Managing misalignments in complex production flows:

A way to integrate shared interfaces by adjusting infrastructural decision areas

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Abstract

Acceleration of technological development has resulted in increased customer requirements. Momentarily customer demand fluctuates that creates uncertainties, which puts pressure on manufacturing companies to respond and incorporate this into the manufacturing strategy to stay competitive. Additionally, manufacturing companies experience complexities with non-linear production flows that share interfaces. Research in manufacturing strategy is more focused on traditional linear production structures and flows. Thus, the objective of this thesis to analyze integration of shared interfaces between non-linear production flows.

Empirical research was conducted in form of a single case study at a production facility of a manufacturing company, to fulfill the thesis objective. The ambition of the case company is to improve the handling of semi-finished products to achieve an increased efficiency. Interviews, observations, analysis in product profiling by Hill et al. (1998) have resulted in that infrastructural misalignments are considered as major aspects affecting integration of shared interfaces. Further, issues regarding the management of infrastructural aspects are found through in-depth interviews, workshop and analysis. Adjustments to these issues have to be considered to achieve an efficient integration of shared interfaces between production flows.

This thesis contributes within the area of manufacturing strategy and infrastructural decision areas. A contribution within this area is the extension of the product profiling framework usage with a comparative analysis of production flows with the considered dimension of shared interfaces. The comparative analysis showed that there were misalignments between aspects that were shared interfaces in the complex production flows. Furthermore, integration of shared interfaces is seen as a way for manufacturing companies to decrease production complexity and increase responsiveness to respond to market requirements.

Keywords: manufacturing strategy, decision areas, product profiling, complex production systems

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Sammanfattning

En ökad takt av teknisk utveckling har lett till ökade kundkrav. Samtidigt förändras kundernas efterfrågan kontinuerligt, och skapar en osäkerhet. Detta ställer krav på tillverkande företag att reagera och anpassa sin tillverkningsstrategi efter osäkerheter, för att behålla konkurrenskraft. Dessutom kan tillverkande företag uppleva en komplexitet med icke-linjära produktionsflöden som delar gränssnitt. Tidigare forskning inom tillverkningsstrategi är mer fokuserad på traditionella linjära produktionsstrukturer och flöden. Följaktligen är syftet med denna studie är att analysera integrationen av delade gränssnitt mellan icke-traditionella produktionsflöden.

För att uppnå syftet har en empirisk studie i form av en fallstudie utförts. Fallstudien innefattade en produktionsanläggning i ett tillverkande företag. Det tillverkande företagets ambition var att förbättra hanteringen av halvfabrikatsprodukter för att uppnå en ökad effektivitet. Intervjuer, observationer och analys genom produktprofilering av Hill et al. (1998) har resulterat i att avvikelser inom de infrastrukturella aspekterna påvisats som de aspekter som påverkar en integrationen av de delade gränssnitten. Vidare har djupintervjuer, workshop och analys resulterat i påvisade problem i hanteringen av de infrastrukturella aspekterna. Justeringar av dessa problem behöver övervägas för att uppnå en effektiv integration av delade gränssnitt mellan produktionsflöden.

Denna studie bidrar inom området tillverkningsstrategi och beslutsområdet infrastruktur. Ett bidrag inom detta område är en förlängning av användningsområdet av produktprofilering-ramverket genom en jämförande analys av produktionsflöden, med den ytterligare dimensionen av delade gränssnitt. Den jämförande analysen påvisar skillnader mellan de aspekter som är delade gränssnitt i de komplexa produktionsflödena. Denna studie bidrar därför till forskning i tillverkningsstrategi av icke-traditionella produktionsflöden. Dessutom ses integrationen av delade gränssnitt som ett sätt för tillverkande företag att minska komplexiteten i produktionen och öka lyhördheten att möta marknadens krav.

Nyckelord: manufacturing strategy, decision areas, product profiling, complex production systems

Foreword

This report was conducted as a Master thesis at the department of Industrial Economics and Management at the Royal Institute of Technology in Stockholm, Sweden. The thesis was designed as a 30 credits course and was conducted from January to June 2015.

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Stockholm, Sweden
June, 2015

Josephine Are & Robin Bhola

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1. Introduction

The chapter provides a brief background and presents the problem formulation and objective of this thesis. Furthermore, it presents the research questions and delimitations, as well as the outline of the thesis.

This thesis aims to investigate management of misalignments in complex production flows, to support an integration of shared interfaces within production systems.

The technological development has accelerated during the last decades, which has resulted in technological shifts occurring in a faster pace compared to earlier. This has led to increased pressure on companies to adapt to this change and respond properly. Momentarily the market expects short lead times, large product varieties, good quality and delivery assurance. Manufacturing companies therefore have to deliver according to these requirements in order to stay competitive on the market.

Furthermore, the level of uncertainty increases as the customer demand fluctuates and the competitive climate on the market increases, which results in further difficulties for manufacturing companies. This uncertainty in demand can be related to volume fluctuations, ordering patterns, seasonal variations and delivery capability (Van der Vorst, et al., 1998). The main difficulty for manufacturing companies is therefore to efficiently produce according to customer demand, while still having the manufacturing capacity for future uncertainties.

It is important that demand uncertainty is incorporated into the overall manufacturing strategy to ensure that it is developed properly across different aspects of the production (Boyle & Scherrer-Rathje, 2009). It is also important that the manufacturing strategy is aligned with the competitive priorities of a company and its market requirements. The competitive priorities are classified into: cost, quality, delivery dependability, delivery speed and flexibility, where chosen priorities result in different outcomes when formulating the manufacturing strategy through the manufacturing capabilities (Dangayach & Deshmukh, 2001). It is important to link market requirements and manufacturing strategy, to be competitive today and in the future. Another part of the manufacturing strategy is to align competitive priorities with manufacturing decision areas, which is about determining upon structural and infrastructural decisions within the factory to support market requirements (Skinner, 1969; Leong, et al., 1990; Miltenburg, 2005; Hill & Hill, 2009).

Additional complexity exists as the factories of manufacturing companies differ vastly depending on characteristics such as products, processes, flow structures and volume levels. These differences are not only visible when comparing factories, but can also exist within the same factory. Therefore, companies are forced to prioritize between competitive priorities, while simultaneously deciding upon the most important characteristic in the factory. These decisions have great impact on the formulation and fulfilling of the manufacturing strategy. One characteristic of emphasis is the production structure in factories, where the structure may cause complexities in the formulation of the manufacturing strategy. As current literature in manufacturing strategy are more focused on traditional linear production structures and flows, there may exist a need for more research within complex production structures such as non-linear flows. It is crucial that today's manufacturing companies are able to find a suitable balance between the different characteristics and are able to successfully integrate them into the strategy in order to stay competitive regardless of production structure.

1.1 Company case

In this thesis, a case study at a large international manufacturing company within the confectionary industry is conducted. The company has several business units and factories worldwide. Each factory within the company is set up as a separate business and operates with considerable autonomy. The case study is performed at a factory in Sweden where one production facility is studied. The production facility manufactures confectionary products that are sold world-wide with emphasis on the Nordic market. The setting of the studied production facility is complex as it deals both with two flows of main products and one flow of semi-finished products. The complexity lies in the semi-finished product flow that is diverging from the main production flows and is seen as non-linear. Further, the production flows differ in production structure and together with the non-linear nature, it constitutes a non-traditional production system. Additional complexity is that the semi-finished product flow and the two main production flows inherit structural and infrastructural shared interfaces. The production flows serves two different types of markets, namely the industrial market and the consumer market.

1.2 Problem formulation

Companies have to handle demand uncertainties to stay competitive on the market. The focus of creating competitiveness in a manufacturing strategy lies in how to align manufacturing capabilities with market requirements. The examined case highlights difficulties in handling demand uncertainties due to complexities in production flows that share interfaces both structurally and infrastructurally. When facing these uncertainties and complexities it is desirable for the examined production facility to gain knowledge of how to manage misalignments and integrate the shared interfaces between the production flows.

1.3 Objective and research questions

The objective of this thesis is to analyze integration of shared interfaces between production flows. Furthermore, it is to investigate management of misalignments in complex production systems related to manufacturing strategy. The objective is achieved by answering the following Main Research Question (MRQ):

MRQ: How is integration of shared interfaces in production flows managed in the production facility?

This question includes investigating relevant aspects for integration of shared interfaces between production flows and how these are managed in the production facility today. Two research questions are formulated to structure the data collection process to answer the MRQ above. Therefore, the first research question is to map the current production flows and their interfaces. Furthermore, relevant aspects affecting integration of shared interfaces and misalignments between production flows are investigated in the first Research Question (RQ1) formulated on next page.

RQ1: What aspects affect integration of shared interfaces between production flows?

The second Research Question (RQ2) concerns how the aspects from RQ1 are managed today in the production facility and what possibilities there are for integrating shared interfaces between production flows. The second research question is formulated below.

RQ2: Considering these aspects, how are they managed in the production facility?

Through investigation and analysis of the current production flows (RQ1) and together with management of identified aspects (RQ2), the objective is to find out how shared interfaces between production flows are integrated (MRQ).

1.4 Delimitations

The case study is delimited to one company within the confectionary industry. Also, it is delimited to one production facility within a factory in Sweden. Within the production facility the case is delimited to analyze the manufacturing function, however activities that require input from other functions such as logistics, marketing and sales are also taken into consideration. Furthermore, the focus of the thesis is on the flow of semi-finished products. However, to provide a holistic understanding, the production flows of main products are included. The researchers will not participate in any implementation processes for the suggested managerial implications.

Separation of production flows is not taken into consideration in this thesis, since the objective is to analyze integration of shared interfaces between production flows. This is because the examined production flows are located in the same production facility with limited space available. Therefore, a complete separation is not possible due to structural constraints.

The analysis of the current state is based on an existing framework on investigating alignment of manufacturing strategy referred to as product profiling by Hill et al. (1998). The framework consists of four levels; products & markets, manufacturing, investments and infrastructure. According to the product profiling procedure, few aspects within each level should be included to keep simplicity. Since the level of investments and its aspects is of less relevance to the examined production facility, it is not included in this thesis. Due to the limited time frame and scope, the thesis is focused on getting a holistic perspective, rather than providing detailed information on specific activities, such as manufacturing processes and planning processes.

The theoretical frameworks and concepts used in the thesis are based on a literature review of scientific articles and books in appropriate areas, to create an overview of the field of manufacturing strategy research. The analysis of the thesis is delimited to concepts and frameworks on manufacturing strategy, production structures and process types, competitive priorities and alignment, focused manufacturing, manufacturing capabilities, and manufacturing decision areas.

1.5 Outline

The thesis is structured as follows:

Chapter 2 – Literature review
The chapter presents a literature review of previous research regarding manufacturing strategy, competitive priorities, decision areas, manufacturing capability, focused manufacturing, choice of production structure, product profiling.

Chapter 3 – Method

The chapter explains the methods used in this thesis on the data collection and analysis. It also provides a perspective of the quality of the thesis in terms of reliability and validity.

Chapter 4 – Results and analysis

The chapter presents the results and analysis of the collected data from the case study. The structure of the chapter is according to the research questions posed in the *Introduction* chapter. The chapter begins describing two flow charts of the three production flows that represent the case and visualizes the structural shared interfaces. Furthermore, it provides an analysis of the case by positioning the production flows in the product profiling framework by Hill et al. (1998). Misaligned aspects from the comparative product profiling analysis are further investigated regarding management of them, to support integration of shared interfaces in the production flows. Lastly, the management of the aspects within decision areas is further connected to level of manufacturing capability and focused manufacturing.

Chapter 5 – Discussion

The chapter presents a discussion on the results and analysis in connection to the main research question. Firstly, the focused manufacturing approach is discussed related to level of manufacturing capability. Secondly, integration of infrastructural aspects is discussed and whether the adjustments are suitable to current case context. Thirdly, the adjustments are discussed from a sustainability and ethical perspective on a general level.

Chapter 6 – Conclusions

The chapter presents the conclusions from the case study by answering the research questions. Further, conclusions from the *Analysis* and the *Discussion-chapter* answer the main research question. Additionally, this chapter presents conceptual contribution and managerial implications together with discussions on limitations and future research.

2. Literature review

The chapter presents a literature review of previous research regarding manufacturing strategy, competitive priorities, decision areas, manufacturing capability, focused manufacturing, choice of production structure, product profiling.

Manufacturing strategy can be analyzed on several levels; industry, company, business units, network and factory etc. Further, factories can be of different size and also consist of one or more factory-within-a-factory (Miltenburg, 2008). The level of analysis in this thesis is factory-within-a-factory, which further is called production facility. Currently in literature there is vast research on manufacturing strategy for linear flows. However, in reality many manufacturing companies have different production structures and flows that somehow share interfaces or complex systems with each other. Today there is limited research on the incorporation of non-linear flows into manufacturing strategy. Hence, this thesis aims to contribute with empirical research to the area of manufacturing strategy in integration of shared interfaces between production flows. A general understanding of manufacturing strategy is necessary to position the case and investigate integration, in order to reach the objective of this thesis,

2.1 Manufacturing strategy

Literature on manufacturing strategy can be classified into content and process. Content literature addresses issues of competitive priorities and decision areas, while process literature addresses a pattern or procedure in which manufacturing strategy is formulated and implemented (Leong, et al., 1990; Dangayach & Deshmukh, 2001). The focus of this thesis is on how integration of shared interfaces is managed in a production facility, hence the empirical findings of the case contributes to the content literature, rather than the process. Further, Leong, et al. (1990) illustrates content of manufacturing strategy as in Figure 1, where the business strategy is aligned with the manufacturing strategy. Furthermore, the most important elements of manufacturing strategy are captured in the two broad categories of *competitive priorities* and *decision areas*. This classification is generally known in manufacturing strategy literature and is recognized from the seminal work of Skinner (1969).

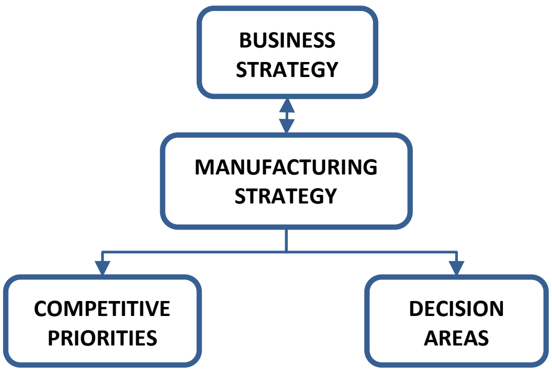

Figure 1. *Content model of manufacturing strategy (Leong, et al., 1990)*

Today, companies are expected to cope with the changing environment in order to survive on the competitive market. Skinner (1969), a pioneer in manufacturing strategy literature, early stated that competitive advantage is achieved by aligning the business strategy with the manufacturing strategy. Alignment can be achieved by prioritizing and determining on competitive priorities and organizing decision areas. The competitive priorities are the goals for manufacturing and should be used to align business strategy and market requirements with manufacturing task and production structure. Further, the choice of manufacturing task and its fulfillment is achieved by determining on the decision areas. The choice of competitive priorities and decision areas decides how well a company fulfills a manufacturing task and its level of manufacturing capability. Chosen balance between different decision areas and manufacturing capabilities positions a company relative to its competitors and industry in terms of its competitive advantage (Skinner, 1969; Hayes & Wheelwright, 1984; Hill & Hill, 2009). The decision areas determine the company's level of manufacturing capability (Miltenburg, 2005). The level of manufacturing capability can be classified to create a holistic understanding of management of decision areas, to investigate management of structurally and infrastructurally shared interfaces,. Competitive priorities, decision areas and manufacturing capability are described in the sections below.

2.1.1 Competitive priorities

According to several researchers in the area, the aim of manufacturing strategy for a factory and production facility is to determine the focus of the competitive priorities (Hayes & Schmenner, 1978; Dangayach & Deshmukh, 2001; Miltenburg, 2008). A definition of manufacturing strategy coined by Skinner (1969) is:

"Exploiting certain properties of the manufacturing functions as a competitive weapon"

Skinner (1969) was first to define the competitive priorities beyond production and delivery of products. Manufacturing strategy consists of deciding upon one's competitive priorities, which is commonly agreed upon in literature. However, a definition of competitive priorities is not commonly agreed upon in current literature and differs between authors. This thesis uses Dangayach & Deshmukh (2001) definition of competitive priorities. The definition is chosen because it is derived from their literature review of 260 articles in manufacturing strategy, and therefore seen as comprehensive and representable of the studied field. The competitive priorities are cost, quality, delivery dependability, delivery speed and flexibility, which are described in Table 1.

Table 1. *Competitive priorities in manufacturing strategy* (Dangayach & Deshmukh, 2001)

COMPETITIVE PRIORITIES	DESCRIPTION
• Cost	The cost of production and distribution
• Quality	The production of products with high quality or performance standards
• Delivery dependability	Meet delivery demands
• Delivery speed	React quickly to customer orders to deliver fast
• Flexibility	React to changes in product, changes in product mix, modifications to design, fluctuations in material, changes in sequence

A production facility cannot focus on all competitive priorities, it is important to decide upon tradeoffs for example between having a narrow product range or a wide product range and the level on which outputs will be provided (Skinner, 1974; Leong, et al., 1990). It is shown that most measures of production performance are better achieved when having a narrow product range, rather than having a wide product range. By focusing on one or several of the competitive priorities depending on market requirements, the manufacturing strategy is differently formulated. (Miltenburg, 2008)

2.1.2 Decision areas

Integration of shared interfaces between production flows is dependent on decisions made related to the manufacturing strategy. Long-term decisions must be taken in order for companies to adapt to the market requirements through the manufacturing strategy (Leong, et al., 1990). These decisions are classified into *structural* and *infrastructural decision categories* (Hayes & Schmenner, 1978; Hayes & Wheelwright, 1984), and are made to fulfill the manufacturing task. The more the structural and infrastructural decisions reflect the competitive priorities and the manufacturing task, the more effective the manufacturing strategy becomes (Miltenburg, 2005; Hill & Hill, 2009). To conclude, different production structures and infrastructures are needed for different purposes. Therefore, a single production facility will tend to experience conflicts and low overall effectiveness if it serves multiple markets with different competitive strategies. (Hayes, et al., 2005)

Definitions of decision areas in the structural and infrastructural decision categories vary between authors, but agreement on the most important characteristics is captured by all authors (Leong, et al., 1990). Different definitions of decision areas are presented in Table 2.

Table 2. *Definition of decision areas by different authors in manufacturing strategy*

DECISION CATEGORIES	SKINNER (1969)	HAYES AND WHEELWRIGHT (1984)	BUFFA (1984)	FINE AND HAX (1985)	MILTENBURG (2005)
STRUCTURAL	• Plant and equipment	• Facilities • Capacity • Technology • Vertical integration	• Capacity/location • Product/process technology • Strategy with suppliers and vertical integration	• Capacity • Facilities • Processes and technologies	• Facilities • Process technology • Sourcing
INFRASTRUCTURAL	• Production planning and control • Organization and management • Labor and staffing • Product design and engineering	• Production planning/ materials control • Workforce • Quality • Organization	• Strategic implications of operating decisions • Workforce and job design • Position of production system	• Product quality • Human resources • Scope of new products	• Production planning and control • Organization structure and controls • Human resources

All definitions of decision areas inherit similar characteristics and minor differences. For example, Hayes & Wheelwright's (1984) definition of quality and organization is captured in Miltenburg's (2005) definition of organization structure and controls. All definitions are applicable for the examined case, however the definition by Miltenburg (2005) is chosen because of its relevance to the level of manufacturing capability framework developed by the same author presented in the next section. Miltenburg (2005) defines the decision areas as levers, however this thesis use the term decision areas. The decision areas reflects and determines the type of production structure that is used, how well it works and at which level the manufacturing outputs of it reflect the competitive priorities. Small adjustments to these areas can be made to improve an existing production system, and large adjustments to the infrastructural and structural areas are made to significantly improve a production system or change an existing one to a different production system. (Miltenburg, 2005)

Structural decisions are related to production facility and equipment and are therefore considered to have long-term implications. Examples of structural decisions are those related to plant size, plant capacity, and age of equipment in a plant. Infrastructural decisions are related to policies that determine how the production facility and equipment are used. Typically, these decisions are under direct control of the operations managers, and are easier to change because they do not require large and costly modifications as structural decisions. Infrastructural decisions include policies related to equipment, quality, inventory, workforce and confusion-engendering activities, e.g. new product introductions and product variety, in a plant. (Hayes & Wheelwright, 1984) It is indicated that little research has focused on what type of infrastructure is needed to utilize process technologies and production systems to its full potential (Maffei & Meredith, 1995).

Structural and infrastructural decisions are closely intertwined with each other, for example work-force policies (infrastructural) relate to the production structure and process choices (structural). Another example is the total annual capacity (structural) that relate either to how constant the rate of production is kept over time (structural), or how frequently the production rate is adjusted to chase demand (infrastructural). (Hayes & Schmenner, 1978)

It is important to link market requirements and manufacturing strategy in order to be competitive today and in the future (Wier, et al., 2000). The manufacturing strategy should be a response to this in terms of process and infrastructure investments. (Berry & Hill, 1992) It is indicated that decision areas affecting strategy are not only depending on process-specific choices such as shop floor control and layout, but also on non-process specific decisions such as product complexity, competitive priorities, top management decisions, strategic direction of manufacturing and size of company. (Choudhari, et al., 2011) Previous research shows the relationship of structural and infrastructural decisions with firm competitiveness, in terms of productivity. It concluded that all structural and infrastructural decisions are relevant and complementary. However, some decisions are more important and allow firms to achieve sustainable competitive advantages. These are plant capacity, quality control systems, work force and operations planning. (Garrido, et al., 2007)

2.1.3 Manufacturing capability

It is beneficial to create a holistic understanding of capabilities of the manufacturing function in order to answer the RQ2 on how shared interfaces are managed in the production facility. This can be done by classifying how well the competitive priorities are reflected in the production facility through the level manufacturing capability-framework, developed by Miltenburg (2005). This framework is used to understand a company's manufacturing capability relative to industry and competitors. It is also used to get a sense of understanding of necessary actions to reach a certain level. A factor to consider upon application, is that the reliability of the input data is of great importance as the classification is precise on different levels. Other frameworks for classifying fulfillment of manufacturing strategy with related decision areas exist, such as a research framework for congruence of decision areas in a production system by Choudhari, et al., (2010). This model is of a more conceptual nature and is used to visualize the current state of a production facility through several aspects on different levels. However, it cannot be used for classifying the management of decision areas in the production facility and positioning of it relative to the industry. In comparison with other frameworks that are based on traditional production structures, the framework by Miltenburg (2005) allows classification of production facilities with production flows of different structures. Therefore, this framework is seen as applicable to the examined case, which is of non-traditional nature with shared interfaces. The framework for classifying manufacturing capability by Miltenburg (2005) is chosen. Therefore, main literature source of this section is Miltenburg (2005).

Manufacturing capability is defined as how well a manufacturing facility is able to organize its resources according to the competitive priorities. The manufacturing capability can be classified into four levels; infant, average, adult and world class. The four different levels are described in detail in Table 3 below. Each manufacturing decision area is evaluated according to its capability and performance level. This level of capability may vary between industries, and what is considered as world class may differ. Aiming for world class level of manufacturing capability in all areas may not be the case for all companies, since it depends on the competitive situation on the market. The framework visualizes the overall level of manufacturing capability in relation to the manufacturing decision areas, seen in Table 4 below.

Table 3. *The four levels of manufacturing capability (Miltenburg, 2005)*

LEVEL 1.0 – INFANT	LEVEL 2.0 – AVERAGE	LEVEL 3.0 – ADULT	LEVEL 4.0 – WORLD CLASS
The production system makes little or no contribution to the organizations success. Manufacturing is low-tech and unskilled. (internally neutrality)	Manufacturing is satisfied to keep up with its competitors and maintain the status quo. Manufacturing consists of standard, routine activities. (externally neutral)	The production system provides order qualifying and order winning outputs at target levels. All manufacturing decisions are consistent with the manufacturing strategy. (internally supportive)	The production system strives to be the best in the world in all activities in the manufacturing subsystems. The production system is a major source of competitive advantage. (externally supportive)

Table 4. *Level of manufacturing capability for each manufacturing decision area*

DECISION CATEGORIES	MANUFACTURING DECISION AREAS	INFANT 1.0	AVERAGE 2.0	ADULT 3.0	WORLD CLASS 4.0
INFRASTRUCTURAL	PRODUCTION PLANNING AND CONTROL		• Centralized, complex • Detailed monitoring of resource usage		• Decentralized, simple • Aggregate monitoring of resource usage
	ORGANIZATION STRUCTURE AND CONTROL		• Hierarchical, centralized • Cost accounting driven performance measures • Staff is very important		• Flat, decentralized • Competitive performance measures • Line is very important
	HUMAN RESOURCE		• Employees are an expense • Unskilled • Human robots		• Employees are an investment • Multi-skilled • Problem identification and solving
STRUCTURAL	SOURCING		• Large number of suppliers • Short-term contracts • Lowest cost		• Small number of suppliers • Partnership, full responsibility • Critical capabilities
	PROCESS TECHNOLOGY		• Mature technology • Developed externally • Reduce cost		• Modern soft and hard technologies • Developed internally • Provide manufacturing outputs
	FACILITIES		• General purpose • Large, infrequent changes • Capital appropriation driven		• Focused • Frequent, incremental changes • Improve capabilities

This framework of manufacturing capability makes it possible to position a manufacturing company in relation to the industry and show a sense of direction on potential areas that can be worked with in order to fulfill the manufacturing strategy. The framework also shows what type of adjustments need to be made, related to each infrastructural and structural aspect, to increase and harmonize the level of manufacturing capability. Characteristics of the infant and adult level of capability are not specifically expressed in the framework, as all levels are not clearly defined areas, but a part of a progressing scale.

2.2 Focused manufacturing

Skinner (1974) developed the concept of *focused manufacturing* which is one approach of determining priority of competitive priorities and organization of the decision areas. Shortly, focused manufacturing is about organizing one's resources and is based on the concept that a factory can achieve superior performance by concentrating its resources on achieving one task, rather than trying to address an endless amount of external and internal sources of demands (Pesch & Schroeder, 1996). It is about deciding upon tradeoffs like for example; quality versus cost or short delivery cycles versus low inventory investments. Focused manufacturing have been widely adopted in manufacturing strategy research (Skinner, 1974; Hayes & Wheelwright, 1984; Pesch & Schroeder, 1996; van Donk & van der Vaart, 2005; Miltenburg, 2008). Focused manufacturing is also about creating simplicity and repetition that breed competence, and is done by aligning business strategy with marketing strategy and manufacturing strategy with a specific focus. Further, Skinner (1974) argues that the choice of manufacturing focus cannot be made independently by production employees. It has to be a decision based on a comprehensive analysis of the company's resources, strengths and weaknesses, position in the industry and on the market, forecast of future customer motives and behavior.

Research by Skinner (1974) shows that focused factories will out produce, undersell and quickly gain competitive advantage over the complex factories. This is because a repetition and focus in one area allows the work force and managers to be more effective in the task that is decided to be of focus and is required for success. Another perspective supporting this is Ward & Duray (2000) that states that manufacturing strategy must be closely linked to the competitive strategy in order to reach high performance. The study emphasize on the term *mediator* instead of focused manufacturing and states that high performing companies use the competitive strategy as a mediator between environment and manufacturing strategy.

There are different approaches for a factory to focus its manufacturing within the competitive priorities and decision areas. A manufacturing facility can either be more focused around resources or markets. Focus on resources is to have a unique manufacturing process that the competitors do not have. Focus on market is to align manufacturing with the competitive priorities of the market and the order winners, and therefore gain competitive advantage (Hill, 2008; Hill & Hill, 2009). Order winner is the competitive factors that make customers choose products from a specific company over competitors.

A study by Hill (2008) found that resource-based focus, for example on processes, is appropriate if a constrained resource exists, either by level of available capacity or the investment cost needed to duplicate it. On the other hand the same study showed that by applying market-based approach, with focus on order winners, led to a shorter and more reliable lead time towards customers. The approach also created room for greater market exploitation and therefore increases in sales and profits. Application of the market-based approach was done by organizing resources to utilize excess capacity, rather than creating buffers in inventories, in order to meet an increasing market demand. To conclude, each approach of focusing resources has different sets of advantages and disadvantages and it is not necessary appropriate to focus all the products or processes within a facility. (Hill, 2008)

In some cases, it may not be appropriate to have a focused strategy within a single factory. This is something that Ketokivi & Jokinen (2006) shows in their study. They conclude that the ability of focusing its manufacturing is related to plant age, predictability in demand, location and types of products or markets that fill up the production capacity. For example, products manufactured to capture excess capacity that are delivered to a separate market are called *filler products*. A production facility with filler products may choose to not implement a focused manufacturing strategy because a single market cannot absorb the total maximum capacity of the production lines (Ketokivi & Jokinen, 2006). Another perspective of Ketokivi & Jokinen (2006) describes that it is easier to implement a focused manufacturing strategy for factories that have stable and long-term customer relationship with few key customers.

Despite the high level of adoption and research into the focused manufacturing topic, there still seems to be little empirical support for it (Ketokivi & Jokinen, 2006). This thesis aims to address this by providing empirical data of challenges when applying the concept of focused manufacturing in a facility of three production lines with shared interfaces, serving two types of markets. The challenge when deciding upon focus approach and competitive priorities is to design a production structure that fulfills the market requirements and the strategic goals of the company. The next section reviews literature on choice of production structure with processes, process layout and products in mind.

2.3 Choice of production structure

Markets are becoming increasingly different from one another and it is therefore important for companies to learn how to compete effectively in several markets momentarily. Choosing the suitable approach of focus and process types to organizing resources is a central strategic decision. Each method varies in cost and inherits both strategic and managerial advantages as well as disadvantages. Therefore, when deciding upon what processes and production system to use when manufacturing ones products, the choice should support a company competitively in its marketplace. Each choice of process brings certain implications for a business in terms of responsiveness to customer, operation characteristics, level of investment required, costs of unit, type of scheduling system and style of management that are suitable. (Hill & Hill, 2009)

Traditionally there are five generic process types; project, jobbing, batch, line and continuous processing. Project and continuous processing are process types that are associated with a particular product type, for example civil engineering or food and liquids. As project is not a process type that is reflected in the examined case of the production flows, it is not further discoursed. However, the other process types are further described below:

- **Jobbing:** process used for products that are special and will not be repeated, for example built-in furniture
- **Batch:** process used for standard up to mass produced products, where volume demand is high, for example machined parts or injection moldings
- **Line:** process used for standard, repeated and high volume mass products, for example motor vehicles and domestic appliances.
- **Continuous processing:** process used for standard and very high volume mass products, for example oil refining. (Hill & Hill, 2009)

The different types of processes have its advantages and disadvantages depending on product structure. Hayes and Wheelwright (1979) developed a framework called product-process matrix that is acknowledged in manufacturing strategy literature. It proposes a relationship between product structure and process structure. This relationship is widely accepted and is seen as one of the concepts creating the foundation for traditional manufacturing strategy. Hayes and Wheelwright's product-process matrix is seen in Figure 2.

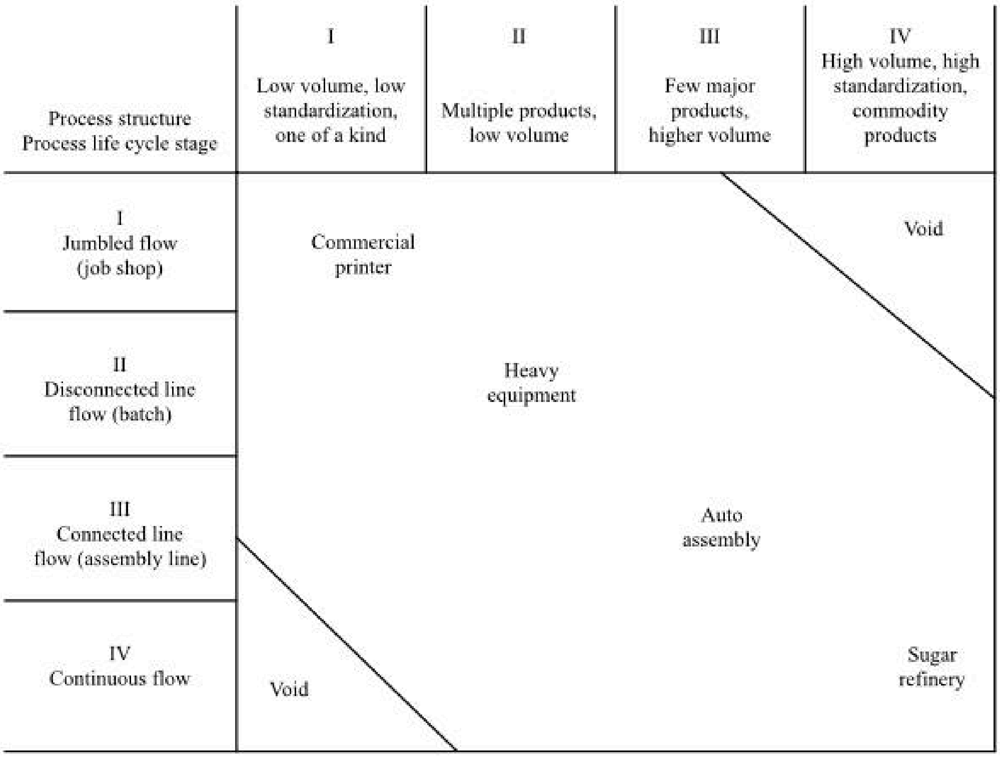

Figure 2. *Product-process matrix by Hayes and Wheelwright (1979)*

The most wanted position in the matrix for the relationship between products variety (process structure) and process type (life cycle stage), is diagonally across the matrix. For example, looking at the process of jobbing, it is highly flexible, cost inefficient process type and suits products of low volume with low standardization. However, for a production of multiple products and low volume, a disconnected line flow or batch process is more appropriate and cost efficient. With few major products with higher volume a connected line flow is preferred. Further, for a product of high volume with high standardization, continuous processing is suitable to be cost efficient, however it is not that flexible. The product-process matrix has further been applied and developed by other studies: (Hill, et al., 1998; Ahmad & Schroeder, 2002; Miltenburg, 2005; Miltenburg, 2008; Hill & Hill, 2009; Choudhari, et al., 2010; Choudhari, et al., 2011).

Helkiö and Tenhiälä (2013) have updated the product-process matrix by Hayes and Wheelwright (1979) with aspects that suits the modern industrial reality in future applications. The study adds simplicity of the process and product dimension and it also add a perspective for the dynamic nature of firm's manufacturing environments. The process dimension is not defined as typical process types, rather a focus on flexibility by defining it as "*the degree to which the process is limited to producing certain outputs".* Further, the study adds simplicity of the product by including a complexity dimension that is labeled as the complexity of the production task. It is defined as the "*heterogeneity and range of activities that must be performed to satisfy the market requirements".* The study proposes that the process design/choice should be aligned with the complexity of the production task. It also proposes that the process design/choice should be aligned with the dynamism of the task environment, where the dynamism is defined as the rate of change in market requirements that is beyond the control of individual business units. (Helkiö & Tenhiälä, 2013) Compared to the original product-process matrix this study shows that in order to maintain good delivery performance, production facilities with highly specific processes must have simple production tasks. Further, it adds: "*when the production tasks become more complex, the highly specific production processes begin to have problems in terms of responsiveness".* (Helkiö & Tenhiälä, 2013) The study is also aligned with earlier studies on the relation to flexibility in process output and kept efficiency in performance (Ahmad & Schroeder, 2002; Ojha, et al., 2013). Since the case of this thesis contains of three production flows that share interfaces, depend on each other and serve two different markets, the dimension of complexity, flexibility and dynamism of the production task are important to take into account. This is because the case represents modern industrial reality of a non-traditional production structure. Again, these dimensions are important and taken into account when answering the MRQ on how integration of shared interfaces between production flows is managed in the production facility.

It is crucial for companies to have a general understanding of their business and competitiveness in order to formulate a manufacturing strategy including choice of processes and production structures that supports this. A further development of the product-process matrix is the product profiling by Hill et al. (1998). This framework goes beyond the product variety and process type by including the dimensions of competitive priorities and decision areas in more depth than in product-process matrix and adds the dimension of the strategic relationship between markets, manufacturing and business. Product profiling is presented in the next section.

2.4 Product profiling

Product profiling is a framework that is used in manufacturing strategy to visualize alignment between three levels: products and markets, manufacturing, and infrastructure. These are then divided into relevant aspects. The objective of the framework is to create a foundation for managing decisions based on aspects and prerequisites of both manufacturing and marketing. Product profiling is also used to visualize alignment with process type based on the position related to alignment to the three levels mentioned above (Hill, et al., 1998; Hill & Hill, 2009).

2.4.1 Product profiling procedure

The product profiling can be conducted at company level or process/flow level. Conducting it at company level provides an understanding of the alignment between different parts of the company and future potential investments in manufacturing. If conducted at process level, potential misalignments between different products can be visualized connected to the process equipment in the facility (Hill & Hill, 2009). The procedure used in product profiling is conducted in four steps, described in Table 5.

Table 5. *Product profiling procedure (Hill, et al., 1998)*

STEPS OF PRODUCT PROFILING
1. Choose relevant aspects for products and markets, manufacturing, and infrastructure with the following criterions: a. The aspects must be related to current issues and strategic dimensions of the markets. b. The amount of aspects must be kept small, in order to visualize the holistic picture,
2. Visualize the tradeoffs for each aspect connected to the process choice.
3. Position the products, product groups, customers or companies based on chosen aspects. The framework is of a comparative nature to show alignment between products and customers, or the situation of a company before and after a change or investment.
4. The final profile should visualize the alignment between market characteristics related to manufacturing and infrastructure. If the degree of alignment is high, it will result in a straight line. In case of a low degree of alignment, the result will be a line with more deviations.

The aspects included in the product profiling framework vary depending on company context and setting. An example of product profiling is seen below in Figure 3.

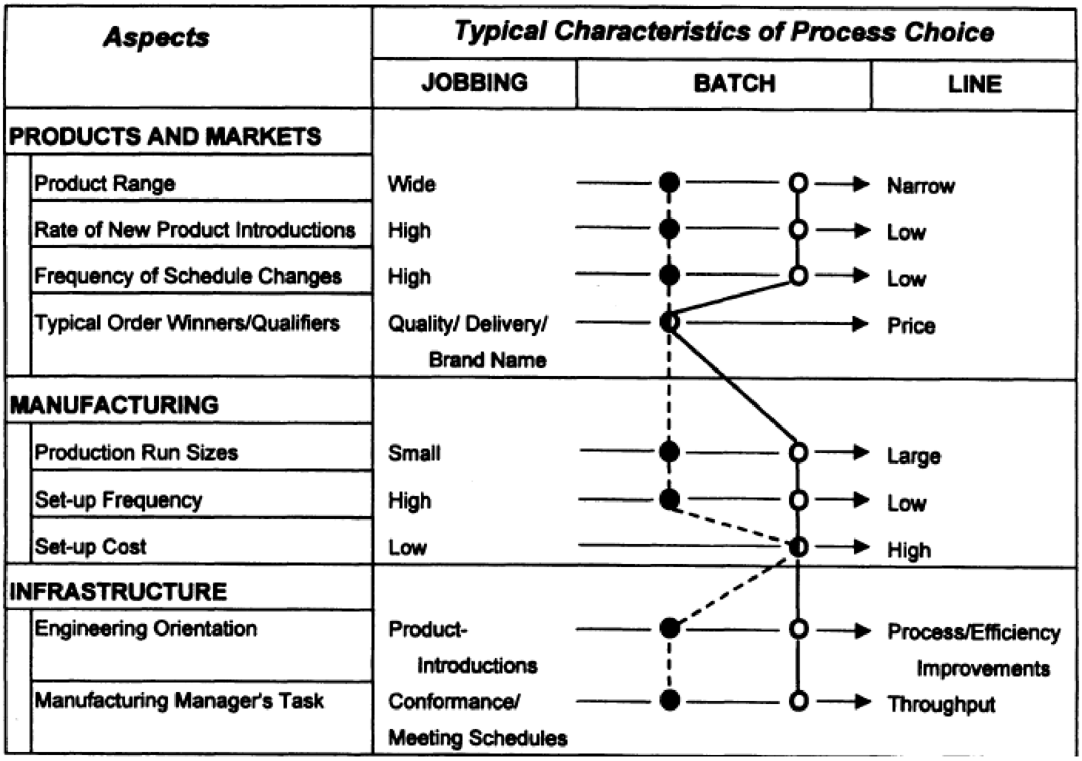

Figure 3. *Product profiling framework by Hill et al. (1998)*

The product profiling framework goes beyond the product variety and process type in product-process matrix by including the possibility to position products, product groups or customers in a comparative nature, described in in Table 5 and Figure 3. This positioning and comparison of different types of products, product groups or customers can visualize differences in competitive priorities and decision areas. The difference between the products, product groups or customers in comparison is visualized as a distance between the positions on the same aspect. The framework is appropriate for this thesis in the manner of comparing two types of customers of main products and semi-finished products represented of three flows in the case. Also, the product profiling framework is chosen for this thesis to visualize the complexity between the case production flows, in contrast to the product-process matrix that is considered as less appropriate for the examined case. The extended product-process matrix by Helkiö & Tenhiälä (2013) takes the complexity into consideration, however the matrix cannot visualize a comparison between two or more production flows. Therefore, is the product profiling framework chosen for this thesis because it takes different aspects into account that may affect integration between shared interfaces.

2.4.2 Managing misalignments

Product profiling is merely a visualization of potential misalignments in manufacturing, when conducted it can be used for further discussions on improving the strategic position and competitiveness of a company. However, the most appropriate strategy does not need to have every "facet" correctly in place; a company can live with misalignments if it is aware of its position (Hill & Hill, 2009).

There are several ways a company can deal with misalignments, visualized through the product profiling framework. Managers must be aware of the tradeoffs that are required depending on the actions they decide to take based on the product profiling. Market-oriented companies may change its manufacturing decisions to align them more with the capabilities of existing investments. These decisions are seen in the manufacturing and infrastructure levels of the framework, which respectively can be reflected as structural and infrastructural decision areas. Naturally, these decisions require the intervention of operation managers and have effects on other parts of the business and must be assessed before conducting any changes. Other companies may choose to change their products and market aspects, for instance by discontinuing certain product groups or by focusing on specific market segments with similar order winners. However, in case of such decisions, the company must analyze its consequences connected to sales volume and market share. Another proposed way to deal with misalignments is by living with them. This requires that the management of the company is well aware of the short and long term consequences of such a strategic decision. (Hill, et al., 1998) Even if management decides to live with the misalignment, it is still valuable knowledge to be aware of the current situation for future strategic decisions.

2.4.3 Critique of the framework

The product profiling framework is a comprehensive model that can be adapted to suit the specific needs of a company. However, little research has been conducted on the link between content and process of manufacturing strategy since the introduction of product profiling by Hill et al. (1998). There appear to be issues connected to the implementation of product profiling and suitable actions to correct an identified misalignment (Swenseth, et al., 2002). Product profiling was used to identify misalignments in a case study and the case company chose to precede in the opposite direction by increasing lot sizes by an average of 100 percent, instead of correcting the misalignment (Hill, et al., 1998). This contradictory approach was questioned and challenged since it did not correspond with accepted practice in many of today's manufacturing organizations (Schonberger, 1999). The original authors justified the approach on the basis of the norms within the industry in question, and that manufacturing's response to misalignments in product profiling not always is consistent with established theory (Hill, et al., 1999).

Even if product profiling is a useful tool for identifying misalignments, the tool alone may not be sufficient to create a driving force for change within the company. A moderating tool, such as simulation, can be required to create this force for change. It serves as graphic and visual proof of the proposed changes by strategic analysis through the product profiling to improve organizational fit and improved company performance based on simulated studies. Graphical simulation can then be used to investigate specific implementation options that are suggested through product profiling (Swenseth, et al., 2002).

Despite the wide acceptance of product profiling, critique has been expressed regarding its limitations. Firstly that it is based on classical process choices and its characteristics, which may not inherit the same relevance today as it used to (Ketokivi & Jokinen, 2006). Secondly it lacks the ability to offer an explicit and comprehensive method to understand and translate customer requirements into product and process choice. Thirdly that it is a strictly qualitative approach and presents its results in graphical form. (Partovi, 2007) This creates limitations when using the results as a foundation for future managerial decisions since they may only provide directional input.

2.5 Integration of shared interfaces

The activity of integrating shared interfaces between production flows can be done and interpreted in several ways. Integration in this thesis is defined as a way to manage misalignments in the production facility investigated through the product profiling framework. The objective of this thesis is to analyze integration of shared interfaces between production flows. This thesis proposes that integration of shared interfaces between production flows can be done within the decision areas with consideration of competitive priorities, business strategy and market requirements. A scarce area of research is the consistency of decision areas in production systems and its configuration. Choudhari et al. (2010) have developed a framework incorporating consistency of decision areas in the different choices of production systems. However, the study do not include the coherence and configuration of production systems with shared interfaces and different process types in the same facility, such as jobbing, line, batch and continuous. This thesis aims to contribute within this area and also extends it with empirical data of configuration and coherence issues occurring in production flows with shared interfaces. This thesis also aims to contribute in complex production flows and non-traditional production systems by extending the usage of the product profiling framework by Hill et al. (1998) by considering the dimension of shared interfaces. Additionally, this thesis aims to contribute in investigating challenges in production systems with different types of products, such as filler products, related to its ability to achieve a world class level of manufacturing capability. Also, it aims to contribute within the area of focused manufacturing and that integration of shared interfaces is seen as a measure to decrease complexity and increase responsiveness (Helkiö & Tenhiälä, 2013).

The structural and infrastructural decision areas constitute the production system and the arrangement of them determines the flow within the production system. In a potential integration in a production facility, the decision areas must be taken into consideration. Adjustments to the decision areas should not be made in an arbitrary way. This because a change from the decision area's overall arrangement can degrade the production system and its production of required manufacturing outputs. According to Miltenburg (2005) there are three characteristics of adjustments that should be taken into account when considering a change in the decision areas. These characteristics are:

- *Is the adjustment appropriate for the production system?*
- *Will the adjustment help provide the required manufacturing outputs?*
- *How will the adjustment affect the other decision areas?*

However, it is not stated that it is always possible to have the best decisions made. There are always tradeoffs involved, for example some equipment are more cost effective for small orders and other equipment are more cost effective for large. As highlighted in the overall literature review tradeoffs should be aligned to the focus and competitive priorities of the production.

2.6 Summary of literature review

To fulfill the objective of analyzing integration of shared interfaces and investigating management of misalignments in complex production flows, literature on competitive priorities, decision areas, manufacturing capability, focused manufacturing, choice of production structure, product profiling are reviewed.

The literature review has provided a general understanding of the content of manufacturing strategy that is divided into competitive priorities and decision areas, which relate to manufacturing capability, which can reflect the examined case of production flows with shared interfaces. Further, the literature review has discussed the concept of focused manufacturing and presented different approaches of how to focus ones manufacturing. The concept of focused manufacturing and manufacturing capability-framework constitute a base of analysis for how integration of shared interfaces within a production system is managed within the case. To position the case and understand the current state, the literature review presents different process types and its applications. It also presents the product profiling framework that can be used to visualize a current and wanted state in manufacturing strategy considering products & markets, manufacturing and infrastructural decisions.

To provide answer to RQ1, visualization with product profiling gives an understanding of the alignment of relevant aspects affecting integration. To provide answer to RQ2, the literature review is a frame of reference for the analysis of what to consider when managing integration of shared interfaces between flows in a production system by adjusting the arrangement of decision areas.

These research areas provide insight and knowledge that is used to understand, analyze and position the case and to answer the research questions of the thesis.

3. Method

The chapter explains the methods used in this thesis regarding data collection and analysis. It also provides a perspective of the quality of the thesis in terms of reliability and validity.

The overall objective of the thesis is to analyze integration of shared interfaces between production flows. Furthermore, it is to investigate management of misalignments in complex production systems related to manufacturing strategy. Therefore, the area of manufacturing strategy was researched, as well as integration of shared interfaces between production flows through relevant aspects. A qualitative approach was used and due to the delimited nature of a thesis, a single case study of a production facility was conducted. The gathered in-depth knowledge and comprehensive understanding of the problem context is a known strength of the case study approach (Collis & Hussey, 2009). The research process of the thesis is visualized in Figure 4 below. The different methods and sources used are visualized in chronological order from left to right.

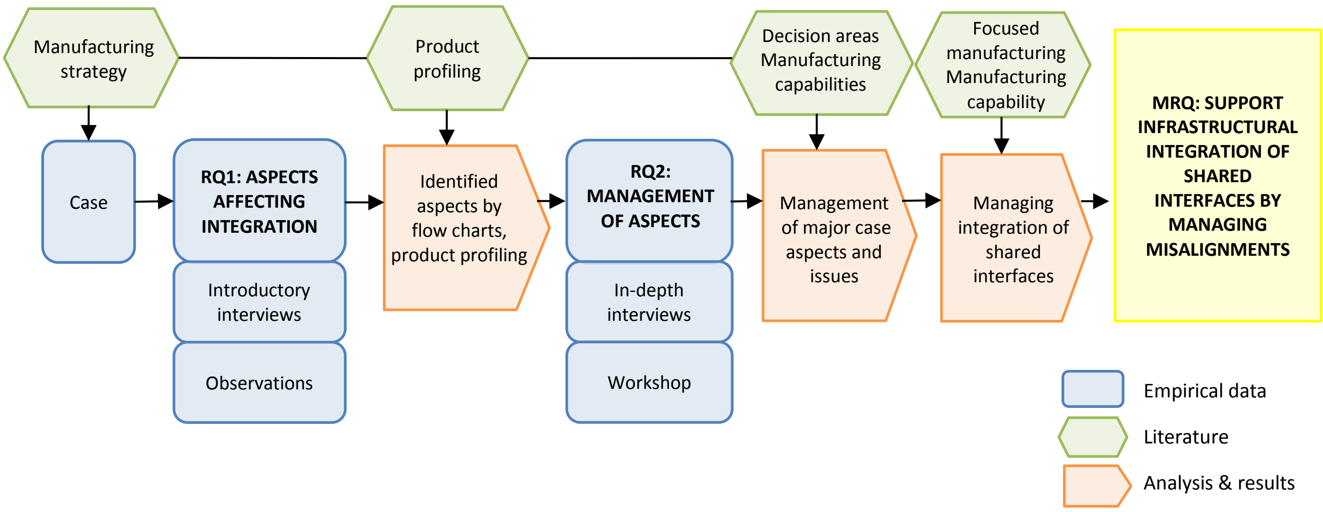

Figure 4. *Chronological illustration of research process*

The research process was designed to answer the MRQ of the thesis. As the MRQ was divided into RQ1 and RQ2 different methods was used to answer these. Throughout the whole research process a literature review was conducted continuously.

In order to answer RQ1, introductory interviews were conducted to create a general understanding of the current state of the production facility. Together with observations made by the researchers, visualization of shared interfaces, in the form of production flow charts of the studied case was made. The data collected through these methods were used together with an extended usage of product profiling, to identify aspects affecting integration.

To be able to answer RQ2, identified misalignments from the product profiling framework were used as a foundation for in-depth interviews, to get detailed information about how the misaligned aspects were managed. The data collected from the in-depth interviews, with focus on the management of misaligned aspects, resulted in identification of major case aspects and issues. These were classified into decision areas and connected to literature on manufacturing capabilities. A workshop was also conducted to verify findings from the in-depth interviews, and create a foundation to connect to MRQ and formulate the final recommendations.

Further, the findings were discussed together with parts of the focused manufacturing concept, level of manufacturing capability and literature on adjustments of manufacturing decision areas. This was used as a foundation for the analysis of what to consider when managing misalignments of infrastructural aspects to support integration of shared interfaces, to answer MRQ.

3.1 Research process

This thesis was conducted as a real-time investigation based on data collected at the case company. This data was obtained over the course of three months from several sources. Primary sources were observations in the production facility, interviews with representatives from the case company who embodied production planning, production managers, production operators, quality assurance, demand planning and continuous improvement resources. As the interviews were conducted with different guidelines and focus, they were divided into three different chronological phases: A, B and C. Secondary sources throughout the case study were company documentations that provided additional understanding of certain topics such as production facility layout, production volumes and product specifications.

The results from the data collection and the analysis were discussed and presented to participants in supervisor meetings and seminars at KTH and at meetings with case company contacts.

3.1.1 Literature review

A literature review was conducted to position the thesis contribution in the context of current research (Carlile & Christensen, 2005). The literature review was also developed to understand the initial case problem better. Further, the literature review was continuously developed throughout the whole research process. The research process of the literature review started by a review of a wide range of articles within the field of manufacturing strategy. Each article was initially shortly reviewed in bullet points, in a separate document. The bullet points were later gathered into themes (Collis & Hussey, 2009), and written down into a fluent text, which constituted the literature review. As the case problem got more defined, additional articles reflecting the problem were summarized and added to the literature review.

The articles used in the literature review were published in different journals and the researchers primarily used the terms: *manufacturing, strategy, decision areas, capability, uncertainty, production, process types, operations, infrastructural, structural, levers, focused, product profiling, competitive priorities, management, complex, system, shared and interface* in different combinations when searching for literature for the research. Some of the articles constituting the literature review, were found through the reference list of reviewed articles, or recommended by the search engine, as similar to the reviewed article.

Ultimately, the main focus of the literature review was on manufacturing strategy, focused manufacturing, choice of production structure, product profiling and integration of shared interfaces. The purpose of reviewing manufacturing strategy regarding decision areas and competitive priorities was to create a foundation for what aspects within decision areas can affect shared interfaces between production flows and how these decision areas can be managed. The purpose of reviewing focused manufacturing was to get knowledge on how to achieve an efficient manufacturing and also what challenges exist when implementing a focused manufacturing strategy. Choice of production structure was reviewed to present the traditional production structures by process types. It was also reviewed to present existing models on analyzing product characteristics in relation to production structures. Further, the review of product profiling was conducted to present a framework for analysis of the examined production flows. The purpose of reviewing the product profiling was to get knowledge on analyzing misalignments in products, product groups or customers. Additionally, a review of literature on adjustments on decision areas was conducted as a mean to support integration of shared interfaces.

3.1.2 Introductory interviews, phase A

During the first two weeks of the thesis, informal discussions were conducted with ten employees directly involved in the examined production line and with different responsibilities. The contacts at the case company provided the researchers with a schedule for the introductory weeks where the informal discussions were planned to get a wider perspective of the production facility and the company. These informal discussions were mainly about understanding the different roles and the relation they had with the examined production lines. The data gathered from the informal discussions were further used to set up a focus of the introductory interviews, which purpose was to get an understanding of the problem and the current state.

Eleven introductory interviews were conducted during the initial weeks of the thesis and are referred to as phase A. The interviewees had different roles and responsibilities in the production facility and were able to provide different perspectives on the flow of semi-finished products. The main purpose of the introductory interviews was to get an understanding of the shared interfaces between the production flows as well as potential issues and challenges for integration. Another focus of the introductory interviews was related to potential weaknesses of the flow of semi-finished products. See Table 6 below for professional title of the interviewees together with date, duration of the interviews and interviewee number that is used as reference in the results and analysis chapter.

Table 6. *Details of the introductory interviews*

PROFESSIONAL TITLE	DATE	DURATION	INTERVIEWEE NUMBER
Production planner	2015-01-23	60 min	A5
Section manager	2015-01-28	75 min	A6
Team leader 1	2015-01-28	40 min	A7
Continuous improvement manager	2015-01-28	20 min	A8
Continuous improvement engineer	2015-01-28	20 min	A9
Team leader 2	2015-01-29	75 min	A1
Production administrator	2015-01-29	70 min	A2
Quality assurance	2015-02-02	60 min	A3
Production conversion-cost analyst	2015-02-06	90 min	A4
Volume planner	2015-03-17	60 min	A10
Security, safety, environment coordinator	2015-02-02	60 min	A11

The interviews were conducted face to face in Swedish and followed a semi-structured interview guideline, see Appendix 1. Interviewees were contacted beforehand by e-mail to schedule the appointment and interviews were held in conference rooms, or in the office of the interviewee at the production facility. One of the researchers was responsible for taking notes and the other for asking questions. By following a semi-structured interview guideline the interviewee had the opportunity to put emphasis on what he/she found of most importance within the subject and at the same time follow the delimitation of the interview. The introductory interviews were about the production flows in the examined case and their interfaces with emphasis on the semi-finished products, the planning and the interviewees' role in the production. These first interviews together with the meeting at the company are seen as initial information collection. The initial meeting with company contacts included an open discussion of the definition of semi-finished products and potential problems in the shared interfaces between production flows.

3.1.3 Observations

Apart from the interviews in the thesis, the researchers conducted observations in the production facility with the purpose of creating a perspective and grasp of the current state. The data was collected from visual observations of the production facility and informal discussions. This was made possible since the researchers had the opportunity to work in an assigned office at the production facility several times per week. The office was located close to the production, which provided insights into the operational work and company culture. Additionally, the researchers participated in three weekly production planning meetings, as well as three daily section briefing meetings. Also, a guided walkthrough in the production site was done during the first two weeks, as well as practical work on the line to understand the operators' perspective.

During all observations, emphasis was put on observing the overall context and its relation to the examined case. The purpose of the observations was not to influence the situation, or its participants. The collected data from observations described the current state in the case study through flow charts that illustrated the characteristics of the examined case. Collected data was documented gradually with the process and provided a structure for the analysis. Two charts of the current production flows were created. The purpose of the flow charts was to visualize and simplify the structural shared interfaces between the examined production flows in a comprehensive manner, rather than providing a detailed production flow chart as a foundation for process optimization and simulation.

The developed design of the flow charts was inspired by Colledani & Tolio (2011). The main product flows were visualized in one flow chart. Thereafter, the semi-finished product flow was visualized in one flow chart. The process of developing the flow charts is further described. Firstly the processes of the production flows were visualized by boxes. Due to the purpose of the flow charts, the level of detail was not to describe the specific process, rather the location of the shared interfaces in relation to the production flows. Secondly, the directions of the flows were visualized by arrows. Thirdly, the structural shared interfaces consisting of throw-outs were visualized in relation to its location in the flow. Finally, the production flow charts were presented to continuous improvement manager, continuous improvement engineer, quality assurance coordinator and section manager with responsibilities related to the examined case. They verified the flow charts and provided feedback on potential clarifications. These clarifications were considered by the researchers.

Based on the introductory interviews and the understanding of the current flows within the case, the shared structural interfaces were identified.

3.1.4 Development of product profiling framework

The product profiling framework was adapted to the examined case context. The adaption was developed according to the general procedure by Hill et al. (1998) presented in Table 5 in literature review. Some aspects in the original product profiling framework presented by Hill & Hill et al. (1998) were included in the adapted framework due to the applicability to the case. These are: product type, product range, customer order size, rate of new products, order winner, frequency of schedule changes, process technology, process flexibility, production volume, number of setups, key manufacturing task, material control and capacity control. However, other aspects were chosen based on the characteristics of the production facility and specific context that were derived from introductory interviews and observations. These are: planning horizon, internal transportation, inventory control, roles & responsibilities, quality control and human interaction.

The adapted product profiling framework was used as a tool to illustrate potential misalignments in the manufacturing strategy on different levels. The adapted product profiling framework was merely used for illustrative purposes and was not seen as a quantitative measure of the different aspects.

3.1.5 Analysis in the product profiling framework

The analysis in the adapted product profiling framework was conducted separately on the main production flows and the semi-finished product flow. In the separate analysis the process types were not taken into consideration when positioning the different aspects of the production flows. The motivation for this is that the purpose of the aspects' positions only was to visualize the degree of tradeoff and not process type. The positioning of each aspect in the separate analysis was based on data collected through observations and introductory interviews of phase A in the production facility.

A comparative analysis was conducted. It consisted of merging the separate product profiling analyses. The comparative analysis in product profiling was conducted according to traditional process types, e.g. jobbing, batch, line, continuous. These process types were not seen as fixed into boxes, rather seen as a continuous grading of production structure. Related to the examined case of non-linear production flows with shared interfaces, the traditional approach composed constraints on analysis of complex production flows. Product profiling is typically used to visualize manufacturing capabilities for certain products, product groups, customers or companies with its market requirements. Therefore, this thesis additionally extended the usage of product profiling framework by analyzing misalignments between production flows and products through comparative analysis, taken shared interfaces into account. Therefore, the framework was used as a tool to find misaligned aspects for the different production flows that affect integration of shared interfaces.

3.1.6 In-depth interviews, phase B & C

The introductory interviews gave an understanding of the initial problems of the shared interfaces. To get an understanding of the management of aspects affecting integration of shared interfaces between production flows, in-depth interviews were conducted. The purpose was to identify major case aspects and issues in managing infrastructural misalignments. The content of the in-depth interviews were dependent on the investigated aspect, such as material control and production planning, and followed a semi-structured guideline. All interviewees were presented anonymously to encourage in-depth responses.

In-depth interviews with employees on a managerial level were conducted; these interviews are referred to as phase B. The interviews of phase B followed a semi-structured guideline with general questions about infrastructural aspects in manufacturing. Interview guidelines for the interviews are available in Appendix 2. The interviews were held face-to-face in Swedish in conference rooms or in the office of the interviewee at the production facility. These were scheduled through e-mail and the interviewee was noticed about the interview area beforehand. One of the researchers was responsible for taking notes and the other for asking questions. All interviewees were asked for permission to record the interviews and the recording was used to ensure accurate quotations. See Table 7 below for professional title of the interviewees together with date, duration of the interviews and interviewee number.

Table 7. *Details of in-depth interviews, phase B*

PROFESSIONAL TITLE	DATE	DURATION	INTERVIEWEE NUMBER
Production administrator	2015-03-25	60 min	B5
Automation engineer	2015-03-25	50 min	B6
Production planner	2015-03-27	60 min	B1
Team leader 2	2015-03-27	60 min	B2
Safety officer	2015-03-27	60 min	B3
Team leader 1	2015-03-31	60 min	B4
HUB-planner	2015-04-17	60 min	B7

Furthermore, in order to provide a holistic perspective on different levels of the production facility, 14 production line operators were interviewed. These in-depth interviews are referred to as phase C. The interviews were conducted in the production facility at their respective working station with semi-structured interview questions, see Appendix 3 for guideline. To get access to operators with relevant experience and give them the opportunity to prepare, the team leaders were contacted beforehand in physical meetings. The researchers also participated in the daily production line briefing to present themselves before the interviews were conducted. The content of the interviews was about roles and responsibilities, semi-finished product flows, and inventory control. Both researchers participated during every interview and took notes for further follow-up. See Table 8 below for professional title of the interviewees, interviewee number, date and duration of the in-depth interviews of phase C.

Table 8. *Details of in-depth interviews with operators, phase C*

PROFESSIONAL TITLE	DATE	DURATION	INTERVIEWEE NUMBER
Process 1-2ABC operator	2015-04-01	15 min	C9
Process 1-2ABC operator	2015-04-01	15 min	C10
Process 1-2ABC operator	2015-04-01	15 min	C11
Single packaging operator	2015-04-01	15 min	C12
Packaging operator	2015-04-01	15 min	C13
Packaging operator	2015-04-01	15 min	C14
Production coordinator	2015-04-01	15 min	C1
Production coordinator	2015-03-26	15 min	C2
Production coordinator	2015-04-01	15 min	C3
Production coordinator	2015-04-01	15 min	C4
Process 3D operator	2015-04-01	15 min	C5
Process 3D operator	2015-04-01	15 min	C6
Transporter	2015-04-01	15 min	C7
Transporter	2015-04-01	15 min	C8

3.1.7 Workshop

A workshop was arranged with stakeholders at the case company in order to get feedback on early analysis and findings, but also to present an early draft of the final recommendations. This allowed the company representatives to provide their view on the findings and issues related to the recommendations. It was also an opportunity for them to add potential overlooked aspects to the findings to make them as complete as possible. See Table 9 below for professional title of the participants.

Table 9. *Details of the workshop participants*

PROFESSIONAL TITLE
Team leader 3
Process 1-2ABC operator
Continuous improvement manager 2
Section manager
Continuous improvement manager 1
Automation engineer
Production administrator
Production coordinator
Team leader 2
Process 3D operator
Process 3D operator
Packaging operator
Production coordinator

The workshop was booked in cooperation with the team leaders to assure that as many employees as possible could participate. Participants from earlier interviews phase A and B were invited to the workshop through e-mail approximately two weeks in advance. The team leaders were given the responsibility to invite production operators from two shifts. Invitations were sent out to production planning and transporters, but they were unable to attend. Presentation slides were sent out to production planning after the workshop to get their feedback on the findings and recommendations.

The workshop was conducted in Swedish in a conference room at the production facility. The structure of the workshop was developed together with the continuous improvement manager and supervisor at KTH. The duration of the workshop was approximately 90 minutes and was conducted on April 22, 2015. Timing of the workshop was in-between two shifts to make it possible for employees from both shifts to attend. The first part of the workshop consisted of a presentation of the findings from the interviews and observations made at the production facility. Afterwards the participants were allowed to pose questions and provide their feedback on the findings. This was followed by a draft presentation of the final recommendations. Further, the participants were divided into groups to discuss a recommendation per group. Every recommendation was provided with discussion topics and questions. Due to the time constraint of the workshop, some participants only participated in the first part of the workshop and did not participate in the discussion of the recommendations. After the group discussions, the participants presented the result of their discussion respectively. Lastly, the workshop ended by a joint discussion with general feedback on the recommendations.

3.2 Quality of research

A single case study approach implies that the results may not be applied in a generalized fashion, as the sample group will not be representative of the industry in general (Voss, et al., 2002; Collis & Hussey, 2009). Nevertheless, the context of the case is within the confectionary industry and it faces similar inherent uncertainties as the process and food industry. It is indicated that there is little empirical research in the area of manufacturing strategy related to integration of shared interfaces between production flows, which is an area of contribution for this thesis.

A method for analyzing the methodology of case studies was developed by Gibbert et al. (2008) where case studies in leading management journals were compared. This was used to test the rigor of field research connected to validity and reliability. The four criteria that are included and assessed lie within the positivistic tradition and are the following: internal validity, construct validity, external validity, and reliability. These are discussed below related to this thesis and what actions have been taken for each criterion.

3.2.1 Internal validity

Internal validity refers to the casual relationship between variables and results in the data analysis phase (Voss, et al., 2002; Gibbert, et al., 2008). It creates the foundation upon which the thesis conclusions are formulated. The following actions have been taken to ensure internal validity:

- Used different theoretical lenses and bodies of literature, as research framework or as means to interpret findings.
- Matching identified patterns by other authors to the findings of the thesis.
- Used a research framework that is derived from literature that explicitly shows the relationship between variables and outcomes.

Despite the inclusion of several perspectives on different organizational levels in the production facility, such as operators, coordinators, team leaders and managers, the perspective of top-management was not considered (Carlile & Christensen, 2005). This may lead to decreased internal validity.

3.2.2 Construct validity

Construct validity of a process is the quality of the conceptualization or operationalization of the relevant concept. It needs to be considered during the data collection phase. It refers to the extent to which a study investigates what it claims to investigate and to what extent the process leads to an accurate observation of reality (Voss, et al., 2002; Gibbert, et al., 2008). The following actions have been taken to ensure construct validity:

- Description of how the data was collected is done through the *Methods* chapter.
- Review of interview guidelines and drafts by peers that are not co-researchers (supervisor, colleagues).
- Review of interview guidelines and drafts by key informants (stakeholders at the studied company).
- Data triangulation of the following sources:
    - Direct observation derived data from the production facility

  - Interview data (from original introductory and in-depth interviews carried out by researchers).
  - Additional data collected from workshop with participants from previous interviews.

One factor to ensure construct validity from Gibbert et al.'s (2008) framework that was not considered in this thesis was the use of transcripts. The in-depth interviews of phase B were recorded, and during all interviews extensive notes were taken to conclude the findings for the thesis. As no transcripts were done and no review of the notes was done, the construct validity may decrease. However, during the workshop, findings were presented from all interviews and reviewed by key informants.

3.2.3 External validity

External validity, also defined as generalizability, refers to how well the research findings can be extended to other cases or settings (Collis & Hussey, 2009). Single or multiple case study approach does not allow for statistical generalization of a population, but the empirics can be used as a starting point for theory development and therefore analytical generalization (Voss, et al., 2002; Gibbert, et al., 2008). The following actions have been taken to ensure external validity:

- A rationale for selection of case study is provided in the *Introduction* chapter of the thesis and why it is appropriate in view of research question.
- Details of case study context through the production flow charts and company problem formulation.

Due to the context of the examined case with shared interfaces between complex production flows, it may be difficult to generalize the findings to other production facilities that inherit more traditional production structures. The extended usage of product profiling may be generalizable to other contexts. However, management of potential misalignments and suggested adjustments may be case specific and less generalizable.

3.2.4 Reliability

Reliability refers to the level of accuracy and repeatability in the study. The study should be possible to repeat under the same conditions including industry, companies, research questions and time frame with similar results. However, the conclusions and analysis of the gathered information may differ (Voss, et al., 2002; Gibbert, et al., 2008; Collis & Hussey, 2009). The following actions have been taken to ensure reliability:

- Case study database with all available documents, interview transcripts and detailed production flow charts is available upon request.

However, factors that can decrease overall reliability could be that different follow-up questions were posed during the semi-structured interviews, depending on the answer of the interviewee, which makes it difficult to repeat the research process under the exact circumstances. Another factor from Gibbert et al.'s framework (2008) that was not met to ensure reliability was the use of the organization's actual name. This factor was not met due to confidentiality agreement between company case and researchers. Therefore, the case company name is kept anonymous and referred to as the case company.

4. Results and analysis

The chapter presents the results and analysis of the collected data from the case study. The structure of the chapter is according to the research questions posed in the Introduction chapter. The chapter begins describing two flow charts of the three production flows that represent the case and visualizes the structural shared interfaces. Furthermore, it provides an analysis of the case by positioning the production flows in the product profiling framework by Hill et al. (1998). Misaligned aspects from the comparative product profiling analysis are further investigated regarding management of them, to support integration of shared interfaces in the production flows. Lastly, the management of the aspects within decision areas is further connected to level of manufacturing capability and focused manufacturing.

The objective of the thesis is to analyze integration of shared interfaces between production flows related to manufacturing strategy. To fulfill the objective, MRQ is answered through RQ1 and RQ2. To answer the RQ1, the production flows are described through flow charts and positioned in the product profiling framework. Further, the production flow charts describe the structural shared interfaces between the production flows. The product profiling describes shared interfaces consisting of infrastructural aspects together with aspects related to products & markets and manufacturing structure. Highlighted misalignments in the product profiling is analyzed further and connected to the level of manufacturing capabilities to answer the RQ2.

4.1 Identified aspects affecting integration of shared interfaces (RQ1)

An understanding of the examined production flows and its shared interfaces is necessary, to answer RQ1, on what aspects affect integration of shared interfaces between production flows. Firstly, the production flows are described and presented in flow charts, where structural shared interfaces are visualized. However, the infrastructural shared interfaces in the examined case are difficult to visualize in flow charts. These interfaces are taken into consideration when analyzing aspects affecting integration of shared interfaces in the extended usage of the product profiling framework.

4.1.1 Visualization of structural shared interfaces

The examined production facility consists of two main production lines L1, L2 and a third line L3 that is diverging from the main lines. These lines are referred to as flows. The examined flows are illustrated with flow charts later in this chapter. L1 and L2 are illustrated in one flow chart since they have similar processes and share characteristics related to products and market. L3 is visualized in a separate flow chart since it inherits distinct process characteristics and delivers to industrial customers. An understanding of the structural aspects of the shared interfaces is provided, by visualizing and describing the production flows.

L1 and L2 produce the same type of confectionary product, in two different sizes. L1 produces the smaller product and L2 produces the larger product. L3 manages different product varieties, depending on its raw ingredient that comes out of L1 and L2 through throw-outs. This raw ingredient will further be called semi-finished product, since it has been processed already and is not a genuine raw ingredient. The throw-outs are locations in L1 and L2 where semi-finished products are rejected due to quality variations or capacity limitations in packaging. There are two types of semi-finished products found in each size/line. These two types are centers and enrobes and are entirely prime products. The centers constitutes the core of the product that later gets covered and becomes enrobed. All finished customer products from the lines are standardized and follows an exact specification regarding qualitative aspects for example taste, weight, texture, appearance, tracking information and content.

The lines share structural interfaces that mainly consists of throw-outs and results in mutual dependability. The lines also share other structural interfaces such as shared buffers, transporting function and initial processes. Further, the throw-outs of semi-finished products are the start of the L3-flow and the semi-finished products are processed into finished products when ending the L3-flow. The flow charts presented in next sections, visualize the shared interface of throw-outs with a circle or triangle with darker color.

The production facility has gone through changes during the previous year, which have resulted in new investments. The changes that have been made are related to the packaging technique and packaging of the product which have required investments in new packaging machines. As a result of the changed packaging technique, issues have occurred in the new packaging stations.

A legend is presented in Figure 5 below to visualize the characters used, in order to interpret the flow charts presented further.

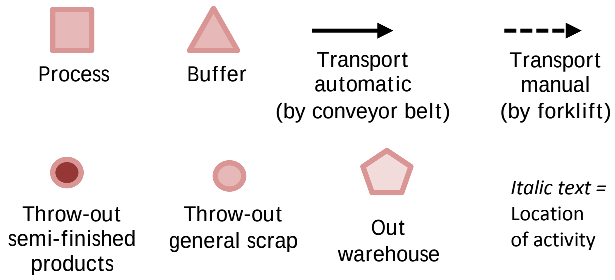

Figure 5. *Explanations of characters used in the flow chart*

Main production flows, L1 and L2

The production flows of L1 and L2 are shown in Figure 6. Both flows start with process A located in the cookery, thereafter they follow separate processes and have several throw-outs of semi-finished products and scrap. After all process steps, products get packaged into singles (customer unit), bag or multipack (customer unit) and into boxes (stock keeping unit). Lastly, boxes are transported to palletizing and further out to the warehouse. Transport or movement of the products within the flow is conducted by conveyor belts, or in containers moved by a transporter with forklift.

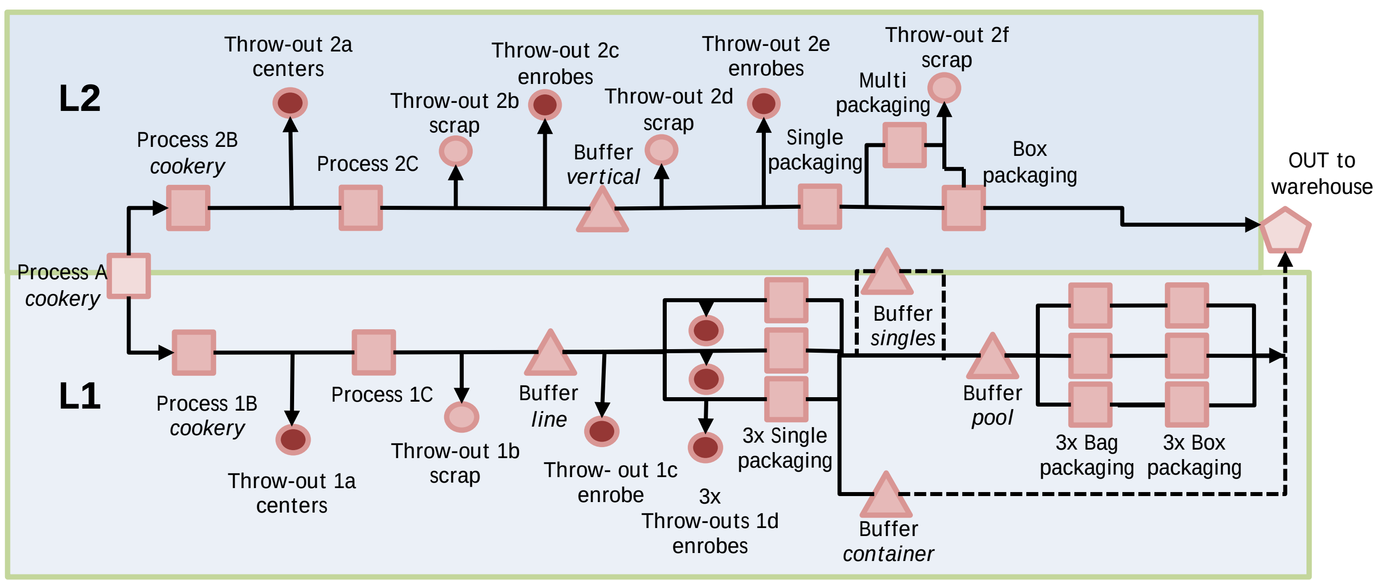

Figure 6. *Map over the main production flows of L1 and L2 in the examined case*

Besides the difference in product size between L1 and L2, other differences between the lines are seen. L1 has a higher amount of packaging stations and buffers than L2. The packaging processes in L1 are seen as bottlenecks from a flow perspective and create buffers along the line. This is due to the new packaging technique and packaging material that the facility recently has invested in. After the 3x single packaging stations in L1 there are three buffers of packaged singles, called buffer singles, buffer container and buffer pool in Figure 6. Whether the following packaging machines require new setups or run badly, the buffer pool or a white container of singles is filled up alongside the line (buffer singles). The buffer singles are placed into the buffer pool and continue through the flow when required by bag packaging. The third buffer after single packaging is the buffer container. This buffer consists of grey containers being filled up and directly sent to the warehouse and further to customers.

A container of some sort is placed at each throw-out to gather the output. It is a white container for semi-finished goods, disposal bag or octabins for scrap. The three throw-outs 1d in L1 collect semi-finished products into small containers that are manually emptied into a large container at each throw-out. The throw-out 2e of enrobes is collected into a small container and manually emptied into a large container close to this station. All other throw-outs of centers and enrobes in L1 and L2 goes directly into large containers that are further transported in the third line L3.

Semi-finished products flow, L3

L3 has a flow of semi-finished products and is therefore referred to as the semi-finished product flow; see Figure 7. L3 starts with several sources diverging from the throw-outs of centers and enrobes (1a, 1c, 1d, 2a, 2c, 2e) from the main lines (L1, L2). These throw-outs act as buffers and are separated in the flow chart due to different semi-finished product type and size, see Figure 7.

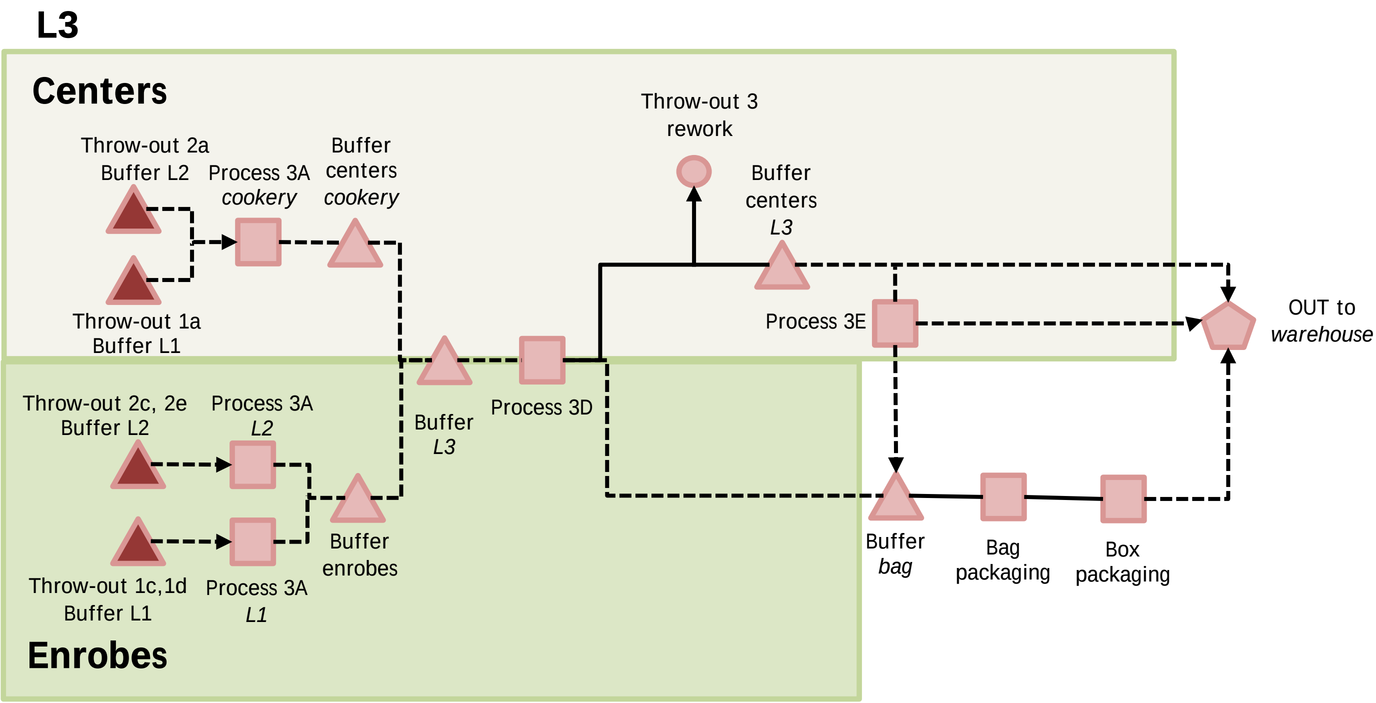

Figure 7. *Map over the semi-finished product flow of L3 in the examined case*

Whether the semi-finished product is a center or enrobe, it takes somewhat different paths after process 3D. Looking at the start of L3, each throw-out is its own buffer and is located on different places along L1 and L2. Operators manually transport the semi-finished products to process 3A when each buffer is full. Process 3A is carried out on three different locations; cookery, L2, L1 depending on the shortest distance to the process. Whether the containers are full and contain enrobes or centers, the position of the buffer differs. The buffers of small and large centers are stored separately in the cookery, close to its throw-outs. The buffer of small and large enrobes are stored behind the packaging station in L2. The distance between throw-outs of enrobes and their buffer is longer compared to the distance of throw-outs of centers to their buffers.

Process 3D is located in a separate space and has its own buffer. Depending on production order, semi-finished products are picked up from different buffers to the L3 buffer. Byproducts come out from throw-outs when processing centers in process 3D. These can be packed and transported out to the warehouse or used for rework. Rework is a product outside the defined specification and goes back into the processes of the production flows. Processed centers continue into a buffer and can either get packaged or sent out to the warehouse. Alternatively, the processed centers can go into process 3E and further into packaging, or out to the warehouse. No throw-outs of byproducts exist when processing enrobes in process 3D.

Processed enrobes go into the bag packaging (consumer unit) and further into box packaging (stock keeping unit) before being transported to the warehouse.

Transport in L3 is conducted manually to a high degree by transporting containers with forklifts, compared to L1 and L2 where the transport is highly automatic. L3 holds different types of semi-finished products in buffers and the mix and volume of them varies depending on market demand.

The structural shared interfaces visualized in the flow charts are throw-outs, shared buffers, transporting function and initial processes. These structural shared interfaces influence the infrastructural interfaces. For example, as throw-outs exist, the material control, which is a shared infrastructural interface is highly dependent on these throw-outs. Further, infrastructural interfaces are difficult to visualize in flow charts. Therefore, an analysis of the infrastructural aspects in shared interfaces together with manufacturing and products and markets are conducted in next section.

4.1.2 Analysis of aspects affecting shared interfaces through product profiling

Product profiling is a framework by Hill et al. (1998) that is used to find potential misalignments between the operations of a production facility related to its overall manufacturing strategy. It is divided into four different levels (products & markets, manufacturing, infrastructure, investment). These levels are further divided into relevant aspects depending on the context of the investigated facility. The tradeoffs related to each of the aspects are then visualized based on the process types, which creates a foundation for further work with the manufacturing strategy. In thesis, the manufacturing level is seen as structural decision areas as it represents aspects related to facilities and process technology as defined by Miltenburg (2005).

From Hill et al.'s (1998) product profiling, four levels are initially presented, however the level of investment is not included in the case profiling due to delimitation of investigating cost of for example work-in-progress, level of inventory and percentage of total costs. Also, due to complex shared interfaces between the flows of L1, L2 and L3, it is difficult to compare and separate the different inventory levels, work-in-progress as well as percentage of total costs. It also comprises complexity by comparing the level of investment when separating the flows due to different use of performance measures within the processes of the production flows.

According to the product profiling procedure presented in the theoretical framework, relevant aspects of three levels are chosen and kept small (Hill, 2009). All these aspects are chosen to show similarities and differences between the flows of main products and semi-finished products. See Table 10 for all chosen aspects for the product profiling analysis.

Table 10. *Chosen aspects to the product profiling analysis framework*

PRODUCTS & MARKETS	MANUFACTURING	INFRASTRUCTURE
Product type Product range Customer order size Rate of new products Order winner Frequency of schedule changes Planning horizon	Process technology Process flexibility Production volume Number of setups Key manufacturing task	Quality control Material control Inventory control Capacity control Internal transportation Human interaction Roles & responsibilities

The difference between flows in each aspect is interesting to highlight due to the RQ1 concerning what aspects affect integration of shared interfaces between production flows. The aspects chosen within products and markets are product type, product range, customer order size, rate of new products, order winner, frequency of schedule changes, planning horizon. The aspect of planning horizon is derived from the introductory interviews while the other aspects within this level are found through literature. The aspects derived from literature, are aspects from a list by Hill & Hill (2009), to consider upon usage of the product profiling framework. In the manufacturing level the chosen aspects are; process technology, process flexibility, production volume, number of setups and key manufacturing task. The infrastructural level is divided into material control, capacity control, internal transportation, inventory control, roles and responsibilities, quality control and human interaction. Material control and capacity control are derived from literature and the rest of the aspects within the infrastructural level are derived from the introductory interviews. All aspects in the product profiling are defined and explained in Appendix 4.

The product profiling is conducted on the main production flows (L1, L2) and the semi-finished product flow (L3). The analysis is based on data collected through observations and introductory interviews of phase A in the production facility. The positioning analysis in the product profiling is done separately for the flows of main products and semi-finished products to get an objective analysis of their current prerequisites. The separate product profiling analysis is not conducted with the process types in consideration, therefore not included in the case positioning of L1 and L2, and L3.

The comparative product profiling analysis is conducted according to traditional production structures, e.g. jobbing, batch, line, continuous. Related to the examined case, which consists of non-linear production flows with shared interfaces, the traditional approach composes constraints on analyzing complex production flows. Therefore, this thesis extends the product profiling framework usage, by analyzing misalignments between these production flows and products/customers through comparison. As the main production flows and semi-finished product flow share interfaces and are mutually dependent on each other, the difference in distance between the positions in the comparative analysis is proposed to be aligned. The shared interfaces are taken into account in the comparative analysis, by visualizing the aspects that affect integration of shared interfaces between production flows. However, the products & markets-level is not seen as a shared interface between the production flows as the flows has different product types and customers. L1 and L2 produce main products to consumer market while L3 produce products used as ingredients by industrial customers. The products & markets- level is included in the adapted framework because it is considered important in the formulation of a manufacturing strategy (Wier, et al., 2000).

Case positioning of main production flows, L1 and L2

The analysis and positioning of the main production flows in the product profiling framework is presented related to the different aspects that are chosen, see Figure 8. For the main production flows red diamonds represent the position of each aspect. The position of every aspect is explained below.

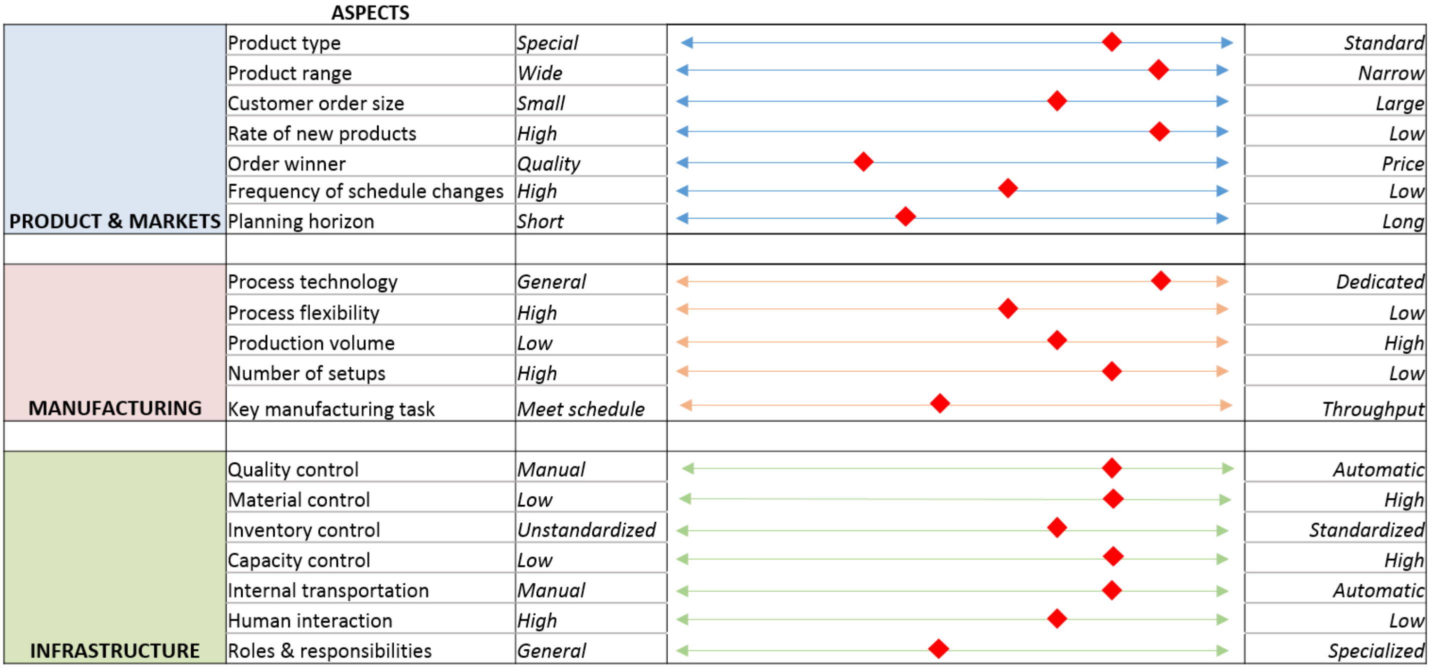

Figure 8. *Product profiling analysis of the main production flows, L1 and L2*

Products and markets

Product type: The products produced in the production lines are of a standardized nature and are not customized upon customer requirements. However, there are occurrences when the main product is altered and produced as a limited edition. This result in that the products are considered as almost fully standardized.

Product range: The products range is narrow since it only consists of two different core products, large and small. These are then packaged in different packaging units and sizes, but the core product remains unchanged.

Customer order size: The size of the customer orders are considered to be quite large in the production lines since the customers are large retailers and order in bulk-volumes, which later are translated into production orders.

Rate of new products: There are seldom new product introductions, except for a few new flavor introductions in the existing core product. Therefore, the rate of new products is considered to be low.

Order winner: The order winner from a market perspective is related to the quality of the products and brand name as an important factor. A flexible production facility that can respond quickly to changes in demand is also an important order winning factor. However, the market is also price sensitive to a certain degree, but it is not considered as the order winning factor.

Frequency of schedule changes: The production planning and scheduling is done with the production lines in focus, but can change due to machine breakdowns and new orders which results in changes in production prioritization. Therefore, the frequency of scheduling changes is considered as a bit lower than medium.

Planning horizon: The production planning horizon is considered as rather short because the planning is conducted on a weekly basis with mid-week checkups to ensure that the weekly scheduled volumes are fulfilled. Due to the short notice and lead time requirement from customers, it is not possible to have a longer planning horizon that is not solely based on forecasts.

Manufacturing

Process technology: The technology for the processes is of a dedicated nature since it is only possible to produce two different kinds of core products. However, it is not seen as completely dedicated since the two core products can be produced. The manufacturing equipment can be adjusted to change the product ingredient mixture and packaging material, but the visual characteristics of the product will still remain.

Process flexibility: The manufacturing processes are rather flexible to demand and schedule changes since it is possible to make use of additional shifts in the facility for increasing demand. In case of decreasing demand, the process speed can be altered to accommodate the requirements. However, the processes are highly inflexible since the whole production line is dependent on the process stations in the beginning of the line. In case of potential breakdowns or process stops, this will result in an eventual total stop of the line when buffers run out.

Production volume: The production volume is considered as almost high in the manufacturing facility, but as there is still room to implement additional shifts and increase speed, the production volume has not reached its peak capacity.

Number of setups: The initial process steps is conducted as a continuous process, while the subsequent packaging processes require different setups depending on the end product type, but the total number of setups is considered as fairly low.

Key manufacturing task: Connected to the high production volume, the production facility demands that an efficient production is carried out with the cost-efficiency constantly in focus. There are also a number of customer and quality specifications that have to be fulfilled, but these are of a standardized nature and will not be changed according to each customer's requirements. The task of the manufacturing is focused on meeting production schedule and producing according to demand, but also to maximize output and utilization of the manufacturing equipment.

Infrastructure

Material control: The level of material control in the manufacturing facility is considered as almost high since the production planning and control reserves the necessary raw and packaging material that are required to meet the production schedule.

Capacity control: The capacity control level is high in the manufacturing facility since the main production lines, L1 and L2, are balanced related to process speed and output to compensate for capacity limitations. However, it can be discussed whether it is a good solution to have a throw-out of centers to compensate for bottlenecks in the production and not deal with removing the bottlenecks completely.

Internal transportation: Internal transportation in the facility is conducted mostly automatically by the use of conveyor belts along the production flows. However, some steps between the production processes require manual transportation such as re-input of thrown-out products and transportation of finished products to storage areas.

Inventory control: There is a rather standardized system to keep check over the inventory level and balances of finished products and raw material. There are specific storage areas for different types of products and packaging material in the facility. In case of volume peaks, material may be stored at other locations except for the designated areas to accommodate the large volumes.

Roles & responsibilities: Considering the main product flows, the roles and responsibilities of the employees are both general and specialized. The operators have competences in different parts of the production within several processes and are able to be stationed on different stations in the facility. Even if an operator is stationed in a specific station, the responsibilities regarding surrounding and supporting activities can be unclear depending on the shift and individuals.

Quality control: The quality control is done through automatic detectors in the production line that is used for metal-detection and product quality deviances, such as visual characteristics. However, some manual quality control exists throughout the production line regarding product weight and temperature characteristics.

Human interaction: The level of human interaction is rather low in the production process. The human interaction activities that exist may include interference in the packaging process in case of problems and change of parameters in the initial process stages. Many parts in the production lines are not closed processes, which poses both quality and security risks since the product can be affected by externalities.

Case positioning of semi-finished product flow, L3

The analysis and positioning of the semi-finished product flow in the product profiling framework is presented related to the different aspects that are chosen, see Figure 9. For the semi-finished product flow white circles represent the position on each aspect. The position on every aspect is explained below.

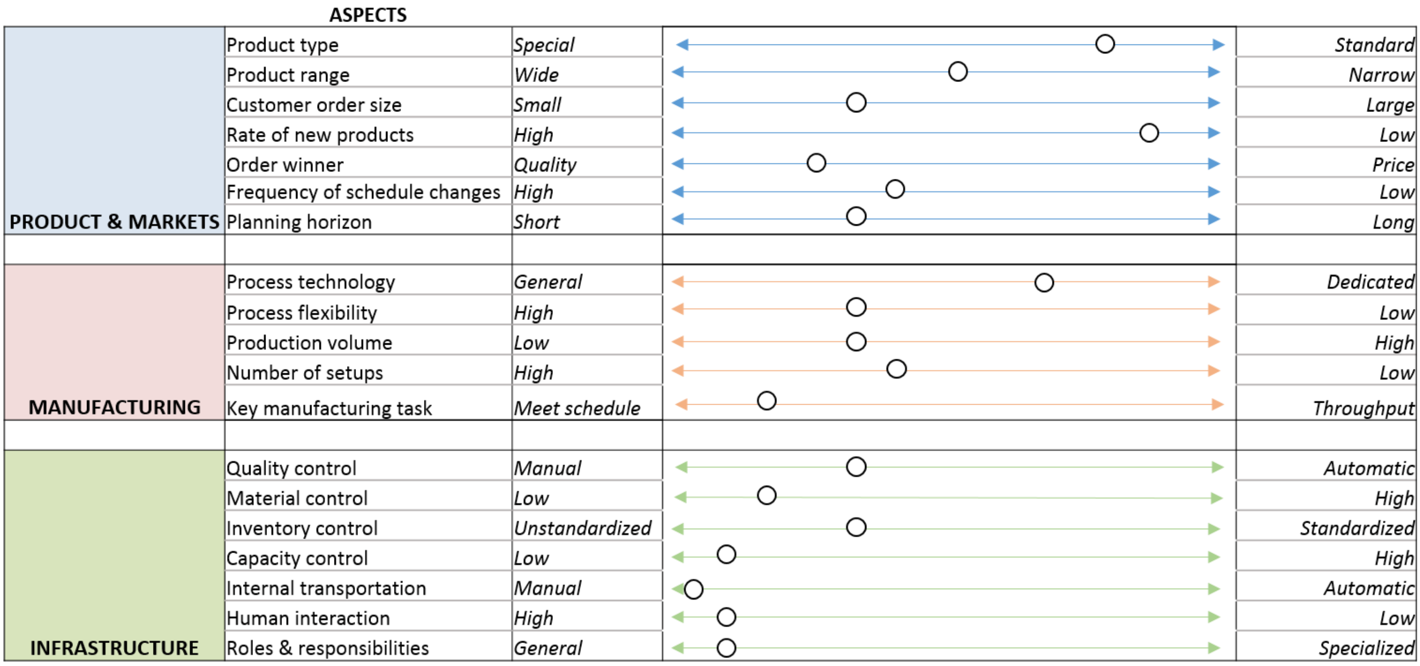

Figure 9. *Product profiling analysis of the semi-finished product flow, L3*

Products and markets

Product type: The products produced in the semi-finished product flow are of a standardized nature and are not customized upon customer requirements. All products are produced based on two different ingredients of semi-finished products. This result in that the products are considered as almost fully standardized.

Product range: The product range in the production line is quite narrow, but there are a few types of products that are packaged and sent to the customer based on the same core ingredients from the main lines. However, the product range is considered as wider because the end products inherit different characteristics regarding size and process type.

Customer order size: Since the product range is wide, the size of the customer orders naturally becomes smaller as the total production volume is spread out. The end products are sold to industry customers that use it as an ingredient in their production processes, which results in that some articles are dedicated to a single customer. This also contributes to the smaller order sizes.

Rate of new products: There are few instances of new product introductions in the semi-finished product flow during the last years. This is due to limitations in the process and ability to only produce one type of product. Therefore, the rate of new products is considered as low.

Order winner: The order winner for industry customers is more focused on the brand name and quality rather than price. This is because the industry customer's end products are dependent on the use of the semi-finished products as an ingredient and therefore are less price-sensitive.

Frequency of schedule changes: The frequency of production schedule changes is seen more high than low. One reason is because the ramp-up time for the equipment is low and therefore more flexible to sudden changes in process orders. This flexibility aspect is frequently utilized for producing production orders on short notice. Another reason is because the semi-finished product flow is dependent of the input of ingredients from throw-outs of the main lines, which can create fluctuations depending on capacity limitations.

Planning horizon: The planning horizon is seen as rather low because sequential planning is conducted with the main lines in focus and the semi-finished product flow as a secondary priority. This is done on a weekly basis with mid-week checkups for assure that the production volumes can be fulfilled.

Manufacturing

Process technology: The process technology is considered to be more dedicated than general because it is possible to process and produce different sizes and types of end products. However, these are based on two different types of ingredients coming out from the main lines, which make the equipment dedicated to specific products.

Process flexibility: The semi-finished product flow is sensitive to breakdowns as the whole line depends on a single process. It is possible to make use of additional shifts in order to fulfill customer orders, but it is not possible to increase the process speed of the equipment and therefore decrease the cycle time. It is possible to produce small volumes without long ramp-up times, which results in a higher process flexibility to meet demand.

Production volume: The production volume is considered as more towards low than high because the equipment has not reached its peak capacity. There are still possibilities for additional shifts and use of the equipment during existing shifts to meet increasing demand. However, when the equipment is used, the production volumes are considered to be high.

Number of setups: The number of setups in the semi-finished product flow is seen as high rather than low because of required tool changes, setup for finished product containers and additional input to produce some products.

Key manufacturing task: The overall objective in the semi-finished product flow is to meet the production schedule in order to accommodate customer demand. The emphasis is on maximizing throughput is less present as the focus is on fulfilling process orders and making to order rather than making to stock.

Infrastructure

Material control: The ability in the semi-finished product flow to reserve and control input material to the production is considered as low. The semi-finished product flow relies on the throw-outs of the main lines and use input material according to demand from the industry customers. Potential surplus in the buffer of centers and enrobes can be used to a certain degree as rework. Therefore, there is no need for any specific control systems since normal operations will always result in throw-out and supply of input material to the semi-finished product flow. In case of high volumes, it is possible for the main lines to only produce centers dedicated for the semi-finished product flow and in that case, the material control is seen as high. However, this is not the typical scenario and is seen as rare, but argues for that the material control is not completely low.

Capacity control: The capacity control in the semi-finished product flow is low as there is no balancing of the different process steps. The cycle time of the processes varies, which creates the need for buffers between the stations. These buffers consist of enrobes and centers in two sizes that are needed for the different varieties of end products. This creates further complexity in managing and controlling the capacity because additional time is required to assure that the correct container is used in the process, which results in a longer cycle time.

Internal transportation: The internal transportation in the semi-finished product flow is conducted manually with high frequency. The transports consist of getting input material to the processes, moving products to and from the buffers in-between the process activities and moving finished products to storage areas. The distance of the transports can also be long between certain processes and storage areas. The long distance creates a high workload for the transporters that have to serve the whole facility.

Inventory control: The inventory control is seen as more unstandardized than standardized because there is a system for keeping check over the inventory balances and its filling date for increasing traceability. However, this system is newly implemented and is not able to communicate with the existing ERP-system that is used by the production planning. The system is also unable to track First-In-First-Out (FIFO) in the inventory, which has to be done manually on a daily basis. In case of high volume peaks, material may be stored at other locations than the designated storage areas. This results in a lack of storage orderliness that may lead to an increased safety risk. The level of communication between different processes and how it is conducted may vary depending on the individuals working in the particular shift.

Roles & responsibilities: Considering the semi-finished product flow, the roles and responsibilities of the operators are seen as general, because all staff are able to work with all involved processes. As one process step has a longer cycle time than the others, the operators are able to help out in other parts of the facility with processes or transportation. The responsibilities can also differ between shifts considering transportation between storage areas and buffers. Therefore, the roles and responsibilities are seen as general as it is also individually dependent without clearly set roles.

Quality control: There are automatic metal detectors placed in the initial process and in the bag packaging. If a detector detects metal in the process, it results in that the whole production line has to be halted in order to resolve the issue manually. The large number of open containers with products poses a quality risk as it is exposed to threats such as foreign objects being dropped into the containers. This potential issue has to be handled manually through visual screening. This is a typical case of sub-optimization where each process has its own quality control mechanisms, but the issue lies in-between the processes where the control has to be done manually. Therefore, the quality control is considered as more manual than automatic since crucial parts of the control process is done manually, which can pose product quality risks.

Human interaction: The level of human interaction is high in the semi-finished product flow because all processes are dependent on the operators that operate them manually. The transportation of containers and material input is also conducted manually. Many control systems depend on the individual as a variable and are subject to human errors in the screening and input process.

Comparative analysis of L1, L2 and L3

The comparative analysis consists of merging the separated product profiling analyses of L1, L2 and L3, see Figure 10. Furthermore, the positions of the aspects within each level visualize misalignments between the production flows. Visualizing alignment between production flows is seen as an extension to the traditional usage of the product profiling framework. The traditional approach shows misalignment between products, product groups, customers or companies. Furthermore, the traditional approach implies a comparison between current state and wanted state, not specifically misalignment between production flows in the current state. Misalignment is defined as a distance between positioned dots of the production flows in the product profiling analysis for each aspect. The production flows inherit different characteristics when analyzed through product profiling.

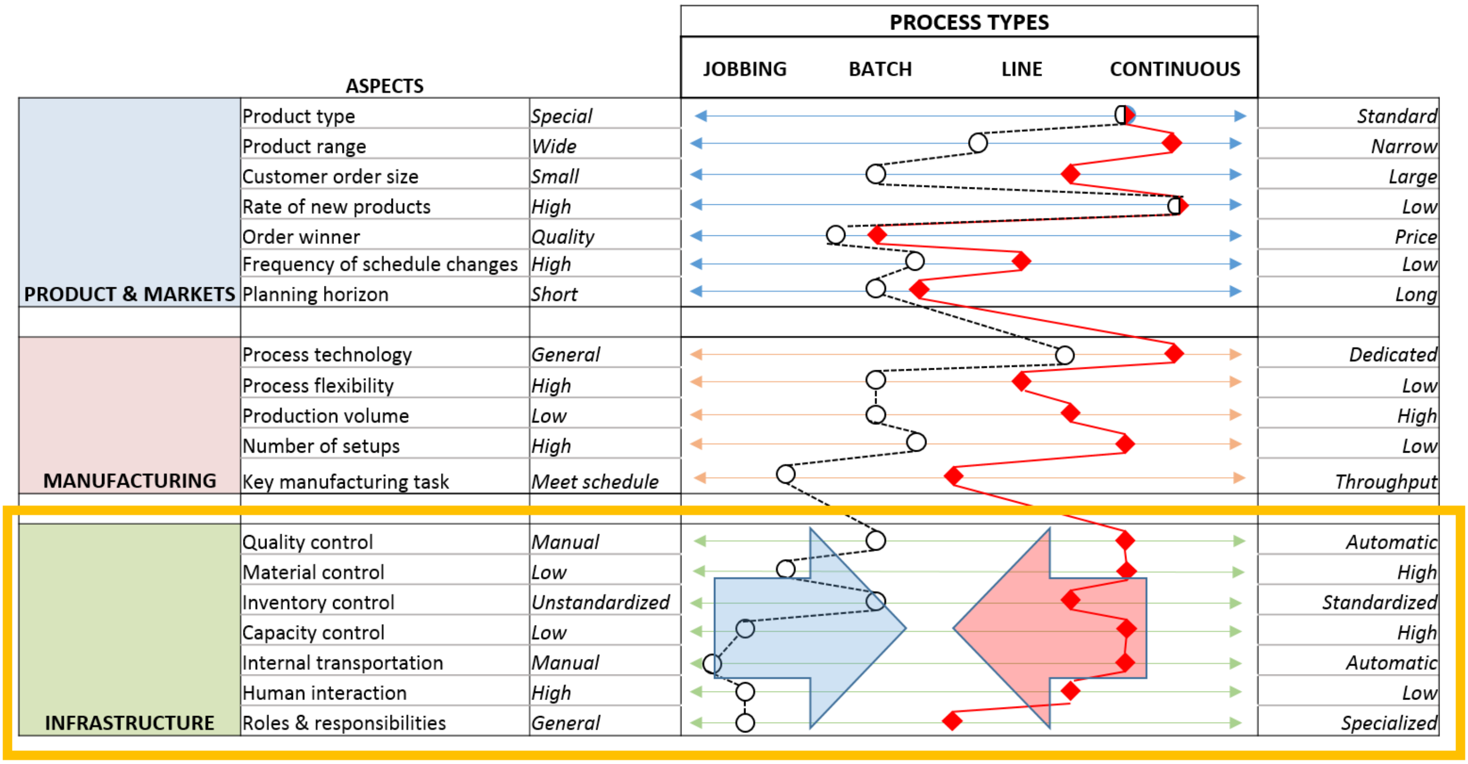

Figure 10. *Product profiling analysis of the production flows within the examined case*

In general, by comparing the examined production flows in the product profiling, the production structure of L1 and L2 are seen as more line and continuous, while L3 is seen at the left-hand side of the framework towards jobbing and batch. In practice this difference in production structure may cause issues such as high inventories and unbalanced capacity. These mentioned issues may have more impact and are related to the structural shared interfaces rather than the infrastructural. As the product profiling framework is extended in this thesis with the complex dimension of shared interfaces, a classification of process types and production structures is not seen as a mean to support integration. Due to the complexity of shared interfaces in the production facility an integration of aspects are proposed, towards a more focused way of managing the aspects and decreasing complexity in production facility.

The main similarities are in the products and markets-level, where the product type is of a more standardized nature and that the rate of new product introductions is considered as low. The similarity can be seen in the close alignment of the positions of the products & markets aspects, see Figure 10. The main differences in the products and markets-level are the product ranges, customer order sizes and frequency of schedule changes. However, the products and markets-level is not considered as a shared interface because the product types and customers differ. Therefore, it is not further analyzed in the integration of shared interfaces.

Comparing the positions of aspects within manufacturing level, misalignments occur to a larger degree compared to the level of products & markets. In the manufacturing-level, the process technology in the semi-finished product flow is of a general nature, which results in a higher flexibility, but also in a decreased ability to handle high volumes. The number of setups is higher since the key manufacturing task is to meet schedule, rather than maximizing throughput. However, even if there are differences and misalignments between the production flows in manufacturing, the level of misalignments within manufacturing is considered as lower than in the infrastructural level.

Within the infrastructural level, both the material and capacity control differ, where the level of control is higher in the main production flows. Internal transports are conducted manually in L3 and automatically in L1 and L2. The inventory control is more standardized in L1 and L2 than in L3. The roles and responsibilities in L3 are of a more general nature than in L1 and L2. Also, the quality control is conducted more automatic in L1 and L2 than in L3. Lastly, the level of human interaction is higher in L3 than in L1 and L2. The level of misalignments of the positioned dots in the infrastructural aspects is considered as the highest compared to the other aspects and levels in the product profiling framework, which is visualized in Figure 10.

Since the production flows share interfaces both structurally and infrastructurally, misalignments have to be handled accordingly. As product profiling framework is developed to be used for traditional production structures, the dimension of shared interfaces between production flows cannot be visualized in the original framework. However, the shared interfaces between the production flows are confirmed by introductory interviews and observations to mainly be presented within infrastructure. Therefore, managing these infrastructural aspects will affect the integration of shared interfaces. From the comparative product profiling analysis, it is shown that there is a high degree of misalignments within the infrastructural aspects and managing these can result in an efficient integration of shared interfaces between the production flows. This is supported by introductory interviews with production employees and managers that highlight issues connected to infrastructural aspects. Additionally, the area of infrastructure research is indicated as scarce, regarding what type of infrastructure that is desired to utilize a production line's full potential (Maffei & Meredith, 1995).

As the examined production facility have recently invested in new process equipment, it is not likely that new investments within manufacturing processes are done within the near future. Therefore, the structural decision area and aspects are seen as fixed and not further investigated in this thesis. The production facility already has established products on the market with few alterations planned for the core products, therefore the products & markets-level is seen as fixed. This is in accordance with Hill et al. (1998), arguing that market-oriented companies with already established products and existing investments in manufacturing processes are more likely to adjust the infrastructural aspects to deal with the misalignments.

There is no standard procedure to manage misalignments found through product profiling (Swenseth, et al., 2002). The suggested recommendations may not always be consistent with accepted practice in manufacturing organizations (Schonberger, 1999) and established theory (Hill, et al., 1999). Therefore, the suggested adjustments have to be adapted to the specific context of the case where it is considered that the largest possibility in handling misalignments is through the infrastructural aspects.

Product profiling has received critique regarding its limitations and that the framework itself is not sufficient to create a driving force for strategic change in manufacturing. It has to be combined with other tools, such as simulation to motivate the managerial decisions and show the effects on company performance (Swenseth, et al., 2002). In this thesis, the product profiling is used as a foundation for further analysis on integrating shared interfaces between the production flows through infrastructural aspects. It is also used to create knowledge about the misalignments in manufacturing through a visual illustration of the current state and potential issues between the production flows. This is something that is valuable in future strategic decisions (Hill, et al., 1998).

Concluding remarks

The identified aspects affecting integration of shared interfaces between production flows are the infrastructural aspects. Firstly, the level of misalignments of the positioned dots in the infrastructural aspects is considered as the highest compared to the other aspects and levels in the product profiling framework, visualized in Figure 10. Secondly, the products & markets aspects are not seen as a shared interface between L1 and L2, and L3. Thirdly, manufacturing level which is seen as a structural interface is considered as fixed, since no new investments within process equipment and technology are possible in the near future, according to case company. Finally based on these mentioned arguments combined with the large emphasis on infrastructural issues in introductory interviews the infrastructural aspects are the aspects affecting integration and are adjustable in the examined production facility. The identified aspects affecting integration of shared interfaces aims to answer RQ1.

4.2 Management of infrastructural aspects (RQ2)

Aspects affecting integration of shared interfaces between production flows are the infrastructural aspects, from the product profiling analysis in the previous section. An analysis of the management of the infrastructural aspects is conducted in this section to answer RQ2. The product profiling infrastructural aspects were used as a basis for the in-depth interviews. These aspects were further developed through in-depth interview findings and workshop into major case aspects that represent the examined production flows, see Table 11. Both the product profiling and major case aspects are connected to the definition by Miltenburg (2005) of infrastructural decision areas. However, the product profiling aspects and major case aspects are not directly connected to each other, but inherit similar characteristics.

Table 11. *Overview of identified aspects in connection to infrastructural decision area*

PRODUCT PROFILING INFRASTRUCTURAL ASPECTS	INFRASTRUCTURAL DECISION AREAS (Miltenburg, 2005)	MAJOR CASE ASPECTS
• Quality control • Material control • Inventory control • Capacity control	PRODUCTION PLANNING AND CONTROL	Production planning
		Control of raw material and semi-finished products
		Semi-finished products inventory and FIFO-control
		Production capacity control
• Internal transportation • Human interaction	ORGANIZATION STRUCTURE AND CONTROL	Manual handling of semi-finished products
		Information sharing in the production facility
• Roles & responsibilities	HUMAN RESOURCE	Communication of roles and responsibilities

The following chapter presents an analysis of the management of the major infrastructural case aspects and related issues. Data from interviews are referenced throughout the chapter. Details of the interviews and interviewees that are used for reference are available in the *Methods*-chapter. Empirical findings not referenced from interviews are based on earlier observations and company documents.

4.2.1 Production planning

The aspect production planning is a shared interface between the production flows. The general perception is that the management of the aspect production planning functions well, and that the communication with manufacturing is good (B4, B5). The level of volume fluctuations and frequent schedule changes are most present in L3-flow (B4). When schedule changes occur, interviewee C5 perceives that these most often are volume changes. The overall goal is to have a flexible production and be able to deliver according to customer requirements (B3). However, there are complexities in the shared interfaces of production planning that may cause issues for integration.

The production planner takes in customer orders of semi-finished products and compares this to current inventory levels. The net balance of semi-finished products is planned as a production order. Customer orders for L3 have to be placed two weeks in advance to assure delivery on time. Production planning has regular meetings with the team leaders to plan the production for the upcoming week and establish a fixed production sequence (B1). If machine breakdowns in the packaging occur during the week when the production plan is fixed, one difficulty is to capture the increasing inventory levels of semi-finished products. Therefore, the production may be scheduled to produce more semi-finished products than required. Production planning does not have any knowledge about the maximum amount of storage in production (B1). This may create difficulties in planning the production and supply of semi-finished products during high volume peaks. Additional complexity relies in the requirement of expiration dates of the different semi-finished products, which have to be taken into consideration when planning. Enrobes have an expiration date of two months and centers one month (C5). This also adds to the complexity of the interface of production planning.

Another reason for increasing complexity in the interface between production flows are due to the planning of different products with different market. The production lines produce two types of products; main and semi-finished products. Further, these products serve different markets. Semi-finished products in L3-flow are delivered to industrial customers that are managed differently than the customers of the main production lines. Orders from industrial customers are managed by production planning, instead of conventional demand planners. These orders are handled differently depending on customer size and if it is internal or external. For example, orders from an important customer can be issued as a production order even if it has been received later than the accepted delivery lead time. However, orders from other customers may be rejected because of unavailable production capacity in the current production plan (B1). This approach by agreeing on a shorter order fulfillment lead time towards customers can cause confusion and unrealistic future expectations of when an order can be placed.

Demand from industrial customers inherits a higher degree of variability than customers of the main production lines (B1, B7). According to Ketokivi & Jokinen (2006), focused manufacturing strategies are easier implemented and sustained when demand is stable. Complexity in demand for L3-flow causes difficulties for the possibility of having a focused manufacturing strategy concerning markets or products. Reduced complexity and increased predictability of demand can be created by long-term and stable relationships with fewer key customers (Ketokivi & Jokinen, 2006).

Production performance measures are set centrally and currently the main focus in to have efficiency and at the same time reducing costs (A4, A6). In case of a customer placing large-sized orders, the main priority is to fulfill that order, rather than risking back orders. To do this, extra shifts are used to maintain a high service level, rather than having a cost efficient production (A6, B2, B4). This may be contradictive with the aim of increasing efficiency set by the central organization. Central management is also strict on reducing inventory levels of packaging and raw material for production (A6). However, evidence proves that the tradeoff between flexibility and efficiency is not as substantial as earlier research has shown. Therefore, increased manufacturing flexibility improves both operational performance through improved efficiency and increased speed of the workflow (Ojha, et al., 2013). It is important to align the competitive priorities and manufacturing decision areas in the manufacturing strategy with the business strategy to be able to achieve competitive advantage (Skinner, 1969; Hayes & Wheelwright, 1984; Hill & Hill, 2009). The planning function in the production facility occasionally shifts priority from cost-efficient production to flexibility in meeting customer demand. Therefore, it is considered that the manufacturing strategy through the planning function is not fully aligned with the overall business strategy.

To conclude the major case aspect production planning is included in the infrastructural decision area production planning and control as defined by Miltenburg (2005). This is characterized as a decision between centralization and decentralization of the production planning function and is one of the more important decisions to achieve sustainable competitive advantage (Garrido, et al., 2007). The studied production facility is considered as going towards a more centralized approach with focus on the competitive priority cost from central management. However, the planning of L3-flow is seen as more decentralized than the main production lines, with more focus on the competitive priority flexibility. Also, the process type of L3 is considered as jobbing and is highly flexible, but not very cost efficient (Hayes & Wheelwright, 1979). As a consequence of this conflicting approach, the overall focus is on different competitive priorities that may provide disadvantages to competitiveness (Skinner, 1969; Leong, et al., 1990; Hill & Hill, 2009).

Considering the management of the aspect of production planning, concluded issues related to the interfaces between the production flows and a potential efficient integration are:

- *Production planning is flexible today for both lines. L3 is seen as more flexible than L1 and L2 due to the production structure of it and the shorter customer order fulfillment. This makes the overall focus and coordination of competitive priorities not fully aligned between the production facility's production flows and the central business organization.*

4.2.2 Control of raw material and semi-finished products

The aspect control of raw material and semi-finished products is a shared interface between the production flows. Material control of semi-finished products is complex since the processes in L3-flow are highly dependent on L1 and L2 to provide semi-finished products as ingredients for production. L1 and L2-production lines always produce a varying amount of semi-finished products with centers and enrobes. Material control of semi-finished products is not seen as complex from an operator's perspective, as quoted by C3 and C9 below.

"The L3-flow is run like a separate business unit. The main focus is on getting centers and enrobes for the production. The operators are content as long as it exists in the inventory buffer."

However, the production structure creates complexities, as the semi-finished products have to be handled regardless of demand. There is a need to plan the semi-finished product flow three weeks ahead (B2). However, this is not possible due to uncertainties in customer demand as orders can be placed within two weeks of production. There are also uncertainties in process output as some machines may run badly and not provide the intended production capacity. Consequently the control and planning of semi-finished products is highly complex, because supply from L1 and L2 may vary. Therefore, a balance has to be found that accommodates the demand, but also maintains minimum inventory levels. As supported by Helkiö & Tenhiälä (2013), complex production tasks make production processes more vulnerable to errors in planning, which may cause delivery delays. According to B6, insufficient production planning causes unnecessary waiting time in processes. Production planning has adapted to the complexities by having short fixed planning horizon of one week. If the planning horizon would be longer, it may not be possible to fulfill all customer orders and deliver in time.

The planning of material control of raw material normally works good and increasing demand volumes can be handled if they are announced in time (B1). However, the main issue with increasing demand is the supply of packaging material from external suppliers. There is barely enough packaging material to accommodate production need for frequent products. Meanwhile, packaging material inventory for less frequent products is too high (B3). The main bottleneck for increasing production volumes is the supply of packaging material from different suppliers with varying lead times (B1).

In case of decreasing demand, the inventory of semi-finished products increases and has to be handled (B5). If this increased inventory cannot be captured by customer demand, it has to be used for rework. This has to be taken into consideration in the production planning process that is highly dependent on the inventory balances in the system and that it reflects reality properly. There is a high amount of non-value adding activities such as long times in buffers between stations, long-distance transports and high amount of rework. However, it can also be considered as a failure if products are reworked constantly as it is an indication of waste in the production processes (A3). A positive aspect with rework is that unused semi-finished products can be reused instead of scrapped, which is an economic loss. However, rework is also seen as an economic loss, as quoted by A6 below.

"Costs can be hidden through rework of semi-finished products"

When using rework, the final products delivered to customers have gone through an additional process cycle compared to using raw material. Therefore, rework is considered as a non-value adding activity that in the end is more costly.

To conclude the major case aspect of control of raw material and semi-finished products is included in the infrastructural decision area production planning and control as defined by Miltenburg (2005). This is characterized by the decision between push- or pull-based production systems (Garrido, et al., 2007). The studied production facility has a combination between the two production systems. As the main lines always produce semi-finished products the material requirement for L3 production line is considered as a push system. At the same time nothing is produced in L3 if it is not demanded by customers and therefore it is also considered as a pull system.

Considering the management of the aspect of material control, concluded issues related to the interfaces between the production flows and a potential efficient integration are:

- *The complexity of the material control consists of the continuous output from L1 and L2, the supply of packaging material, the use of rework and the different production systems of push and pull. This complexity creates an overall issue when finding a balance to accommodate the demand.*

4.2.3 Semi-finished products inventory and FIFO-control

The aspect semi-finished product inventory and FIFO- control is a shared interface between the examined production flows. The view of semi-finished product inventory levels varies. Some claim that the inventory levels are normal and under control (B3, C1, C5, C7), other claims that they are high due to low production capacity (C6, C13). Further, interviewee C4 claims;

"When the inventory levels are high, it is because the supply of semi-finished product from L1 and L2 is higher than the demand from L3."

Some perceive the inventory levels as low (C8, C9, C10, C11). Operators in L2-packaging and L1-single packaging state that they do not have any knowledge about current inventory levels (C12, C14). Perceived level of inventory differs between the person's role in the production and different production lines. In case of high production volumes of centers, the inventory area in the cookery cannot accommodate these volumes and the containers have to be stored elsewhere in the production facility (C10, C11). The buffer of semi-finished products in the L3-flow is filled according to available space in the inventory area, not according to production orders and batches (C6). There are differences between the semi-finished products, when it comes to inventory handling. As mentioned, centers and enrobes have different expiration date. Furthermore, containers of centers spend less time in inventory than enrobes (C4). Enrobes are produced according to production orders and L3 demand, while centers are produced according to production order but also continuously when processes, such as packaging, run badly. Centers produced without a production order are used when L3 demand occurs (B5). Since the production of enrobes and centers is costly to stop frequently this together with above mentioned issues creates challenges in avoiding obsolescence and maintaining sufficient quality in the products.

Inventory levels in the IT-system are not always correct and reflecting the actual levels in the production. The most frequent error is in the L3-flow where the production operators write shift production volumes manually. Production output is reported after each shift by article number and checked off in the production plan schedule (C6). These volumes are based on outcome volume from the process, not the inserted volume. The volumes are later reported into the IT-system and can be mistaken because of faulty handwriting (B5). Semi-finished products inventory levels are checked manually on a daily basis. The IT-system is considered as fragile since the inventory levels in the system are not reliable and therefore dependent on manual input of one person (B3, A6, A8, A9).

To maintain high quality in the products, First-In-First-Out (FIFO) is used throughout the production for semi-finished products inventories and buffers. It is managed by sorting the containers of products depending on date and shift, where the oldest should be placed in the front position of the inventory area (B5). This is to simplify the handling of containers for the operators in L3-flow and minimize the risk of scrapping expired products. Further, lower inventory levels simplify the handling of FIFO (B1, B4). The responsibility for managing FIFO is divided between operators and transporters. In practice it is perceived that the responsibility for taking containers according to FIFO lies more with the L3-operators, rather than transporters (C3, C8). Operators generally put more emphasis on the date, rather than the shift, when storing and taking containers from inventories (C14). The handling of FIFO also varies between different operators and shifts (C5). There is a low level of standardization on how FIFO should be conducted and it is not communicated properly to operators. Therefore, different operators do it differently. Some operators explain that an interval of plus/minus one day is accepted when taking containers of semi-finished products according to FIFO (C10, C11).

A scanning system has been implemented, to decrease manual inventory control and reduce typing errors due to human interaction (B11, C12). This is used to track the semi-finished products internally and increase traceability. A container is scanned when being filled, emptied or moved from a throw-out or process. Currently, a label is printed out and placed on to the container after scanning. The label describes the contents of the container such as product type, date and weight. The scanned information is transferred into a database which has not yet been integrated with the common IT-system. There is no possibility to see the location of containers containing semi-finished products in the production facility through the scanning system (B6). One of the original objectives with the scanning system is to get rid of the labels (B6). The scanning system makes it possible to remove physical labels in the long run, but in order to do this there is a pressure on the system to work properly (B6). If the labels are removed, the ability of having an overview of the inventory decreases as containers have to be scanned in order to see its content.

The scanning system is able to alert when there is a risk for containers with expired ingredients, but not for FIFO in inventories (B6). The quality control systems depend on regular sample checks conducted by production operators. However, the current control system is highly dependent on personal preference of the operator conducting the check. An affecting factor can be that the operators evaluate the quality of their own products in the production line (B3). This may create differences in the level of quality control and sometimes a quality check with inferior quality can be approved because of unstandardized routines and lack of time (B4).

To conclude the major case aspects of inventory control and FIFO-control are included in the infrastructural decision area production planning and control as defined by Miltenburg (2005). As previously mentioned, the production facility uses a combination of push- and pull-system, which creates complexities in the inventory control. The combination of operation systems may also result in higher levels of inventory. To handle the inventories today, more manual effort is required and a greater emphasis is placed on the FIFO-structure to work. As the current inventory control is time consuming with controls every day, it is an issue to highlight for an efficient integration of the production flows. What is also reflected in the decision area of production planning and control is the size of work-in-process (Miltenburg, 2005), which is considered in major case aspects of inventory control and FIFO-control.

Considering the management of the aspect of inventory control, concluded issues related to the interfaces between the production flows and a potential efficient integration are:

- *The inventory control is conducted manually to a high degree and not very efficient. However, the manual control is required due to the insufficient support of the current IT- and scanning system.*
- *The FIFO-structure is handled differently among employees*.

4.2.4 Production capacity control

The aspect production capacity control is a shared interface between the examined production flows. Management practices and issues related to capacity control were highlighted from interviews as planning of overall capacity, strategy of capacity, planning of staff and processes.

The main production lines are unbalanced where initial process has a higher production capacity than the packaging side (A6, B3). This unbalance is somewhat taken into account for in current planning process. However, there exists an uncertainty in the supply of semi-finished products that depends on how well the packaging machines works and the capacity is utilized. These semi-finished products are used in the L3-flow that serves a different market than the main production lines. The semi-finished products in this case can be referred to as *filler products* as defined by Ketokivi and Jokinen (2006). These are products that may not fit the main manufacturing task, but is available to capture excess capacity and in order to achieve a higher efficiency. Manufacturing facilities that make use of filler products may choose to not implement a focused manufacturing strategy. This is because a single market cannot absorb the total maximum capacity of the production lines (Ketokivi & Jokinen, 2006).

Maximum production capacity is taken into consideration when planning, for example planned production stops such as machine set-ups and cleaning (A4, B1). Also, normal output of semi-finished products from L1 and L2 is taken into account in capacity planning for different articles and process orders. The maximum capacity is a theoretical capacity that is programmed into the system. However, this does not reflect reality for all machines/processes since they do not account for the higher speed-loss with increasing age (A4, B2). The capacity of the lines does not reflect the total production capacity of all the processes combined since they cannot be run with maximum capacity during a longer period of time (C1). Another aspect to take into consideration when measuring maximum production capacity is that L3 is not running at all available production time. The production line is utilized when demand occurs and is considered as a batch flow. This is contradictory to the main lines, L1 and L2, which are considered as in-between line flow and continuous process (Hill & Hill, 2009), see product profiling analysis in Figure 6 in chapter 4.1.1. The errors and constraints in planning of capacity are issues for an efficient integration of shared interfaces between the production flows. To bypass these errors, the daily capacity planning at the production facility is highly dependent on the experience of the team leader (B2).

The most common cause of increased lead time is machine breakdowns due to lack of maintenance. Planning of maintenance is difficult because critical issues are prioritized before preventive measures (B4). In case of machine breakdowns, the staff can be moved to other process stations to increase the output speed there (B2). The production facility is able to adapt their amount of running shifts from two to three shifts when needed and can also go from five up to seven producing days a week. The production is flexible in changing staffing through shift planning and additional competence in the form of external consultants (B4). Planning of staffing is highly dependent on the experience of the team leader. However, there are difficulties in planning of staffing because it is hard to find the correct competence (B4). One of the main challenges with increasing production capacity and output is to maintain skill levels with increased staffing (B2).

Transporters are dedicated employees that move goods in the production facility with the aid of forklifts. Delivery of packaging material causes peaks in workload for the transporter since it is uncertain of exactly when the delivery will take place during the shift (B2, C7). These deliveries have to be handled instantly and be prioritized before other transporter tasks (C8). This causes additional stress for transporters and operators, as quoted by A2 below.

"Friday is the most stressful day when all deliveries of packaging material take place. And all deliveries are sent through the use of one elevator"

Because of increased workload due to delivery, there are issues in planning the staffing of transporters and balancing transporters workload during the course of the week. The issues occur mainly when there is a peak in production capacity. Currently this is handled taking help from an additional person from the production during peak workloads (B2, C7). This is outside the person's main responsibilities (B5). However, the transporter perceives that additional help is not offered as often as it is needed. A reason for this may be that production staff levels are balanced between periods of peak capacity and low volume production to avoid redundant staff. Therefore, operators may have difficulties in providing help to the transporters as they have to prioritize their own responsibilities.

To conclude the major case aspect production capacity control is included in the infrastructural decision area production planning and control, because it reflects the decision of how to schedule products into production (Miltenburg, 2005). Plant capacity can be seen as a structural aspect and related to the process equipment and layout in a production facility (Garrido, et al., 2007). However, control of production capacity in the studied case is considered as an infrastructural aspect due to its intangible nature and high human interaction. This implies that control of production capacity plays a crucial role in the outcome of the production processes.

Considering the management of the aspect of capacity control, concluded issues related to the interfaces between the production flows and a potential efficient integration are:

- *The capacity is not synchronized between processes in the main production lines, which uses semi-finished products as filler products and require high experience in planning of staffing and control of production capacity.*

4.2.5 Manual handling of semi-finished products

The aspect manual handling of semi-finished products is a shared interface between the examined production flows. Issues related to manual handling are within transportation, defective containers and human interaction. The amount of manual transportation is higher for semi-finished products compared to the main production lines. Transportation by forklift is an important function for all production lines (B4). There is only one transporter per shift that serves all production lines.

In case of high production volumes and no available containers for semi-finished products, single-use octabins have to be used. These are disposable and intended for external deliveries, not internal transports (C7). Assembling these octabins result in additional workload for production staff. The octabins also results in extra material costs that are not included in the initial material requirement planning. A major reason for this is the low inventory turnover of containers. Another issue is that some containers for semi-finished products are defective and cannot be used as intended for storage, for example the stacking of containers in the inventory area. Further, the defective containers may hinder the use of FIFO and maximum use of the storage area. It may also increase the risk of safety.

There is a low level of standardization in the production facility related to different processes (B6). The outcome of the production processes is highly dependent on the individual (B2). Certain processes are also highly dependent on the interaction and skill of the operator (B2, B4). In some parts of the production flows, the process speeds are altered in order to create a more balanced flow (B5). However, the speed cannot be too low or too high as the quality of the products may be compromised (A6, C10, C11). Therefore, the monitoring of the processes is dependent on the skill and experience of the operator since it is not fully standardized. Another aspect where output is dependent on human interaction is the scanning system. The level of correct usage of the scanning system differs and it can cause inefficiencies as it may not be used as intended (B6).

To conclude, the major case aspect manual handling of semi-finished products is included in the infrastructural decision area organization structure and control as defined by Miltenburg (2005). However, this inclusion can be argued as a structural aspect instead. Manual handling can be seen as a type of linkage between production flows and therefore considered as process technology. However, in this analysis the aspect of manual handling emphasize on human interaction through manual handling that is set in the organizational structure and control standards.

Considering the management of the aspect of manual handling, concluded issues related to the interfaces between the production flows and a potential efficient integration are:

- *Semi-finished products are handled manually to a high degree in form of transportation by forklift, monitoring of processes, handling of containers.*

4.2.6 Information sharing in the production facility

The aspect information sharing in the production facility is a shared interface between the production flows. The aspect inherits issues affecting integration of shared interfaces and the management of it is analyzed by firstly describing the culture following with information sharing in improvement systems, between flows and lastly between shifts.

The general culture at the production facility is perceived differently among production employees. Interviewees C8 and C3 perceive that there is an unwillingness of sharing information among employees and that people have a general defensive approach. However, this view is not shared by other interviewees that perceive that an open culture exists where people share information and help each other out (C13). There are cultural differences between shifts and production lines, which may result in varying expectations and outcomes (B3, B5). A sense of competition is also present between shifts and production lines (B6).

The existing system for reporting deviations and improvements in the production does not properly function due to lack of time of team leaders (B3). However, there are other reasons for the ill-functioned improvement system. There are difficulties in knowing who to report to or turn to with suggestions when issues occur. Issues not directly affecting production output are rarely reported (A3, B2). Another reason for not reporting is because of the hierarchical company culture, which is indicated to make operators afraid of getting blamed, rather than rewarded for their suggestions (B6). Sometimes process improvements have been suggested by operators, but not dealt with by management (C9). For example, a transporter has come up with an efficient procedure to scan and label containers of semi-finished products (C8). This has been communicated to the team leaders, but not yet implemented as a standard procedure. From the perspective of production planning, regular communication between production employees and planners is carried out, discussing potential improvements of production plans and providing information of upcoming production volumes (B1). This enhances the possibility for production employees to influence and get a sense of the volume variations.

There is a lack of communication and understanding of the workload in L3-flow between operators and transporters (B2, B4). Others claim that the communication works well between operators and transporters. Some operators and transporters communicate the bare minimum that is required (C7, C13). In case of issues between operators and transporters, some turn to the coordinators for assistance (C1). There are two coordinators on each shift that are respectively responsible over L1 and L2, L3. They coordinate breaks and are responsible of production output. Communication between operators of the initial processes of L1 and L2, and operators in L3 is said to be non-existent as long as there are centers and enrobes in the inventory/buffer (B2, C10, C11). Also, no communication takes place between operators in L1- and L3-flows (C1). However, the communication between coordinators on the production lines works well (C1, C3, C4). L1 and L2 together with L3 are separately managed by two different team leaders that may emphasize different requirements of the operators. As the production flows are dependent on each other, a separate management structure results in a lack of information sharing between them. This is confirmed by interviewee B4:

"The production flows are separated. They are different product-wise. However, there is a need for collaboration since they are dependent on each other"

Communication between different shifts works poorly according to some interviewees (B2, B5). However, production staff perceives that communication between shifts works well (C1, C3, C6). Sometimes handover between shifts does not take place, other times the handover takes place but does not include the important information needed for the following shift operator (B2). Some production staff, such as operators at the initial processes of L1 and L2 and transporters, are not entitled to a paid handover session to the previous and subsequent shift (C8). Meaning that the content of the information and whether it is shared may vary between shifts and individuals (C3, C7). Critical information that operators want from the previous shift are connected to the general production status such as current issues and if volumes are according to production plan (C8, C12, C14).

To conclude the major case aspect information sharing in the production facility is included in the infrastructural decision area organization structure and control as defined by Miltenburg (2005). The aspect is included there because it covers the relationship between employees and the underlying culture in the production facility, which is defined as an decision to consider within the decision are (Miltenburg, 2005).

Considering the management of the aspect of information sharing, concluded issues related to the interfaces between the production flows and a potential efficient integration are:

- *Information sharing between production flows and shifts vary in the production facility, it may create confusion on how and if it should be conducted. The current organizational structure encourages some employees to share information, while other employees may not find incentives for it.*

4.2.7 Communication of roles and responsibilities

The aspect communication of roles and responsibilities is a shared interface between the examined production flows. Communication of roles and responsibilities is an aspect affecting integration of shared interfaces and this together with the management of it is analyzed below.

The general perception is that roles and responsibilities in the production facility are somewhat unclear, it varies depending on shift and individual (B2, B6, C12). For example in the L3-flow, there are different structures of who does what depending on shift. In both shifts, the transporter is responsible for replacing, scanning out full containers and scanning in empty containers in all throw-outs of enrobes. Scanning help from operators is provided when needed. The operators in the initial processes of L1 and L2 are responsible for scanning out and in containers in the throw-outs of centers. Further, the container of enrobes and centers are transported from throw outs with forklift, to a buffer area in the factory and respectively to the initial buffer in L3. What differs connected to responsibilities is who moves the containers of semi-finished products from the buffer areas. The operator in process 3E in L3 is usually responsible for moving containers of centers into the buffer in L3. This applies for the first shift while the second shift makes use of additional transporters to get centers into the L3 buffer. However, the responsibility of moving containers of enrobes between buffers does not differ between shifts and lies mainly on the process 3E-operator, but also on transporters when they have got time (C5, C6, C7, C8). Another aspect that varies is the FIFO-structure that is being used. For example in the second shift, the transporter and process 3E-operator moves containers from enrobes buffer area to L3-buffer. This is stated by interviewee C5:

"How containers are placed according to FIFO depends on who is working".

Assignment of responsibilities and tasks are not formulated explicitly as it can be taken for granted that the operators know what to do (B4). The standards and routines for different processes are ill-formulated and there is also a lack of communication of these to the production operators (B3). Interviewee C8 perceived that the areas of responsibility were clear when he/she started working as a transporter in the production facility. Interviewee C4 states that:

"Everyone that works here has been working for a long time and knows what to do"

Assignment of roles and responsibilities among current operators are perceived as clear. However, issues may occur with sudden changes in the production facility, such as sudden production volume changes or process alterations. This may cause confusion in the assignment of responsibilities and communication of these. Many of the employees in the production facility will retire in the upcoming years. This may create problems as it is not clear on how new employees should be introduced to their responsibilities and tasks. There is a lack of communication of responsibilities and work tasks to new employees (B2, B4).

All operators and transporters in the production have shared responsibility for scanning containers of semi-finished products (B6). Since the scanning system is newly implemented, this may create difficulties in responsibility division throughout production. Interviewee C12 states that he scans containers of semi-finished products if the workload for transporters is high, but C12 also states that it is not included in his regular responsibilities. The scanning process is time-consuming for the user (C6), especially for the transporters because of their high usage frequency. It is highlighted that planning of the transporters time and responsibilities should be managed better (B2). There are issues with low skill-levels among operators with the usage of the scanning system due to lack of training between all shifts (B5).

To conclude the major aspect communication of roles and responsibilities in the production facility is included in the infrastructural decision area human resource as defined by Miltenburg (2005). Garrido et al. (2007) defines it as work force management and mentions it as one of the more important decision areas for achieving sustainable competitive advantage. Communication of roles and responsibilities is seen as a decision within human resource decision area because it covers job classifications and responsibility and decision making given to employees according to Miltenburg (2005).

Considering the management of the aspect of communication of roles and responsibilities, concluded issues related to the interfaces between the production flows and a potential efficient integration are:

- *Within the semi-finished product flow the roles and responsibilities is more unclear compared to the main production flows. It is especially critical when changes occur in demand volumes.*

4.2.8 Classification of infrastructural decision areas related to manufacturing capability

The major decision areas, aspects and issues in the production facility can be summarized in Table 12 below. These are visualized in connection to the infrastructural decision areas as defined by Miltenburg (2005) and level of manufacturing capability. This builds the foundation for achieving a higher integration of misalignments in the infrastructural aspects between the production flows in the facility.

Table 12. *Summary of case issues connected to infrastructural aspects*

INFRASTRUCTURAL DECISION AREAS	LEVEL OF MANUFACTURING CAPABILITY	MAJOR CASE ASPECTS AND ISSUES	EMPIRICAL EVIDENCE
PRODUCTION PLANNING AND CONTROL	Adult 3.0	• Production planning is flexible today, but the overall business and manufacturing focus and coordination is not fully aligned.	*"More important to fulfill customer orders than to produce cost-efficient from central management." (WS)*
		• The control of material is complex with difficulties in finding an efficient balance that accommodates the demand.	*"The demand of semi-finished products and its production sequence is often communicated by mail, without an acknowledged system" (WS)*
		• Inventory control is conducted manually to a high degree.	Inventory control is done manually on a daily basis and reported into the system. A scanning system has been implemented, but the balance is also reported manually to prevent errors.
		• The FIFO-structure in inventories is handled differently among employees.	*"How containers are placed according to FIFO depends on who is working". (C5)* *"Some emphasizes on having nice-looking rows in the inventory, rather than according to FIFO" (WS)*
		• The capacity is not synchronized between processes and requires an experience-based control.	Planning of staffing and capacity is highly dependent on the experience of the team leader.
ORGANIZATION STRUCTURE AND CONTROL	Average 2.0	• Semi-finished products are handled manually to a high degree.	Transportation in L3 is done manually to a higher degree than in L1 & L2. Many processes are dependent on human interaction and experience.
		• Varying degree of information sharing between production flows and shifts.	Information sharing between shifts and how it is conducted varies. Some do not have the right to a paid handover.
HUMAN RESOURCE	Adult 3.0	• Unclear communication of roles & responsibilities related to semi-finished products.	*"Everyone that works here has been working for a long time and knows what to do"(C4)* It is not explicitly stated who should move the containers of semi-finished products. This may create difficulties with new employees.

The infrastructural decision areas are analyzed to describe its level of capability, in order to achieve a higher integration in the production facility. The analysis below is conducted from the perspective of the production facility, rather than the organization and is based on the model presented by Miltenburg (2005). This framework positions the infrastructural decision areas connected to its level of manufacturing capability. The level of manufacturing capability is defined as how well a manufacturing facility is able to organize its resources according to the competitive priorities. It can be classified as *infant 1.0, average 2.0, adult 3.0 or world class 4.0.*

Furthermore, different characteristics are connected to these levels, which are used for the analysis below to classify the infrastructural decision areas.

The studied case is positioned as a*dult 3.0* related to production planning and control in Miltenburg's (2005) model showed in Table 12. The production planning function within the organization is in the process of going towards a more centralized and harmonized structure. Earlier, the planning function was more connected to each production facility and therefore more decentralized. The processes in the facility are monitored on a detailed level. This is due to the complex nature of the control of capacity and material. However, focus is not on numerical measures of specific processes, but on the total output of the production lines. Therefore, the level of manufacturing capability is adult 3.0, rather than average 2.0 or world class 4.0.

Related to organization structure and control, the facility is positioned as a*verage 2.0*. Central management puts pressure on the facility to deliver according to customer requirements and momentarily produce cost-efficient. These objectives are set centrally with little possibility to influence them locally in the production facility. Production staff is seen as very important and much of the output of different processes are highly dependent on the interaction of operators with specific skills and experience. As the information sharing in handover is not commonly established, it may indicate a more individual focus than line focus. Therefore, the level of manufacturing capability is average 2.0, rather than infant 1.0 or adult 3.0.

Human resource aspects in the facility are positioned as *adult 3.0*. The employees are very valuable in the production facility and many have worked there for a long time. Even if the number of operators has decreased with increased automation, they are valued for their knowledge in the processes. Many employees are multi-skilled and have the ability to work in different process stations throughout the production facility. Improvements from employees are highly valued, but the communication of these to management is lacking and therefore the level of manufacturing capability is not seen as world class 4.0, instead average 3.0.

Concluding remarks

The identified misaligned infrastructural aspects from the extended usage of product profiling were classified into Miltenburg's (2005) definitions of infrastructural decision areas; production planning and control, organization structure and control and human resource. Furthermore, these aspects were investigated through in-depth interviews and workshop and developed into major case aspects and issues:

- Unfocused production planning
- Complex material control
- High degree of manual inventory control
- Lacking communication of FIFO-structure
- Unsynchronized and experience-based capacity control
- High level of human interaction in semi-finished product flow
- Varying degree of information sharing between flows and shifts
- Unclear communication of roles and responsibilities

These issues reflect to the management of the major case aspects in the production facility. Additionally, a classification of level of manufacturing capability related to infrastructural decision areas is conducted to describe the management of the infrastructural aspects. The major case aspects and issues together with the classification of level of manufacturing capability aim to answer RQ2.

5. Discussion

The chapter presents a discussion on the results and analysis in connection to the main research question. Firstly, the focused manufacturing approach is discussed related to level of manufacturing capability. Secondly, integration of infrastructural aspects is discussed and whether the adjustments are suitable to current case context. Thirdly, the adjustments are discussed from a sustainability and ethical perspective on a general level.

A proposed way to manage integration of shared interfaces between production flows is to manage misalignments in the production facility. The shared interfaces in the production facility are highly influenced by the organization of the decision areas consisting of structural and infrastructural aspects. It is pointed out that the decision areas should not be analyzed in isolation, but in a wider perspective to increase the competitiveness of a firm (Garrido, et al., 2007). From the results and analysis, all investigated decision areas are somewhat misaligned between the examined production flows. However, the overall focus is on the infrastructural aspects as it is considered as the area with the highest degree of misalignments and shared interfaces. It is also the area with the highest potential for adjustments to support efficient integration. From the manufacturing capability analysis connected to infrastructural decision areas it is also indicated that the production facility is positioned as average/adult. Therefore, the infrastructural aspects and issues have to be managed in order to aim towards a world class level of manufacturing capability.

In contrast to integration of shared interfaces between production flows, a way to manage misalignments is to separate the production flows and therefore removing the shared interfaces. A separation is achieved by separating production planning of the production flows, removing the throw-outs of semi-finished products from the main production lines and investing in new process equipment to supply L3 with semi-finished products. As a result of the separation, a focus manufacturing strategy may be implemented for the separated production flows and opportunities for increased efficiency may be achieved. However, there are potential disadvantages of a separation. The main production lines will have difficulties in achieving balanced capacity utilization since they are dependent on L3 to capture excess capacity from throw-outs through filler products. There is a potential issue of not being able to rework excess products and therefore they have to be scrapped, causing cost-inefficiencies. As the process for supplying the production lines with semi-finished products are of a continuous nature, separate equipment for L3 will not be fully utilized due to low production volumes. Also, the available space is limited in the production facility and a separation would require additional space for inventories and equipment. Due to the above mentioned arguments, a separation of the production flows is not suggested, since it is not considered as suitable for the production facility to aim towards a cost-efficient production.

A discussion is conducted below regarding focused manufacturing and level of capability. Furthermore, a discussion is conducted on how misalignments of infrastructural aspects are adjusted in production facilities.

5.1 Focused manufacturing and level of capability

It is important that a production facility does not apply a single manufacturing strategy for all of its factories as they may face different strategic and environmental uncertainties (Ketokivi & Jokinen, 2006). Currently the production facility has a conflicting focus between lines with different competitive priorities. L1- and L2-flows are more cost-focused and centered on efficiency and compliance to schedule. While L3-flow is more flexibility- and delivery-focused to accommodate customer needs. This indicates that the production facility does not have a focused manufacturing strategy, which is needed in order to outperform competitors (Skinner, 1974; Ward & Duray, 2000). This finding is also in accordance with Ketokivi & Jokinen (2006) that states that a production facility with filler products besides main products cannot implement a focused manufacturing strategy. In the studied case, the filler products are seen as the semi-finished products to capture excess capacity and improve efficiency.

According to Miltenburg (2005), a production facility is able to provide more than one manufacturing output if it possess world class level of manufacturing capability. These manufacturing outputs consist of the different competitive priorities. Therefore, a production facility has the opportunity to apprehend a major competitive advantage over competitors. Thus by working with the highlighted issues of managing the infrastructural aspects affecting integration presented in previous sections, the production facility may move towards a world class level of manufacturing capability. The production facility may also have the ability to focus on several competitive priorities.

Parts of the focused manufacturing concept may be utilized for integrating shared interfaces of infrastructural aspects in the production facility. These parts cover organization of ones resources in a focused manner towards a mutual objective. Skinner (1974) states that simplicity, repetition and focus in one area allow work force and managers to be more effective. An example of a utilization of the focused manufacturing concept in the studied production facility is within roles and responsibilities. Some roles are perceived as unclear related to handling of semi-finished products in the production flows. By creating a clear and more focused structure for roles and responsibilities in the production facility, especially for the transporters, increased efficiency may be achieved. Another example of applying the focused manufacturing concept is within certain processes with high human interaction and experience-based control. This interaction and control of these processes may result in variations of product quality. This type of activity is not considered as a neither simple, nor repetitive, which is not in accordance with the focused approach. These activities is highlighted both in empirical findings of the case study and in literature as inefficient. Therefore, by aiming towards a more focused manufacturing approach within infrastructural aspects, resources at hand may be utilized more efficiently. Freed resources can then be utilized for achieving world class manufacturing capabilities within the competitive priorities required by customers.

Focused manufacturing strategies are easier to implement when customer relationships are stable and long-term (Ketokivi & Jokinen, 2006). Today the L3-flow delivers to a separate customer market of industrial customers that use the delivered products as ingredients. Therefore, the demand is seen as unstable because the industrial customers are dependent on orders and demand from their customers. Consequently the demand planning of L3 products is somewhat separated from the demand planning of the main products. Because of the mentioned nature of the different products, customer relationships are kept on a more short-term basis for L3 than for L1 and L2. By working more closely with industrial customers towards a more stable and long-term relationship, a focused manufacturing strategy may be easier to implement in the production facility. A result of an implementation is that a reduction of complexity and increased predictability of demand is achieved. (Ketokivi & Jokinen, 2006) This may contribute to decreasing the overall demand uncertainty and increasing the simplicity in the production facility.

Through focused manufacturing for the specific production facilities, competitive advantage can be gained over unfocused and more complex factories (Skinner, 1974; Ward & Duray, 2000). However, as the examined production flows inherit certain shared interfaces, the findings from the case study propose that there is a need to manage misalignments between the production flows. It is proposed that management of infrastructural misalignments is a way to integrate shared interfaces and focus the decision areas. It is also pointed out in literature that infrastructural decisions are of great importance for managers to consider in the formulation of a competitive manufacturing strategy (Ojha, et al., 2013). By managing infrastructural misalignments and decision areas, it may contribute to the company's ability to stay competitive and maintain an efficient production according to market requirements.

5.2 Integration of shared interfaces by managing infrastructural decision areas

Managing misalignments of the infrastructural aspects in the production facility creates a foundation for integrating shared interfaces between the production flows. To manage infrastructural misalignments, adjustments are done to handle major aspects and issues derived from case study in the production facility presented in the section 4.1. Before making adjustments to the major aspects and issues in the production facility, careful consideration must be made connected to the three characteristics of good adjustments to the decision areas by Miltenburg (2005) presented in the literature review. Each characteristic is discussed below.

- *Is the adjustment appropriate for the production system?*

The production system consists of L1, L2 and L3 production flows and is described in chapter 4.1.1. The focus on managing infrastructural misalignments derives from observations and analysis in the product profiling framework. Furthermore, these aspects have been investigated and analyzed in detail through in-depth interviews. L1 and L2 differ from L3 regarding production structure which is a consequence of the different product types and customer requirements of separate markets. The production flows share interfaces both structurally and infrastructurally. The structural aspects in the production facility are difficult to change, as some may involve large investments in new process equipment and inventory areas. Due to the different markets, product types, structural constraints and the shared interfaces between the production flows, adjustments in infrastructural aspects are considered as most appropriate for the examined production facility.

- *Will the adjustment help provide the required manufacturing outputs?*

The infrastructural decision areas in need for adjustments consist of production planning and control, organization structure and control, and human resource. From empirical findings, most issues are highlighted within the area of production planning and control. This indicates that misalignment between the main production lines and L3 is most apparent connected to these issues. Adjustments within production planning and control are considered of high value in achieving a higher integration of the shared interfaces between production flows. If adjustments within infrastructural decision areas are done it may result in a more efficient handling of semi-finished products, when dealing with demand uncertainties. For example, related to the current handling of FIFO in inventories, a major issue is that employees handle it differently. A practical adjustment and implication of this is to agree upon a common FIFO-structure and communicate this to employees. By adjusting the aspect of inventory control within the decision area of production planning and control, lower tied up capital in inventory and higher service levels may be achieved.

Another example of an issue is the varying degree of information sharing between production flows. Information sharing is an aspect within the decision area organization structure and control. A practical adjustment and implication of this is to create a clear structure for handover between shifts, which enables operators to perform their tasks efficiently. In case of large volume fluctuations, the change in production orders and sequences can be captured quickly. Therefore, operators are able to prioritize properly between different production orders and ensure that required material is available.

The complexity within the production facility lies within the shared interfaces between the production flows. Adjustments of the infrastructural misalignments towards a focus and integration of shared interfaces may be conducted to simplify and decrease complexity. The dimensions complexity, flexibility and dynamism developed by Helkiö & Tenhiälä (2013) extend the product-process matrix by Hayes & Wheelwright (1979) towards a more up-to-date reflection of the manufacturing industry. Traditionally, manufacturing strategy literature is focused on linear flows with traditional process types: jobbing, batch, line and continuous processing (Hill & Hill, 2009). As the examined production facility inherits characteristics of non-linear production flows with shared interfaces that may not be correctly reflected by these types, it is important that these are taken into account when suggesting adjustments. This thesis takes the characteristics into account by extending the product profiling framework with the dimension of shared interfaces. With an increased integration of the shared interfaces between production flows, complexity in the production facility may decrease. According to Helkiö & Tenhiälä (2013), complex production tasks may cause problems with process responsiveness. Fulfilling customer requirements by focusing on the competitive priorities flexibility and delivery are of importance to the examined production facility. Furthermore, responsiveness is highly connected with fulfilling customer requirements. Therefore, it is important for the production facility to achieve a lower degree of complexity, in order to maintain responsiveness. These are examples of adjustments within the decision areas that will help to provide required manufacturing output for the production facility.

- *How will the adjustment affect the other decision areas?*

Despite the high contribution of adjustments in production planning and control for achieving an efficient integration of shared interfaces, the other decision areas have to be taken into consideration. This is because an adjustment in one decision area may have direct consequences in another decision area that is needed for support. For example adjustments in production planning and control may require adjustments in human resource policies (Miltenburg, 2005). For example creating a common FIFO-structure requires support from the organization to communicate the structure and train employees within it. Changing the FIFO-structure is an adjustment within production planning and control. However, it also influences the decision area of human resources by the need to provide training and updated work descriptions. Additionally, it also influences the structural decision area by requiring structural support to maintain a FIFO-structure. For example, currently in case of high production volumes, the containers of semi-finished products are stored in different locations in the production facility instead of its designated areas. An increased inventory area or a higher inventory turnover through improved process technology is required, to maintain the FIFO-structure during high production volumes. Therefore, adjustments in the infrastructural aspects are highly intertwined with structural aspects (Hayes & Schmenner, 1978). Consequently adjustments in infrastructural aspects need to be adapted to the structural aspects in the production facility to maintain performance and competitiveness.

5.3 Reflections on sustainability and ethics

Companies are able to measure sustainability by using the Triple Bottom Line (TBL)-framework. The TBL-framework consists of three different dimensions; economic, environmental and social. The economic dimension is easier to measure compared to environmental and social dimensions (Slaper & Hall, 2011). The sustainability dimensions and sustainable development are discussed below in connection to managing infrastructural misalignments.

This thesis contributes within the area of integrating shared interfaces between production flows related to manufacturing strategy. It is crucial that suggested adjustments within infrastructural aspects are of a long-term and sustainable nature. The economic dimension is in focus in efficiency improvements as cost performance measures are easily conducted and determines the survival of a company. Therefore, the findings in this thesis contribute to a potential sustainable economic development through increasing overall efficiency, when implementing the suggested adjustments of major aspects and issues. For example, a clear FIFO-structure and improved inventory control may decrease capital tied in inventories. This inventory adjustment may improve overall profitability in the long run.

The environmental dimension may be improved as a direct consequence of efficiency improvements in the production facility. Potential risks of scrapping and reworking semi-finished products may decrease with a clear FIFO-structure and more accurate control of inventory levels. Variations in product quality caused by experience-based control of processes can be reduced through standardization and result in lower amount of scrapping.

Employee welfare and working environment are included in the social dimension of sustainable development. Working environment and employee welfare for both new and current employees may be improved by implementing the suggested adjustments. For example, if the control of inventory levels is improved, it may result in an enhanced safety in the production facility when managing demand uncertainty with high volume peaks. Also, by decreasing manual handling of semi-finished products, the working conditions for employees may be improved by reducing manual lifts and unnecessary transports.

Ethical aspects have to be taken into consideration in adjustments within the decision area of organization and control, especially when concerning roles and responsibilities of the employees. Employees that have worked in the production facility for a long time may feel intimidated by changes in roles and responsibilities. Some employees may be afraid of losing their jobs when adjustments in infrastructural aspects are made and efficiency improvements are implemented. As the production facility earlier have gone towards higher degree of automation with new processes and less operators involved, they may be reluctant to changes within these areas. Therefore, potential issues concerning employee reluctance connected to infrastructural adjustments have to be handled. For instance by visualizing the overall goal and creating awareness of the importance of suggested adjustments for the company's competiveness. Increased standardization of roles and responsibilities may restrain creativity and reduce the amount of improvements as it goes beyond ones defined role. It is important to find a balance between a general and detailed work description. A more focused manufacturing approach with increased repetition and simplification may cause a working atmosphere that lacks inspiration and interest from the employees.

6. Conclusions

The chapter presents the conclusions from the case study by answering the research questions. Further, conclusions from the Analysis and the Discussion-chapter answer the main research question. Additionally, this chapter presents conceptual contribution and managerial implications together with discussions on limitations and future research.

The overall objective of the thesis is to analyze integration of shared interfaces between production flows related to manufacturing strategy. A main research question was formulated to address the overall objective. Furthermore, two research questions were formulated in order to answer the main research question. The answers to the research questions are derived from case study findings of a production facility and are presented below.

RQ1: What aspects affect integration of shared interfaces between production flows?

Structural and infrastructural aspects affect integration of shared interfaces between production flows. Data collected from the introductory interviews and observations were analyzed through the product profiling framework and indicated misalignments between the main production flows and semi-finished product flow. The major misalignments were found in the infrastructural level. These misalignments are reflected in the manufacturing strategy as infrastructural decision areas. Additionally, structural aspects are considered as fixed since no new investments within process equipment and technology were possible in the near future, according to case company. Therefore, it is proposed that infrastructural aspects affect the integration of shared interfaces between production flows and are adjustable in the examined production facility.

RQ2: Considering these aspects, how are they managed in the production facility?

The infrastructural aspects from RQ1 were classified into decision areas. The decision areas were further developed through in-depth interviews and workshop, into major case aspects that represent the examined production flows. The examined production flows inherit certain complexities; shared interfaces, different production structures and markets. The current management of the infrastructural aspects is not fully adapted to these complexities resulting in the following major aspects and issues in the shared interfaces. These are presented below:

- Unfocused production planning
- Complex material control
- High degree of manual inventory control
- Lacking communication of FIFO-structure
- Unsynchronized and experience-based capacity control
- High level of human interaction in semi-finished product flow
- Varying degree of information sharing between flows and shifts
- Unclear communication of roles and responsibilities

Furthermore, the infrastructural decision areas of the case were classified according to its level of manufacturing capability. The results from the classification showed that the production facility is classified as adult 3.0 level within production planning and control, and human resources. The decision area of organization structure and control is classified as average 2.0

level. Therefore, the production facility is not classified as world class level of capability within any of the infrastructural decision areas.

Finally, the answers to RQ1 and RQ2 above together with ideas connected to literature in the *Discussion* addresses the MRQ.

MRQ: How is integration of shared interfaces in production flows managed in the production facility?

MRQ was addressed in the *Discussion* by contrasting focused manufacturing and manufacturing capability with findings from *Results* and *Analysis*-chapter regarding integration of shared interfaces in production flows. Integration of shared interfaces is currently managed inefficiently in the structural and infrastructural aspects in the production facility. It is indicated that the production facility is not adapting or focusing its misaligned infrastructural aspects between the production flows, in order to achieve an efficient integration of shared interfaces. Additional complexity in the shared interfaces exists, as the production flows are dependent on each other as the semi-finished product flow is a mean to capture excess capacity through so called filler products.

6.1 Conceptual contribution

This thesis contributes within manufacturing strategy literature and infrastructural decision areas. The main focus is complex production flows with shared interfaces.

Firstly, the contribution is within the product profiling framework by Hill et al. (1998). The product profiling framework usage is extended by a comparative analysis of complex production flows with the considered dimension of shared interfaces. From the comparative product profiling analysis, it was shown that there was a high degree of misalignments within the infrastructural aspects and managing these may result in an efficient integration of shared interfaces between the production flows. Additionally, the extended usage of the framework provided empirical data from a production facility that does not inherit the traditional characteristics of a linear flow. A limitation of the product profiling framework is that it may only provide directional input as a foundation for future managerial decisions (Partovi, 2007). In this thesis, suggested adjustments on managing misalignments are provided within the infrastructural level from the directional input of the product profiling. A way to manage infrastructural misalignments is by adjusting issues within infrastructural aspects.

Secondly, according to Miltenburg (2005) a production facility is able to have a focused strategy with several competitive priorities if it inherits world class level of manufacturing capability. However, according to Ketokivi & Jokinen (2006) production facilities with filler products and conflicting competitive priorities with main products may not be able to implement a focused manufacturing strategy. In this thesis, it is suggested that production facilities with main and filler products have to achieve a world class level of manufacturing capability to be able to focus on several competitive priorities and stay competitive. According to traditional manufacturing strategy literature, production flows that inherit different production structures and market characteristics require separate competitive priorities and require different managerial approaches of organizing the infrastructural decision areas. However, for production flows with shared interfaces and different production structures, this thesis proposes that parts of the focused manufacturing concept can be utilized. These parts are related to the organization of one's infrastructural resources for achieving world class level of manufacturing capability.

Thirdly, non-linear production flows with shared interfaces are seen as complex production structures. Further, when the competitive priorities consist of flexibility and delivery, the need for responsiveness increases to deliver according to customer requirements. Helkiö & Tenhiälä (2013) states that production flows with increasing complexity in tasks may experience problems in terms of responsiveness. In this thesis, integration of shared interfaces between complex production flows is seen as a measure to decrease complexity and therefore increase responsiveness. This adds to Helkiö & Tenhiälä's (2013) research contributing to support the complexity-, flexibility- and dynamism-dimensions by an additional empirical case of complex productions flows. Decreasing complexity in a production facility can be seen as a way to increase simplicity, which is core within a focused manufacturing strategy according to Skinner (1974). Therefore, by aiming towards a more focused manufacturing approach within infrastructural aspects, resources at hand may be utilized more efficiently. Freed resources can then be utilized for achieving world class manufacturing capabilities within the competitive priorities required by customers.

6.2 Managerial implications

The empirical findings of this thesis address the case company's challenges of handling uncertainties in the semi-finished product flows in the production facility. The product profiling framework was utilized to visualize misalignments between production flows. Further, the infrastructural misalignments were investigated through in-depth interviews where major aspects and issues were highlighted. The major aspects and issues created the foundation for adjustments and managerial implications. These proposed adjustments were reviewed and verified in a workshop at the production facility. Below in Table 13 major case aspects and issues are presented together with proposed adjustments and managerial implications.

Table 13. *Summary of managerial implications connected to empirical findings*

INFRASTRUCTURAL DECISION AREAS	MAJOR CASE ASPECTS AND ISSUES	PROPOSED ADJUSTMENT AND IMPLICATIONS
PRODUCTION PLANNING AND CONTROL	• Production planning is flexible today, but the overall business and manufacturing focus and coordination is not fully aligned.	**1.** Increase the coordination of the company's overall business strategy with the manufacturing strategy of the production facility.
	• The control of material is complex with difficulties in finding an efficient balance that accommodates the demand.	**2.** Adapt the production planning after available inventory locations in the production facility.
	• Inventory control is conducted manually to a high degree.	**3.** Create a common structure for handling FIFO in inventory areas to simplify material handling and communication between different production processes and shifts, reduce manual inventory control and human interaction.
	• The FIFO-structure in inventories is handled differently among employees.	
	• The capacity is not synchronized between processes and requires an experience-based control.	**4.** Decrease manual handling of and interaction with semi-finished products since many activities are dependent on the experience and skills of specific operators.
ORGANIZATION STRUCTURE AND CONTROL	• Semi-finished products are handled manually to a high degree.	
	• Varying degree of information sharing between production flows and shifts.	**5.** Create a clear structure for handover between different shifts, which assures that important information is communicated.
HUMAN RESOURCE	• Unclear communication of roles & responsibilities related to semi-finished products.	**6.** Clarify and balance the role of the transporter.

Proposed adjustments and managerial implications are described in detail below, to make relevant adjustments to major aspects and issues. It is proposed that an implementation of the managerial implications results in a more efficient integration of shared interfaces between the production flows.

1. Increase the coordination of the company's overall business strategy with the manufacturing strategy of the production facility. Harmonize the strategy and objectives of the overall organization with the production facility regarding cost-efficiency opposed to service level. Today, the planning function in the production facility occasionally shifts priority from cost-efficient production to flexibility in meeting customer demand. These strategies may be contradictive and it is of great importance that it is clear for production planning what the most important factor is for the production facility related to customer requirements.

2. Adapt the production planning after available inventory locations in the production facility. Currently, the production planning is flexible in handling changing customer order volumes. However, the control of material is complex with difficulties in finding an efficient balance that accommodates demand and momentarily keep low inventory levels. The difficulties in finding an efficient balance can be improved by mapping maximum available inventory area in the production facility. The maximum available inventory area and the current inventory levels of it should be communicated regularly to production planning.

3. Create a common structure for handling FIFO in inventory areas. This common structure simplifies material handling and communication between different production processes and shifts. This adjustment is to facilitate the current inventory control which is conducted manually to a high degree. It is also about finding a unified method to handle FIFO in inventories that today is handled differently between employees. Further, the current scanning system can be used to localize the containers and its content in daily inventories. This reduces manual inventory control and human interaction. A common FIFO-structure also facilitates the learning of it to new employees.

4. Decrease manual handling of semi-finished products and human interaction. Currently many activities are dependent on the experience and skills of specific operators. Capacity and process control should be standardized to assure product quality and for future employees to perform efficiently. Further, to reduce manual and highly physical activities, some containers for storage of semi-finished products should be exchanged to standardized containers instead of single-use octabins. The current production structure creates a high dependability on the team leader related to capacity control. With a standardized control, the production output is more predictable and simplifies the planning process.

5. Create a clear structure for handover between different shifts, which assures that important information is communicated. Today there is a varying degree of information sharing between flows and shifts. Also, not all production employees are entitled to a paid handover. Therefore, in order to integrate the production flows, all employees should have the possibility for a paid handover. To assure an efficient handover, a clear structure of agenda should be implemented to assure that important information is communicated to everyone. A suggested aspect to consider in the agenda is to communicate production status not only in case of potential problems, but also when production stations have been running well.

6. Clarify and balance the role of the transporter. The responsibility of the transporter stretches over the whole production facility and both production flows. Currently there is an unclear communication of roles and responsibilities related to the semi-finished products. As production volumes increases it is difficult to assign responsibilities for current and new employees. This difficulty especially leads to high workload for the transporters that have many different locations to keep check over momentarily. Therefore, by clarifying the role of the transporter, the responsibilities related to semi-finished products will be easier to prioritize among all employees in the production facility.

6.3 Concluding remarks

One way of managing misalignments in complex production flows is to integrate shared interfaces by adjusting the infrastructural decision areas. Modification to traditional manufacturing strategy practices has to be made, to support an efficient integration of shared interfaces. As misalignments in production flows occur, they have to be handled according to the conditions of the specific production facility. It is important to take the holistic perspective of the production lines into consideration when making adjustments to the misalignments. In some cases it may not be suitable to make adjustments, rather live with the misalignments since it may be most beneficial for the total production output. When it comes to the focus of this thesis, which is complex production flows with shared interfaces, it is suggested that issues within infrastructural aspects have to be adjusted to support integration. Furthermore, it is proposed that parts of the focused manufacturing concept may be utilized to gain increased overall efficiency. These parts are about organizing ones resources towards the same objective and simplifying the production structure. Consequently, decreased complexity may lead to increased efficiency in the production, and an increased ability to use resources to achieve world class level of manufacturing capability.

An efficient integration of shared interfaces between complex production flows leads to an increased ability to handle demand uncertainties, such as volume fluctuations. This is of great importance because of the dynamics in industries and markets. Therefore, the ability to handle uncertainties is crucial for manufacturers, in order to create sustainable competitiveness and survive on the market.

6.4 Limitations and future research

The results from the case study add empirical data to manufacturing strategy literature of major aspects and issues that cause misalignments in production facilities. Findings from this thesis create a foundation for managing misalignments in manufacturing decision areas in the context of non-linear production flows with shared interfaces. However, these findings are based on a single case study of one production facility within a production unit. Even though the case context is within the confectionary industry, the ambition is that the findings of this thesis can be applicable to other manufacturing industries with non-linear flows that share interfaces.

Further, results and analysis are based on observations and qualitative interviews of employees within the production facility. As interviews with top management in the case company were not conducted, this can be seen as a limitation for the holistic perspective of the findings. However, the time frame of the thesis is seen as a limiting factor for conducting more interviews and fully understanding different levels of the company with its complexity. Also, an implementation of the managerial implications has not been conducted due to the time frame constraint of the thesis. An implementation is required for verification of the findings, to assure that an efficient integration of shared interfaces between the production flows is achieved.

The empirical findings in the thesis are based on the specific characteristics of the studied production facility. Therefore, it may be difficult to apply the managerial implications directly on another case. Demand uncertainties are one of the main challenges for the examined production facility and have been a focus throughout the data collection. This is reflected in the findings of the thesis where infrastructural aspects are considered as the highlighted area of improvement when it comes to managing demand uncertainties. Despite specific characteristics of other manufacturing companies, the approach of this thesis on managing demand uncertainties may be useful for others that face misalignments between production flows.

Based on the limitations and findings in the thesis, it is proposed that the following areas of research are explored in the future:

- In contradiction to the findings of the thesis and the focus on infrastructural aspects as a mean to efficiently integrate shared interfaces between production flows, an interesting research topic is to thoroughly investigate the influence of structural aspects. For instance, process improvements to handle unbalanced capacity in production lines as a mean to reduce misalignments and integrate the shared interfaces efficiently.
- Even though there is existing empirical research on managing misalignments in product profiling, there is still need for additional empirical research on the management of misalignments for non-linear production flows with shared interfaces.
- Efficient integration of shared interfaces between production flows has only been presented conceptually together with empirical data of major aspects and issues, to support integration. However, to assure the appropriateness of the findings, an implementation of the managerial implications is needed.

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Appendix 1: Introductory interviews, A-guideline

1. Inledande kort presentation av oss och vårt syfte med intervjun.
2. Skulle du kunna presentera dig och din yrkesroll i produktionen.
3. Hur skulle du beskriva produktionsflödet?
    a. L1
    b. L2
    c. L3
4. Utvärdering av produktionen och flödet relaterat till följande egenskaper:
    a. **Kostnad** (Cost: Unit cost, Labor productivity, Machine utilization, Yield)
    b. **Kvalitet** (Quality: Percent defective, Rework costs, Mean time between failures)
    c. **Leverans** (Delivery/Time: Quoted delivery time, Percentage on-time shipments, Order entry cycle time, Average lateness, Number of expeditors)
    d. **Prestationsförmåga/Effektivitet** (Performance: Number of standard features, number of advanced features, Product resale price)
    e. **Flexibilitet** (Flexibility: Number of products in product line, Number of options allowed, Minimum order size, Length of frozen schedule, Average lot size)
    f. **Innovationsförmåga** (Innovativeness: Lead time to design new products, Lead time to prepare customer drawings, Number of engineering change orders per year, Number of new products introduced each year)
5. Skulle du kunna definiera halvfabrikat och hanteringen av dessa?
6. Vad finns det för styrkor och svagheter i hanteringen av halvfabrikat?
    a. Lagrings- och förflyttningsprocesser
    b. Interna transporter och logistiklösningar
7. Övriga kommentarer från respondenten

Appendix 2: In-depth interviews, B-guideline

- Generell introduktion av examensarbetet och vad vi har kommit fram till hittills.

1. Hur tycker du att lagernivåerna är just nu? Varför tror du det är så?

Planering

1. Diskutera angående planering av halvfabrikat:
   a. Hur upplever du att hanteringen och planeringen av volymförändringar av halvfabrikat fungerar? (Ökning/minskning av volymer, personal, kompetens, råvarulager, halvfabrikatslager)
   b. Hur ofta upplever du att produktionsschemat ändras för att hantera plötsliga volymförändringar?

Styrning

2. Diskutera hur material- och lagerstyrning av halvfabrikat sker idag:
   a. Hur upplever du att säkerställningen av material fungerar idag? (problem, potentiella förbättringar)
3. Diskutera angående taggningssystemet:
   a. Vilka fördelar/nackdelar har det nya taggningssystemet medfört?
   b. Hur har personalen anpassat sig till det nya systemet och användningen?
4. Diskutera kring flexibilitet planering och produktion:
   a. På vilket sätt är ni flexibla i produktionen gentemot förändrad efterfrågan?
   b. På vilket sätt är ni flexibla i planeringen gentemot förändrad efterfrågan?
   c. Hur väl tycker du att verkligheten speglas i produktionseffektivitetsmåtten som används?
5. Diskutera kring kvalitéstyrning
   a. Hur upplever du att kvalitetskontrollen fungerar och möter gällande krav angående livsmedelssäkerhet?
   b. Hur tycker du att rutiner och standarder följs för säkerställning av produktkvalité?

Mänskliga faktorer

6. Diskutera hur arbetsuppgifter och ansvarsområden kommuniceras till de anställda? (Instruktion, Frekvens, Jmf. nyanställd, bemanningsfirma och ordinarie)
   a. Hur tycker du att kommunikationen av arbetsuppgifter fungerar mellan operatörerna (linjeoperatörer, transportörer, koordinatorer)?
   b. Hur tycker du att kommunikationen av arbetsuppgifter fungerar mellan operatörer och ”ledning” (Team leader, sektionschef)?
7. Hur säkerställer man att avvikelser och problem rapporteras?
   a. Hur tycker du att kommunikationen av potentiella förbättringar/problem fungerar mellan operatörer och ”ledning” (CI, Team leader, Sektionschef)?

Övrigt

1. Hur sker din kommunikation med sälj- och marknadsavdelningen gällande produktionsbehov?

2. På vilket sätt tycker du att integreringen mellan halvfabrikatsflödet med L1 och L2 fungerar bra idag? På vilket sätt fungerar det mindre bra? (ansvar, onödiga moment, lagerplats, säkerhet)
    a. Vad skulle kunna förbättras?
    b. Vilken av följande tre aspekter tror du är avgörande för ökad integration av produktionslinjerna? (**Planering**, **materialstyrning** (FIFO & transport), **mänskliga faktorer**)

TILL TEAMLEADERS

3. Hur planeras personalbehov? (frekvens, kompetens, vem bestämmer, kostnad, olika skift)

TILL PLANERING:

8. Diskutera angående produktionsvolymer och planering (Skillnaden mellan halv- och helfabrikat)
    a. Vem tar in kundorder? Och hur lång tar det från orderläggning till leverans? (halvfabrikat, färdigvaror)
    b. Hur uppnås en kortare ledtid?
    c. Hur ofta ändras produktionsschemat för att hantera brådskande ordrar?

Appendix 3: In-depth interviews, C-guideline

- Generell introduktion av oss
2. Hur tycker du att lagernivåerna är just nu? Varför tror du det är så?
3. Vad är dina arbetsuppgifter? Hur vet du vad du ska göra och vem har gett dig den informationen?
4. Hur hanterar du halvfabrikat? (Frekvens, När, Hur/Process, kontroll av fyllnadsgrad)
    - Byte av bassäng vid utkast, vägning, taggning, borttransport, lager
5. Vad ser du för problem/förbättringar?

Extra frågor till: L3 flödet, transport

1. Hur hanterar du halvfabrikatsbassänger? (Vem hämtar, hur mycket, när)
2. Hur kommunicerar du detta? (mellan operatörer, transportörer, skift)?
3. Hur säkerställer du att du tar/placerar enligt datummärkning?(FIFO)

Appendix 4: Definition of product profiling aspects

Products and markets

- Product type: Describes the characteristics of the product that is manufactured. This varies from a specialized product based on the needs of every customer to products that are fully standardized.
- Product range: The amount of product varieties that are produced in the factory. Varies from a wide to a narrow assortment of products.
- Customer order size: The size of the customer orders that is the foundation for the production planning when creating production orders. Varies from small to large order sizes.
- Order winner: Describes the criteria upon which orders are won within relevant segments. Varies from flexibility to price.
- Frequency of schedule changes: The frequency level that the production schedule is changed by the production planning. Varies from a high to a small frequency level of changes.
- Planning horizon: The planning horizon that the production planning takes into consideration when planning upcoming production activities and capacity. Varies from a short to a long horizon.

Manufacturing

- Process technology: Describes on what level the technology in the facility is adaptable to different product types. Varies from a general to a dedicated technology level.
- Process flexibility: What level the processes in the manufacturing facility is flexible to schedule and demand changes. Also, includes the dependability on certain equipment in case of e.g. breakdowns. Varies from a high to a low level of process flexibility.
- Production volume: The level of volume that is produced in the manufacturing facility. Varies from a low to a high production volume.
- Number of setups: The amount of setups that is required in the manufacturing facility to produce according to the production schedule. Varies from a high to a low number of setups.
- Key manufacturing task: States the overall objective of the manufacturing facility and what main focus the production has. Varies from meeting the production schedule to maximizing throughput.

Infrastructure

- Material control: The level of control that is incorporated in the manufacturing system, for instance that productions order automatically reserves the required input material in the system such as ingredients and packaging material. Varies from a low to a high level of material control.
- Capacity control: The level of control over the capacity in the manufacturing system includes capacity limitations and difference in operation times for different processes

that is taken into consideration when planning the production. Varies from a low to a high level of capacity control.

- Internal transportation: Describes how internal transportation of goods is conducted in the manufacturing facility. Varies from manual transportation by lifting or using forklifts to automatic transportation by using conveyor belts.
- Inventory control: States how the inventory control is carried out on an operational basis and to what degree a standardized system exists to keep check on the inventory balances. Varies from an unstandardized to a standardized control system.
- Roles & responsibilities: Defines the nature of the roles and responsibilities that the employees have in the manufacturing facility. Varies from general roles to specialized roles of the employees.
- Quality control: Describes how the quality control in the facility is carried out. Varies from manual quality control by the operators to automatic quality control, e.g. by laser technologies.
- Human interaction: The level of human interaction that takes place in the facility during normal operations related to quality, safety and communication. Varies from high to low human interaction.