorbs uncertainty, and the mitigation of uncertainty is mostly dealt with through planning activities and decisions.

Similar to one of the fish case studies in Ivert et al. (2015), a characteristic of the planning function is rapid corrective actions in the event of uncertainty. Supply uncertainty initiate the need for having frequent meetings in order to continuously update plans, as well as coordinating the different functions within the company. Okongwu et al. (2016) argue that different products require different planning horizons, and the case company is using a planning horizon covering one week to one year, which is shorter than suggested by Gupta & Maranas (2003) and Fleischmann et al. (2015). This is believed to be a result of low forecast accuracy which was considered to be the most severe uncertainty (C-U11). Instead of measuring the forecast errors over the planning horizon and making adjustments (Graves, 2011), the case company postpones decisions until the impact of uncertainties occur.

Concluding the discussion of RQ1, it is important to mention that there seems to be little focus on the tactical planning on fresh products at the case company. Due to the perishability and supply uncertainties, the case company are often compelled to approach planning of fresh fish with a more operational perspective. However, it is possible to reduce or cope with supply uncertainty through a more structured tactical SCP, such as S&OP. For example with proper measurements and IT solutions, the tactical process can be more resilient to supply uncertainty. This will be discussed in the following section.

## 6.2 RQ 2: Designing the tactical SCP process

Through answering research question 1, it has been established the intersection of supply uncertainties and SCP. The necessary empirical and theoretical insight into the tactical SCP process and uncertainties have been obtained, and the next step is therefore to propose a design of the SCP process for the case company which can mitigate supply uncertainty. That means answering this report's second and last RQ: *How can the tactical supply chain planning process be designed to mitigate the impact of supply uncertainties?*

The deficiencies in the current planning process of the case company will be used as a starting point for the proposal. Here, the assessed integration maturity of the S&OP process will give some indications of deficiencies. The proposed design is developed through two steps. Firstly, through revisiting some central concepts from the literature review (table 4.4), it will be discussed supply chain planning strategies or measures for mitigating uncertainty. Subsequently, it will be described how these planning strategies can be incorporated into the design of the tactical SCP process. In other words, how can the structure and processes of the planning process be tailored to align with these strategies.

### 6.2.1 Planning strategies

In accordance with Simangunsong et al. (2012), it is here distinguished between two categories of uncertainty mitigation strategies:

- **Reducing uncertainty strategies:** measures taken to reduce uncertainty at its source.
- **Coping with uncertainty strategies:** measures taken which do not directly influence uncertainty, but aim at reducing the potential impact of uncertainty.

As found in the literature review, categories of uncertainties serve well as precursors for developing appropriate strategies. In the following it is therefore argued that the four categories of supply uncertainty that have been identified can be assigned to either reducing strategies or coping strategies.

### Reducing uncertainty

Uncertainties that are supplier related or supply chain related can be reduced. This argument is based on the notion that these sources are controllable insofar as companies can influence the structure of the supply chain and can choose their own suppliers. When there is variability in supply quantity and quality, it may be beneficial to involve suppliers in the planning process (Yurt et al., 2010; Dreyer et al., 2018). The supplier related uncertainties often cause these variations, and an uncertainty reducing strategy is therefore to integrate suppliers in the planning process. By doing so, the uncertainties of fishers selling to competitors (S-U7), late delivery of catch (S-U9) and raw material quality not preserved by fishers (S-U10) may be reduced at its source. However, in order to integrate suppliers, incentives and supplier development programs are needed, because all participants should benefit from it (Esteso et al., 2017).

Lack of information from suppliers (C-U2) that cause uncertainty can be reduced by implementing IT solutions that allows for a better sharing of information (van der Vorst & Beulens, 2002). Moreover, lack of information can also occur due to low integration and coordination between the functions both within and outside the firm. In addition to being a necessity for achieving supply-demand balance (Noroozi & Wikner, 2017), coordination facilitates sharing of knowledge and information. Currently, LNS is running a pilot project with an app that aims at improving the process of raw material delivery and facilitating sharing of information between coastal vessels and processors. Through the app, fishers can register the volume of their catch, providing the plants with important information prior to the landing of the catch. This ultimately gives planners the ability to optimize operational production planning but also to make earlier decisions regarding market contracts. Christopher & Peck (2004) and Jüttner et al. (2003) both suggest that sharing information increases the visibility of the supply chain, which normally is obscured or distorted by the presence of uncertainty. Although the app seems useful for operational planning, there is still a lack of focus on the tactical planning process. Acquiring more long-term information from the suppliers (e.g., planned fishing trips, planned equipment investments, on-board handling procedures) through the app could increase the accuracy of tactical plans and enhance the S&OP plan integration.

Additionally, the app allows fishing vessels to receive a reservation at the harbor and the estimated queue time. As discussed earlier, offering extra services is an important step in reducing uncertainty S-U7.

### Coping with uncertainty

Although the impact of supply uncertainties on SCP cannot be completely eliminated, there exist a number of useful approaches, or coping strategies, that can be taken to decrease the impact. It is argued that uncertainties that are external or related to inherent characteristics cannot be reduced, but only coped with. The argument here is that these uncertainties originate from outside factors which cannot be directly influenced by companies. Change in catch quotas (E-U5) and expensive raw material (E-U6) are two external uncertainties that lie beyond processors' ability to affect.

One of the more common measures to lessening the impact of uncertainty is forecasting (Simangunsong et al., 2012). The use of advanced forecasting techniques is an example of a coping strategy in planning which helps dealing with uncertainty related to raw material input. Such techniques can increase forecast accuracy and reduce the potential impact, but they do not reduce the level of raw material input uncertainty. Advanced forecasting techniques do however require rich and up-to-date information from the supply side, and are as such dependent on a novel IT system that can provide this. To date, the IT system of the case company has limited ability to provide such information. Supply-side analytics detecting external mechanisms such as changes in quotas, governmental regulations and market prices can therefore be implemented to increase the tactical planning accuracy.

Dreyer & Grønhaug (2012) regard flexibility as an uncertainty coping strategy, and Esmaeilikia et al. (2016) suggest that SCP flexibility becomes particular relevant in planning environments with higher levels of uncertainty. A way of incorporating flexibility in planning is adopting an event-driven planning process (Fleischmann et al., 2015). As found in the literature review, this is an advantageous technique in planning environments with uncertainty since it forces functions to be well coordinated. A severe uncertainty was found to be inclement weather conditions (I-U4). The risk here is that the fishers are unable to go on fishing trips, potentially causing a production stop at the processor. In a situation like this, flexibility seems essential and addresses the processors ability to act on sudden changes in the planning environment. A tactic used by the company to cope with this kind of uncertainty is to exploit the geographic dispersion of their production network. With plants placed along large parts of the Norwegian coast they are safeguarded against complete stop in raw material input. If northern areas are hit by heavy weather, raw material transshipment from southern plants can be made, or vice versa. This puts the company in a better position to also cope with sudden changes in fish migration pattern (I-U8). This example accentuates the value of an event-driven planning process (Fleischmann et al., 2015).

### 6.2.2 Designing the tactical planning process

With the intrinsic focus on integration, coordination and information sharing, as well as concerning the whole supply chain from suppliers to customers, S&OP is suggested as a starting point for the design of the tactical SCP process. As it was presented in the literature review, Jacobs et al. (2011) explain that S&OP comprises a five stage process. However, as proposed by Ivert et al. (2015), food producers should not implement the process according to the literature, but adapt the processes to the planning environment. Considering the maturity stages from Grimson & Pyke (2007), as well as incorporating uncertainty reducing and coping strategies as suggested in the previous section, the tactical planning design tailored to the case company's planning environment will in the following be suggested. The design is described by the five elements of a S&OP process and structure (Ivert et al., 2015).

**Design variables**

Design variables dictate the set-up of the S&OP process. Ivert et al. (2015) argue that industrial food producers subject to supply variation and perishability should consider high planning frequency, shorter planning horizon and planning for SKUs. The findings from the case study analysis show that some of these design variables are already in place. High planning frequency and shorter planning horizons facilitate supply-demand balance, in particular for fresh fish, and maximize raw material utilization. This also increases flexibility, which is regarded as a central strategy for coping with uncertainty (Jüttner et al., 2003; Christopher, 2011; Dreyer & Grønhaug, 2012).

**Meetings & collaboration**

In order to achieve a balance of supply chain and demand it is essential to integrate people from different areas, both within and outside the company (Noroozi & Wikner, 2017). LNS has already addressed the importance of including retailers in the planning process to reduce demand uncertainty caused by for instance campaigns. However, as previously mentioned, it may be beneficial to include suppliers in the planning process (Dreyer et al., 2018) to reduce supply uncertainty. In the case study analysis it was found that supplier related uncertainties constituted the most severe source to uncertainty. This stresses the need to integrate suppliers in planning. In that lies the interest of suppliers participating in S&OP meetings. Today, the central planner arranges separate meetings with key persons and functions within the company. However, this can lead to distortion of information when recast to customers, suppliers and to functions within the firm. Dedicated S&OP meetings where all functions (both external and internal) that affect the planning process are involved can increase the integration and coordination of the supply chain.

Additionally, to address the dynamic nature of fresh fish products event-driven S&OP meetings can be beneficial. Event-driven meetings supersede scheduled meetings, and are carried out when a supply-demand imbalance is detected (Yurt et al., 2010). In other words, event-driven planning allows the supply and demand to be balanced in real-time.

**Metrics**

Both Jacobs et al. (2011) and Grimson & Pyke (2007) emphasize the importance of measuring the performance of the planning process. In the case study analysis there were shown no clear signs of specific measurements for the planning process except deadlines. The sales department is however measuring the service level to customers. Measurement is essential for both implementation and for continuous improvement, and should be as specific as possible, clear and assigned to a person who will be accountable for the results (Grimson & Pyke, 2007). Considering the large extent to which the raw material plan dictates decisions and subsequent plans and the high severity score of uncertainty C-U11, there is a clear need to ensure that the plan is of highest possible accuracy. Yurt et al. (2010) argue that a sophisticated S&OP process measures forecast accuracy on a regular basis and takes targeted action. Measuring the forecast accuracy in the raw material plan and taking targeted actions is therefore suggested, since it can improve the quality and accuracy of all subordinate plans. Additionally, planning related metrics should be linked with critical business measurements to ensure sufficient alignment.

As already underlined, supplier integration in the S&OP process is necessary to reduce supplier related uncertainties. Suppliers should therefore also be asked to partake in S&OP evaluation, to enhance alignment.

**Organization**

Today, the case company does not have a formal S&OP team nor a sophisticated S&OP process, but elements and tasks are incorporated in other roles. The white fish processing team and the central planner undertakes the primary tasks of coordinating sales and operations with financial goals in mind. In an ideal planning structure, every member understands and is fully aware of the role that S&OP initiatives play in company success (Grimson & Pyke, 2007). By building a formal S&OP team where central functions are represented, the transparency of the planning process can be increased and uncertainties can be better dealt with.

**Information technology**

From the analysis it was found that the case company's planning process produces many disparate spreadsheets, and the maturity of IT systems were placed between the second and third stage (Grimson & Pyke, 2007). An ideal S&OP process has aligned supply and demand plans that are developed with an S&OP workbench (Grimson & Pyke, 2007). Such a process also calls for an IT system which is capable of shifting its plans according to real-time information (Yurt et al., 2010). Using a S&OP workbench, data is available and can efficiently be extracted from all team members (van der Vorst & Beulens, 2002). As event-driven planning requires continuous information availability, a S&OP workbench can be of high relevance and significance to the planning process in order to mitigate uncertainty. As already presented, analytical tools should also be included in the company's planning design to capture external trends that affect the S&OP process.

It is already established that there is a need for sufficient measurements of forecast accuracy when raw material availability is uncertain. In addition to measurements, there is also a need for using novel forecasting software or techniques, to increase the accuracy itself. It is argued that measurement systems and forecasting software in combination can give planners increased ability to mitigate supply uncertainty.

From the discussion above, it has been proposed how the tactical SCP process can be designed to mitigate the impact of supply uncertainty. The list below highlights the essential elements in the proposal:

- Establish a formal S&OP team
- Integrate suppliers in the planning process
- Event-driven S&OP meetings
- Implement S&OP workbench
- More and better measurements of the planning process (e.g., forecast accuracy)
- Invest in IT systems and analytics to facilitate information availability

# Chapter 7

# Conclusion

This thesis has investigated how supply uncertainty affects tactical SCP processes. From a systematic literature review, S&OP was found to be an appropriate framework for describing the tactical SCP process. Moreover, supply uncertainties were categorized as inherent characteristics, external, supplier related and supply chain related. Building on the literature, a four-phase framework for establishing the impact of supply uncertainty on tactical planning processes was proposed and applied in a single case study of a Norwegian white fish processor.

Through the case study, 11 supply uncertainties were identified, and under/over estimation of incoming raw material was found to be the most severe supply uncertainty. In addition, supplier related uncertainty was found to be the most severe category. The findings suggest that there are four types of supply uncertainty: variations in quality, quantity, lead time and price. These variations have impact on the planning process, and typical symptoms were found to be lower sales prices, increased production costs and impaired ability to fulfill customer contracts. In order to cope with these variations, the tactical SCP process of the case company incorporated a short planning horizon, frequent meetings, and continuous revisions and coordination of plans. Important findings also include the lack of advanced information technology systems which can facilitate information sharing and coordination. It was also found that a majority of the case company's plans were to some extent contingent on an annual raw material plan which anticipated a whole year's raw material availability. However, the case company did not use advanced forecasting methods (or IT tools) nor supply chain analytics to ensure sufficient accuracy in the raw material plan, causing subordinate plans to be uncertain.

The thesis also suggests how tactical planning processes could be designed to mitigate supply uncertainty. Through a discussion, it was concluded that a mature S&OP

process helps in reducing and coping with supply uncertainty. The design suggests integrating suppliers in planning to reduce supplier related uncertainties. It also emphasizes the need for an increased focus on information availability, mainly through more sophisticated IT systems and supply chain analytics, which can play an important role in reducing uncertainty related to accuracy of forecasts and plans. A limitation of the study is that the results cannot be generalized. Still, inherent characteristics and external uncertainties are believed to apply for all Norwegian white fish processors. However, the level of impact on planning might differ, depending on the planning process.

As this thesis has taken a qualitative approach to investigate the tactical planning process at a Norwegian white fish processor, it is highly suggested that the findings should be validated through quantitative analysis. One of the key findings showed that the case company's tactical planning process was based on a raw material forecast that is highly uncertain. As uncertainty propagates through the supply chain, further research should consider the development of a forecast model or method increasing the forecast accuracy. It is important to account for external mechanisms such as catch quotas and fleet structure, and historical supply information.

This thesis has covered how a tactical planning process can be designed to mitigate uncertainty. However, the planning often require more advanced decision support, and most production planning models from a white fish processors perspective is concerned with the operational (short-term) planning. Further work should consider creating a tactical production planning model that incorporates the identified uncertainties as well as accounting for the network of specialized plants.

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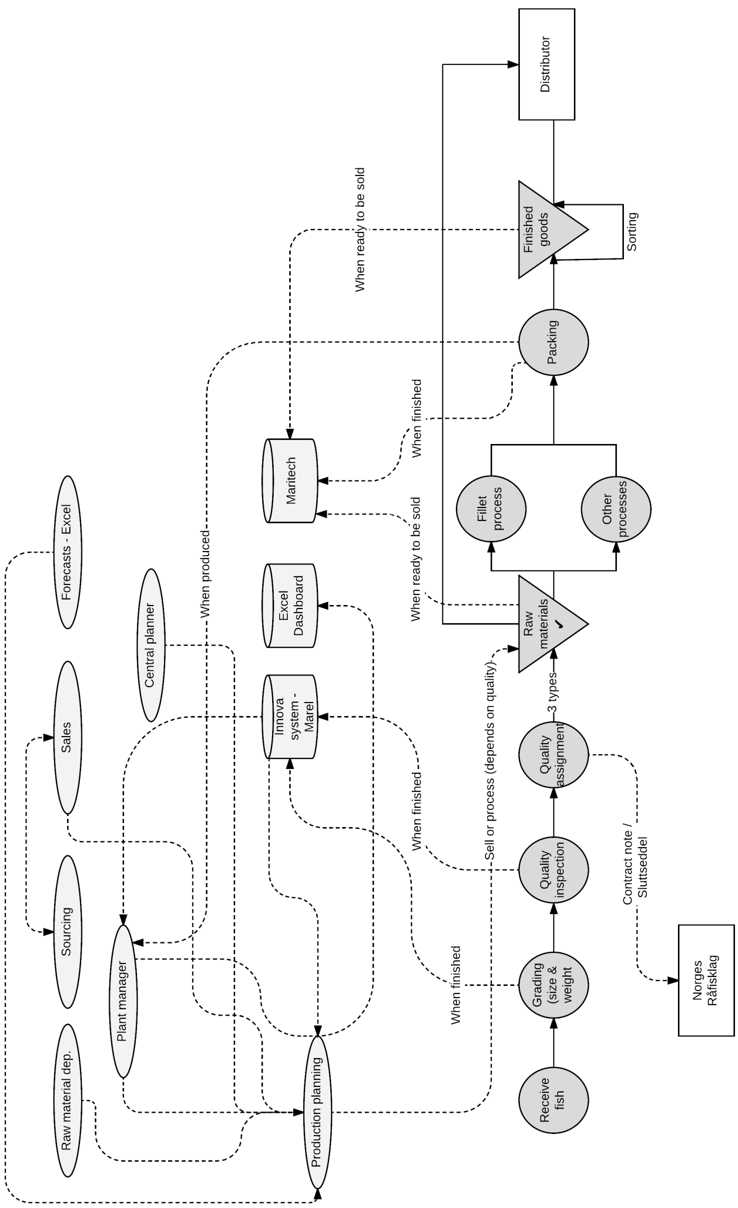
# Appendix A

# Lerøy Norway Seafood's value chain



# Appendix B

# Supply uncertainty ranking criteria

| Measure | Rating | Description | QM |
|---|---|---|---|
| **Probability** | Very low | Uncertainty that is extremely rare | 1 |
| | Low | Uncertainty that is rare, but has a little chance of manifesting itself | 2 |
| | Medium | Typical uncertainty that has a 50/50 chance of occurring | 3 |
| | High | Uncertainty that most likely occurs | 4 |
| | Very high | Uncertainty that is almost guaranteed to manifest itself | 5 |
| **Impact** | Very low | Uncertainty that does not have any genuine consequences on planning | 1 |
| | Low | Uncertainty that has a potential to cause negative consequences, but has little impact on planning | 2 |
| | Moderate | Uncertainty that have negative consequences as well as having a moderate impact on planning | 3 |
| | Serious | Uncertainty that cause significantly negative impacts on planning | 4 |
| | Very serious | Uncertainty with catastrophic consequences and has a destructive impact on planning | 5 |