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TOWARDS ACHIEVING NETWORK CAPABILITIES IN GLOBAL PRODUCTION NETWORK OF CONTRACT MANUFACTURERS

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Abstract

The growth of global trade throughout the world has created remarkable opportunities for manufacturing companies to capture potential market share. This along with access to low-cost production resources and knowledge has encouraged manufacturing companies including global contract manufacturers to establish production plants overseas. However, managing and operating a network of geographically dispersed production plants all over the world requires systematic network management for achieving critical network capabilities. Network capabilities have been introduced and examined extensively, yet few studies, if any, have studied network capabilities in a contract manufacturing context. Therefore, the objective of this research is to develop knowledge regarding network capabilities in a global contract manufacturing context.

In order to fulfil the objectives of this research, literature reviews were conducted as well as three case studies with data collected in a global contract manufacturing company headquartered in Sweden.

The results refer to cost and flexibility as two major challenges facing global contract manufacturers. Moreover, product, production processes and complementary processes were identified as three synergetic areas within the production network of a global contract manufacturer. Working actively with those synergetic areas in the production network could facilitate the achievement of network capabilities especially in response to demands of being cost efficient and flexible. Finally, taking into account the unique needs of global contract manufacturers when developing the production systems, some results refer to possibility of achieving network capabilities during the production system development process.

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October 2015, Eskilstuna, Sweden

Farhad Norouzilame

List of publications

Appended papers

Paper I – Norouzilame, F., Grönberg, M., Salonen, A. and Wiktorsson, M. (2013), "An industrial perspective on flexible manufacturing: A framework for needs and enablers", *Proceedings of 22nd International Conference on Production Research*, Foz do Iguacu, Brazil.

Norouzilame collected and analysed the data and was the main author of the paper. Grönberg contributed to the empirical data collection. The rest of authors reviewed and assured the quality of the paper.

Paper II – Norouzilame, F., Moch, R., Riedel, R. and Bruch, J. (2014a). "Global and Regional Production Networks: A Theoretical and Practical Synthesis", *Proceedings of International Conference on Advances in Production Management Systems 2014*, Ajaccio, France.

Norouzilame collected and analysed the data regarding global production network and was the main author of the paper. Moch collected and analysed the data regarding regional production network. The rest of authors reviewed and assured the quality of the paper.

Paper III – Norouzilame, F., Bruch, J. and Bellgran, M. (2014b). "Production plants within global production networks: Synergies and redundancies", *Proceedings of the 21st EurOMA Conference*, Palermo, Italy.

Norouzilame collected and analysed the data and was the main author of the paper. The rest of authors reviewed and assured the quality of the paper. They also were actively involved in reviewing the findings and discussing the results.

Paper IV – Norouzilame, F., Bruch, J. and Granlund, A., (2015), "Production system design in a global manufacturing context: A case study of a global contract manufacturer", *Proceedings of the 26th Production and Operations Management Society Annual Conference,* Washington, D.C., USA.

Norouzilame collected and analysed the data and was the main author of the paper. The rest of authors reviewed and assured the quality of the paper. They also contributed by reviewing the findings and discussing the results.

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1 Introduction

This chapter introduces the research, initially by providing a background and the problem description. Then the research objective and the research questions are followed by research delimitation. Finally, the general structure of the thesis is presented.

1.1 Background

The fact that business is becoming more and more international is indisputable. Global trade and investment have increased dramatically in recent years with a profound effect on the economies of nations worldwide (Prasad and Babbar, 2000). For example between 2000 and 2007, the global manufacturing output had an annual growth of 2.5 % in advanced countries and 7.4 % in emerging economies (Manyika, 2012). This has consequently changed how operations are managed today compared to a few decades ago. To be able to compete in the fast-evolving global economy, it is of vital importance for manufacturing companies to disperse their plants all over the world (Canel and Khumawala, 2001). Accordingly, the role of production networks has changed from supplying domestic markets with products, via supplying international markets through export, to supplying international markets through local manufacturing (Rudberg and Olhager, 2003). Consequently, this has led to a new paradigm with a focus on network structure of production (Cheng et al., 2015).

Global production networks are defined as globally dispersed production plants where single factories affect each other and cannot be managed in isolation (Rudberg and Olhager, 2003, Shi and Gregory, 1998). The expansion from an individual plant to a global production network entails taking many constructs into consideration which makes managing such networks a complex task (Mundt, 2012). The challenge is how to align the network with the ever-changing market needs and also how to link and integrate the plants to support strategic business objectives (Cheng et al., 2011). Two main aspects of managing a global production network are configuration and coordination. Configuration refers to the location in the world where each activity in the value chain takes place and coordination refers to how like or linked activities are coordinated with each other (Colotla et al., 2003, Porter, 1986).

A well-configured and well-coordinated global production network results in four different capabilities at the network level, *accessibility*, *thriftiness*, *mobility*, and *learning* (Shi and Gregory, 1998). *Accessibility* of a network refers to proximity to markets and access to important production factors (Colotla et al., 2003). *Thriftiness* ability refers to the ability of a network to provide economically efficient solutions while *mobility* is about shifting or transferring products, staff, processes, or production volume within the network plants (Shi and Gregory, 1998). Finally, *learning* ability allows a network to use internal and external sources to foster its required knowledge (Miltenburg, 2005).

One specific type of global production network is represented by global contract manufacturers that build a network of production plants worldwide mainly to serve their global customers and also to gain access to new markets and low-cost production resources. Although contract manufacturing has been studied from an organisational point of view, not much attention has been paid to the operations management perspective of global contract manufacturing (Schilling and Steensma, 2001, Ernst, 2002).

Considering the fierce competition in the market, global contract manufacturers are expected to provide their global customers with cost efficiency (Han et al., 2012) as well as flexibility (Schilling and Steensma, 2001) to be able to survive in the fierce and volatile market today. It is therefore extremely vital for global contract manufacturers to make the best use of all their existing synergies, described as the cooperation among different plants in one or more specific areas, which produces an overall better result than if each plant would work separately. This can be supported by a good configuration and coordination of the production network in order to minimise cost and provide the customers with flexible solutions. Having a network perspective seems to be inevitable for global contract manufacturers in order to leverage the existing potential of their production network.

1.2 Problem statement

Contract manufacturing is an increasing trend in different sectors of industry (Han et al., 2012). For instance, Auerbach (2011) estimated that the contract manufacturing share will climb from 30% to 70% for large US pharmaceutical companies while the remainder will be produced in-house. When more OEMs contract out their production globally and keep fewer processes in-house, there are more opportunities for global contract manufacturers to grow their businesses by taking a greater share the production processes of OEMs.

This growth however, whether through the expanding the existing competences or acquiring new competences, entails some challenges for global contract manufacturers. As the main incentives of OEMs to contract out their processes are cost reduction (Cao and Zhang, 2011) and flexibility, contract manufacturers are required to focus even more on their production solutions. The challenge is how to utilise the existing resources and potential synergies within the network to be able to meet the global customers' ever-increasing expectations regarding cost and flexibility. This consequently requires better coordination among the plants of the network and capabilities beyond plant level.

Network capabilities provide a suitable ground for global contract manufacturer to achieve their desired cost efficiency and flexibility. Therefore, working towards the achievement of network capabilities could smooth the way for global contract manufacturers to make the best use of the resources and synergies within their network and move on towards global growth.

Although network capabilities have been discussed in the literature for quite a long time (Shi and Gregory, 1998), they have not been particularly studied in the contract manufacturing context. Also, despite broad research around global production networks, there is still a small but significant gap between the network and plant level which calls for more research to bridge the gap between a firm's strategy and the characteristics of its production network (Ferdows, 2014).

Considering the growth of contract manufacturing within industries and also the pressure on global contract manufacturers from a cost and flexibility perspective, more empirical research would be required to clarify and understand the interactions among different plants in the production network of a global contract manufacturer and to achieve network capabilities that support long-term business strategy.

1.3 Objective and research questions

Following the identified problem, **the objective of this research is to develop knowledge that supports global contract manufacturers in achieving network capabilities.**

Considering the background of the research, the problem described and the research objective, three research questions have been formulated:

RQ1: What are the characteristics of global production networks of contract manufacturers?

The first question is raised to understand the global production network of a contract manufacturing company. As a first step, it is necessary to study such a production network and understand its challenges and opportunities.

RQ2: What synergies can be found among the plants of a global contract manufacturer?

It is crucial to identify the synergic areas that a network of a global contract manufacturer can provide. This can be a basis for further analysis of how to work with similarities among plants in a network.

RQ3: How can global contract manufacturers achieve network capabilities in their global production network?

This question investigates different ways that a global contract manufacturing company can achieve desired network capabilities.

1.4 Delimitations

The case studies included in this thesis were mostly performed in the manufacturing context in the automotive sector at a global contract manufacturing company headquartered in Sweden producing mainly parts for commercial vehicles.

This research covers both configuration and coordination aspects of a global production network. However, the focus is more on network capabilities related to the coordination aspect than on configuration.

The type of network that is the focus of this study is the *intra-firm* network i.e., a network made up of a single organisation and multiple sites (Rudberg and Olhager, 2003). Looking into the generic types of networks, the main case company involved in this study (Case company X) had a web structure (Miles and Huberman, 1994) in the sense that all plants had an almost full set of competences and orders were balanced among them.

Apparently, the global production network of a contract manufacturing company belongs to a larger supply chain of its customers and also includes a network of its suppliers. In this research, the production network of the case company has been studied in relation to its global customers' supply chain. The supply chain related to the suppliers has been excluded in this research project.

Further, not all of the production plants of the main case company were studied. The plants in China and Hungary and one of two new plants in Sweden which all were added to the network in 2014 were not covered. Information about the plants studied is provided in the next chapter, where each case study is presented in detail. The interviews made in the case studies were performed with people with strategic roles in the network, most of them working in the headquarters in Sweden.

1.5 Outline of the thesis

This thesis is comprised of six chapters in total as shown in Figure 1. The first chapter makes the reader familiar with the background, problem statement, research objective, and research questions. Chapter two clarifies how the research has been performed in detail and how the data were collected and analysed. The third chapter provides a background of research in the research area and refers to the existing models. Chapter four presents an overview of the empirical findings. Chapter five provides some discussions and analyses of the results and finally in Chapter six, conclusions are presented and future research is suggested.

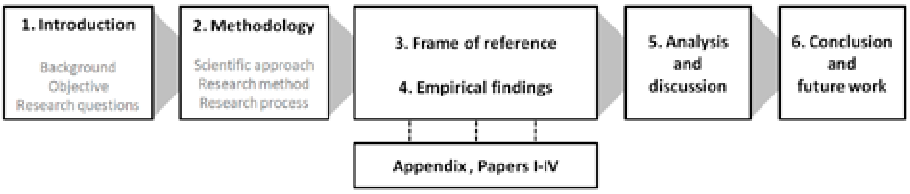

Figure 1 – A schematic structure of the thesis.

2 Research methodology

This chapter describes how the research presented in this thesis has been conducted. The research approach and the research method are first introduced followed by a description of the research process. Then the case studies including the collected data and data analysis are presented. Finally, the chapter concludes with a discussion around the role of the researcher and the quality of the research.

2.1 Research approach

Research is an organised, systematic, data-based, critical, scientific inquiry or investigation into a specific problem, undertaken with the objective of finding answers or solutions to it (Sekaran, 2006). As for methodological approach, the model suggested by Blessing and Chakrabarti (2009) was adopted (see Figure 2). The model provided a step wise approach to design research methodology (DRM), which was a suitable framework for formulating the research. Four distinctive stages of DRM are: research clarification (RC), descriptive study I (DS I), prescriptive study (PS), and descriptive study II (DS II). This research, up to licentiate thesis stage covers research clarification and descriptive study I. Prescriptive study and descriptive Study II are expected to be performed after the licentiate thesis.

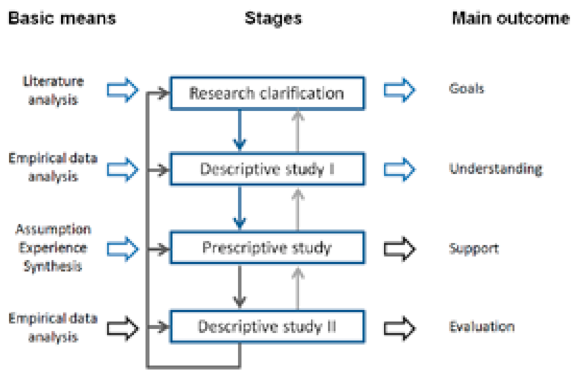

Figure 2 – DRM Framework and links (adopted from Blessing and Chakrabarti, 2009)

The research clarification helped to define the research area through the literature studies conducted. Then the descriptive study I phase was conducted, which included the empirical studies.

An abductive approach has been taken in the licentiate thesis, which leads to a new insight into existing phenomena by examining these from a new perspective (Kovács and Spens, 2005). Abductive reasoning emphasises the search for suitable theories to make an empirical observation, what Dubois and Gadde (2002) call “theory matching”. This provides an opportunity to go in a “back and forth” direction between theory and empirical studies (DuBois and Oliff, 1992).

The abductive approach suited this research as it attempted to extend the existing theories. Using the abductive approach, the researcher started with some theoretical knowledge related to the topic. However, to closely examine this starting point, it was tried to perform “theory matching” to find the theories matching the empirical findings and vice versa.

2.2 Research method

The case study method was chosen in the current research as a suitable method for studying “how” questions as well as exploratory “what” questions (Yin, 2009). A case study is an empirical inquiry that investigates a contemporary phenomenon (the “case”) in its real-world context, especially when the boundaries between phenomenon and context may not be clearly evident (Yin, 2009).

Another motivation for choosing case study as the research method was the need to gather a rich set of data from practice in order to facilitate the understanding of the phenomenon regarding different aspects of each study (Voss et al., 2002). The case study method enables the researcher to add two sources of evidence not usually available when using other methods e.g., interviews with the persons involved and direct observation of the events being studied (Yin, 2009). Consequently, selecting case study as the research method allows an in-depth study of the case (Yin, 2009) as well as accumulating a rich variety of data sources (Eisenhardt and Graebner, 2007).

2.3 Research process

The research process is seen as the sum of all the sequential steps that a researcher engages in that are necessary for following the path of a specific research approach (Kovács and Spens, 2005). Figure 3 illustrates the steps taken during the research so far including literature reviews and empirical studies.

The theoretical reviews were done in order to acquire the fundamental knowledge relevant to the research area as well as to develop a theoretical reference for the case studies as a part of the design phase (Yin, 2009). The literature review will be presented in Chapter 3. The literature studies were carried out in parallel with the empirical findings to strengthen the ground and to assert the authority and legitimacy of the research (Karlsson, 2009).

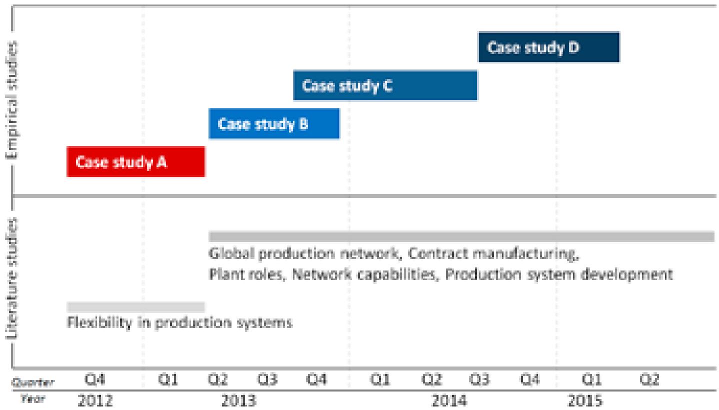

Figure 3 – The studies performed including literature studies and empirical studies.

The empirical part is comprised of four case studies (here designated as Case studies A–D). Case study A was done in order to identify and refine a research problem (RC) and the other case studies were conducted in order to gain sufficient understanding of the current situation (DS I). Figure 4 shows how the empirical studies are related to the research questions as well as the papers. RQ1, RQ2 and RQ3 refer to research question 1, research question 2 and research question 3, respectively, and RC stands for the research clarification phase.

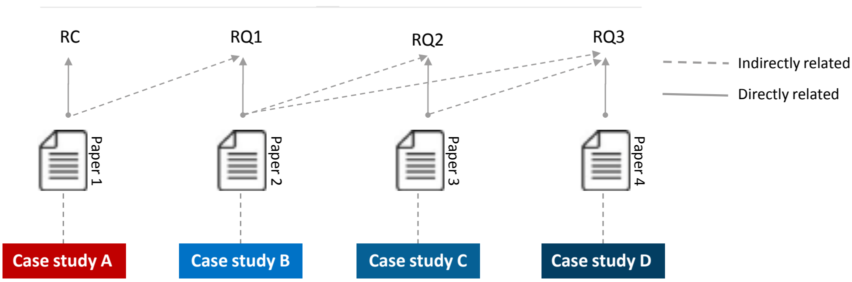

Figure 4 – The performed studies and their relation to the papers and research questions.

2.4 Presentation of the case studies

In total, four case studies have been conducted during the research project. Table 1 provides an overview of the empirical studies including the number of case companies, study topic, contribution to research questions, units of analysis, and the related papers described later in detail.

Table 1 – An overview of the case studies conducted.

	Case study A	Case study B	Case study C	Case study D
No. of case companies	2	2	1	1
Study topic	Flexibility in manufacturing	Production networks of contract manufacturers with respective challenges and opportunities	Plants in global production networks at a contract manufacturer	Production system design at a global contract manufacturing company
Contribution to RQs	RC	RQ1	RQ2, RQ3	RQ3
Unit of analysis	Flexibility requirements and their enablers at different levels of a global industrial organisation	Production network of a global contract manufacturer with a focus on challenges and opportunities	Plants of a global contract manufacturing and relations among them	Production system development process in a global manufacturing context
Data collection techniques	Interviews, documents, observations	Interviews, documents, observations	Interviews, documents, observations	Interviews, documents, observations, informal talks
Study outcome	Understanding of flexibility requirements at different levels of a manufacturing company	Mapping of two different types of production networks and their respective challenges and opportunities	Increased understanding of the synergies among plants of a global contract manufacturer	Where/how to consider network capabilities during the development of production systems
Presented in paper	I	II	III	IV

2.4.1 Case study A

Case study A was conducted in two global manufacturing companies in order to investigate the requirements and enablers regarding flexibility at different levels of such companies. Data were gathered from two manufacturing companies (here called case company X and case company Y). Case company X was a global contract manufacturing company headquartered in Sweden with approximately 1,250 employees and eleven production sites in six countries. The core business of the company was production of mechanical and electromechanical components for commercial vehicles, construction and mining industries and general industry. Case company X was included in all case studies.

Case company Y was a large electronics manufacturing service provider (EMS) for professional industrial electronics headquartered in Switzerland. The company's characteristic capability was a flexible operation model that enabled it to react quickly to changing market situations. As a provider of industrial electronics manufacturing service, the company had about 6,000 product variants, of which 1,400 types were produced yearly. The company had long experience of serving industrial electronics customers. The company had production plants in Finland, Sweden, Estonia, Switzerland, Slovakia and China, and a sourcing office in Hong Kong, altogether employing about 3,000 people.

Data were collected using semi-structured interviews regarding both flexibility requirements and enablers at different levels of the organisations. In addition, observations were made of the production line of a few products, and documents were studied.

Six semi-structured interviews were conducted in this study as shown in Table 2.

Table 2 – Details of the interviews conducted in case study A.

Respondents	Duration (min)	Content
Production Engineer, Case X	90;30	Flexibility requirements and enablers at different levels of a global manufacturing company
Technical Manager, Case X	90;30	
Manager, Manufacturing Services, Case Y	120;30	

The respondents were provided with the background and purpose of the study and were handed the interview questions. Then, a semi-structured interview was conducted with each respondent at the company. Each interview started with questions around how flexibility was understood and classified. Then questions about different types of flexibility requirements at different levels of the organisation were asked. Finally, the enablers for the respective flexibility types were explored. Each interview was followed by another shorter interview in which further issues that arose in the first interview were addressed. Then the interviews were followed up in order to clarify vague points and complete lacking information.

In both companies, a tour of the operations of each site (two sites in total) was organised by a production manager/engineer including explanations of the concepts of flexibility. The observations provided an opportunity to see, discuss and understand how the case companies worked with flexibility in practice.

The documents gathered in this study were layouts of two production cells in one of the plants and presentation material of both companies. The layouts were used to provide a general picture of operations and also referred to specific flows that were visited.

2.4.2 Case study B

Case study B was performed in order to understand the challenges and opportunities of the production network of a global contract manufacturer. The unit of analysis in this study was the network of case company X and its challenges and opportunities.

Data were collected mainly via semi-structured interviews and informal discussions were held with people with different roles in the organisation of case company X. In this study, ten semi-structured interviews were conducted in case company X (see Table 3). Given the extensive information provided by some respondents, some interviews had to be extended resulting in multiple sessions.

Table 3 – Details of the interviews conducted in case study B (case company X).

Respondents	Duration (min)	Content
Chief Executive Officer	60;30	Challenges/opportunities of a global production network from a business as well as an operational perspective
Chief Operating Officer	60;30	
Production Manager	60	
Key Account Manager	60;30	Configuration of the network and the global customers
Purchase and Sales Manager	60	
Supplier Quality Manager	60;30	Production network challenges/opportunities from an external perspective

The interviews focused on understanding the challenges and opportunities that a production network has from the perspective of people working in different roles in the company.

During this study, four plants of the production network of case company X including two production plants in Sweden, one in Germany, and one in Brazil were visited. Apart from a guided tour, the global production network of the company was explained by a Key Account Manager and the strategy of the company was presented by the CEO of case company X.

The documents used in this study included presentations of the companies including information regarding geographical distribution, core competence, product groups and customers of each plant in the network. The global production network of case company X was demonstrated by a Key Account Manager, which led to the creation of a map of the global production network of the company.

2.4.3 Case study C

This was a single-case study performed at a global contract manufacturing company (case company X) aimed at identifying synergies among production plants in the global production network. The unit of analysis in this study was the plants in the network and their relation to the other network plants. Data were collected through interviews, observations and documents as described more in the following.

In total, ten semi-structured interviews were conducted in this study with more details provided in Table 4. All the respondents except one (Executive Supplier Quality Manager) came from the headquarters. However, they all had responsibilities on network level and therefore related to other production plants in the network. In this study also, due to the extensive amount of information by some respondents, multiple sessions of interviews were organised.

Table 4 – Details of the interviews conducted in case study C.

Respondents	Duration (min)	Content
Chief Executive Officer	120;90;60	The specifications of the plants in a global manufacturing context, the strategy of the company, the development of the network over time, the process of establishing a new plant in the production network, mergers and acquisition activities, the relationships among the network plants, plant competence and standardisation of production system components
Chief Operating Officer	90;90	
Production Manager	90;60	
Key Account Manager	90	
Supplier Manager	90	
Executive Supplier Quality Manager[1]	120	

[1] External (This respondent was supplier quality manager of one of the main global customers)

The respondents were selected based on their roles on a global level in the organisation and their knowledge about the plants of the network. An external respondent was also interviewed because of his continuous contact with the case company as supplier quality manager providing him with good knowledge about the different plants. The interviews were carried out based on an interview guide aimed at bring up the related theories for discussion.

Apart from the plants visited during case study B, one new production plant of the company in Sweden was also visited. The plants in China and Hungary and one of two new plants in Sweden that joined the network in 2014 were not covered in this study. The major goal of the interviews and plant visits was to learn about different competences of plants and the possibility of synergetic cooperation among plants.

The documents used in this study were the company's presentation, layouts of three production plants, data regarding the product portfolio of the case company (e.g., axle components, gearbox and gearwheel and various shafts), different processes (hard machining, soft machining, heat treatment, quality control, etc.) in the network plants.

Further, the researcher, being an industrial PhD student, had the opportunity to participate actively in regular project meetings (every two months) that involved people with global roles in the network aimed at developing the management system of the company. In addition, the researcher participated in two Gemba meetings at the headquarters plant. Gemba meetings were management meetings that were held daily to control and set the right priorities and act and react in real time to disruptions. The role of the researcher in the Gemba meetings was that of a passive observant. However, in the meetings regarding the management system of the company, the researcher participated in the meetings and discussions in the role of project manager.

2.4.4 Case study D

Case study D was also a single-case study performed at case company X and aimed at realising the possibilities of achieving network capabilities during the development of a production system in a network context. Data were collected through semi-structured interviews, documentation, and observations (see Table 5). Unit of analysis in this study was the process of production system development in the global contract manufacturing company.

In total, ten semi-structured interviews were conducted as detailed in Table 5. All respondents except one (the global project manager) came from the headquarters in Sweden. However, all respondents had responsibilities on network level and were therefore connected to all plants of the network. The global project manager worked at the plant in Latvia. The plant manager was interviewed twice since the project model required extensive clarification.

Table 5 – Details of the interviews conducted in case study D.

Respondents	Duration (min)	Content
Chief Operations Officer	120	The production system development process, project model, network capabilities, and workflow in one development project
Plant Manager	90;60	
Global Project Manager	90	
Quality Coordinator and Project Leader	90	
Production and Maintenance Manager	90	
Global Marketing and Sales Manager	90	

Further, as mentioned earlier, the researcher was involved in a project meant to develop the management model for the case company consisting of six modules, each with one person in charge. One of the six modules regarded the project model in the company and was thus directly related to the current study. The project model was the core process used in the company to develop production systems.

The documents collected in this study were the project model in the case company, the presentation of the project model (education material) and documents regarding the strategy of the company. The researcher also benefited from informal discussions with the global market and sales manager, the chief operations officer, and production and maintenance manager, all at the headquarters.

2.5 Data analysis

Qualitative data analysis is the process of making sense of data, which involves consolidating, reducing and interpreting what people have said and what the researcher has seen and read, which will later be communicated to others via reports, books and articles (Merriam, 2014). There are as many ways of going about making sense of data as there are methods and techniques to produce data. The different qualitative analysis techniques are often aligned with particular methods, theoretical positions, disciplinary areas or topic areas (Merriam, 2014).

The analysis of the data was conducted as an interaction of theory and the data collected (Miles and Huberman, 1994). The literature reviewed was primarily classified based on focus and stored in a database. Data collected in the case studies were also documented and stored in separate folders including interview audio and text files, notes from observations and document files.

Since the research was of a qualitative character rather than quantitative, the analysis of data followed the structure and guidelines for analysing qualitative data proposed by Merriam (2014). It was primarily ensured that the transcription was correct (data cleaning). Typographical errors were corrected and input from multiple sources was adjusted. All interviews were transcribed, saved as separate word-processed files and stored along with their respective transcriptions in a database. Also, data collected from documents and observations were stored with the related studies in the database.

After cleaning, data were coded (by phrases, numbers and sometimes colours) as a basis for categorising the data and finding themes (compatible with the body of literature) to which data were sorted (Merriam, 2014). For instance, in case study 4, the collected data were related and categorised based on four network capabilities introduced in the frame of reference chapter.

While coding and categorising the data, self-memos were written to retain the ideas that occurred, as proposed by Saunders et al. (2011). Then an attempt was made to make sense of the data in line with the related theories. This step called "making inference" is described by Miles and Huberman (1994) as "moving up from the empirical trenches to a more conceptual overview of the landscape".

It should be noted that the process of data collection and analysis was recursive and dynamic. This is not to say that the analysis was finished when the data had been collected; it rather became more thorough as the study progressed, as discussed by Merriam (2014).

2.6 The role of the researcher

Being an industrial PhD student, (from a manufacturing background), the researcher had continuous presence including specific project responsibility in case company X during the project time starting in October 2012. The time distribution between the academic project and the industrial work was 80 % and 20 %, respectively. Thus, a key aspect of the research was the presence of the researcher in the case company, which facilitated a good understanding in greater depth compared to a few sporadic visits, which is often the case otherwise. This was particularly valuable regarding the possibility to access groups of people and making observations of the production plants the in real world, which was otherwise inaccessible. Also the proximity to the industrial environment made it possible to have close interaction with the people involved in the data collection.

The researcher's role during the studies gradually changed over time from solely a passive observant to a participant-observant (Yin, 2009). The most distinctive opportunity was therefore to perceive reality from the viewpoint of someone "inside" a case rather than someone external to it (Yin, 2009). Also, it was possible to have access to and visit different plants and facilities in the global production network of the case company and to meet groups and individuals from different departments.

The challenge regarding participant observation is, however, that of being biased and risking objectivity. Davison et al. (2004) suggest avoiding over-identification with the organisation and its members in order not to sacrifice objectivity. To tackle this, other external senior researchers were involved in order to carefully review the findings of the research.

Further, Yin (2009) mentions another challenge regarding the limitations of the researcher to be present at the right place at the right time in a physically dispersed organisation. However, this was not a big challenge since the researcher could have regular meetings with key people participating in this research and had the possibility to be mobile and visit or communicate with people in other production plants during the project.

2.7 Research quality

Research quality can be measured from different aspects, especially when the research is of a qualitative nature (Corbin and Strauss, 2008). When it comes to the quality of the research, the two significant aspects of validity and reliability determine the quality of the research.

Construct validity refers to the identification of correct operational measures for the concepts being studied (Yin, 2009). It is related to the level of conformity between what is actually studied and the intended subject of study (Saunders et al., 2011).

In order to improve construct validity, which can be problematic in case study research (Yin, 2009), data triangulation (Voss et al., 2002) was performed by means of collecting data from multiple data sources such as interviews, observation and documentation in all case studies. Further, regarding the interviews conducted (as a major data source in the current research), different respondents with different roles in the organisation were chosen. Also, as mentioned before, the findings were verified by other researchers.

External validity of the research is associated with the generalisation of the findings of a study beyond its immediate study. A downside of using the case study method is the inability to generalise from the results of limited cases (Yin, 2009). However, for case studies the issue relates directly to analytical generalisation (Yin, 2009) and cases are chosen for theoretical reasons rather than statistical in order to either replicate or extend emerging theories (Eisenhardt, 1989).

To increase external validity, based on suggestions by Eisenhardt and Graebner (2007), the findings of the empirical studies in this research were compared with the related literature to find justifying and contradictory points. Although single-case studies provide a rich description of the phenomena (Eisenhardt and Graebner, 2007), multiple-case studies have higher external validity (Voss et al., 2002). Therefore, it should be mentioned that the results of this study are drawn from a limited number of empirical studies making it difficult to generalise to a wider scale. Therefore, the external validity of the results of this study could be increased by performing multiple-case studies in further stages of the research.

Another aspect of research quality is the reliability of the research, which is defined as the extent to which the research results can be repeated (Arbnor and Bjerke, (2008)), in other words, if another researcher could be able to replicate the case study and arrive at similar findings and conclusions (Yin, 2009).

Transparency and careful documentation of the research has been mentioned as a key to increase reliability (Gibbert et al., 2008). The studies conducted in this research project have been documented to a high degree comprising interviews, observations and documents. Also, a short diary was prepared for case studies C and D. Besides, all the interviews in studies B, C and D were double-checked with the respondents. However, it should be taken into consideration that due to constant changes in the organisation and people involved, recreating the constraints and conditions and thus complete replication of the studies is not possible (Merriam, 2014).

3 Frame of reference

This chapter presents the theoretical background of the research. The chapter is organised as follows: first, the concept of global production networks is explained along with related typologies. Then, theories around the configuration/coordination aspects of global production networks are provided. After that, plant and network capabilities are described. Some theories regarding strategic views on plant and network level are presented followed by theories on the production system development process. Finally, the chapter ends with literature about contract manufacturing and a summary of the theories.

The current research deals with network capabilities of a global production network in global contract manufacturing context (Figure 5).

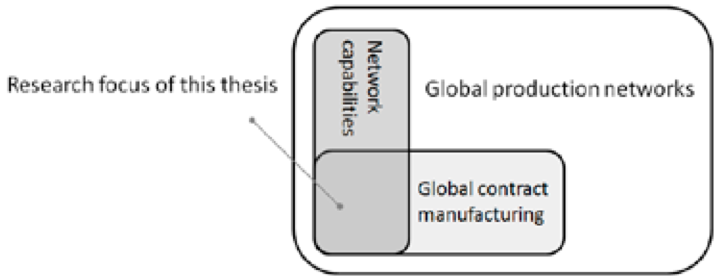

Figure 5 – Research area and the position of the current research.

3.1 Global production network

In general, production networks come under the category of superior value networks, which are categorised into four types, each having specific characteristics and requirements as shown in Figure 6 (Rudberg and Olhager, 2003). A production network is defined as multiple production sites within one organisation (Feldmann, 2011) as opposed to supply chains, in which more than one organisation are involved. A global production network is defined as globally dispersed production plants where single factories affect each other and cannot be managed in isolation (Rudberg and Olhager, 2003, Shi and Gregory, 1998). From the definitions above, a few characteristics can be attributed to a global production network, i.e., globally dispersed plants, single organisation and interdependency among production plants. In this thesis, the term "global production network" is adopted to refer to a set of interrelated production plants as a part of a single organisation with a centralised strategy.

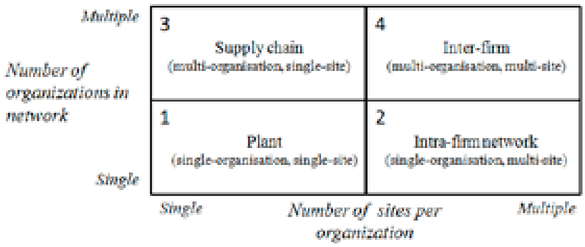

Figure 6 – Classification of value chains (Rudberg and Olhager, 2003).

From a structural level perspective, the network level can be considered as the highest level, which is interpreted as production units linked by material and information flows (Wiendahl et al., 2007). Regarding the formation of a production network, it takes years to put production networks in place and it is difficult to change them quickly. Many variables, often outside the control of the firm, affect these networks and make it a challenge to control their evolution (Ferdows, 2014).

In the literature, a few categorisations based on different criteria have been provided in order to classify production network types. Considering a manufacturing company's policy regarding centralisation, three categories are proposed by Bartlett and Ghoshal (1999): multinational, international and global solution (Table 6). They also introduce the "transnational solution", which combines those three concepts and can ideally provide flexibility, innovativeness and competitiveness.

Table 6 – Classification of networks based on degree of centralisation (Bartlett and Ghoshal, 1999).

Multinational	***International***	***Global***
Building strong local presence through sensitivity and responsiveness to national differences	Exploiting parent company knowledge and capabilities through worldwide diffusion and adaption	Building cost advantages through centralised global-scale operations

It must be noted that trying to generically fit all parts of a company into one model is not necessarily the right way to go for all companies; marketing, for example, is an activity that demands high local responsiveness, while R&D is often global (Feldmann, 2011).

Another categorisation of production networks, is that of Miles and Huberman (1994), who consider how production steps are distributed in the production network, resulting in five generic types of production networks: world factory, local for local, hub and spoke, sequential or convergent, and web structure. The structure of such networks is illustrated and described in Figure 7.

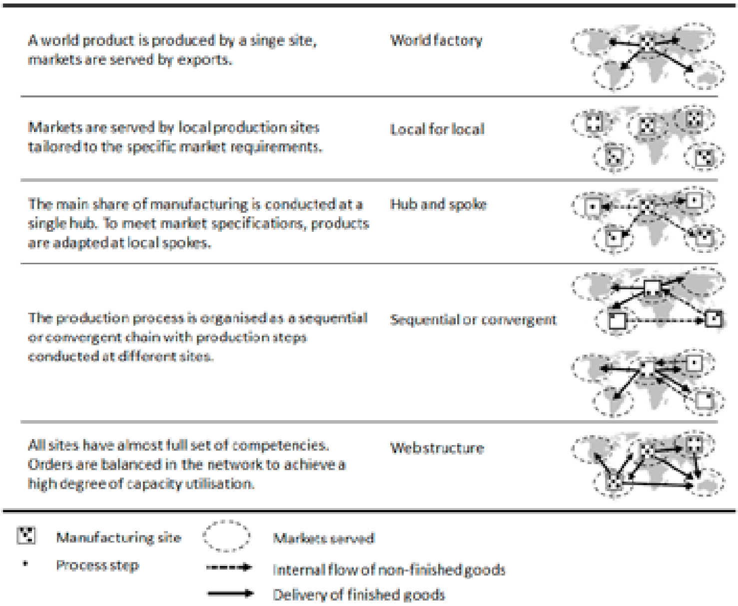

Figure 7 – Generic network types (adopted from Miles and Huberman (1994)).

3.1.1 Configuration and coordination of production networks

Theories on management of global production networks focus on two main dimensions, configuration and coordination (Rudberg and Martin West, 2008). Originally, configuration refers to the location in the world where each activity in the value chain takes place whereas coordination discusses how like or linked activities are coordinated with each other (Porter, 1986). Colotla et al. (2003) reaffirm and add configuration as the *structure* of multi-plant networks and coordination as the *infrastructural* process of linking activities among plants in a network. Considering global production network as a set of *nodes* (plants) and *linkages* (interplay) between them, it could be supposed that the configuration aspect deals with the nodes of the network whereas coordination looks at the linkages between those nodes (Mundt, 2012).

Compared to the abundant research on the configuration aspect of production networks originally in the topic of plant location decision making (Rudberg and Olhager, 2003), less attention has been paid to the coordination aspect of global production networks (Mundt, 2012). This is despite the fact that the awareness of coordination already exists in early literature. Flaherty (1986), for example, reports how some US companies have evolved from a manufacturing configuration of plants, located in different countries and managed fairly independently of each other, towards a coordinated manufacturing network that benefits from the synergies among the plants.

3.1.2 Plant capabilities vs. network capabilities

Traditionally, research on operations management has had a focus on single plants (Shi and Gregory, 2005), resulting in knowledge about the organisation, optimisation, planning and daily running of a business on production plant or shop floor level (Mundt, 2012). Research on management of manufacturing at plant level has led to the identification of capabilities at that level, i.e., *cost*, *quality*, *delivery speed, reliability*, *flexibility*, and *innovativeness* (Miltenburg, 2005). Decisions regarding these capabilities have been divided into *structural* and *infrastructural* types. Structural decisions involve decisions on issues such as capacity, production processes and facilities, whereas infrastructural decisions include issues such as quality, work organisation, performance measurement system and production planning and control (Barnes, 2008).

However, globalisation of manufacturing in recent decades has added new missions for global manufacturing companies such as market presence, resource searching, global competitiveness, potential tapping and capability building (Shi and Gregory, 1998). This has introduced decisions on a distinct network level aiming at the global operations management area (Mundt, 2012, Vereecke and Van Dierdonck, 2002). Table 7 reflects some decisions on both plant and network level.

Table 7 – Different levels of decisions in global production networks (adopted from Vereecke and Van Dierdonck (2002) and Miltenburg (2005)).

Decision areas at plant level	Decisions on network level
Capacity	The ideal number of plants
Process technology	The geographical dispersion of the plants
Organisation	The strategic role of the plants
Production planning / control	The level of competence/autonomy for each plant
Product development	Products/capacity produced in each plant
Performance measurement system	

Similar to the capabilities on plant level, the "networked" structure of global manufacturing companies can yield unique capabilities that could turn into a wining factor on a long-term basis. *"If well managed, a firm's production network can be a formidable source of competitive advantage; if not, it can significantly limit the firm's strategic options"* (Ferdows, 2014, p. 1).

In the literature, four network capabilities that can be derived from a well-configured and well-coordinated network have been explicitly introduced by Shi and Gregory (1998). These capabilities, or what Miltenburg (2009) calls "network outputs", are explained in the following and elaborated further in Table 8.

1) **Accessibility**: a network's capability to provide market proximity and access to resources of strategic importance (Miltenburg, 2005).
2) **Thriftiness**: a network's capability to achieve high economic efficiency (Miltenburg, 2005). It has been divided into the two categories of economy of scale and economy of scope, which are obtained from aggregation of production volumes across plants and aggregating different product types in the global product portfolio, respectively (Colotla et al., 2003).
3) **Mobility**: a network's capability to shift or transfer products, staff, processes or production volume to achieve *flexibility* and optimise resource utilisation (Miltenburg, 2005) in response to changes in customer needs, production factors, competitors, regulations and company strategy (Colotla et al., 2003).
4) **Learning**: long-term capability of a network (Shi and Gregory, 1998) to foster external and internal learning in terms of culture, customer needs, employee needs and government regulations as well as product technology, process technology and managerial systems (Miltenburg, 2005).

Table 8 – Strategic capabilities of global production networks (Shi and Gregory, 1998).

Accessibility

- Strategic markets: beating trade barriers, being close to the customers, quick response.
- Production factors: labour, materials, energy, product and process technology, etc., to tap national resources and advantages.
- Managerial skills: managerial knowledge, organisational skill, administration heritage, and corporate value and culture.
- More sensitive to global changes: understanding a wide range of different customer requirements, being more sensitive to future trends, information, technology and competition.
- Other special benefits: nontax, policy benefits, partners' business and social connections.

Thriftiness ability

- Economy of scale: specific to the dispersed value-added chain.
- Economy of scope: wide product lines with shared R&D, engineering, manufacturing, marketing and distribution facilities.
- Reducing duplication of activities: for all business activities.

Manufacturing mobility

- Product/process mobility: transferred technology and system for donors and receivers and robust process for such transfer.
- Managerial skill mobility: learning process for the skill, knowledge, culture, value.
- Factory manufacturing flexibility: wider product lines and economy of scope for global changes and competition, more flexible system for the product life cycle.
- Network manufacturing flexibility: network is more flexible to location change, node linkages, value-chain relationship.

Learning ability

- Special learning opportunity: wider internal and external comparison, exchange, and benchmarking.
- National capability integration: culture fusion, learning and tapping the special national strengths.
- Global product integration: learning from worldwide market demands and abstracting core requirements for development of world product.

In the literature, the relations between the configuration and coordination aspects and network capabilities have been discussed. Configuration or what has been called "design" of a global production network (Shi and Gregory, 1998) can help a global manufacturing company to achieve accessibility. The other three network capabilities could be derived from coordination or "operation" of the network plants (Colotla et al., 2003). Coordination of a production network concerns issues around how to organise, link and integrate the production plants in order to achieve strategic business objectives (Chang et al., 2011).

In an extensive study on design, management and optimisation of intra-firm networks, Mundt (2012) mentions, "... although of key managerial and academic interest, the coordination layer is either neglected or only addressed very basically" (p. 2). He provides a framework for the architecture of networks focusing on network strategy, configuration and coordination. Considering "what" should actually be coordinated among the plants of a network, Bartlett and Ghoshal (1999) refer to material, information, people, and financial resources as different flows. In the management of production networks, the flow of information has been the main focus (Vereecke et al., 2006). There are two different types of information flows, administrative information flow (e.g. purchase, inventory, production plans, etc.) and knowledge flow (Gupta and Govindarajan, 1991). From a coordination perspective and aiming to achieve learning, mobility, and thriftiness, knowledge flows seem to be far more interesting than administrative information. People, as a crucial element of coordination, could be considered as "knowledge carriers" (Mundt, 2012).

3.1.3 Strategic view of plant and network level

Manufacturing strategy is about specifying strategic priorities in manufacturing order to leverage competitive advantage in business strategy (Wheelwright, 1984). In the manufacturing strategy literature, four key competitive dimensions, called competitive priorities have been introduced: cost, quality, delivery and flexibility (Hayes and Wheelwright, 1984, Rosenzweig and Easton, 2010). Decisions on the mentioned competitive priorities should support the overall business strategy of a company and its mission. There has been some debate about the existence of a trade-off relationship among the competitive priorities, for instance between flexibility and cost, (Skinner, 1989). This is in contradiction to "world-class" manufacturing delivering high-quality at low cost mentioned by Schonberger (1986).

On the other hand, four capabilities on network level have been addressed as strategic capabilities by Shi and Gregory (1998) achieved from a good configuration and coordination of global production networks. Those capabilities, i.e., accessibility, thriftiness, mobility and learning could be related to competitive priorities such as flexibility and cost, which are explicitly mentioned in connection with mobility and thriftiness (see Table 9).

On the plant level, considering production plants as an integral component and basic construct of a global production network (Cheng et al., 2015), a strategic perspective on network plants has been considered in the literature (Feldmann and Olhager, 2013, Ferdows, 1997). There are a few models of assigning a certain range of expectations or so-called "role" of plants of a global production network. De Meyer and Vereecke (2000) have divided plants in a global production network into four types by analysing the role of the plants of eight international companies and considering a number of characteristics of the plants such as age, autonomy, size, relationships with suppliers, level of investment and capabilities developed in the plant and performance in terms of quality, cost and speed:

1) **Isolated plants**: isolated position in the network receiving few innovations
2) **Blue print plants**: receiving lots of innovations but returning hardly any
3) **Host plants**: plants that have an essential role in the knowledge network of the organisation; plants with a frequent exchange of innovations
4) **True innovators**: plants that score high on all dimensions of communication centrality, high level of autonomy, sources of innovations for the rest of the organisation

Another model for assigning the strategic role has been provided by Ferdows (1997) based on the strategic reason for a plant's location and the plant's competence (see Figure 8). This model, which gained academic recognition (Cheng et al., 2015, Vereecke and Van Dierdonck, 2002), became the basis for further research (see, e.g., Feldmann and Olhager, 2013, Meijboom and Vos, 2004, Vereecke and Van Dierdonck, 2002). Ferdows (1997) proposed six different strategic roles for the plants of global manufacturers labelled as *offshore*, *source*, *server*, *contributor*, *outpost* and *lead* plants. Ferdows (1997) describes those roles as the follows: An *offshore* plant is established to produce certain products at a low cost. A *source* plant is similar to an *offshore* plant with a broader strategic role; and its managers have greater authority over procurement and selection of suppliers. The primary role for an *outpost* plant is to collect information, which is only theoretically possible. This is because in reality it is indeed unlikely that a plant would be located in an area rich of know-how acting only as a "window" to access this know-how and not exploit it (Vereecke and Van Dierdonck, 2002). A *lead* plant creates new processes, products, and technologies for the entire network by tapping into the local technological skill and having a role greater than merely collecting information (Ferdows, 1997). Managers of a *lead* plant have a more decisive role in the network and stay in direct contact with the customers, suppliers, and research centres (Ferdows, 1997). A *server* plant is meant to supply specific markets by overcoming tax barriers, reducing logistic costs, and diminishing foreign exchange fluctuations. A *contributor* plant is similar to a *server* plant with extended responsibilities for product and process engineering as well as authority over the choice of suppliers and procurements. In this way, a *contributor* plant may fall in competition with a *lead* plant in the network (Ferdows, 1997).

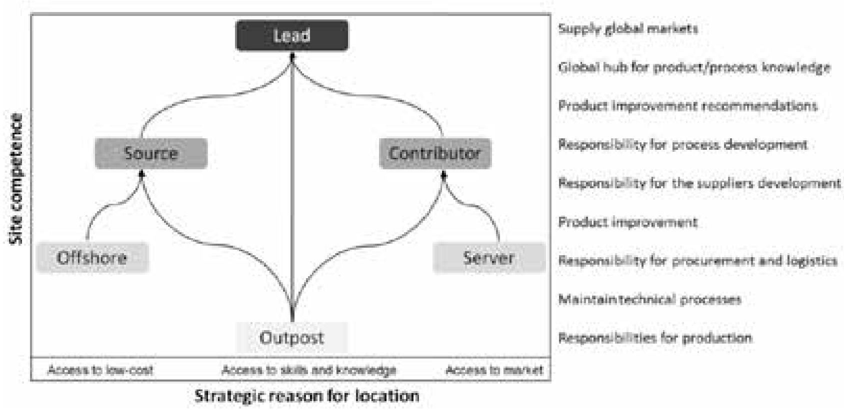

Figure 8 – Six different roles for plants in a global production network (adopted from Ferdows (1997)).

Ferdows's model offers a good starting point for studying the roles of plants in a production network. However, it has some ambiguity regarding the vertical axis (Meijboom and Vos, 2004). The concern about the vertical axis of Ferdows's model is that site competence has been provided in a continuous way from assuming responsibility for production up to being a hub for product and process knowledge but there is no clear border in between.

Another concern regarding to Ferdows's model is that it suggests that there is some hierarchy of competencies in a plant. However, it is possible, for example, to give a certain plant the responsibility for product development without decentralising procurement or logistics (Meijboom and Vos, 2004). In this regard, some authors have mentioned secondary roles for the plants in a global production network meaning that a plant can take two roles at the same time depending on its market focus (Vereecke and Van Dierdonck, 2002). Feldmann and Olhager (2013), have, based on Ferdows model, taken further steps and provided more detailed categories for plants of a global manufacturer specifying three levels according to the autonomy level of the plants: production, supply chain, and development.

To conclude, Ferdows's model provides a suitable ground for further discussion about the roles of plants in global production networks. However, this might not apply completely to all global manufacturing companies as in some cases there might not be a hierarchy in the competence of the plants but rather a combination of competences for each plant in the global production network.

3.2 Production system development

In the manufacturing context, the process of product design and development has been extensively researched (see, e.g., Brown and Eisenhardt, 1995, Cross, 2008, Krishnan and Ulrich, 2001) and so has the design and development of production systems (Bellgran and Säfsten, 2010, Bennett, 1986, Bennett and Forrester, 1993, Wu, 1994).

Regarding how the term *production system* is perceived, there are quite different perspectives. Production itself has been defined as the process of creating goods and/or services through a combination of material, work, and capital (Bellgran and Säfsten, 2010). The word *system* comes from the Greek *systema* which means "organised whole" and is perceived as a collection of elements that function together to achieve some objective (Blanchard, 2004).

According to Jacobsen et al. (2002), a production system is defined as a viable and agile system that transforms product specifications, expectations from the market, and raw materials into products. In the transformation, workflow, suitable manufacturing and control process based on environmental principles, and a combination of human intelligence wherever necessary are used. Bellgran and Säfsten (2010) mention different notions of the production system such as line, workshop, and plant depending on to what level a production system is referred. In this thesis, production system boundaries are considered within the walls of a production plant and the term global production network refers to a set of interconnected production plants scattered worldwide.

The life cycle of production systems covers both design and development of production systems. Production systems design, refers to a multidisciplinary process (Bruch, 2012) that supports manufacturing companies in their attempt to achieve faster time to market, smoother production ramp-up, enhanced customer acceptance of new products, and/or a stronger proprietary position (Hayes, 2006). Production system development includes, in addition to the design of the system solution, also the implementation of the designed solution, which involves building and industrialisation of the production system (Bellgran and Säfsten, 2010).

In the literature, there are several models regarding the tasks and activities concerning the design and development of production systems. Wu (1994), for example, has proposed a process that takes into account different factors regarding the design of production systems. Also Bennett and Forrester (1993) provide a process for design of production systems with a focus on the market including guidelines for requirements analysis and suggest a number of feasible options.

Another example is a comprehensive process for the development of production systems provided by Bellgran and Säfsten (2010), in which they divide the development activities into different phases as shown in Figure- 9.

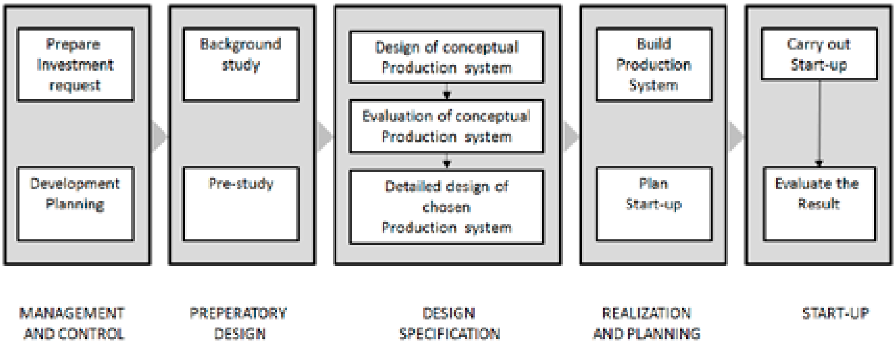

Figure 9 – Production system development process, adopted from Bellgran and Säfsten (2010).

Despite being distinguished from the operation of production systems, both design and operation of production systems are tightly interlinked and interacting (Canel and Khumawala, 2001).

All in all, the development of production systems in a global manufacturing context could be seen as a set of decisions in certain phases that, by using the available network potential, aim at achieving the design and implementation of the most optimal solution. Bellgran and Säfsten (2010) discuss that it is neither possible nor desirable to achieve a completely general way of working that is at the same time specific for all situations; therefore the production development process should be adapted to a company's context.

3.3 Contract manufacturing

Much manufacturing has now come to be based on the organisational structure of having a lead manufacturer (usually the manufacturer responsible for the final assembly of the finished product) and a group of partners that produce components and sub assemblies (Buzacott and Peng, 2012). One specific type of partnership is contract manufacturing which is defined as a supply chain arrangement by which a manufacturing firm outsources some of its manufacturing processes to an outside supplier through a contractual agreement (Kim, 2003). Contract manufacturing may lead to benefits such as risk sharing (Johnson and Houston, 2000), cost reduction, improved delivery and increased added value for original equipment manufacturers (OEMs) (Han et al., 2012, Cao and Zhang, 2011). In this way the OEMs keep the ownership of their products and focus their efforts on product design and marketing services while contract manufacturers provide production solutions to OEMs. At the same time, because contract manufacturers do not have their own research and development process, they need to come up with production solutions that can satisfy their global customers' demand. Kim (2003) discusses that a contract manufacturer often initiates improvements in its production processes as the "core" of its business, thus leading to benefits to the OEM company.

Therefore, contract manufacturers allow brand-owner firms to meet the scale of current market demand without committing to long-term capital investments or an increase in their labour force, thus giving the firms greater scale flexibility (Schilling and Steensma, 2001). This permits production capabilities to be loosely coupled to a firm, enabling it to specialise in those activities central to its competitive advantage while other firms provide the necessary support and specialised resources that it does not possess (Schilling and Steensma, 2001). Thus, contract manufacturing also yields scope flexibility (Holmes, 1986). If utilised in a proper manner, contract manufacturers can both save cost and provide flexibility to their customers.

Ernst and Kim (2002 , p.1420) state:

"Due to the fierce competition in the global market, no firm, not even a dominant market leader, can generate all the different capabilities internally that are necessary to cope with the requirements of global competition. Competitive success thus critically depends on a capacity to selectively source specialised capabilities outside the firm that can range from simple contract assembly to quite sophisticated design capabilities".

On the other hand, global contract manufacturers like any other global manufacturers must be able to adopt a structure and an organisation that allow them to respond to the conflicting and ever-increasing demands of their global customers (Cheng et al., 2015).

3.4 Summary of the literature review

The literature review led to some conclusions for the current research project. This section provides a summary of the literature.

First of all, the review provided a holistic view of production networks including theories regarding different typologies, and some background on reasons and motivations behind the existence of global production networks.

Besides, network capabilities were introduced and explained as capabilities on the plant level along with the plant-level capabilities. Taking the focus from plant capabilities to network capabilities entails a network perspective on the plants in a global production network. In this regard, different aspects of global production networks were elaborated in correspondence with the network capabilities, i.e., configuration and coordination. While configuration deals with the structure of sites and network, the coordination aspect considers the interaction between plants and relations among them.

Furthermore, considering a production plant as an integrated part of a global production network implies some responsibility for the plant, especially plants with higher autonomy. Ferdows's model (1997) was explained as a suitable basis for discussing plant roles in a global production network (Vereecke and Van Dierdonck, 2002). However, Ferdows's model does not explicitly define how the plant role is related to its contribution to the coordination of the network.

Also some theories regarding production system design and development were provided. To be able to consider network capabilities in a production system development process, it was necessary to understand how production systems are designed, implemented and operated through different steps.

Finally, contract manufacturing has been introduced to complement the theoretical framework regarding the context of the current research. This helped to understand the requirement put by OEMs on contract manufacturers. Consequently, the importance of a well-coordinated production network for global contract manufacturers was recognised.

4 Empirical findings

This chapter summarises the empirical findings from the case studies conducted. In total four case studies were carried out during the research project. Each case study is introduced with some information regarding its purpose, and then the findings are summarised.

4.1 Case study A

The purpose of case study A which was conducted in the first stage of the research project (research clarification) was to investigate various flexibility requirements and enablers at different levels of two manufacturing companies (see appended Paper I). The purpose was to find out how flexibility was defined and achieved in the case companies.

Case company X was a global contract manufacturer with eleven production sites in six countries, and case company Y was a large electronics manufacturing service provider (EMS) with production plants in six countries. It became evident from the collected data in general that flexibility was a vital capability in both case companies X and Y. Both companies, in different ways, had the intention of achieving a certain level of flexibility to be able to respond to changes imposed by the market.

Since case company X was a global contract manufacturer, flexibility was a significant capability for its plants as the company needed to adjust its production volume to its global customers' demands. To achieve the desired flexibility, case company X focused more on changeover and volume flexibility which is explained in the following. Regarding changeover flexibility, the company was able to shift quickly between different products via designing adaptable fixtures and tooling systems. Concerning volume flexibility, case company X combined dedicated machines with flexible ones to handle fluctuations in customer demand.

Based on the data collected from case company X, it became evident from an analysis of the customers' orders in recent years that the company needed to achieve a tolerance of ±30 % in production volume. The company had practical solutions to achieve this goal, which were addressed during observations in one of the production sites and explained by a production engineer at case company X. As shown in Figure 10, there are two dedicated cells to produce two different components in high volumes. However, there is a flexible production cell that is able to produce both components in lower volume. This way, the company could handle fluctuations in demand for products A and B to a certain level without investing in new separate dedicated production cells. Building a flexible cell required certain competence and incurred some costs to the company that was taken into consideration.

Figure 10 – Two dedicated production cells and a flexible one to achieve volume flexibility at case company A

Case company Y concentrated more on two flexibility types, i.e., mix and sequence flexibility. Regarding product mix, the company produced around 1,400 product variants annually and at the same time needed to produce as many different product variants as possible in a single machine. Also, due to the high mix of products, the company preferred to reduce multiple changeovers between different product types to be able to produce the same batches of products consecutively.

Regarding sequence flexibility, case company Y was heavily dependent on the availability of material from their suppliers. Depending on product type, the waiting time for the suppliers to deliver the products could range from 3 days up to 30 weeks. This placed high demands on the company to acquire sequence flexibility to be able to handle uncertainty in delivery from the suppliers.

Apart from the flexibility types mentioned, both case companies referred to human resources as a vital enabler of flexibility. It was revealed that both companies required staff with diverse skills who could easily switch between different tasks. For instance, in case company X, the ability of the operators to run different machine tools in the workshop was of great significance.

In conclusion, flexibility in global contract manufacturing companies is a matter of trade-off between choosing the right combination of flexibility types and choosing the right level for each flexibility type. As flexibility imposes high costs to manufacturing companies, determining a certain level of each flexibility type seems necessary.

4.2 Case study B

Case study B aimed at studying a production network of a global contract manufacturer (case company X) with production plants located in different countries in the world in order to understand its characteristics as well as challenges and opportunities.

In the interview with the CEO of case company X, global production network of a contract manufacturer was defined as fully owned factories branding the parent company. The factories would be able to supply their customers with locally produced products but to a global standard of quality.

Regarding the development of the production network of case company X, the company was established its first plant in 1982 in Sweden. This plant later became a *lead* plant that and supported other plants of the network regarding development of new processes (headquarters). The plant, for instance, has supported the establishment of the heat treatment process in two other plants of the network. The company established its first production plant abroad in Latvia in 2003. About four years later another plant opened in Latvia followed by a plant takeover in Sweden in 2008. The production plants in Latvia were primarily *offshore* plants to take advantage of low-cost manufacturing; however, later the strategic role of those plants in Latvia changed from being merely *offshore* plants to *source* plants with more autonomy. The plant in Sweden was a takeover from one of the biggest global customers outsourcing one of its plants in 2008. This takeover allowed case company X to acquire the production competence for a component that later turned out to be a strategic component for the company. In 2012 the company set up a new plant as a *server* plant to supply a global customer in Brazil. One year later the company added another plant to its global production network by acquiring a factory in Germany. This plant had two advantages: it allowed access to the market of a new country and also added a new competence to the existing competences of the network, namely the design and production of gearboxes. This plant, therefore, was more of a *contributor* plant with extended responsibilities for product and process engineering. The company added two other plants in Sweden, one plant in Hungary and one in China between 2013 and 2014. The plants in Sweden were *contributor* plants with competence in machining cast parts in high volumes. Both plants in Hungary and China acted as *server* plants to customers in Southern Europe and Asia respectively. The company also established a business unit in India as part of a plan for future expansion.

The company experienced a rapid expansion by adding six production plants in four years to its global production network. Furthermore, as early as in 2013, the company started to negotiate a new quotation from one of its largest global customers, which already had a presence in Brazil. The negotiations continued for about two years before a contract was signed. This became an opportunity for the plant in Brazil to grow and take further responsibilities in the network. Initially, only the required capabilities were available at this plant but later a new line was planned to be developed after the new contract was signed.

It was also revealed that to keep costs down, the case company had a strategy of utilising second-hand machineries in the production systems at different plants. This, combined with a high level of competence in maintenance of production equipment, turned out to be a winning factor for the company. Also, the company normally developed costly processes in just one or a few plants. Such processes were transferred to other plants if required by using a certain process for competence transfer.

Some challenges of a global contract manufacturer became obvious; they are briefly outlined in the following:

The global customers' strategies regarding different markets were an important factor mentioned in the interviews. According to the interviews in case company X, it was particularly important for case company as a contract manufacturer to be able to follow the global customers' trends and strategies to be able to adjust production volumes.

Other challenges have also been mentioned that are more general and might apply outside the contract manufacturing context. Legislations and regulations in different countries influence the business of global contract manufacturing companies. For example, case company X had to wait a few extra months for their equipment to be cleared in the customs when establishing a production plant in Brazil. This was unwanted but inevitable due to the national regulations. Finally, fluctuations in exchange rates and culture were also mentioned as challenges facing global contract manufacturers just like all other global manufacturing companies. It was also extremely important for the case company to pass on the core values of the parent company to the new plants in the network.

4.3 Case study C

Case study C focused on the plants of the global production network of case company X. Case study C was conducted with the main purpose of exploring the synergies among different plants of a global contract manufacturer.

The product portfolio of the case company showed that the company produced a wide range of products by using various production processes in the different plants of the network. Some of those were common in certain plants and some were unique to a specific plant. A part of this information is shown in Table 9. As listed in Table 9, some processes such as turning, milling, and end milling were common among the plants of the network. However, some processes were carried out in specific plants such as case hardening, friction welding and washing.

Table 9 – Examples of production processes in some plants of case company X

Plant	Main production processes
Sweden 1	End milling, Turning, Milling, Curvic Milling, Splines milling, Drilling, Threading, Broaching, Diameter grinding, Centre-less grinding, Induction hardening, Case hardening, Annealing, Straightening, Crack detection, Torque testing, Splines shaping, Splines Hobbing, Washing
Sweden 2	End milling, Turning, Milling, Curvic Milling, Splines milling, Drilling, Threading, Broaching, Diameter grinding, Centre-less grinding, Tumbling, Induction hardening, Friction welding, Assembly, Painting, Balancing, Washing
Latvia	End milling, Turning, Milling, Curvic Milling, Splines milling, Splines hobbing, Drilling, Threading, Broaching, Diameter grinding, Centre-less grinding, Induction hardening, Annealing, Washing
Brazil	End milling, Turning, Milling, Splines milling, Drilling, Threading, Broaching, Diameter grinding, Centre-less grinding, Induction hardening, Friction welding, Assembly, Painting, Balancing, Washing
Germany	End milling, Turning, Milling, Splines milling, Splines shaping, Splines hobbing, Drilling, Threading, Diameter grinding, Centre-less grinding, Case hardening, Assembly, Washing, Shot pinning
Hungary	End milling, Turning, Milling, Drilling, Broaching, Assembly, Washing

Within the network of the case company, some of the products were produced in more than one plant creating a potential for a synergetic cooperation between them. One example of such products was explained by the CEO during the interviews as he referred to propeller shaft as a common product in two production plants, one in Sweden (shown as Sweden 2 in Figure 11) and one in Brazil. The darker line in the figure indicates an example of a strong relation (common product, production process or a complementary process) between two plants, which in this case was due to producing a common product. The other lines simply denote a network structure.

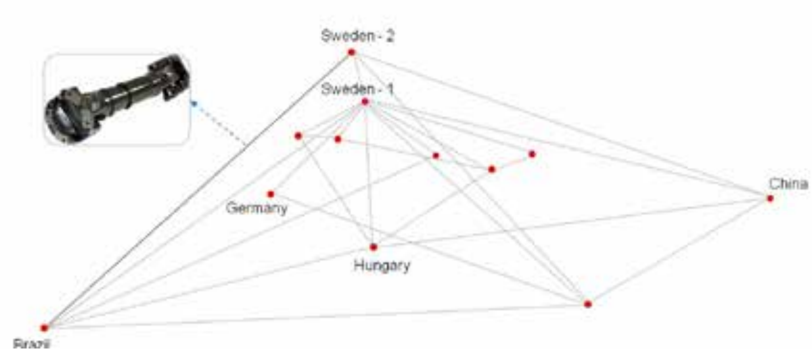

Figure 11 – Propeller shaft, a product that links two production plants.

Based on the interview with a production manager at the headquarters and based on the documents regarding the product and process portfolio of the case company X, it became evident that there were some processes in common between certain plants in the network (see Table 9). One example of such a process was gear cutting, which was a production process available in plants in both Germany and Sweden 1 (see Figure 12). The darker line in this figure indicates a strong relation among certain factories due to having common processes and the other lines simply denote a network structure.

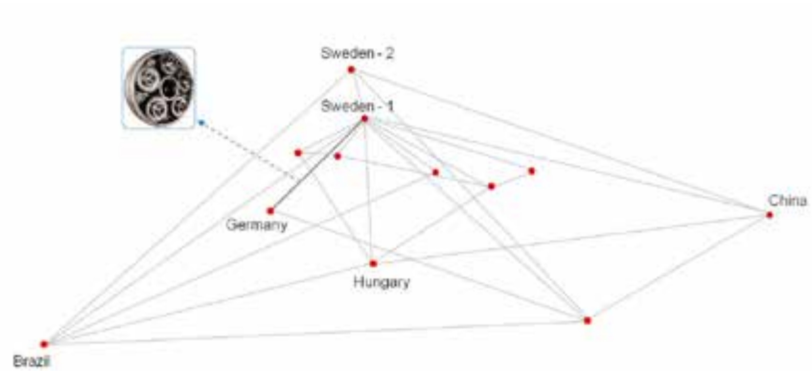

Figure 12 – Gear cutting, a process that ties links production plants.

Furthermore, it was revealed from the interviews and documents that the processes were divided into two distinct groups: production processes and complementary processes. Production processes were processes used directly to produce parts, such as turning, milling, gear hobbing, etc. Complementary processes were defined as processes that were not used directly to produce the parts; they were rather required as a complement to a production process, such as measurement, calibration and project management. Regarding the distribution of complementary processes in different plants, project management was mentioned as an example for a complementary process that was used in all plants while calibration was available in the headquarters.

In all cases, whether product, production process or complementary process, there was a potential for collaboration among plants in synergetic areas. This put more responsibility on lead plants regarding specific synergetic areas to support other plants in the network with competence transfer.

It also became evident from the interviews that in the network of the case company there were "semi-identical" processes that were used to produce the same products in two different plants. Those processes, referred to as "redundant" processes, were used as back up in case of failure in a certain flow. For instance, two plants of the network (Sweden-2 and Latvia) both produced a specific product that allowed the company to keep on delivering products to the customer in case of disturbance in the flows in a certain plant.

4.4 Case study D

The aim of case study D was to investigate where and how network capabilities could be considered during a production system development process.

Studying the document regarding how the production system was developed in the case company, revealed that production systems were designed, implemented and operated through certain stages of a process called "project model". The project model was the underlying roadmap for typical projects in response to customer demands within the case company for design, implementation and operation of production systems. The process mentioned included all necessary actions and interactions by and among different departments and stakeholders involved. The process comprised two main parts (separated by contract handover) and five different phases (see Figures 13 and 14).

Regarding the autonomy of the network plants in using the project model, it was revealed that the first part of the process was handled by the market and sales department which was a function in headquarters. They did an initial assessment to see if it is possible to produce the demand and in that case which plant would be the most suitable one. Then the selected plant was informed and decided to accept or reject after analysing the demand and comes back with an answer to the market and sales function. The market and sales, thus, had the responsibility to process the incoming quotation requests until it turns into a contract. From this stage, the local plants take responsibility of the project up to the end. So, in general, each plant in the network is responsible for conducting the second part of the process, including three phases of design, implementation and operation. The plants were therefore responsible to assign a project manager and all required resources to the project.

However, there would be exceptions in some cases when for instance the project is strategically important for the company or if a plant does not have the competence required despite of an existing demand from a customer in a specific market. In this case, it would be tried to make advantage of the network potential and the existing competence in the plants. A team might be formed in such cases with people from different plants in the network to support a plant to perform a project.

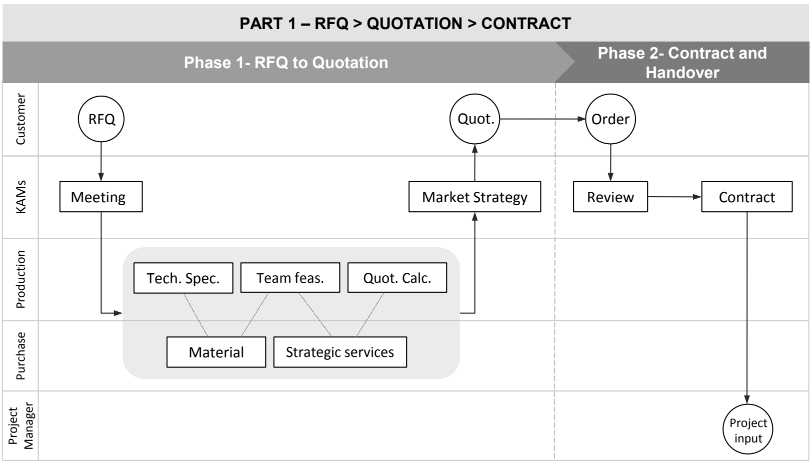

Figure 13 – The project model in the case company (Part 1).

The first part of the process starts with a quotation request from the customer and ends with a production order (contract) if the customer is satisfied with the quote. Following a signal from the market, a quick analysis of the feasibility of the order is performed and the competence available in the network is assessed. A preliminary sketch is prepared for the interesting requests that fit the company's portfolio. Based on this preliminary result, a quotation is sent to the customer.

Although a detailed design is not prepared in this part of the process, an initial sketch is made, which is further developed into a detailed design in the next part.

If the quotation is approved by the customer, the process enters its second part. The next part of the project model encompasses three phases: detailed design, implementation and handover of the production system to the operation (see Figure 14).

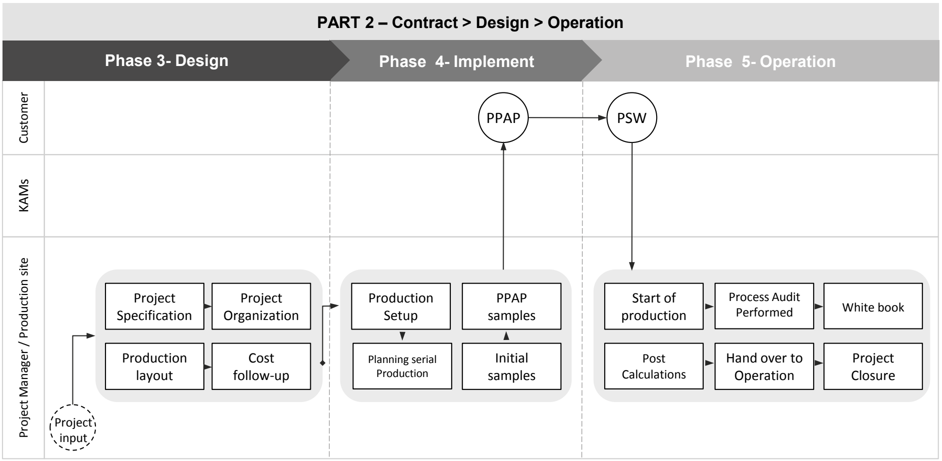

Figure 14 – The project model in the case company (Part 2)

The project organisation is established in the design stage, which mainly involves people in charge from production and operations as well as the project manager. Then the production layout is designed in detail. Based on this design, a cost follow-up is prepared after pre calculation to spot any deviation.

In the next phase, the design is implemented, and after producing a few test orders (PPAP samples), the process enters its next phase (operation), where the production system is handed over to the operations and maintenance department. Although the project model demonstrates a linear sequential process theoretically, in practice, the project usually progresses in different phases at the same time most often.

Regarding the network capabilities, the interview with the global marketing and sales manager made it obvious that the company had an ambition to make the best use of its network structure during production system development. Also, there were some actions and collaboration among certain plants in the network. However, at the time when the study was conducted, there was no systematic approach towards how or when network capabilities should be considered during the development of production systems in the company's production network.

4.5 Summary of the empirical findings

To summarise, the conclusions from case study 1 are that flexibility requirements vary on different system levels of a global contract manufacturing company from station level up to network level. Consequently, enablers of each flexibility type differ. Also, flexibility is a vital capability for a global contract manufacturing company considering the varying demands of global customers.

The conclusions from case study 2 are that the production network of the global contract manufacturer faced different challenges and provided different opportunities. For production network of a global contract manufacturer, it is important to follow the global customers' strategies and be able to handle their fluctuating demands. This puts pressure on global contract manufacturing companies to achieve flexibility.

The conclusions from the case study 3 are that in plants of a global contract manufacturer, common products, processes and complementary processes among certain plants of a production network can be a basis for synergetic cooperation between different plants. A strategic approach towards using the synergies among different plants of a network would contribute to the growth of the production network. This in turn requires coordination among the plants to enhance the possibilities concerning existing synergies in the network. With regard to the continuous growth of the case company, which has expanded from a limited number of plants in one country to a global contract manufacturer in several countries, having a strategic view of the global production network of the case company and making use of potential synergetic areas became even more important.

The conclusions from the case study 4 are that there was an awareness of network capabilities in the case company regarding the use of existing competence in the network to facilitate learning and also provide economic solutions to the customers. However, a systematic approach towards achieving network capabilities during the development of a production system in the network could better promote a realisation of the desired network capabilities.

5 Analysis and discussion

This chapter provides an analysis of the findings. The analysis answers the research questions and relates to the frame of reference.

5.1 Global production networks of global contract manufacturers and their plants

Global contract manufacturers have no products of their own and produce based on their global customers' demand. As a consequence, global contract manufacturers find themselves in a special position. Global contract manufacturers should be able to provide their customers with a better price. This consequently means that they need to have lower production costs compared to their competitors and also what customers themselves can obtain by using their in-house manufacturing. For instance, case company X had a strategy to utilise second-hand production equipment to keep the production costs as low as possible.

In addition to being cost-efficient, global manufacturers should be able to provide flexible solutions to react to the changes imposed on their global customers. In this way, they enable their global customers to handle changes in a better way. Cost efficiency and flexibility become two important factors to be considered by global contract manufacturers.

According to the empirical findings from case study A, flexibility on the network level means to be able to provide global customers with the desired mix and volume of products and also to be able to accept new demands from customers and produce through collaboration between different plants in the network. However, to achieve flexibility on the upper network level, flexibility also needs to be realised on lower levels (plant, system, cell, station). According to the empirical findings from case study A, the achievement of a flexible global production network primarily requires an awareness of market demand dynamics which is gained through relations with customers and suppliers. Additionally, a sophisticated coordination of production plants is required to achieve economy of scale and scope as put forward by Shi and Gregory (1998).

Another challenge of great importance for global contract manufacturing companies is the ability to understand their global customers' strategy. This puts a demand on global contract manufacturing companies to take further steps and foresee changes in the market and adapt their production plants accordingly. On the other hand, to be able to grow their network, global contract manufacturers need to be certain of a specific product volume and contract length. This intensifies the importance of building close relations and partnerships with their global customers.

As mentioned earlier in the findings, case company X achieved considerable growth by being able to add six new production plants to its global production network in four years. Three strategies for expanding the network in the future could be implemented (see Figure 15):

1) Consolidating the existing network
2) Continuing growth at the current pace
3) Expand at even higher pace

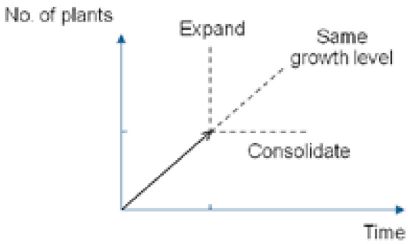

Figure 15 – Three strategies regarding the growth of the network

The evolution of a global production network of a contract manufacturer is affected by external variables, as put by Ferdows (2014). For instance, the expansion of a current global customer or emergence of a new customer in a specific market might encourage a global contract manufacturer to establish a plant and therefore expand its network as it is important for global contract manufacturers to be close to their global customers. Each of these alternative paths brings along different challenges regarding trade-offs between available resources used for the daily operation of each plant and resources needed for the coordination between plants. Hence, different strategies have to be adopted regarding the configuration and coordination of the network depending upon the selected path.

5.2 The plants of global contract manufacturers

When it comes to the production plants of a global contract manufacturing company, the results of the case study C show that each production plant, considering its role in the network, adopts certain competences, some of which could be common with other plants while some could be unique to that specific plant (see Figure 16).

As mentioned in Paper III, besides the similarities among the plants of a global contract manufacturer that could result in synergetic effect, the dissimilarities could also be regarded as distinct advantages for the plants and consequently the whole network. The unique competences of each plant (core competence) could be transferred later to other plants of the network if required. For instance, heat treatment was a core competence of the headquarters plant that was sent to a few plants in the network once it was required.

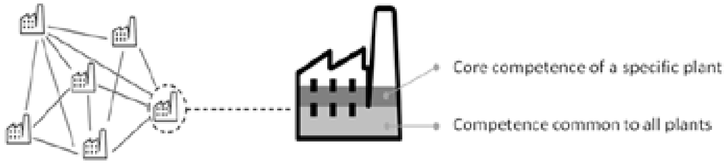

Figure 16 – Commonalities and core competence of plants in the global production network of contract manufacturers

The identification of common areas among the plants can facilitate the creation of synergies in a global production network. Thus, it would be useful to conduct a mapping of the existing commonalities among different plants of the network. This would help global contract manufacturing companies to become fully aware of common areas among the plants that are capable of creating synergy.

Based on Paper III, three areas regarding product, production process and complementary process were identified for further investigating synergies among the plants in the production network of a global contract manufacturer. Also, this could lead to the identification of redundant production processes in the global production network. Having deliberate redundant flows in the network would enable the operation to continue in cases of failure in a plant or increased customer demand.

Following the identification of synergetic areas within the network, collaboration on such areas (product, processes and complementary processes) can facilitate the achievement of network capabilities in the company. For example, collaboration between two plants of the case company X (Sweden 1 and Germany) with a production process in common (gear cutting) created the possibility of the transfer of knowledge regarding the process mentioned to the plant in Brazil (learning).

This was significant for the company because being aware of this possibility resulted in sending a successful quotation for one of the most strategic projects. Furthermore, to be able to conduct the project mentioned, the company had to form a group of experts with different competencies from certain plants of the network and send to the plant in Brazil (mobility) to support regarding the planning and implementation of the mentioned project. In this way, the company avoided extra costs of hiring external consultants in Brazil (thriftiness).

The responsibilities of the plants in a global production network of a contract manufacturer and their contribution to network capabilities could be related to theories on plant roles (Ferdows, 1997) as well as the model proposed by Feldmann and Olhager (2013), in which they suggest production, supply chain and product and production development as competence bundles for plants in a global production network.

In the production network of case company X, a *lead* plant had more responsibility regarding the challenges on the network level as such a plant is theoretically responsible for creating new processes for the whole network with a decisive role in the network. Also both *contributor* and *source* plants were expected to be involved in more than merely "production". For instance, in the project mentioned, a *lead* (Sweden 1) and a *contributor* plant (Germany) were expected to collaborate regarding the transfer of a production process to a *server* plant (Brazil). This collaboration might in future enhance the role of the plant from being a *server* to being a *contributor* plant.

Regarding what constituents of production systems should be standardised in the plants, the results of case study C showed different levels of standardisation for building blocks of the production systems within the network of a global contract manufacturer. There was an agreement to fully standardise some aspects such as operation model, project model, control system and ERP system. Some other aspects, such as production processes and production equipment, which can affect the competence of each plant, cannot be standardised to an overall level.

Interestingly, the results showed that the closer role of the respondents were to the top management, the more standardised they believed those aspects must be. Conversely, people working directly with the specific aspects were more averse to full standardisation. This was partly due to the fact that those working directly with a certain task required a degree of freedom to handle various problems that they were facing. For example, the COO of case company X preferred all production processes to be standardised in different plants of the network while the production and maintenance manager in the headquarters believed they could only be standardised to some degree.

5.3 Production system development in global contract manufacturing

Global contract manufacturers, like any other global manufacturer, possess a network of dispersed production plants worldwide. The distinguishing point is however the fact that global contract manufacturers do not have their own product portfolio and thus do not have a research and development (R&D) process. Instead, they follow their customers' product design, which might be different from one customer to another. This imposes high requirements on the production systems of global contract manufacturers as being their actual "product" offered to their customers and therefore making production their most strategic asset.

According to the empirical findings from case study D, production systems in the case company were developed in three main stages: design, implementation and operations (see Figure 17), which is in line with the production system development process proposed by Bellgran and Säfsten (2010) presented earlier in this thesis. Those stages are in close interaction with each other, as stated by Canel and Khumawala (2001) referring to a link between production system design and operations.

Further, based on the analysis of the empirical data collected from case company X, the design stage itself is composed of three smaller parts. This is to some extent in accordance with earlier theories when Bellgran and Säfsten (2010) suggest to distinguish between preparatory design and design specification. They also explain that the former phase is very crucial for the possibility of developing production systems that meet the preconditions of each company; it mainly involves analysis, while the latter phase involves the utilisation of both creativity and analysis.

In case company X as a global contract manufacturer, the preparatory phase occurs in two smaller steps: a quick analysis is often made by the marketing department in order to investigate the feasibility of the order (sketch). After that, the design concept is prepared in order to be able to send a response to the customer (see Paper IV for more details).

Figure 17 – Production system development in a global contract manufacturing company

The process mentioned satisfies the need for the development of production systems within the walls of a production plant. However, developing production systems that are part of a global production network, adds additional dimensions caused by the expectations of the whole network. As discussed by Miltenburg (2005), apart from the capabilities on the plant level, there are some capabilities that could be obtained from a well-configured and well-coordinated production network. Thus, one possibility to achieve network capabilities could be opened up during the development of production systems in the network.

As stated in Paper IV, there are a few potential points in the process of production system development of global manufacturers where network capabilities could be considered and embedded.

Considering the production development process presented earlier (Bellgran and Säfsten, 2010), there is a learning potential already in the preparatory design during background and pre-study phases. Here, the potential is to learn about the previously conducted projects and how production systems were developed in similar projects. Much of this part of the process happens in the mind of experienced people in certain plants, (mainly headquarters). Therefore, a learning mechanism could be created to store, re-use and spread the mentioned knowledge to other plants of the network. This will help to avoid repeating the same mistakes in similar projects at other plants.

Further, accessibility and thriftiness of the network could be considered during the initial stage and right after the quotation signal has been received when preparing the investment request. This might be facilitated by forming a group of key people in the company who have information about the production resources and the competence within the network.

Furthermore, some network capabilities might function as a prerequisite for other network capabilities. For instance, as explained earlier, a good level of accessibility (proximity to certain markets and access to production factors) could help a global contract manufacturing company to provide cost-efficient (thrifty) solutions through the existing economy of scale and scope. This can be further supported by moving the available resources (mobility) in the network and obtaining a higher return of investments.

According to the empirical findings in case study D, accessibility could also be taken into account during the production system development process. Although the decisions regarding configuration of the network have already been taken when a plant is established, it could be argued that the selection of the right plant in the network to develop a production system could contribute to the accessibility of the network. During the development of a production system in a contract manufacturing context, the focus would be on which plant provides the best settings to produce a part requested by the customer. This is in line with existing theories, as accessibility has been mentioned to be derived from the dispersion of the network (configuration) while other network capabilities are acquired via coordination of the network (Shi and Gregory, 1998).

Furthermore, mobility could also be considered during the early phases of production system development. This could be either managerial or technical skills or the machinery and equipment available in certain plants that are supposed to be transferred to another plant in the network. The mobility concept was practised in company X as the company moved resources such as production process, equipment and staff between certain plants to increase the receiver plant’s competence in specific areas. The different points where network capabilities could be considered during the process of production system development are shown briefly in Figure 18.

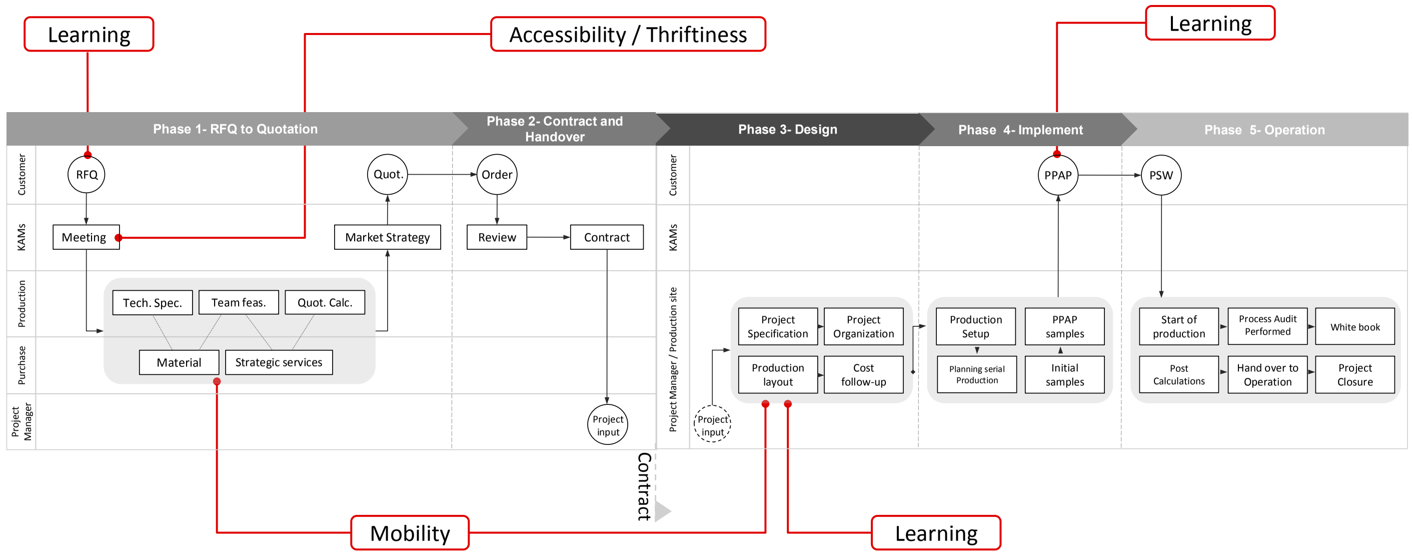

Figure 18 – Considering network capabilities during the production system development process.

The empirical data in case study D show that network capabilities could be considered and realised to a certain extent during the development of a production system in the plants of a global contract manufacturer. As the theories indicate, there is interdependency between plant level and network level, and both plant and network level capabilities affect the competitive advantage of a global production network (Colotla et al., 2003).

Despite of being a complex and wide process, development of production systems in a global context can provide a competitive edge not only through creation of efficient individual production plants, but also through being in accordance to other plants of the network leading to a well coordinated network and at the same time towards global business strategy. From a practical perspective, it could be argued that the decisions during the development of the plants, apart from the financial benefit/loss, will affect the network capabilities of the company and are therefore worth to be studied, analysed, and improved from a network perspective.

5.4 Decision layers in global production networks of global contract manufacturers

From the empirical findings in this research and taking into consideration the theories, different decision layers regarding the management of the production network of a global contract manufacturer could be identified, each containing important factors to be considered.

As mentioned earlier in the frame of reference, the network capabilities should primarily be in line with the global strategy. Global strategy can particularly reconcile network trade-offs when there is a need to make a compromise between different network level priorities. For example, to choose between access to low-cost labour in developing nations versus proximity to markets in developed nations (Colotla et al., 2003).

In addition to global strategy, identifying and prioritising network capabilities could be considered, which can give useful insight into the configuration and coordination of the production network. Decisions on configuration and coordination of the plants can pave the way for a definition of the roles of the production plants (Ferdows, 1997). Specifying the desired network capabilities, which elucidates the plant roles, can be the first step to determine the competence bundle of plants (Feldmann and Olhager, 2013). Further, the selection of plant roles and the competence bundle, which is affected by corporate strategy and network capabilities, can provide useful input into the structure of the production plants as a part of a global production network. Those decisions could be regarded as the least abstract specification of a production plant. Production processes, production technology, capacity of the plant, work organisation, planning and control are among such tangible decisions. Figure 19 illustrates those decision layers, i.e., global strategy, network capabilities and production plants.

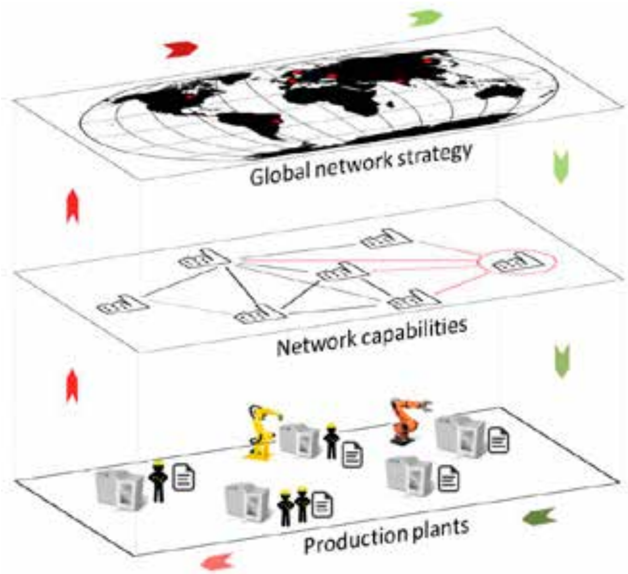

Figure 19 – Decision layers in global production networks of contract manufacturers.

To summarise, to be able to respond to their global customers, global contract manufacturers have to build a network of production plants across the world with a set of network capabilities that enable them to:

- be present in the strategic markets and be accessible to their global customers,
- make use of the potential synergies and redundancies in the network to provide the most economical solutions to their customers' requirements,
- exploit the mobile production resources within the network,
- use internal learning mechanisms as well as external opportunities via education centres

Therefore, the plants of a global contract manufacturer, besides being efficient, should contribute to the network capabilities. One way to consider network capabilities is through the process of production system development which specifies key characteristics of the plants that include those production systems. However, considering the capabilities on both plant and network level and taking into the account complexity of global production networks, there is a need for a comprehensive framework covering different factors that must be considered on different decision layers of a global production network. To fully leverage the network structure of a global contract manufacturer, there is a need for a well established strategy that:

- defines and prioritises network capabilities,
- includes a systematic way to develop those capabilities based on the strategic role of the network plants

6 Conclusion and future work

This chapter provides a general conclusion of the thesis. The contribution of the work is presented followed by further discussions on the quality of the research. Finally future research is suggested.

The main objective of this research was to develop knowledge that supports global contract manufacturers in attaining network capabilities. This was achieved by studying the challenges of a global contract manufacturer, identifying synergetic areas among the plants of a global contract manufacturer and considering network capabilities during production system development. The objective of the research was fulfilled by answering the research questions through a combination of literature study and the empirical studies conducted.

6.1 Contribution

This research increases the understanding regarding global production network of contract manufacturers. Furthermore, the research aimed at raising awareness of network capabilities and their significance in global production networks of contract manufacturers. Most of the theories in this area are useful and reliable but still do not particularly discuss how to obtain network capabilities in a global contract manufacturing context.

The scientific contribution of the current research is:

- Providing insight into global production networks of contract manufacturers and their characteristics.
- The identification of synergetic areas in the production network of global contract manufacturers.
- Embedding network capabilities in the process of production system development in a global contract manufacturing context.

And the industrial contribution is:

- Providing a basis regarding the synergetic areas in a production network for further collaboration between the plants.
- Increasing understanding and awareness of network capabilities and their strategic importance for global contract manufacturers.

- Putting forward some suggestions on consideration of network capabilities as inputs to the development process of production systems in a global contract manufacturing context.

6.2 Research method discussion

Different aspects of research quality as well as the role of the researcher as an industrial PhD student were addressed in Chapter 2.

The data collection and analysis in case study research may be influenced by the researcher's background and interpretation of the data (Williamson, 2002). The open access to the case company provided a suitable setting for carrying out the research. However, collecting data mainly from one global contract manufacturer (single-case study) makes the results difficult to generalise (only in case study 1 another company was involved). Choosing single-case study as research method allows studying the case at two or more points in time; however, the vulnerability of a single-case study is that the case might not turn out to be the case it was thought to be at the outset what is referred to as "misrepresentation" (Yin, 2009). Also, it must be noted that the data came primarily from the headquarters, where most of the respondents worked.

Further, considering the role of the researcher (industrial PhD) and his presence in the company, which increased over time, objectivity has always been critical during the research project. As mentioned earlier, a major challenge related to participant observation is the potential biases produced (Becker, 1958).

Adding further cases in future may play a significant role in increasing the quality of the research providing more empirical data and so might studying cases in which the researcher has no role.

6.3 Future research

There is a lack of empirical research tailored to the needs of global contract manufacturing companies when it comes to the achievement of network capabilities. Therefore it would be interesting to further investigate network capabilities and their generation not only during production system development but also in general.

Further, the interaction among network capabilities and how they affect each other has not adequately investigated and could therefore be studied. This would possibly make it easier to prioritise the network capabilities. Also, a potential research would be to look at how the configuration and coordination layer affects the role of a plant and vice versa in the network that might lead to clarifying a plant's competence bundle in more details (the interplay of plant and network level). Furthermore, it would be interesting to investigate how the strategy of a global contract manufacturing company affects the choices regarding network capabilities.

Finally, future research could fill the gap between strategy level and network capabilities. A part of future research could investigate the choice of network capabilities that are in consistent with the network strategy.

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