Doctoral theses at NTNU, 2020:393

Maria Flavia Mogos

An Efficient Production Transfer Process

Doctoral thesis

NTNU
Norwegian University of Science and Technology
Thesis for the Degree of
Philosophiae Doctor
Faculty of Engineering
Department of Mechanical and Industrial
Engineering

NTNU
Norwegian University of
Science and Technology

Maria Flavia Mogos

An Efficient Production Transfer Process

Thesis for the Degree of Philosophiae Doctor

Trondheim, December 2020

Norwegian University of Science and Technology
Faculty of Engineering
Department of Mechanical and Industrial Engineering

NTNU
Norwegian University of
Science and Technology

NTNU
Norwegian University of Science and Technology

Thesis for the Degree of Philosophiae Doctor

Faculty of Engineering
Department of Mechanical and Industrial Engineering

ISBN 978-82-326-5132-0 (printed ver.)
ISBN 978-82-326-5133-7 (electronic ver.)
ISSN 2703-8084 (online)
ISSN 1503-8181 (printed ver.)

Doctoral theses at NTNU, 2020:393

Printed by NTNU Grafisk senter

"We hold these truths to be self-evident: that all men are created equal; that they are endowed by their Creator with certain unalienable rights; that among these are life, liberty, and the pursuit of happiness."

Thomas Jefferson (1743-1826)

Abstract

Companies transfer production activities when they implement production relocation strategies such as offshoring and outsourcing. The relocation of production activities is a common phenomenon among production companies, which, in the pursuit of higher competitiveness, try to reap the benefits that different locations and suppliers provide (e.g. De Backer et al., 2016, Fredriksson and Jonsson, 2019). Companies have different goals when they relocate production. For instance, some may offshore production to suppliers in low-cost countries to reduce their production costs. Other companies may outsource production to external suppliers in order to access certain production technologies that these suppliers possess, or to achieve economies of scale. In the future, Organisation for Economic Co-operation and Development (OECD), EU and academic studies alike predict that companies will continue to conduct production relocations of different types due to the increasingly shifting global conditions regarding access to advanced technology, skills, low production cost and markets in light of growing environmental requirements (Dachs et al., 2019, ManuFuture-EU, 2019, Heikkilä et al., 2017, De Backer and Flaig, 2017). Moreover, the digital transformation trend plays a central role in the future of production relocations. Innovative communication and monitoring technologies facilitate the management of globally distributed activities within production networks (De Backer and Flaig, 2017, ManuFuture-EU, 2019). Furthermore, although production costs in traditionally low-cost countries such as China and India are rapidly rising, companies are still expected to offshore production to these countries due to the size and growth of their customer markets (Heikkilä et al., 2017, De Backer et al., 2016).

Production transfer is the process of relocating production activities (e.g. the activities that are necessary for the manufacturing of a specific product or sub-assembly) between two production units, *sender* and *receiver*. This process typically includes the transfer of the equipment, inventories, documentation, administrative systems, knowledge, and the subsuppliers that are needed to perform the production activities. A production transfer process is considered *efficient* if the receiver achieves a full-scale and stable production volume, according to schedule and at targeted levels of performance, which can be indicated by the cost and quality conformance levels.

When companies transfer production from the sender's production environment to the receiver's, a series of new risk sources are introduced, which can affect their ability to achieve the pursued relocation goals. The existing literature reports on several failed production relocations, which have, for instance, led to suboptimal product quality, significant cost overruns, reshoring, and even factory close down (De Backer et al., 2016, Fratocchi et al., 2014, e.g., Kinkel and Maloca, 2009). However, the offshoring/outsourcing literature has so far focused on the decision-making process, that is, whether to relocate production or not, and how to select the most suitable production activities for relocation and the right supplier. Nevertheless, the success of a relocation also depends on how well the production transfer is planned and conducted (e.g. Aaboen and Fredriksson, 2016). Furthermore, because of the increased risk level in the supply chain, several production transfer scholars have

acknowledged the importance of preparing production transfers based on risk management principles (e.g., Fredriksson et al., 2015, Malm, 2013, Cheng et al., 2010). A number of studies have investigated how parts of the production transfer process and of the risk management during this process should be performed (e.g. Fredriksson et al., 2015, Malm, 2013, WHO, 2011, Madsen, 2009). Nevertheless, the existing knowledge is scattered, and it is difficult to get a clear and holistic overview of how to systematically conduct the production transfer process and the risk management during this process from the beginning to the end.

Thus, the overall purpose of my PhD research has been to investigate how production transfer processes can be conducted in order to mitigate the transfer risk. The final goal of the research has been to develop a procedure for efficient production transfers, based on risk management principles. I have addressed the following research questions:

1. What are the potential risk sources when transferring production?
2. What are the facilitators of efficient production transfers?
3. What are the main actions in a production transfer procedure that aids transfer risk mitigation?

The theoretical foundation of the PhD research is positioned within the field of operations management of multisite production networks. The research focuses on the process of implementing production relocation strategies such as offshoring and outsourcing, that is, the production transfer process, as well as on risk identification and mitigation during this process. The unit of analysis is the production transfer process within the dyad composed of a sender and a receiver. The research strategy has been design science, as described by Holmström et al. (2009). This strategy is recommended both for the development of procedures with enhanced practical relevance (the final goal of my research) and for the development of theory (e.g., Van Aken and Romme, 2009, Holmström et al., 2009). As design science is a multi-method strategy, the PhD research combined systematic literature reviews, production transfer studies, a longitudinal field study and action research. The main production transfer in the longitudinal field study is a transfer of electronics from a Norwegian producer to their subsidiary in Spain. The production transfer procedure was implemented during this ongoing transfer, and iteratively refined and validated together with the transfer parties over a two-year period (through the action research method). In total, the procedure was refined seven times. To this end, I organised nineteen workshops with the sender and receiver's transfer personnel. Moreover, I organised an international workshop to validate the applicability of the procedure for other types of industries. Three practitioners reviewed and confirmed the applicability of the procedure for three transfers with which they had worked. In total, I studied eight transfers, including five transfers of electronics at the Norwegian electronics producer, one transfer of food production, one of maritime technology, and one of aircraft production.

In response to the first research question, the PhD research primarily proposes a framework of transfer risk sources. This framework includes a set of 46 risk sources, which are divided into the following categories: (i) *transfer object* (e.g. the risk that the tacit knowledge about the production activities that are transferred is difficult to codify and document), (ii) *receiver* (e.g. the risk of high employee turnover rate), (iii) *sender-receiver relationship* (e.g. the risk when the bargaining powers of the sender and receiver are unbalanced), and (iv) *the* *transfer's impact on the business profit* (e.g. the risk when the volume of goods that will be produced by the receiver is low compared to their remaining portfolio). This framework can be applied during the risk identification process. During this process, a risk management team with representatives from both transfer parties should identify the risk sources that have the potential to give rise to transfer disruptions and losses.

In response to the second research question, the PhD research primarily proposes a framework of facilitators of efficient production transfers. The framework includes a set of 40 facilitators that are divided into the three main transfer phases: (i) *preparation* (e.g. the receiver should review the documentation from the sender to identify any missing information), (ii) *execution* (e.g. the sender should temporarily transfer experienced production personnel to the receiver to facilitate the transfer of tacit knowledge), and (iii) *start-up* (e.g. the sender should transfer the production stepwise in order to enable the receiver to increase the production volumes incrementally). Moreover, the framework includes facilitators of efficient relationship management throughout the transfer (e.g. the sender and receiver should hold regular status meetings). This framework can be applied during the risk mitigation process. During this process, the risk management team should identify and implement preventive actions in order to mitigate the likelihood of disruptions with an unacceptable risk level. This research indicates how the facilitators of efficient production transfers can act as preventive actions, by applying the framework in two production transfers. Moreover, the PhD research provides a set of lessons learned that should also be considered during the risk mitigation, based on the longitudinal field study (e.g. 'The more significant the changes applied to the transferred production, the higher the risk level and the longer the transfer process.').

In response to the third research question, this thesis primarily provides a detailed and thoroughly validated procedure for the preparation phase that includes a set of preventive actions. This procedure is based on the framework of facilitators of efficient production transfers, which was implemented during the ongoing electronics transfer from Norway to Spain, and iteratively refined with the transfer parties. This research focused on the preparation phase as the actions implemented during this phase have a high potential to prevent the occurrence of disruptions and losses during the execution and start-up phases. At the end of the ongoing transfer, I conducted a user experience evaluation. The sender and receiver confirmed that the procedure had a positive impact on the efficiency of the transfer. The amount of disruptions was reduced, the start-up time was shorter, and both the on-time delivery and the product quality were better compared to earlier transfers. In addition, the practitioners at the international workshop that I organised confirmed that the procedure was useful for production transfers within other types of industries. The procedure includes 37 preventive actions that were refined with the transfer parties. The preventive actions are divided into the following categories: (i) *organisation and project management* (e.g. the transfer parties agree on transfer performance indicators and their continuous monitoring), (ii) *sourcing* (e.g. the transfer parties verify transportation requirements such as customs requirements and trade agreements that are applicable when delivering goods from the receiver vs. the sender), (iii) *quality management* (e.g. the sender evaluates the receiver's readiness with regards to facilities, equipment and support services), (iv) *process technology* (e.g. the receiver pilots and validates any design change on the process technology, to identify any necessary adaptations), (v) *test* (e.g. the sender sends personnel to the receiver to perform training on testing methods), (vi) *production* (e.g. the sender verifies the knowledge transfer at the receiver, for instance by checking the transfer documentation and testing the personnel), (vii) *plan for enterprise resource planning set-up* (e.g. the transfer parties update the bill of materials, inventory policies, capacities, etc., in their enterprise resource planning systems), and (viii) *Health, Safety and Environment* (HSE) (e.g. the sender provides to the receiver HSE information about the transferred production activities, such as material safety data sheets and information about risk mitigation actions and waste management). The procedure should aid the transfer parties during the risk mitigation process and when preparing the transfer action plan.

Thus, the main theoretical contributions of the PhD research include an increased knowledge of potential transfer risk sources, and of facilitators of efficient production transfers during all the transfer phases. Moreover, the research provides a thoroughly validated preparation procedure that aids transfer risk mitigation and facilitates efficient production transfer processes. Based on the cases studied during the PhD research, examples of transfers where these contributions should be particularly important include those in which the receiver is located far away from the sender, when the sender applies design changes to the products that are planned for transfer, when the transferred production activities involve a great amount of tacit knowledge, when the receiver has little experience with the transferred production activities and when the receiver replaces the sender's sub-supplier with local sub-suppliers. These types of transfers can lead to disruptions such as supply disruptions (e.g. material shortages and significant schedule disruptions), operational disruptions (e.g. quality nonconformances) and eventually to significant material losses (e.g. scrap and excessive inventory). These contributions will aid practitioners—both senders and receivers—to manage such situations, and production transfers in general, more efficiently. Thus, this research can facilitate efficient production transfers during relocation processes such as offshoring and outsourcing.

Acknowledgements

This project would not have been possible without the help, support and encouragement from my colleagues, industrial and academic contacts, family and friends.

I would first like to thank my supervisor Associate Professor Erlend Alfnes for his encouragement, friendly advice, constructive criticisms, and countless supervision hours throughout the PhD period. I would also like to thank my co-supervisor Professor Jan Ola Strandhagen for all the helpful advice he has shared with me, and for raising the quality and clarity of my work through his reflective questions and ideas. Thank you both for having faith in me and making me feel welcome at NTNU! Moreover, thank you for providing me the opportunity to take part in lecturing, student supervision, seminars and proposal writing!

A warm thank you goes to Associate Professor Anna Fredriksson, as a co-author and co-supervisor, as a friend and as a great mentor! I cannot thank you enough for your countless revision hours and comments that have repeatedly enabled me to quickly understand how to improve my work. Thank you also for welcoming me at Linköping University, along with Professor Martin Rudberg!

I will also thank Børge Sjøbakk, Dr. Natalia Swahn and Kristoffer Magerøy, who joined me as co-authors, for your input into this research project and a great collaboration. Thanks also to Associate Professor Marco Semini, Professor Heidi C. Dreyer, Associate Professor Anita Romsdal, Professor Fabio Sgarbossa, Professor Hans-Henrik Hvolby and to docent emeritus Peter Falster for your great help and valuable feedback!

Both in and out of our PhD seminars, my fellow PhD students and friends have been an important source of advice for the development of this thesis. Many thanks to Gabriele Hofinger Jünge, Natalia Iakymenko, Olumide Oluyisola, Tara Nezhrati, Sven Vegard Boer, Aili Biriita Bertnum, Kasper Kiil, Emrah Arica, Pavan K. Sriram, Oladipupo Olaitan, Philipp Spenhoff, Lukas Chabada, Maksim Kapranov, Kristina Kjersem, Bella Nujen and Maggie Bresler.

My colleagues and friends at the research institute SINTEF Manufacturing also deserve a warm thank you for their support and patience during the final phase of the PhD! Tusen hjertelig takk!

However, the best parts of my research would have been impossible to perform without the industrial collaboration. Therefore, I must show my deep gratitude to the company representatives that have been involved in this work. Tusen hjertelig takk to my contacts in Norway, especially Kjell Gjestad, Dr. Daryl J. Powel, Tom Victor Kolkien and Roger Lundegaard! Muchissimas gracias also to Agustin Mayans, Ruben Garcia, Dr. Celia Guillem and Pablo Gimeno! I am also extremely indebted to Jaakko Aho and Tuomo Salmi from Finland, Dr. Anna Malm from Sweden and Karol Dabrowski from Norway for your extremely valuable contribution! You have all been extremely open-minded, kind, and thoughtful with my research and me.

I would like to extend my gratitude to the Norwegian taxpayers, and the projects that have supported both my research and my development as a researcher, particularly the research project SoundChain and SMARTLOG. Without financing from the Norwegian Research Council, this project would have never seen daylight.

Many thanks also to the administrative staff at the Department of Mechanical and Industrial Engineering for your kindness, patience and help!

I would also like to give truly unbounded thanks to my family. I could not be the person I am today without your care, help and support. Thanks for always being there when I need you, and for always making me feel like I never left home!

Trondheim, 14 December 2020

Maria Flavia Mogos

List of Appended Papers

The author's contribution to each of the appended papers

	Paper	Declaration of authorship
1	*Sjøbakk, B., Mogos, M.F., Magerøy, K. 2016. Transfer of production to strategic suppliers: a case study. WIT Transactions on Engineering Sciences, 113, pp. 279–86. (Published; double blind peer-review process.)*	I conducted and wrote the literature review and contributed to the data collection and analysis.
2	*Mogos, M.F., Sjøbakk, B., Alfnes, E. 2017. A production transfer risk assessment framework. IFIP International Conference on Advances in Production Management Systems, 514, pp. 29–39. (Published; double blind peer-review process.)*	I conceptualised the article along with Alfnes and Sjøbakk, and conducted the literature review, in-depth case study and analysis. Moreover, I developed the framework of risk sources with input from Alfnes, and wrote the article with input from Sjøbakk and Alfnes.
3	*Mogos, M.F., Alfnes, E., Swahn, N. 2016. Prerequisites for Successful Production Transfers in the Electronics Industry. Lecture Notes in Business Information Processing, 262, pp. 168–181. (Published; double blind peer-review process.)*	I conceptualised the article along with Alfnes, and I carried out the literature review and case analysis. Moreover, I developed the framework of facilitators of efficient production transfers, with input from Alfnes, and wrote the article with input from Alfnes and Swahn.
4	*Mogos, F.M., Fredriksson, A., Alfnes, E., Strandhagen, J.O. 2020. Investigating relationships between production transfer-management and transfer success. Journal of Manufacturing Technology Management. (In review; double blind peer-review process.)*	Fredriksson and I conceptualised the article with input from Alfnes. I carried out the literature review and analysis and developed the literature-based frameworks with input from Fredriksson and Alfnes. Moreover, I conducted the longitudinal field review, with input from Alfnes, and wrote the article with input from Fredriksson, Alfnes and Strandhagen.
5	*Mogos, F.M., Fredriksson, A., Alfnes, E. 2018. A production transfer procedure based on risk management principles. Journal of Global Operations and Strategic Sourcing, 12 (1), pp. 103–150. (Published, double blind peer-review process.)*	Fredriksson and I conceptualised the article with input from Alfnes. I carried out the literature review and analysis with input from Fredriksson, and developed the literature-based transfer-preparation procedure. Moreover, I conducted the action research and the procedure validation during an international workshop with production transfer practitioners, with input from Alfnes. Thereafter, I wrote the article with input from Fredriksson and Alfnes.
6	*Mogos, M.F., Sjøbakk, B, Alfnes, E. 2016. A structured outsourcing procedure. IFIP International Conference on Advances in Production Management Systems, 488, pp. 739–747. (Published, double blind peer-review process.)*	Sjøbakk and I conceptualised the article and carried out the literature review and analysis. Sjøbakk and I developed the outsourcing procedure and applied the procedure to the transfer studies with input from Sjøbakk. Thereafter, I wrote the article together with Sjøbakk, and with input from Alfnes.

Abbreviations

AHP	Analytical Hierarchy Process
APQP	Advanced Product Quality Planning
BBN	Bayesian Belief Network
BOM	Bill of materials
ERP	Enterprise Resource Planning
ESD	Electrostatic discharge
ETA	Event Tree Analysis
EU	European Union
FIFO	First In, First Out
FMEA	Failure Mode and Effects Analysis
FTA	Fault Tree Analysis
HSE	Health, safety, and environment
IP	Intellectual property
ISO	International Organization for Standardization
ICT	Information and communications technology
KPI	Key performance indicator
NTNU	Norwegian University of Science and Technology
OECD	Organisation for Economic Co-operation and Development
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PT	Production transfer
QA	Quality assurance
R&D	Research and development
RCA	Root cause analysis
RQ	Research question
SPC	Statistical process control
TQM	Total Quality Management

Table of Contents

PART I. Main Report

1. Introduction

Companies transfer production activities when they implement production relocation strategies, such as offshoring and outsourcing. The relocation of production activities is a common phenomenon among production companies, which, in the pursuit of higher competitiveness, try to reap the benefits that different locations and suppliers provide (e.g. De Backer et al., 2016, Fredriksson and Jonsson, 2019). A study of 847 companies with over 50 employees from Sweden, Denmark and Finland shows that 48% of the surveyed production companies had relocated production during the five preceding years (Heikkilä et al., 2017). For instance, companies offshore production to suppliers in low-cost countries to reduce their production costs and outsource production to external suppliers in order to access certain production technologies that these suppliers possess (Mykhaylenko et al., 2015). In addition, production relocations can be motivated by the possibility of aggregating demand at suppliers, thereby achieving economies of scale, as well as by the possibility of releasing labour capacity by relocating non-core activities to other production sites (Beckman and Rosenfield, 2008). In the future, both the survey of Nordic companies (Heikkilä et al., 2017), OECD and EU studies (Dachs et al., 2019, ManuFuture-EU, 2019, De Backer and Flaig, 2017) estimate that companies will continue to conduct production relocations of different types. However, the relocation reasons are expected to differ. For instance, although production costs in traditionally low-cost countries like China and India are rapidly rising, companies will offshore production to these countries due to the size and growth of their customer markets (De Backer et al., 2016). Moreover, companies are expected to relocate production in the future due to the increasingly shifting global environment regarding access to advanced technology, skills, markets and low production cost, in light of the digital transformation trend and growing environmental requirements (Dachs et al., 2019, ManuFuture-EU, 2019, De Backer and Flaig, 2017, Heikkilä et al., 2017).

1.1. Production Transfer

Production transfer is the process of relocating production activities (e.g. the activities that are necessary for the manufacturing of a specific product or sub-assembly) between two production units, *sender* and *receiver* (Fredriksson and Wänström, 2014). The receiver can, for instance, belong to a wholly owned supplier from a foreign and often low-cost country (*production offshoring*) or to an external supplier (*production outsourcing*). Furthermore, the *production transfer process* consists of a series of actions taken in order to transfer the equipment, inventories, documentation, administrative systems, knowledge and the subsuppliers that are needed to perform the relocated production activities (Fredriksson and Wänström, 2014). Figure 1 depicts the main phases of a production relocation process. The production transfer typically encompasses three main phases: (i) the *preparation*, (ii) *execution* and (iii) the *start-up* of production at the receiver's production site (Madsen, 2009, Fredriksson and Wänström, 2014). The execution phase consists primarily of a *physical transfer* of equipment and inventory from the sender to the receiver (Madsen, 2009). A production transfer process is considered efficient if the receiver achieves a full-scale and stable

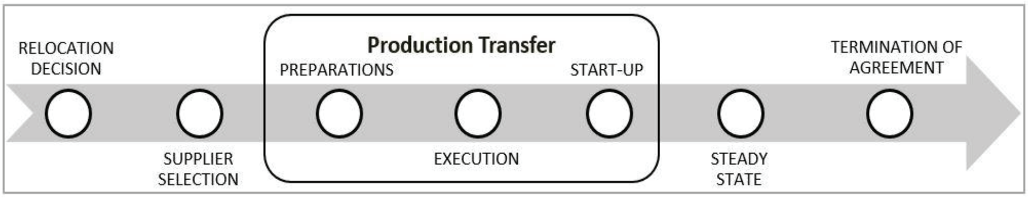

Figure 1: The production-relocation process (adapted from Fredriksson and Wänström [2014] and Madsen [2009])

production output (*steady state*) according to schedule and at the targeted performance levels (Terwiesch et al., 2001, Almgren, 1999). In line with Fredriksson (2011), supply performance measures are typically related to: (i) *cost* (e.g. to the cost of tied-up capital, transportation, administration and damage), (iii) *quality* (e.g. percentage of nonconformances per unit, scrap level and level of customer complaints), (iv) *reliability* (e.g. on-time delivery, schedule adherence, order fulfilment, mean time between failures and delay complaints), (ii) *time* (e.g. lead time and purchase order cycle time) and (v) *flexibility* (e.g. delivery flexibility).

Furthermore, production transfers are usually preceded by processes such as the decision to relocate production or not, the selection of appropriate production activities for relocation and the selection of appropriate locations and suppliers (Momme and Hvolby, 2002). Moreover, a production transfer is also a constitutive part of the process of relocating earlier offshored production activities to the home country or a neighbouring country (*production reshoring*), and of the process of relocating and reintegrating earlier outsourced production-activities from a supplier into the in-house production of a buyer (*insourcing*) (Stentoft et al., 2015, Heikkilä et al., 2017).

When companies transfer production from the sender's production environment to the receiver's, a series of new risk sources are introduced, which can affect companies' ability to achieve their pursued relocation goals. The existing literature reports on several failed production relocations, which for instance led to suboptimal product quality, significant cost overruns and even factory close down (e.g., Kinkel and Maloca, 2009, Fratocchi et al., 2014, De Backer et al., 2016). Moreover, in recent years, a considerable number of companies reshored production. The survey of Nordic companies showed that 38% of those companies that had conducted production relocations had also engaged in reshoring and insourcing. The results from an extensive survey in which 3500 European production companies participated indicate that the most frequent reasons for reshoring to home countries were the poor quality of goods produced at the receivers, the loss of flexibility to respond quickly to demand changes and unexpected events, and excessive transportation costs (Dachs and Zanker, 2015). A study of 476 cases of reshoring to Europe and the USA shows that the decreasing labour cost gap between emerging and developed countries and the negative effects on companies' reputations are also among the reshoring reasons that companies identify (Fratocchi et al., 2014). Furthermore, an analysis of 39 German companies that had reshored production back to Germany highlights that on average, production start-up times at the receivers were ultimately 2.5 times longer than originally planned (Kinkel and Maloca, 2009). The period between start-up and steady state ranged in almost all cases between two and three years. Consequently, the extended start-up times entailed higher costs of coordination, support and quality assurance (QA) than planned, which represented approximately 10% of the total costs. However, the offshoring/outsourcing literature has so far focused on the decision-making processes before the production transfer, that is, whether to relocate or not, and how to select the most suitable production activities for relocation and the right supplier. Nevertheless, the success of a relocation also depends on how well the production transfer is planned and conducted (e.g. Aaboen and Fredriksson, 2016). To facilitate smoother production relocations, the gap between decision-making and implementation should be reduced (Slepniov and Waehrens, 2008). Moreover, because of the increased risk level in the supply chain, the production transfer process should be conducted based on risk management principles (Malm, 2013, Fredriksson et al., 2015, e.g., WHO, 2011, Cheng et al., 2010), and each production transfer action should be carefully identified, planned and monitored (Terwiesch et al., 2001). In this thesis, I discuss how production transfers should be conducted in order to mitigate the transfer risk and facilitate efficient transfer processes.

1.2. Research Motivation

At the beginning of the PhD research, I got involved in a three-year research project, a collaboration between two major Norwegian electronics producers (hereafter named *Sender.Co* and *Receiver.NO*) at the Norwegian University of Science and Technology (NTNU) and Norway's largest research institute, SINTEF. The electronics producers are two of the case companies in this research. I visited their plants and participated in workshops with managers, purchasers, engineers and operators from both companies. We studied two production outsourcing projects between the two companies, one of them retrospective and one ongoing. Although the two electronics producers had transferred production between them and to/from other actors several times before, I observed that they were encountering a series of challenges during the ongoing transfer, which led to high scrap and inventory levels and to an excessively long production start-up. The findings from these two transfer studies suggested that several of the challenges experienced by the two companies could have been avoided or more easily dealt with if the companies had planned the transfers more thoroughly and had conducted risk management activities with the personnel in the early phases of the transfers. For instance, Sender.Co asked Receiver.NO to secure costly material from sub-suppliers without any formal agreement between them having been signed. Later, Sender.Co decided to upgrade the product selected for transfer. Sender.Co conducted the product development activities, whereas Receiver.NO developed the assembly procedure for the new product version. After Receiver.NO had purchased the material, Sender.Co sent several engineering changes. Thus, a significant amount of the purchased material became obsolete and the financial responsibility for this loss remained unclear for a long time. However, even though the need for a production transfer procedure was clear, the personnel pointed out that they were unaware of any established transfer procedure that they could apply. Subchapter 4.1.1 and Paper 1 include further details about these empirical findings.

During these first two transfer studies, several questions arose in my mind: 'Are other companies also experiencing similar challenges?', 'What are the most common risk sources during production transfers?', 'Have scholars or practitioners published any production transfer procedure?', 'If so, do these procedures address the risk management during production transfers?' and 'How should production transfers be conducted according to the academic literature, and what are the success factors that are highlighted?'. I decided to address two major questions: 'What are the potential risk sources when transferring production?' and 'What are the facilitators of efficient production transfers?'. A *facilitator* is a person or thing that makes an action or process easy or easier (Oxford Dictionary, 2020c). To study these topics, I reviewed the existing academic and non-academic publications and discovered that this topic was receiving increasing attention from both researchers and industry. However, I was surprised to only find a few scattered publications about the production transfer process.

Although many frameworks and procedures for production relocation exist (e.g., Moses, 2009, Zeng, 2003, Momme and Hvolby, 2002, Cánez et al., 2000, McIvor, 2000, Platts et al., 2002, Probert, 1996, Franceschini et al., 2003), most of these frameworks and procedures end before the physical transfer of equipment and inventory (also shown by Fredriksson [2011]). A (production transfer) *framework* is any kind of basic structure that supports the production transfer process, whereas a (production transfer) *procedure* is a framework consisting of a series of specific production transfer phases and actions that are conducted in a certain order or manner (based on Fredriksson, 2011). In a broad sense, an *action* can be defined as the act of doing something in order to achieve an aim (Oxford Dictionary, 2020b) (e.g. to temporarily transfer experienced production personnel from the sender to the receiver to facilitate the transfer of tacit knowledge). Production relocation procedures and frameworks addressing the production transfer process either provide a rather vague overview of transfer actions (e.g., Madsen, 2009, Zeng, 2003, Momme and Hvolby, 2002), or they only focus on certain parts of the production transfer process (e.g. the physical transfer in Kowalski et al. [2018] or the planning and control of the material supply in Fredriksson et al. [2015]). Furthermore, these publications do not explain how the transfer risk should be managed throughout the production transfer process. There is a need to increase the knowledge about production transfer management, and in particular, about the systematic actions (including risk management actions) that are important for efficient production transfer processes.

1.3. Research Purpose and Questions

Thus, the overall purpose of my PhD research has been to investigate how production transfer processes can be conducted in order to mitigate the transfer risk. The theoretical foundation is positioned within the field of operations management of multisite production networks. The final goal of the research has been to develop a procedure for efficient production transfer processes, based on risk management principles. I have addressed the following research questions:

1. What are the potential risk sources when transferring production?
2. What are the facilitators of efficient production transfers?
3. What are the main actions in a production transfer procedure that aids transfer risk mitigation?

Table 1 presents the relation between the research questions and the appended papers. The table also summarises the main phases of the PhD research, and the research methods related to each paper (further details in Chapter 3).

*Table 1: The relation between the research questions, the papers included in the dissertation and the research design (*Papers 1, 2, 3, 4 and 6 address the whole production transfer process, while Paper 5 only addresses the preparation phase)*

Purpose	To investigate how production transfer processes can be conducted in order to mitigate the transfer risk, and to develop a procedure for efficient production transfer processes.					
Research question	**RQ 1:** What are the potential risk sources when transferring production?		**RQ 2:** What are the facilitators of efficient production transfers?		**RQ 3:** What are the main actions in a production transfer procedure that aids transfer risk mitigation?	
Papers	**#1:** *Transfer of production to strategic suppliers — a case study*	**#2:** *A production transfer risk assessment framework*	**#3:** *Prerequisites for successful production transfers*	**#4:** *Investigating relationships between production transfer management and transfer success*	**#5***: A transfer procedure based on risk management principles	**#6:** *A structured outsourcing procedure*
Method	Multiple case study	Systematic literature review, in-depth case study	Systematic literature review, multiple case study	Longitudinal field study	Action research, multiple case study	Multiple case study
Research phase	**Phase 1:** Field-problem framing		**Phase 2:** Transfer-procedure incubation		**Phase 3 & 4:** Transfer-procedure refinement & development of substantive theory	

1.4. Research Scope

The theoretical foundation for my PhD research is positioned within operations management, that is, the discipline concerned with an efficient planning, scheduling and control of the activities involved in managing the resources (e.g. equipment, people and knowledge) that are dedicated to the production and delivery of goods and services (Slack et al., 2010). When companies configure their multisite production networks, they can relocate production activities within the network. This research addresses the process of implementing production relocation strategies such as offshoring and outsourcing, that is, the production transfer process, as well as the risk management during this process. During production transfers, the *operations* are jointly *managed* by the sender and the receiver, with a decreasing involvement of the sender as the receiver approaches the production steady state. Examples of resources that are managed during a production transfer include the production equipment, inventory, production knowledge, administrative systems and the sub-suppliers that are necessary for the transferred production activities, as well as the personnel that might be temporarily transferred to the receiver or sender. As a production transfer is part of a project (a production relocation project), that is, a one-time undertaking that is finished after a period of time and planned to achieve a specific purpose (Cambridge Dictionary, 2020a), key project management principles and methods were addressed. However, the final goal of the research has been to develop a production transfer procedure (see previous subchapter). Thus, the main focus of this research has been the field of operations management of multi-site production networks, as it provided findings about specific production transfer actions that can facilitate an undisrupted supply of goods to customers along the transfer process.

The focus of the PhD research is the production transfer process within the dyad composed of a sender and a receiver. The research addressed both transfers to suppliers that are wholly owned by the sender and transfers to external suppliers and focused on both production off-shoring and outsourcing cases. Moreover, the research addressed the activities related to the physical transfer of equipment and inventory, the knowledge, administrative and supply chain transfer, the management of the transfer organisation and the project and quality management. Finally, the PhD research paid particular attention to the transfer risk management process, centring on the risk identification and mitigation during this process (i.e. on negative risk).

2. Theoretical Background

This chapter presents the theoretical background for this PhD research and the theoretical framework that guided the selection and analysis of relevant literature.

The production transfer process is an inherent part of production relocation strategies, such as offshoring and outsourcing. During outsourcing processes, companies transfer production to external suppliers (Awasthi et al., 2018). The decision whether to outsource certain production activities or continue to dedicate resources to them in-house is taken during the early phase of a relocation process—the Relocation Decision phase in Figure 1 (Chapter 1). During offshoring processes, companies transfer production to internally owned suppliers. This may occur when companies establish a new facility (and transfer production from an older facility to the new one), close a facility (and transfer production from the closed facility to a new facility), or when they relocate volumes and product portfolios within their existing production networks (Loertscher and Riordan, 2019). The site where the relocated production activities will be conducted will depend on factors such as the proximity to raw materials, access to novel technology, access to skilled employees and access to low cost (Grant and Gregory, 1997). Thus, the selection of the production locations and suppliers (during the Supplier Selection phase in Figure 1), as well as the eventual configuration of a multisite production network, will be influenced by the access to production resources and their management (Rudberg and Olhager, 2003, Barney, 1991). During the production transfer phase, part of the sender's resources devoted to the relocated production activities (e.g. equipment, knowledge and people) will be transferred to the receiver. During this phase, the resources dedicated to the relocated production activities are jointly managed by the sender and the receiver, with decreasing involvement of the sender as the receiver approaches the production steady state. Thus, both the production transfer and the other production relocation phases will depend on the way the resources that are required for the manufacturing of the products/parts in question are managed—locally and at a multisite production network level. Production relocation is a topic within the operations management of multisite production networks (Rudberg and Olhager, 2003).

Furthermore, when companies transfer production from the sender's production environment to the receiver's, a series of new risk sources are introduced, which can negatively impact the resources required for the relocated products/parts, and the supply of those products/parts to customers along the transfer process. Thus, an efficient multisite operations management will also require an efficient risk management when production is transferred from one site to another.

Finally, even though production relocation studies often do not explicitly state the underlying theories used (Mihalache and Mihalache, 2016), a rich tapestry of multidisciplinary theoretical and conceptual foundations has influenced the production relocation and transfer literature. As I will discuss the research results in light of relevant underlying theories (in Subchapter 5.1), these will be introduced in this chapter.

Thus, in the remainder of this chapter, I will provide further details about the following topics of relevance to the PhD research: types of production relocation strategies, the production relocation process, the production transfer process and risk management concepts and theoretical perspectives that are important for production transfers. I will conclude with the theoretical framework that guided the PhD research.

2.1. Types of Production Relocation Strategies

Although the academic literature shows disagreement over the exact terminology, I identified five main types of production relocations. In line with recent advancements in the production relocation literature, I adopted the following definitions of the relocation strategies:

i. *Production offshoring* is the relocation of production activities from a company's country to an external or internally owned supplier in another country (Heikkilä et al., 2017).
ii. *Production outsourcing* is the transfer of production activities from the ownership of one company to the ownership of an external supplier of the company (Heikkilä et al., 2017).
iii. *Production back-shoring* is the reshoring of the production activities that a company had previously offshored to the home country of the company (Heikkilä et al., 2017, Kinkel and Maloca, 2009).
iv. *Production near-shoring* is the reshoring of activities that a company had previously offshored to a neighbouring country of the company's home country (De Backer et al., 2016).
v. *Production insourcing* is the process of reintegrating earlier outsourced production-activities from a supplying company into the in-house production of the buying company (Stentoft et al., 2015, Heikkilä et al., 2017).

In conclusion, production outsourcing/insourcing decisions affect the ownership (vertical integration) of production activities, while production offshoring/back-shoring/near-shoring strategies imply the geographical transfer of the production activities to another country (Heikkilä et al., 2017). This research focusses on production offshoring and outsourcing.

2.2. The Production Relocation Process

Although several procedures for production relocation exist (e.g., Moses, 2009, Zeng, 2003, Momme and Hvolby, 2002, Cánez et al., 2000, McIvor, 2000, Platts et al., 2002, Probert, 1996), almost all of these procedures end before the production transfer process. Figure 2 illustrates the main phases of a production relocation process.

Existing production relocation procedures addressing the production transfer process (often outsourcing procedures) provide a rather vague overview of production transfer activities. Moreover, in a similar way as for the classification of production relocations, the academic literature shows a certain disagreement over the main phases of a relocation process or uses different terms for the same phenomenon. Two illustrative examples for production relocation procedures that address the production transfer process are found in Momme and Hvolby (2002) and in Zeng (2003).

Momme and Hvolby's (2002) outsourcing procedure addresses the production transfer

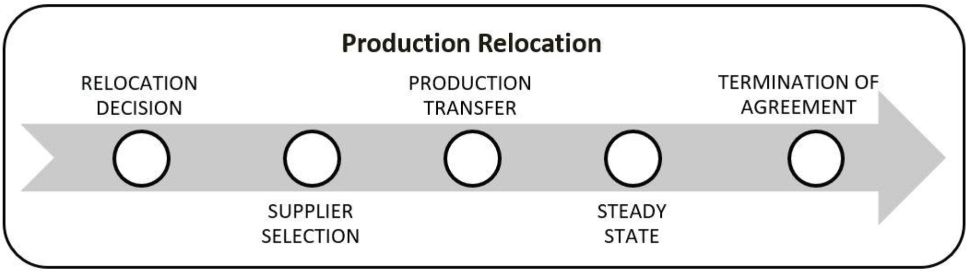

Figure 2: The main phases of the production relocation process (adapted from Fredriksson and Wänström [2014] and Madsen [2009])

process under the procedure phase 'project execution and transfer'. The authors provide three examples of production transfer-specific activities, that is, establishing the basis for supplier integration, defining workflow interfaces, and adapting the organisation to supplier performance. However, those activities are not further described in the paper. Moreover, the procedure is not based on the perspective of both transfer parties, only on the sender's perspective.

Zeng's (2003) outsourcing procedure addresses the production transfer as 'implementation'. During this phase, Zeng (2002) recommends the implementation of a performance analysis program that can include activities such as establishing an implementation team, preparing and publishing an implementation strategy and schedule, preparing and publishing the expected results, developing agreements on supply and logistics terms and developing agreements on shared resources.

Interestingly, although both Momme and Hvolby (2002) and Zeng (2003) claim that the outsourcing implementation process is the focus of their studies, neither describes production transfer-specific activities, such as the physical transfer of production equipment and inventory or the transfer of administrative systems (e.g. ERP).

Furthermore, in the abovementioned relocation procedures, Momme and Hvolby (2002) and Zeng (2003) structure the relocation process rather differently, and sometimes use different terms for similar phenomena. Based on a systematic literature review on outsourcing, Busi and McIvor (Busi and McIvor, 2008) recommend that one simple way of structuring the outsourcing process is to look at it from the point of view of the key research questions that were addressed in the literature (also in Weimer and Seuring, 2008). Along the same line, Fredriksson's (2011) literature review reveals that outsourcing processes mainly focus on what to outsource, whom to outsource to, how to outsource, how to manage the relationship with the receiver and how to terminate the outsourcing contract. Based on these earlier research publications, the relocation process in my PhD research is divided into the following general phases:

1. *Relocation decision* (Why should a company relocate, and what should be relocated?)
2. *Receiver selection* (To what location should the production be relocated, and to what external/internal supplier?)

3. *Production transfer* (How should the production relocation decision be implemented?)—the focus of this PhD research
4. *Steady state*
5. *Termination of agreement*

2.3. The Production Transfer Process

The previous subsection indicated that the production transfer is an inherent part of both outsourcing and offshoring processes. However, the production transfer process is not always the same. For instance, all (e.g. an entire factory), some (e.g. a production line) or none of the equipment may be physically transferred from the sender to the receiver. If the production transfer implies a transfer of equipment, the production rate will be reduced from the beginning of the phase out, at the sender, until the steady state is reached at the receiver, and, in many cases, there is no production output at all during a certain period (Fredriksson et al., 2015). Two additional types of production transfer are the transfers with a steep start-up or with a stepwise start-up (Madsen, 2009, Terwiesch et al., 2001, Fredriksson et al., 2015). The extreme version of a production transfer with a steep start-up is a 'clear cut' production transfer, where the start-up of production at the receiver coincides with the production stop at the sender. Conversely, during a stepwise start-up, the production at the sender is gradually decreased until the receiver achieves the intended production output and the steady state (Fredriksson et al., 2015).

Furthermore, according to Madsen (2009), the production transfer can be divided into seven phases: (i) preparation, (ii) initial training and education, (iii) physical transfer of equipment, (iv) production testing, (v) production with moderate output, (vi) improvement of production and (vii) production development, continuous improvement and innovation. Madsen (2009) also describes activities that should be performed during each of these phases. However, these activities focus on the knowledge transfer between the operators, and (to a lesser extent) on the physical transfer of equipment. As Chapter 1 explains, apart from the transfer of knowledge and equipment, the production transfer process includes the transfer of administrative systems, inventories and the transfer of subsuppliers that are necessary to perform the relocated production activities (Fredriksson and Wänström, 2014). Moreover, Madsen (2009) does not address the risk management process.

Madsen's (2009) research shows that even though in reality, the production transfer phases are not perfectly sequential (the transfer phases can overlap and/or they can be merged together), breaking down the production transfer into sequential phases is useful as the managers can allocate objectives, actions and methods to each phase. This thereby fosters a common understanding among the transfer personnel about how to systematically carry out the production transfer. Thus, the production transfer process can be roughly divided into three major phases: i) the process before the physical transfer, when an increase in output and workload is expected, ii) the physical transfer of equipment and iii) the start-up at the receiver, characterised by fluctuations in the production volume and performance until the intended output is achieved. This is also in line with Fredriksson and Wänström (2014), who divide the production transfer into: i) preparation, ii) physical transfer and iii) production start-up at the receiver. This PhD research continued in the same vein, but replacing 'physical transfer' with 'transfer execution'. The literature and empirical findings have shown that apart from the physical transfer of equipment and inventory, this phase includes an administrative transfer (e.g. of ICT systems) and knowledge transfer.

In addition to the knowledge transfer and the physical transfer of equipment (as in Madsen, 2009), this PhD research addresses the activities related to the administrative transfer, supply chain transfer, management of the transfer organisation, project management and quality management. Moreover, this research pays particular attention to transfer risk management. Finally, the PhD research addresses all the production transfer types that were presented in the beginning of this subchapter.

2.4. Theories that Are Relevant for Production Transfer

Theories with particular relevance for the production transfer process include the transaction cost economics, agency theory, resource-based view, knowledge based-view, task interdependence theory, eclectic theory and the organisational learning theory (Mihalache and Mihalache, 2016, Tsay et al., 2018).

According to the *transaction cost economics theory* (Williamson, 1975, Coase, 1991), conducting transactions entails a wide range of costs that should be carefully addressed (e.g. during the make-or-buy decision), and these costs depend on how the transaction is organised (e.g. within a market or a firm) (Rindfleisch, 2019). Activities generating transaction costs include searching for and selecting a business partner, negotiating on price and other terms, writing contracts, monitoring and enforcing contractual compliance and renegotiating contracts (Tsay et al., 2018). Transactions can be governed on a continuum from market (i.e. arms-length) to hierarchy (i.e. in-house production) (Williamson, 1975). Transactions that are frequent and characterised by higher transaction-specific investments require a close relationship with the business partners, such as in buyer-supplier partnerships, joint ventures or in-house production (ibid.). In line with this theory, the production transfer literature highlights the importance of a close relationship between the transfer-parties (Fredriksson et al., 2014, Terwiesch et al., 2001), and encourages a long-term commitment and investments in receiver development (Modi and Mabert, 2007, Bocquet, 2011). Moreover, the importance of signing a formal agreement that includes specifications about expected performance targets is widely emphasised (e.g., Danilovic and Winroth, 2005, Zhu et al., 2001, Franceschini et al., 2003). Furthermore, this theory sheds light on two of the major risk sources that may affect transactions, that is, the decision makers' opportunism and the information asymmetry between the transaction parties, which means that either party may have more knowledge than the other about the transactions (McIvor, 2009, Williamson, 1975). These topics are central in the *agency theory*, which emphasises that the interests of a principal and an agent can be misaligned (Mihalache and Mihalache, 2016, Eisenhardt, 1989a), which may for instance lead to poor product quality and lost brand reputation. Risk mitigation actions that the agency theory recommends include monitoring the agents' behaviour through facility audits (Handley and Gray, 2013, Eisenhardt, 1989a). Similarly, the production transfer literature recommends a continuous monitoring of the start-up progress, customer demand, safety stock level (Fredriksson et al., 2015) and supply performance indicators (Gero and Stefan, 2009, Madsen, 2009). Moreover, the sender should conduct audits both (i) at the beginning of the production transfer, to evaluate the receiver's readiness for transfer (Modi & Mabert, 2007; WHO, 2011), (ii) prior to the production start-up, to verify the knowledge transfer and (iii) at the end of the transfer (Hilletofth et al., 2015, Zhu et al., 2001), to validate the production at the receiver.

Based on the *resource-based view theory*, production activities that are valuable, rare, inimitable and non-substitutable, hence acting as barriers against competitors ('core competencies'), should be conducted in-house (Penrose, 1959, Barney, 1991, Hamel and Prahalad, 1994). Nonetheless, when interorganisational collaboration enables access to, and the development of, complementary resources that contribute to competitive advantage, outsourcing of core activities might be encouraged (McIvor, 2009). However, as in the case of transaction cost economics, the more attractive the resources that the sender outsources, the closer the collaboration with the receiver should be (Fredriksson, 2011). Furthermore, this theory has given rise to the *knowledge-based view* (Grant, 1996a, Grant, 1996b, Kogut and Zander, 1992), which focuses on how easy it is to develop and share knowledge within and between companies (particularly tacit knowledge). When a transaction depends on the exchange of a significant amount of tacit knowledge, this view does not recommend outsourcing the activity to another company (Tsay et al., 2018). Theories with relevance for the knowledge transfer also include the *task interdependence theory* (e.g., Thompson, 1967, Van de Ven et al., 1976, Kumar et al., 2009). Based on this theory, the greater the interdependence between tasks, the greater the expenditure required to transfer the task information (e.g. because of the significant communication and coordination effort) and the greater the chance of defects, especially when tasks are distributed globally (Kumar et al., 2009). Task tacitness, complexity, security, ambiguity, size and stickiness are positively related to the level of sender-receiver integration (Mihalache and Mihalache, 2016, Monostori et al., 2016). Moreover, the task stickiness depends on the characteristics of the sender (e.g. sender's disseminative capacity (Malm et al., 2016)), the receiver (e.g. receiver's absorptive capacity (ibid.)), the organisational context of the information transfer, and the information itself (Argote et al., 2003, Von Hippel, 1994). To reduce the task stickiness, companies can invest in, for example, modularisation, human interfaces (e.g. client representatives offshore and employee exchange), technological interfaces (e.g. collaborative work technologies) and in virtually immersing the receiver in the sender's context (Kumar et al., 2009). In line with these theories, the production relocation literature highlights risk sources such as the difficulty to codify the tacit knowledge about the transfer object (Tatikonda and Stock, 2003, Grant and Gregory, 1997), a low degree of internal and external modularity (e.g. the transfer object is entangled in a larger system), high BOM complexity (Tatikonda and Stock, 2003, Beckman and Rosenfield, 2008) and long physical distance between related processes (e.g. the development and manufacturing units) after the transfer execution (Fredriksson et al., 2014, Terwiesch et al., 2001). Coping mechanisms include (i) codifying and documenting the tacit knowledge, (ii) a joint review and update of the transfer documentation and the planning and control systems by the transfer parties (McBeath and Ball, 2012, Terwiesch et al., 2001, Fredriksson et al., 2015), (iii) using a common software for managing information flows (Malm, 2013, Terwiesch et al., 2001) and (iv) temporarily transferring personnel across sites for learning-by-doing and other knowledge transfer activities (McBeath and Ball, 2012, Grant and Gregory, 1997, Terwiesch et al., 2001, Galbraith and Galbraith, 1990, Madsen, 2009). Moreover, novel, complex, and/or tacit transfer objects require tight communication, collaboration and coordination between the sender and receiver (Stock and Tatikonda, 2000, McCormack et al., 2008, Vitasek and Manrodt, 2012).

Based on the *eclectic theory*, when companies decide on conducting production activities internationally (or other direct foreign investments), they need to assess three distinct but interrelated sets of variables: ownership-specific advantages (e.g. the company will gain competitive advantages by offshoring), location-specific advantages (e.g. the availability and cost of resources in the selected location are better than in other locations) and internalisation-specific advantages (e.g. it is more advantageous to conduct the production activities in-house than to outsource them) (Dunning, 1979, Mukherjee et al., 2019). A company that decides to engage in a specific offshoring should benefit from these three advantages. In line with this, the production relocation literature highlights certain variables that can influence both the selection of a receiver in a specific location and the subsequent transfer process and production steady state. Examples include the quality, cost, flexibility, service level, reliability and proximity of local and international subsuppliers, the emission regulations at the receiver's location, labour law, import duties and the employee turnover rate (Grant and Gregory, 1997, Chopra and Meindl, 2013).

Lastly, the theories that are relevant for production transfers also include the *organisational learning theory* (Mihalache and Mihalache, 2016). This contends that companies can learn from their own experience and from others' (e.g. Levitt and March, 1988). In consonance with this, the transfer literature shows that the level of experience that the sender and receiver have with transferring production between them significantly influences the risk level during the transfer (Tatikonda and Stock, 2003, Fredriksson et al., 2014). Moreover, the transfer literature emphasises that it is important to document the transfer process, including deviations, actions and lessons learned, so that future transfers can capitalise on this knowledge (Zhu et al., 2001, WHO, 2011, Stock and Tatikonda, 2000). Thus, the contributions of this PhD research will be discussed in the light of the following relevant theories (see Subchapter 5.1): *transaction cost economics*, *agency theory*, *resource-based view*, *knowledge based-view*, *task interdependence theory*, *eclectic theory* and the *organisational learning theory*.

2.5. Risk Management Concepts Relevant for Production Transfer

As previously described (Chapter 1), because of the increased risk level during production transfers, it is important to dedicate resources to risk management. However, even though some of the production transfer studies (Fredriksson et al., 2015, Malm, 2013, WHO, 2011) acknowledge the importance of managing risk during production transfers, they do not provide clear guidelines for this. The *risk* can be defined as the effect of uncertainty on objectives, which can be negative and/or positive, and can address, create or result in threats and opportunities (ISO, 2018a). *Risk management* represents the coordinated activities to direct and control an organisation with regard to risk (ibid.). There are many types of risk management, for example, enterprise risk management, financial risk management, supply-chain risk management, project risk management, safety management, environmental risk management, security management and social risk management. In 2009 and 2018, the International Organization for Standardization published the ISO 31000 standard and its update, respectively, in order to 'harmonize risk management processes' (ISO, 2009a). ISO 31000 can be 'applicable to all organizations, regardless of type, size, activities and location, and covers all types of risk' (ISO, 2018b). Thus, in this research, the starting point for the description of the risk management process that is relevant for production transfers is the ISO 31000 standard in combination with academic publications on (supply chain) risk management. The supply chain risk management literature proved to provide detailed and useful findings about potential risk scenarios during production transfers. Note that this research focuses on the negative risk during production transfers that can lead to consequences such as suboptimal product quality, excessively long production start-ups, significant supply delays and cost overruns and even factory close down (e.g., Kinkel and Maloca, 2009, Fratocchi et al., 2014, De Backer et al., 2016), thus resulting in the inability to achieve the pursued relocation goals (see examples of goals in Chapter 1).

The (supply chain) risk management literature shows that a risk management process (for negative risk) can be structured into three main steps: (i) risk identification, (ii) risk assessment and (iii) risk mitigation (Kern et al., 2012, Bode and Wagner, 2009, Kleindorfer et al., 2005).

First, one should proactively identify potential disruptions, as well as the risk sources that may trigger these disruptions and their negative consequences (i.e. *losses*) (Rausand, 2013, McCormack et al., 2008, ISO, 2009b). In other words, one should address the question 'What can go wrong?' A *disruption* is an abnormal situation in comparison to everyday business that can lead to negative deviations from performance targets and result in significant losses for the affected companies (Rausand, 2013, McCormack et al., 2008). Examples of disruptions during production transfers include raw material shortages (Fredriksson et al., 2015), fires (Norrman and Jansson, 2004) and machine breakdowns (Almgren, 1999). *Risk sources* are tangible or intangible elements, which alone or in combination with other risk sources have the intrinsic potential to give rise to disruptions (Norrman and Jansson, 2004, ISO, 2018a). Examples of risk sources during production transfers are the transfer-parties' limited experience with production transfers, receivers' limited experience with the production activities, the complexity and novelty of the transferred production activities (Tatikonda and Stock, 2003), a large distance between the transfer-parties' sites (Terwiesch et al., 2001) and the reluctance of senders' personnel to the transfer (Fredriksson et al., 2014). For instance, a risk source such as the receiver's inexperience with the transferred production equipment may trigger machine breakdowns and subsequent capacity deviations. Furthermore, these breakdowns may eventually lead to significant losses, such as the receiver's inability to deliver on time (Chopra and Meindl, 2013, Fredriksson et al., 2015).

Second, the risk level should be estimated based on the likelihood of each potential disruption and an estimation of its negative impact on performance should it occur (during *risk assessment*) (Rausand, 2013, Kern et al., 2012). Risk assessment methods can be based on data (quantitative methods) if this is available, on expert judgment and scenarios (qualitative methods) or on both (semiquantitative methods) (Fan and Stevenson, 2018). Common quantitative/semiquantitative assessment methods include the Failure Mode and Effects Analysis (FMEA), the Analytical Hierarchy Process (AHP) and the Bayesian Belief Network (BBN). However, the method that researchers and practitioners apply most often is the likelihood-impact risk matrix (ibid.). This matrix can clearly display those disruptions with a risk level that is unacceptable for the companies (Rausand, 2013). It is a comprehensive yet rapid and cost-efficient assessment method (Fan and Stevenson, 2018, Zsidisin et al., 2004).

Third, actions aimed at mitigating the risk of those disruptions with an unacceptable risk level should be identified and implemented (*risk mitigation*) (Kern et al., 2012, Rausand, 2013). However, this should be only done after a cost-benefit analysis for the alternative risk-mitigation actions (Norrman and Jansson, 2004, Rausand, 2013). Risk mitigation strategies (with examples from the production relocation-literature) include (ISO, 2018a):

i) Avoiding the risk by deciding not to start or continue with the activity that triggers the risk (e.g. by not changing subsuppliers during start-up to avoid an increased risk of quality deviations (Aaboen and Fredriksson, 2016))

ii) Implementing *preventive actions* to reduce the likelihood of disruptions (e.g. by temporarily transferring experienced production personnel to the receiver to facilitate the transfer of tacit knowledge and prevent quality nonconformances (Fredriksson et al., 2015, Minshall, 1999))

iii) Implementing *corrective actions* to reduce the negative consequences caused by

disruptions that could not be avoided (by ensuring express deliveries to the customers in case of schedule disruptions (Fredriksson et al., 2015, Chopra and Sodhi, 2004))

iv) Accepting the risk by informed decision (e.g. by engaging in production relocations (e.g. Malm, 2013))

v) Sharing the risk (e.g. through an agreement that the sender shares the cost of obsolete material (Zhu et al., 2001), or with a business interruption insurance company (Zhen et al., 2016))

Finally, the risk level should be continuously monitored and the risk management process should be regularly reviewed in order to promptly identify deviations and implement risk-mitigating actions (Kern et al., 2012, McCormack et al., 2008, ISO, 2018a). The risk management process and its outcomes should be documented, and the relevant stakeholders should be informed and consulted about the risk management activities. Note that risk identification, assessment and mitigation are iterative processes (ibid.).

Figure 3 summarises the risk management process described above, highlighting the concepts that are relevant for production transfers. This PhD research focused mainly on the identification of (negative) risk sources and risk mitigation through preventive actions.

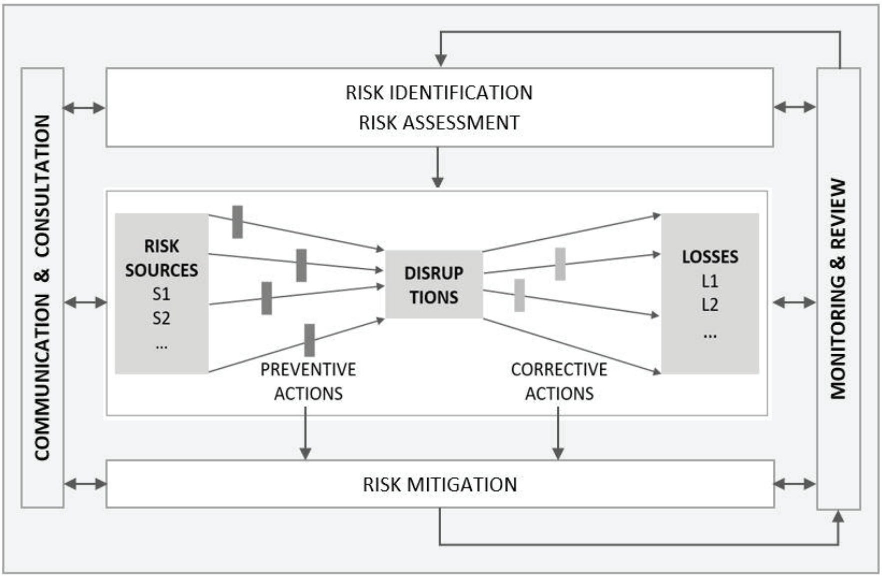

Figure 3: The risk management process during production transfers (based on Kern et al., 2012 and ISO, 2018a)

2.6. Theoretical Research Framework

This subchapter presents the theoretical framework that I developed after synthesising the theory presented above and that guided the research process. The framework is depicted in Figure 4, indicating how the research questions relate to central concepts from the theoretical study.

Based on the studies of Madsen (2009) and Fredriksson et al. (2015) presented in Subchapter 2.3, this PhD research divides the transfer process into three main phases: (i) *production transfer-preparation*, (ii) *production transfer-execution* and (iii) *production start-up* at the receiver's site. Moreover, this research is based on the risk management process depicted in Figure 3.

The first research question addresses the *transfer risk sources* that may trigger disruptions and losses during production transfers, while the second research question addresses facilitators of efficient transfers. The third question addresses the main actions in a production transfer procedure that aids transfer risk mitigation, and focused on a detailed transfer preparation procedure based on *preventive actions*. Preventive actions are typically more efficient than corrective actions at risk mitigation as preventive actions can hinder the occurrence of both disruptions and losses. However, this research also addresses the *corrective actions*, as well as potential *transfer disruptions* and *losses*.

This PhD research primarily centres around the *production transfer process*, (transfer) *risk dentification* and *risk mitigation*, and is based on *production offshoring* and *outsourcing cases.* The research addresses the transfer risk assessment and the cost-benefit analysis (see Subchapter 2.5) to a lesser extent.

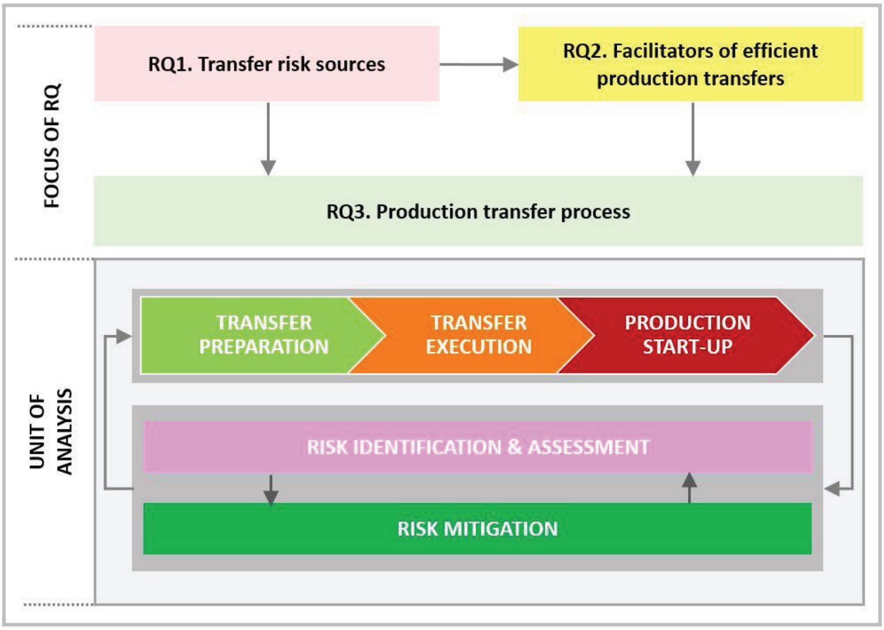

Figure 4: The theoretical research framework (RQ=research question)

3. Research Design

The selected research strategy should ensure a good fit between the studied problem, intended contributions and the research methods applied (Karlsson, 2009, p.23). As Chapter 1 shows, the theoretical and practical problem addressed through this research is the lack of established procedures for efficient production transfers and risk management during the transfers, and the main contributions of the project include the development of such a procedure. Therefore, I adopted the design science research strategy, as described by Holmström et al. (2009). This strategy is recommended both for the development of 'artefacts' with enhanced practical relevance (such as procedures), and for the development of theory (e.g., Holmström et al., 2009, Van Aken and Romme, 2009).

Table 2 presents the four phases of the research process (*field-problem framing*, *procedure incubation*, *procedure refinement* and *substantive theory-development*), their relation to the research questions, as well as research methods, data collection approaches, and main research outcomes. The first phase is inspired by Van Aken and Romme's (2009) recommendations about design science research and its purpose is to define and frame the field problem. The last three phases are based on the recommendations of Holmström et al. (2009). As design science is a multi-method strategy, the PhD research combined systematic literature reviews, eight production transfer studies (one of them longitudinal), and action research. Note that *production transfer (study)* and *case (study)* are used synonymously in this dissertation.

Table 2 shows that the first research question ('What are the potential risk sources when transferring production?') emerged during the Field-problem framing phase, when two exploratory production transfer studies were conducted with the aim of gaining an in-depth understanding of the production transfer phenomenon (Yin, 2004) and more specifically, of potential challenges during this process (see Paper 1). As introduced in Chapter 1, the cases were two transfers of electronics production from Sender.Co to Receiver.NO. Thereafter, I specifically addressed the first research question through a systematic literature review of potential risk sources and a longitudinal field study of a transfer of electronics production from Sender.Co to Receiver.ES (see Paper 2). The second research question ('What are the facilitators of efficient production transfers?') was addressed during the procedure incubation phase through a systematic literature review, two production transfer studies (the same as in Paper 1) and a longitudinal filed study (the same as in Paper 2). First, I developed a framework of facilitators of efficient production transfers, based on the literature review. Thereafter, I applied the framework to the two production transfers that I studied, showing how the framework could have guided the management of these transfers (see Paper 3). Paper 4 provides a set of lessons learned about efficient transfer (risk) management—that is, potential facilitators of efficient transfers—based on the longitudinal field study. The third research question ('What are the main actions in a production transfer procedure that aids transfer risk mitigation?') was addressed during the Procedure refinement and

Table 2: Research design

Research question	Phase & objective	Method	Data collection	Main outcome	Paper
RQ1: What are the potential risk sources when transferring production? *(Papers 1 & 2)*	Phase 1: Field problem framing (exploratory research)	Multiple case study	Qualitative data collected through semi-structured interviews (during multi-disciplinary workshops with both transfer parties), from company documents, and by taking field notes during tours of both transfer parties' sites. Two production transfers were studied (outsourcing)	Possible challenges during production transfers and preliminary facilitators of efficient production transfers	**#1 (2015)**
		Literature study	Key production transfer concepts and typical challenges during this process	A literature gap is identified: a lack of established frameworks for how to efficiently conduct production transfers in the electronics industry	
		Systematic literature review	Potential risk sources from the operations management and risk management literature; risk management definitions from the risk management literature	A framework of risk sources based on the literature, and the following literature gap: a lack of a holistic overview of how to systematically conduct the production transfer process and risk management during this process from the beginning to the end	**#2 (2017)**
		In-depth case study	Rich qualitative and quantitative data collected from both transfer-parties through participant observation, studies of company documents, semi-structured interviews, and informal conversations. The data was collected during an ongoing production transfer (offshoring) and during a period of 12 months		
RQ2: What are the facilitators of efficient production transfers? *(Papers 3 & 4)*	Phase 2: Transfer procedure incubation (exploratory research)	Systematic literature review	Potential facilitators of efficient production transfers from the operations management literature; risk-mitigation actions and risk management definitions, methods and tools from the risk management literature	A framework of facilitators of efficient production transfers based on the literature	**#3 (2016)**
		Multiple case study	Same as for Paper 1. In addition, 1 follow-up workshop with only the sender's representatives		
		Literature study	Disruptions, corrective actions, and losses from the production transfer and risk management literature	A set of lessons learned about production transfer (risk) management; potential facilitators of efficient transfer processes	**#4 (2017 – 2020)**
		Longitudinal field study	Qualitative and quantitative data collected at both transfer parties through participant observation, studies of company documents, semi-structured interviews and informal conversations. The data was collected during an ongoing production transfer (same as in Papers 2 and 5) and during		

Research question	Phase & objective	Method	Data collection	Main outcome	Paper
			a period of 26 months. Moreover, the data collected during the action research from Paper 5 and data about two additional production transfers between the transfer parties also informed this study		
RQ3: What are the main actions in a production transfer procedure that aids transfer risk mitigation? *(Papers 5 & 6)*	Phase 3: Transfer procedure refinement (exploratory research)	Systematic literature review	Same as for Paper 3. In addition, I studied seminal Risk Management publications to define the meaning of risk management during production transfers	A procedure for the preparation phase of production transfers, based on risk management principles	**#5 (2017 – 2018)**
		Action research	Data about intended/unintended consequences of the implementation of the transfer procedure. I refined the procedure by implementing it during the transfer from Paper 2, and iteratively evaluating and refining it during 19 workshops with both transfer parties (7 iterations)		
		Multiple case study	I collected quantitative and qualitative data during an international workshop. With the help of a questionnaire, transfer practitioners applied the procedure to 3 production transfer examples with which they had broad experience, and validated it. The transfers were from distinct industries and the practitioners presented them prior to the survey		
	Phase 4: Development of substantive theory (explanatory research)	Theoretical discussion	NA	Propositions about efficient transfer (risk) management (both Papers 4 and 5); new types of preventive actions that are important for efficient transfers, and the relation between them; reflections about the theoretical utility of the transfer-preparation procedure beyond the context of the transfer during which it was implemented and validated	
		Literature study	Outsourcing frameworks collected from the operations management literature	Presents how the framework from Paper 3 (preliminary production transfer procedure) can be integrated into one of the possible relocation processes, the production outsourcing	**#6 (2016)**
		Multiple case study	Same as for Paper 1		

Substantive theory-development phases, through action research in Paper 5 and through the multiple case study in Paper 6.

Paper 5 presents how the framework of facilitators of efficient production transfers was implemented during the electronics transfer from Sender.Co to Receiver.ES and was iteratively evaluated and refined together with both transfer parties. To this end, I conducted 19 workshops and 7 refinement iterations. Subsequently, the framework was synthesised into a transfer preparation procedure based on risk management principles. In evaluating the research quality of design science studies, criteria such as the validity (the artefact works and does what is meant to do) and utility (it has value outside the development environment) of the developed artefact are highlighted (Gregor and Hevner, 2013). Thus, Paper 5 also presents how at the end of the Procedure refinement phase, I interviewed key-informants from both transfer parties about the utility of the procedure and its implementation by help of an action plan (further details in Subchapter 3.3.1). Furthermore, Paper 5 outlines how during the substantive theory development phase, the utility of the transfer procedure was validated beyond the context of the electronics industry. Thus, at an international workshop that I organised, three practitioners outside the main case company validated the procedure on production transfers with which they had worked, from the food, maritime technology and aircraft industries. Moreover, according to Holmström (2009), the success of a design science approach hinges on its ability to integrate itself with the theory-oriented mainstream research. The research findings were systematically compared with the earlier research on the topic of production transfer, and significant similarities and differences were highlighted. In addition, the co-authors and I paid attention to describing the research process and results in a detailed manner, in order to support researchers and practitioners that want to (further) validate or use (Holmström in Kaipia et al., 2017) the transfer preparation procedure in Paper 5. Moreover, apart from the transfer during which the procedure was implemented, the sender had conducted 19 other production transfers. Thus, on numerous occasions, the informants compared happenings during the in-depth study with other production transfers with which they had worked and provided rich and interesting empirical evidence.

The production transfer that was studied in Paper 5 is the same as in Papers 2 and 4. However, both Papers 5 and 4 are based on 26 months of empirical data, from the selection of the transfer object right to the start-up phase, which is over one year more than in Paper 2. Finally, Paper 6 presents how the framework from Paper 3 can be integrated into the production-outsourcing process and applies the resulting outsourcing framework to the same production transfers from Paper 3.

The reminder of this chapter will present in greater detail the research methods that were applied in the six appended papers. The methodological limitations of the research design are discussed in Subchapter 6.2. For a full account, please see the methodology sections in each of the appended papers.

3.1. Literature Review

As introduced in the previous subchapter, I conducted a systematic literature review to address the first and second research questions. I conducted this review with assistance from researcher Børge Sjøbakk from SINTEF. During the summer and autumn of 2015, we reviewed dictionaries, peer-reviewed journal and conference articles, dissertations, monographs, books and guidelines on the topics of *production transfer* and *risk management during production transfers*. The literature review method is based on Karlsson's (2009, p.48) recommendations. We started with the most recent literature review on the production transfer topic that we identified, Fredriksson's (2011), and conducted a backward and forward reference search. Thereafter, we searched for additional relevant literature in NTNU's online library (Oria), which provides access to the main databases for peer-reviewed literature, and on Google Scholar. The keywords used are listed in Table 3. Since keywords directly related to the production transfer topic ('production transfer' and 'product transfer') rendered few results, we expanded the list with additional keywords, based on Fredriksson's (2011) and other seminal literature that we had hitherto identified. Furthermore, we combined the keywords from Group B-Part I (see Table 3), which rendered many results but with marginal relevance, with the keywords in Part II, to increase the relevance of the findings.

Table 3: Search key words ("Part I" AND "Part II")

	Part I	**Part II**
Gr. A	"production transfer" OR "product transfer" OR "manufacturing transfer" OR "manufacturing relocation" OR "production relocation" OR "production offshoring" OR "production outsourcing" OR "production start-up" OR "production ramp-up" OR "production subcontracting" OR "contract manufacturing" OR "external manufacturing"	
Gr. B	"knowledge transfer" OR "technology transfer" OR "risk management" OR "supply chain risk management" OR "supplier assessment" OR "supplier audit"	"outsourcing" OR "offshoring" OR "manufacturing" OR "production"

Throughout the review process, we scanned over 900 publication titles and abstracts. All relevant publications were stored in a bibliographic database and were subject to several iterations of reading and considerations for inclusion. Out of an initial sample of 269 papers, we identified only 55 relevant papers. The process of article selection is depicted in Figure 5, according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flowchart (Moher et al., 2009). Out of the 55 relevant papers, 24 explicitly addressed either the entire production transfer process (13 papers), the knowledge transfer (5), the production start-up (2) or the technology transfer (4), and they were particularly relevant for at least one of the three main phases of the production transfer process. Technology transfer has many similarities with production transfer, with the difference that during the former, if production activities are to be transferred, these were not necessarily previously performed by the sender (Malm, 2016). Hence, the concept of technology transfer can have a broader meaning. The 55 included papers are briefly presented in Appendix 1.

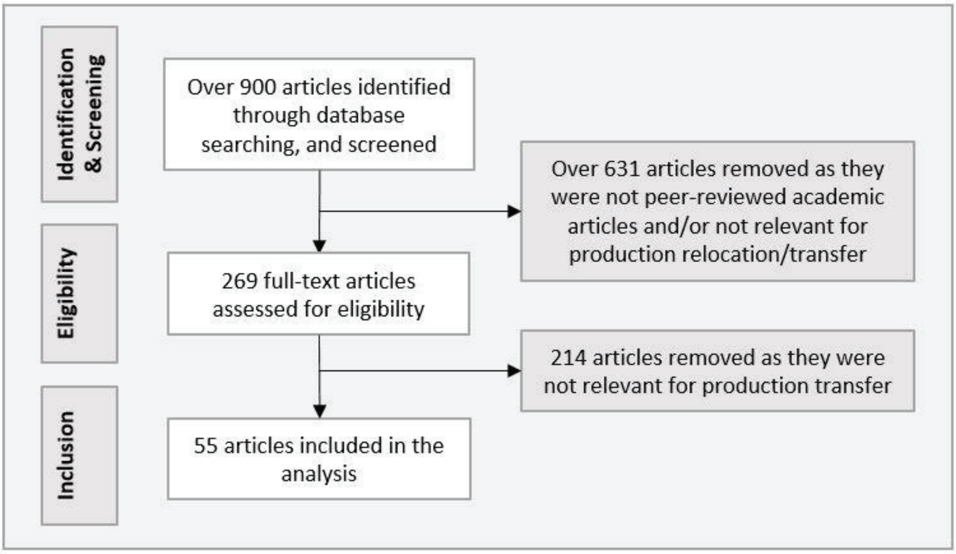

Figure 5: Flowchart illustrating the different phases in the systematic literature review (adapted from Moher et al. (2009))

The publication years are presented in Figure 6, showing an increasing rate of publication and interest for the topic between 1990 and 2018. Only the above mentioned 24 seminal papers were considered. Most of the papers (16 papers) appeared in operations management journals, but contributions also stem from production management (4), manufacturing strategy (1), research and development (R&D) (1) and organisation management (1) journals, which add important perspectives to the research on operations management of multisite production networks. These findings point to a rather scattered academic interest for production transfer management that spans several academic communities, and this comes as no surprise considering the complex and multifaceted environment in which production transfers are conducted. Moreover, we found out that there was little knowledge about how to manage risk during production transfers (for more details see Chapter 1).

The methodologies applied in the papers are presented in Table 4. Most of the research takes a qualitative approach, but quantitative and conceptual studies are also represented. Case

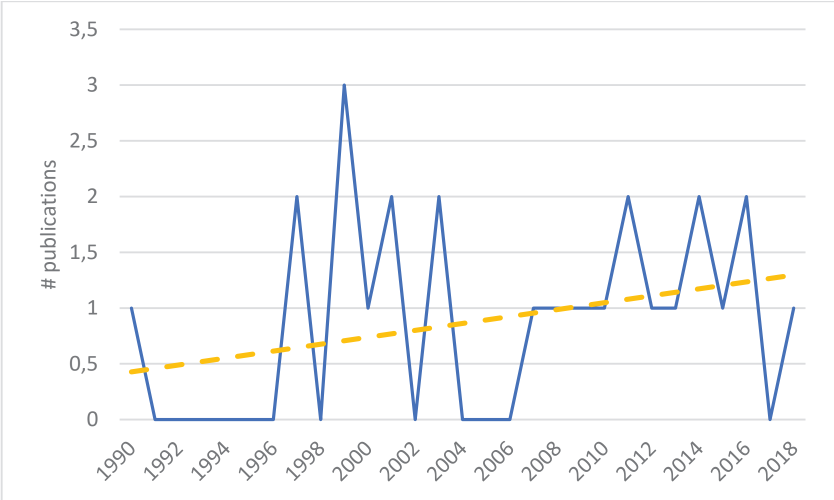

Figure 6: Publication rate over the years

Table 4: Research methodologies in the seminal papers

Qualitative methodologies			**Sur-vey**	**Conceptual**	**Industrial guidelines**
Single case	**Multiple case**	**Longitudinal field study**			
4	8	4	2	5	1

research (single case study, multiple case study and longitudinal field study) dominates the sample. Arguably, the complexity of the production transfer process makes the modelling and testing of relationships through survey data difficult, so researchers prefer in-depth studies of one or a few cases. Moreover, emerging fields of research are typically predominantly conceptual and qualitative, as in this phase, researchers try to establish a common vocabulary, define and classify concepts and describe the patterns and structures pertaining to the studied phenomenon.

Next, to map the literature, we prepared an Excel spreadsheet, where for all the 269 potentially relevant papers we recorded title, author, type of publication (e.g. journal or conference paper), publication name (e.g. journal name), year, abstract, search phrase, database name, number of citations (in Google Scholar), methodology, keywords, research group and key findings. The key findings were further divided into 'risk sources/challenges' and 'facilitators of efficient production transfers/success factors/recommendations', in order to simultaneously address the two first research questions. For the seminal publications, we conducted forward and backward reference searching, and included the key findings in the Excel record.

During the autumn of 2015, based on the potential facilitators of efficient production transfers that were identified through the literature review, I developed the preliminary version of the production transfer procedure (see Tables 10 and 11, Subchapter 4.2.1). The facilitators were formulated as actions, and the procedure suggests a certain sequence of those actions, which is based on descriptions of the production transfer process from the literature. Nevertheless, the exact sequence of the actions is expected to vary from transfer to transfer. The actions are classified into categories that are based on arguably the most comprehensive frameworks and guidelines in the existing production transfer literature (Madsen [2009], Fredriksson & Wänström [2014] and WHO [2011])

3.2. Case Research

Design science research ‘can, in principle, use all known methods for data collection and analysis’. However, ‘in practice the strategies tend to be case-based, collaborative and interventionist’ (van Aken and Romme, 2009). All the appended papers in this dissertation are based on case research, including 8 transfers with various degrees of study depth, depending on their purpose in the papers. As the previous subchapter showed, case research is also the dominant data collection method in the seminal papers on which this research is based. The production transfers included in the appended papers are presented in Table 5.

Table 5: The cases included in this PhD research (RQ=research question)

Study	Transfer	Relocation type	Industry	Sender	Receiver	Research method	RQ	Paper
A	**1**	Outsourcing (domestic)	Electronics	Company in Norway (Sender.Co)	Company in Norway (Receiver.NO)	Multiple case study	RQ1, RQ2, RQ3	#1, #3, #6
	2	Outsourcing (domestic)	Electronics	Company in Norway (Sender.Co)	Company in Norway (Receiver.NO			
B	**3**	Offshoring	Electronics	Site in Norway (Sender.Co)	Site in Spain (Receiver.ES)	In-depth case study	RQ1	#2
						Longitudinal field study of the in-depth case	RQ2	#4
						Action research during the in-depth case	RQ3	#5
	4	Offshoring	Electronics	Site in Norway (Sender.Co)	Site in Spain (Receiver.ES)	The study of 2 production transfer-examples, conducted for theoretical replication	RQ3	#4, #5
	5	Offshoring	Electronics	Site in Norway (Sender.Co)	Site in Spain (Receiver.ES)			
C	**6**	Offshoring (nearshoring)	Food production	Site in Sweden	Site in Estonia	The study of 3 production transfer examples through a survey during an international workshop on	RQ3	#5
	7	Offshoring	Thruster production	Site in Finland	Site in China			

Study	Trans fer	Reloca-tion type	Indus-try	Sender	Receiver	Research method	RQ	Pa-per
	8	Outsourc-ing (offshore outsourc-ing)	Aircraft produc-tion	Company in Sweden	Company in India	production transfer; the out-sourcing exam-ple was selected for literal repli-cation		

Figure 7 presents what paper used the data from each study and when the papers were written. *Study A*, *Study B* and *Study C* refer to transfers 1–2, 3–5 and 6–8, respectively, in Table 5.

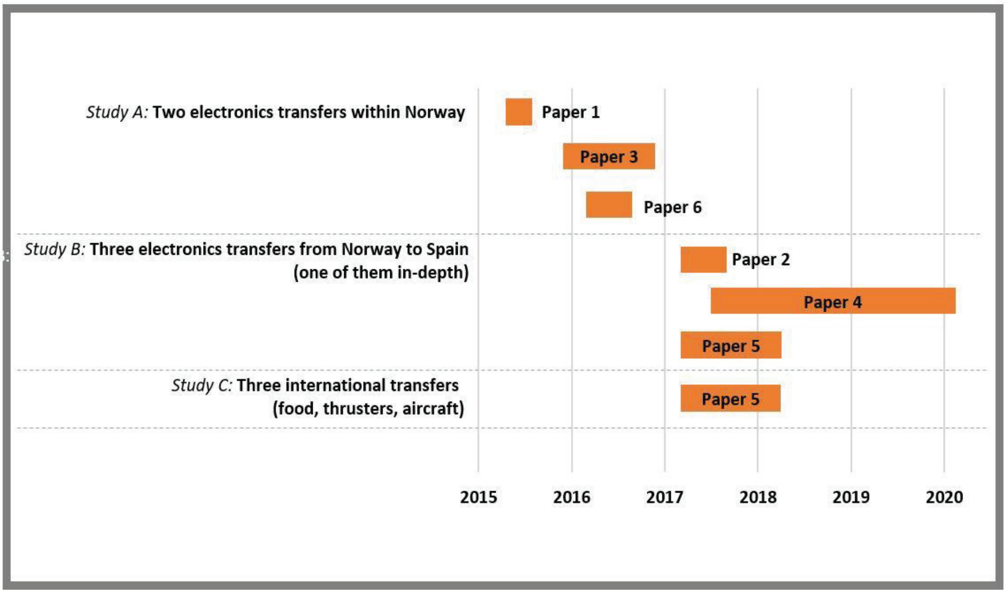

Figure 7: The relationship between the production transfer studies and the appended papers

As introduced in Chapter 1, at the beginning of the PhD research, I became involved in a 3-year research project. Sender.Co and Receiver.NO were central partners in this research project. Thus, I had very good access to empirical data and an excellent forum for discussion and validation of findings. Transfers 1–2 were conducted from Sender.Co to Receiver.NO, while transfers 3–5 were from Sender.Co to their subsidiary in Spain, Receiver.ES. For many years, Sender.Co had been a global leader within the premium segment of electronics (sensor systems) that they produced. However, in recent times, competitors from low-cost countries had been improving the performance of their products, determining Sender.Co to streamline their supply chains and production systems. Thus, to achieve an increased cost-efficiency and at the same time release more resources for product innovation, Sender.Co began to transfer parts of the production to strategic suppliers in their supply chains. For instance, to achieve better economies of scale, they transferred high demand products with low IP-risk to domestic series producers such as Receiver.NO (transfers 1 and 2 in Table 5), and labour-intensive parts and products to Receiver.ES, close to an emergent customer market (transfers 3–5, Table 5).

To ensure a greater diversity and minimise bias, in addition to the production transfers that involved Sender.Co, I studied production transfers involving other multinational companies, industries and countries (transfers 6–8, Table 5). The companies conducting these additional production transfers were selected as they had relocated production several times. Moreover, one of the transfers was described as particularly successful: the production transfer between the Finish and Chinese production sites of a major technology company. The Chinese receiver achieved all the expected production transfer-performance targets, the deliveries were reliable, and the product quality was as required by the sender.

The remainder of this subchapter presents in greater detail how the case research was conducted in each of the appended papers.

Papers 1, 3 and 6 include data about two production transfers from Sender.Co to Receiver.NO (production transfers 1–2 in Table 5). Both production transfers were recent, so the informants could recall important events relatively easily (Karlsson, 2009, p. 171). The double case study enabled a fruitful cross-case analysis, an easier identification of representative relationships between the challenges experienced by the transfer parties during the transfers and their causes, and thereby a higher internal and external validity (Eisenhardt, 1989b).

In April and September 2015, as part of the research project in which I participated, SINTEF organised three workshops with the sender and receiver's transfer personnel, where I assisted the main organiser (researcher Børge Sjøbakk, lead author of Paper 1) with the data collection. The workshops were combined with tours of the transfer-parties' sites, during which we studied the production processes of the two transferred products. During the workshops, key transfer personnel (managers, purchasers, product-developers, process engineers and operators) from both companies were interviewed about the challenges they had experienced during the production transfers, possible causes of these, and facilitators of efficient production transfers. Thereafter, the interview data was compared with the field notes taken during the site tours and with relevant secondary data from Sender.Co. A case study report was prepared based on the collected data. For increased accuracy of the empirical findings and increased construct validity (Karlsson, 2009, p.182), key informants reviewed the report. The field problem that we identified based on this data was the lack of thorough planning of the studied transfers and of transfer risk management, combined with a lack of established production transfer procedures.

Paper 2 presents an in-depth case study of the production transfer from Sender.Co to Receiver.ES (transfer 3 in Table 5). In this paper, we adopted the case research method because it enabled the identification of risk sources during an ongoing production transfer and with a relatively full understanding of the nature and complexity of the transfer process (Karlsson, 2009, p. 164). Although Sender.Co had conducted production transfers many times before, including to the Spanish subsidiary, they experienced a series of challenges during the sonars (acoustic sensors) transfer. This made the selected production transfer an interesting case to study and get a better understanding of how to identify areas where risk-mitigation actions can be implemented to improve the transfer process. The project owner and the QA & risk manager of the studied production transfer, both with extensive experience from earlier production transfers, applied the risk assessment framework proposed by this paper to the case. A semi-structured interview was conducted, during which the informants jointly analysed and ranked the impact of the risk sources on the overall risk level during the sonars transfer. For increased construct validity, responses were cross-referenced (triangulated) with company documents and 12 months of rich field notes from the in-depth transfer study.

In March 2017, the Production Management group at the Department of Mechanical and Industrial Engineering at NTNU and I organised an international workshop on the topic of 'production transfer'. During this workshop, three practitioners applied the literature-based production transfer procedure in a transfer project (No. 6–8 in Table 5) with which they had broad experience and verified it. The participants included an external production transfer consultant who applied the procedure on a production transfer at a large Italian food company ('Transfer #6'), a production transfer manager from a major Swiss technology company ('Transfer #7') and a production transfer-specialist from a large Swedish aeronautics company ('Transfer #8'). These had 8, 6 and 7 years, respectively, of experience with managing production transfers. First, each participant presented a production transfer with which (s)he had worked. Thereafter, I presented the production transfer procedure and administered an electronic questionnaire to the experts. The questionnaire consisted of several closed-ended questions with space for open-ended comments after the answers. The questions were mainly related to the relevance of the actions in the production transfer procedure (whether they had low, medium or high relevance for the transfer examples). Since the selected production transfers had rather contrasting characteristics, I had the opportunity to study the relevance of the actions in the procedure for both outsourcing and offshoring, and for different industries (i.e. literal replication [Karlsson, 2009, p.172]). Furthermore, I could compare how relevant the actions in Paper 5 were for the transfer between Sender.Co and Receiver.ES (transfer 3, Table 5) with how relevant they were for the three transfer examples. Although only three PT practitioners tested the utility of the procedure, the introduction of a potential solution in several contexts is a significant step toward theory development (Holmström et al., 2009). Moreover, according to Gregor and Hevner (2013), when a researcher has expended significant effort in developing the solution design in a project, often with much formative testing, the final testing should not necessarily be as full or as in-depth as the evaluation in a research project where someone else developed the solution design (Gregor and Hevner, 2013).

3.3. Longitudinal Field Study

Paper 4 is based on a longitudinal field study (production transfer 3 in Table 5), which was conducted as recommended by Karlsson (2009, p. 196). Thus, the co-authors and I developed a theoretical frame of reference that we used as a lens during both data collection and analysis. The frame of reference was based on the following dimensions: (i) transfer risk sources, (ii) preventive actions, (iii) potential disruptions, (iv) corrective actions and (v) losses that the disruptions may trigger. The transfer to Spain provided a rare opportunity to study a noticeable organizational change, ‘where issues were likely to occur’, as Karlsson (2009, p.203) recommends. For instance, we studied the risk-mitigating effect of the preventive actions from the production transfer procedure that was implemented during this transfer.

I collected the empirical data in the period between May 2016 and June 2018 and at both transfer-parties’ sites, through methods such as participant observation, semi-structured interviews, studies of secondary data from Sender.Co and Receiver.ES and informal conversations. Since the data was collected during an ongoing study and on a frequent basis, it was easier to determine the causal relationship between risk events (risk sources, disruptions, etc.) than during retrospective studies. Nonetheless, the evidence collected through distinct methods was compared (triangulated), which further increased internal validity. Finally, I took fieldnotes (e.g. about the effects of the implemented preventive and corrective actions) during project meetings and tours at Receiver.ES’ premises. To ensure the reliability of the evidence, I paid attention to separate observations from their interpretation. Moreover, for all the observations, I recorded the date, place and individuals that were present when the data was collected. To increase the internal validity of the evidence, soon after the visits, the field notes were transcribed in a case study protocol. Furthermore, the findings were reviewed by managers in the transfer parties. For a full account of data collection (e.g. the interview guide and timeline) and analyses please see the methodology section in Paper 4.

3.3.1. Action Research

As introduced earlier, Paper 5 is based on action research that was conducted according to Coughlan and Coghlan’s (2002) recommendations. The action research was part of the longitudinal study of the production transfer from Sender.Co to Receiver.ES (transfer 3 in Table 5). Paper 5 belongs to the design science phases ‘Transfer-procedure Refinement’ and ‘Development of substantive theory’ (see Table 2). Thus, the Action research was adopted based on the recommendations of Holmström et al. (2009) about how to conduct design science research. Paper 5 shows how the literature-based framework of facilitators of efficient production transfers (from Paper 3) was implemented and iteratively evaluated and refined during the ongoing transfer to Receiver.ES. The action research approach allowed me to both implement the procedure at the case-companies in order to solve the field-problem, and affect the way the procedure was modified by the case-companies (Coughlan and Coghlan, 2002). The organisation chart of the transfer to Spain is depicted in Figure 8. As the chart indicates, I was part of the transfer organisation and had the role of Transfer Facilitator. However, I was not employed by the transfer parties (I was an ‘outside agent’). Thus, it was relatively easy for me to step back and analyse not only the progress of the production transfer but also the research itself (Coughlan and Coghlan, 2002). Furthermore, I had a steering committee with members from both transfer parties, who enabled me to build insider knowledge. The committee members were the employee responsible for the action-plan & sourcing, the project owner, the QA & risk manager and the project manager.

In total, the literature-based procedure was tailored to the studied production transfer, evaluated and refined 7 times. To this end, 19 workshops were organised in which the transfer-parties personnel participated either live or via video. For a full account of the procedure-

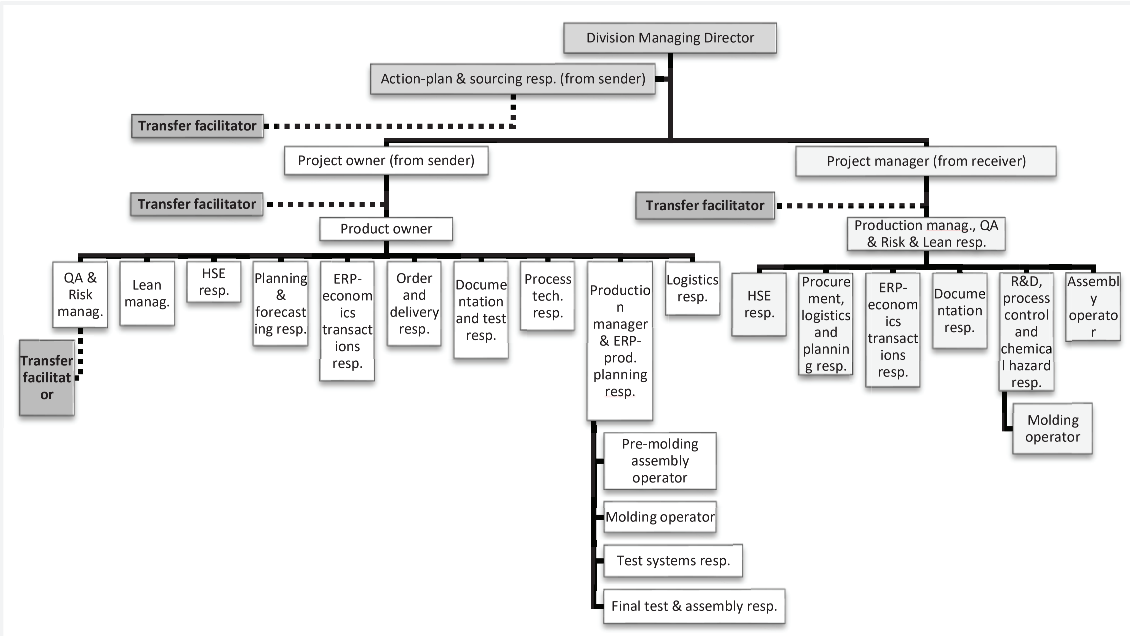

Figure 8: The organisation chart of the production transfer to Spain (QA-quality assurance, HSE-Health and Safety Executive, ERP-Enterprise Resource Planning, R&D-Research and development)

Table 6: The action plan used during the (production transfer) procedure refinement process (with an example)

Id	Area	Action	Relevance	Status	Open/ Closed	Sub-action	Owner	Start date	End date	Duration (working Days)	Gantt chart
1	Organisation & project management	Organise a project start-up meeting with representatives from both the sender and receiver and all affected disciplines. Announce the transfer object, reasons for the transfer, the relationship between Sender.Co and Receiver.ES, expected performance targets, etc.	High	We have not organised the start-up meeting yet	Open	**1a.** Organise a start-up meeting at Sender.Co with Sender.Co's transfer personnel	Kjell G.	03/10	12/10	8	XXX
						1b. Organise a start-up meeting at Receiver.ES with Receiver.ES' transfer personnel	Antonio M.	05/10	18/10	10	XXX

refinement process, please see Appendix 1 in Paper 5. This appendix also provides details about data collection methods, the date when the data was collected and main events during the procedure refinement. Prior to the first workshop with Sender.Co and Receiver.ES' personnel, the actions from the literature-based procedure were transferred to an action plan prepared in Excel. The headlines of the action plan are presented in Table 6, with an example of how the actions were evaluated during the workshops. During both the live-workshops and the videoconferences, the Action plan was projected to a common screen. In this way, I also minimised researcher bias and increased construct validity. The workshop-participants were asked to evaluate whether the actions had low, medium or high-relevance for the transfer to Spain. Consensus was achieved on each action before proceeding to the next. For those actions evaluated as having low relevance, the participants were asked to provide explanations. For medium or highly relevant preventive actions, the participants were asked if the actions had been implemented (*Status*) and whether any sub-actions were needed to implement them (*Open* action) or not (*Closed* action). If necessary, new sub-actions were identified, as well as their action-responsible (*Owner*), start date, end date, amount of working days and corresponding Gantt chart. The transfer parties' personnel readily embraced this meeting format, maintaining it throughout the entire procedure refinement process.

In April 2018, at the end of the action research, the co-authors of Paper 5 and I conducted an evaluation of the users' experience. Key informants from Sender.Co and Receiver.ES were interviewed about their experience with the transfer procedure and its implementation. Prior to the interviews, we sent a questionnaire to the informants and their answers were used as a starting point for the interview discussions. In the questionnaire, the informants were mainly asked to evaluate the utility of the procedure and its implementation (in the form of an action plan), as well as the start-up time and delivery precision compared with earlier transfers—two transfers to a Norwegian supplier and one earlier transfer to Receiver.ES (transfer 1, 2 and 4 in Table 5).

The project owner (from Sender.Co) reported the following:

> *There is no doubt that the methodology we have followed during the transfer to Spain has been very useful and an appropriate procedure and method to follow. […] The activities in the procedure are very important and the production transfer processes benefit a lot of such process tools.*

Furthermore, the employee responsible for the action plan (Sender.Co) and the QA & risk manager (Sender.Co) reported that the transfer procedure ensured that important preventive actions were implemented, and it reduced the amount of disruptions. Moreover, Sender.Co's key informants reported that the start-up time had been shorter, and both the on-time delivery and product quality had been better compared to earlier transfers. Receiver.ES' personnel also expressed their satisfaction with how the transfer action plan worked. The Receiver's production manager said in an email sent to the lead author: 'without the transfer plan, the sonars transfer would have been more complicated'. The project manager (from Receiver.ES) also made similar remarks on several occasions throughout the production transfer. At almost the same time as the studied transfer case, Receiver.ES was taking on the production of another product offshored by Sender.Co. According to the project manager and the production manager, although the transfer during which the procedure was implemented was more complex than the other transfer, due to the use of the action plan, the transfer tempo was considerably faster, and Sender.Co's assistance was more substantial and timelier.

Note that even though Paper 5 only focuses on the preparation phase, the entire production transfer procedure was refined.

4. Presentation of Main Findings

In this chapter, I present and discuss the main findings from the six included papers, in relation to the three main research questions. Table 7 provides an overview of the appended papers, their related research question and main outcomes.

Table 7: An overview of the appended papers, their related research question and main outcomes (RQ=research question)

Paper	Paper short title	Related RQ	Main outcome/result
Paper 1	Transfer of production to strategic suppliers	*RQ1:* What are the potential risk sources when transferring production?	An overview of potential challenges and inherent risk sources during transfers, based on empirical research
Paper 2	A production transfer risk assessment framework		A framework of transfer risk sources for the risk management in the early phase of a production transfer
Paper 3	Prerequisites for successful production transfers	*RQ2:* What are the facilitators of efficient production transfers?	Proposes a framework of facilitators of efficient production transfers
Paper 4	Investigating relationships between production transfer management and transfer success		A set of facilitators of efficient production transfers and lessons learned about production transfer management (including risk management)
Paper 5	A transfer procedure based on risk management principles	*RQ3:* What are the main actions in a production transfer procedure that aids the transfer risk mitigation?	A validated procedure for the preparation phase of the production transfer, based on risk management principles
Paper 6	A proposed outsourcing procedure		Presents how the framework from Paper 3 (preliminary production transfer procedure) can be integrated into one of the possible relocation processes, the production outsourcing

4.1. What are the potential risk sources when transferring production?

The first research question is addressed in Papers 1 and 2. Paper 1 sets out to explore and better understand the phenomenon of production transfer, presenting a series of potential challenges and inherent risk sources during transfers, based on two transfer studies. Paper 2 presents a framework of risk sources, based on the literature. These risk sources may lead to disruptions ('challenges') and losses during production transfers. The utility of the framework for transfer risk management is tested by applying it on an in-depth production transfer case.

4.1.1. Paper 1: Transfer of Production to Strategic Suppliers

Paper 1 presents in detail two production transfers between Sender.Co and Receiver.NO ('Transfer A' and 'Transfer B' in the paper). Transfer A was the first production transfer from Sender.Co to Receiver.NO and the object of the transfer was the assembly and testing of an acoustic sensor (Product A). Product A was the first one to be transferred to Receiver.NO because it was cheaper, less complex and produced in higher volumes (tens of thousands) than most of Sender.Co's products. For Transfer B, the production transfer object was a new version of a signal converter, part of several of Sender.Co's sensors. Receiver.NO was commissioned to install all electronics, including their own circuit boards, and ship the product to Sender.Co for final testing. The contribution of this paper is an overview over potential challenges during production transfers, based on two case studies. Table 8 lists the main challenges that were reported by the informants.

Table 8: Possible challenges during production transfers

No.	Challenges during the transfer studies (Transfer A and Transfer B)
1.	During Transfer A, the Product Team at the sender was not involved in the transfer decision-making process and hence, they misunderstood the purpose of the transfer. They thought that it was a cost-reducing measure, when in fact the main driver was the high volume and low complexity of the production not being consistent with Sender.Co's core competences. 'Why should they have it easier than us?', one of the informants reported as having heard his colleagues saying. Both transfer parties agreed that the transfer process should have been initiated with a kick-off meeting.
2.	During Transfer B, the main contact person at the sender reported that it was difficult to know whom to contact at the receiver throughout the transfer. She also experienced that two different contact points at the receiver had different bill of materials (BOM) revisions.
3.	In the early stages of Transfer B, the sender asked the receiver to secure necessary material from subsuppliers, without having signed a formal agreement. Because of BOM changes, some of the material that the receiver had to purchase became obsolete, and during the second data collection workshop, it was unclear how the receiver would be compensated for this. Furthermore, the transfer-parties had not clearly agreed on future volumes. This posed a risk for the receiver, as they had to make significant investments in the transfer.
4.	During Transfer A, initially it was decided that all the original test equipment would be transferred from the sender to the receiver. When the Product Development team found this out, they realised that the sender would be unable to run spot checks anymore, thereby losing the control over the quality of their deliveries. Therefore, only copies of this equipment were transferred to the receiver.
5.	During Transfer A, the original plan was that the sender would produce the product until Easter, and the receiver would produce everything after that. During the second workshop, the transfer parties reported that this was unrealistic. 'It is impossible to transfer years of competence overnight'. Furthermore, during the start-up phase of Transfer B, the transfer parties identified problems with the product design that should have been addressed during the pilot production phase. Moreover, the transfer parties agreed that the sender should maintain some production capacity to secure deliveries during the start-up.
6.	During Transfer A, the receiver provided many suggestions about how to improve the production process. According to the receiver, the sender had rejected part of those suggestions without clear explanations. Moreover, during Transfer B, the sender had problems with their product lifecycle management (PLM) system, which did not allow purchasing materials for prototypes before design-freeze. Thus, to be able to purchase materials, the sender had to freeze the design prematurely. Subsequently, many design changes were not recorded until the product developer started to collect them in an Excel file. The transfer parties agreed that change suggestions should have been treated in a systematic manner and decisions should have been supported by factual explanations. Moreover, systems continuously keeping track of valid documentation should be implemented.
7.	The department owning the product that had been transferred during Transfer A did not have a clear overview of the cost-benefit of the transfer.
8.	During the second workshop, to the receiver's surprise, the sender revealed their plans to develop a new version of Product A. The receiver had scheduled production improvement activities, which would be futile if the new version was launched.

4.1.2. Paper 2: A Production Transfer Risk Assessment Framework

While Paper 1 focused on the increased risk level during production transfers and possible challenges that companies may experience because of this, Paper 2 dives deeper into the topic of production transfer risk management, shedding light on what may trigger these challenges, that is, on the risk sources. The remainder of this subchapter presents a selection of findings from Paper 2, as well as their relation to Paper 1.

When we reviewed the literature to identify relevant risk sources during production transfers (see Subchapter 3.1), we found that each risk source could be assigned to one of four notable categories. These categories are (i) (transfer risk sources) related to the transfer object, (ii) related to the receiver, (iii) related to the supplier relationship and (iv) related to the profit impact. The literature-based framework of risk sources is presented in Table 9.

Next, we used the in-depth study of the production transfer of a family of acoustic sensors (sonars) from Sender.Co to Receiver.ES to test if the framework could be useful as a transfer risk assessment tool. To this end, the transfer project owner and the QA & Risk manager (both from Sender.Co) jointly assessed and ranked the risk sources according to their contribution to an increased transfer risk level. Both informants had experience with several of Sender.Co's earlier production transfers. The framework was able to capture all the risk sources that had arisen during the sonars transfer, suggesting its usefulness as a simple checklist for identifying and assessing transfer risk sources.

Sender.Co offshored the production in order to get better access to the developed customer market and the material technology expertise in Spain, as well as to reduce labour cost and delivery time. Sender.Co was transferring all the production activities to their subsidiary in Spain, apart from the acoustic technology, which contained high-level IP. Empirical findings that are illustrative of the literature-based risk sources are presented in Table 9 (right column). The table only displays an average of the informants' rankings of the risk sources in each area (1—low/2—medium/3—high contribution to increased risk).

Paper 2 presents a series of risk sources *related to the transfer object*. Particularly, the paper presents risk sources related to the similarity of the transfer object produced by the receiver to the object produced by the sender (R3, Table 9), the receiver's limited experience with the transferred production (R2 and R4, Table 9), the transfer-parties' lack of experience with the production transfer process (R1 in Table 9) and the amount of tacit knowledge (R14, Table 9). For instance, Sender.Co modified the transferred sub-assembly (see R3, Table 9), asking Receiver.ES to develop a new moulding material. This process delayed the production start-up by nearly one year, leading to a monthly estimated loss of ca. 30 000 EUR.

Moreover, the receiver had to purchase most of the machines needed to produce the sub-assembly (see R4, Table 9). As the machines had been purchased before the decision to change the moulding material, the receiver did not get any return of their high investment for over one year. In addition, when the moulding equipment was tested, the receiver found out that it did not cope with the high viscosity of the new material; hence, they had to modify the equipment - a process that delayed the start-up even more.

Interestingly, the challenges presented in *Paper 1* are reflected by the literature review in Paper 2 rather well. For instance, during Transfer B (Paper 1), Sender.Co modified the transfer product (see R3, Table 9), while asking Receiver.NO to secure necessary material from

Table 9: Potential transfer risk sources from the literature, and during the production transfer to Receiver.ES

Literature	Case (1—low/ 2—medium/ 3—high contribution to increased transfer risk)	
I. Related to the transfer object		
1. Novelty R1. Degree of experience the sender and receiver have with transferring production between them (Tatikonda and Stock, 2003, Fredriksson et al., 2014) R2. The receiver's experience with similar production (Tatikonda and Stock, 2003, Fredriksson et al., 2014) R3. The similarity of the transfer object produced by the receiver to the object produced by the sender (Tatikonda and Stock, 2003) R4. The similarity of the transfer object produced by the receiver to other production at the receiver (e.g. if receiver's equipment can be used) (Fredriksson et al., 2014) R5. Production site's maturity (e.g. greenfield or brownfield) (Cheng et al., 2010)	The sender had transferred production several times before, but the receiver had initially only carried out sale and service operations for the sender and did not have much production experience. However, they had successfully undertaken production from the sender before (the assembly of a simple component), and they had been maintaining a good collaboration for 20 years. Moreover, receiver had employed a researcher with a PhD in material technology who was developing a new moulding material, a process that could delay the transfer. Most of the machines had to be purchased and there were certain distinctions between this equipment and the original one at the sender. In addition, the receiver had bought these expensive machines too early (more than one year before start-up). Finally, because of increasing production activities, the receiver also had to buy a facility to move to before start-up, and its layout had to be changed. The constructors they contracted for the first part of the building project submitted an offer too costly for the second part, and the process of contracting new ones delayed the start-up by weeks.	3
2. Complexity R6. Degree of internal and external modularity (e.g. the object is part of a larger system) (Tatikonda and Stock, 2003, Beckman and Rosenfield, 2008) R7. The amount of elements, configurations and functions the object has (e.g. BOM complexity) (Tatikonda and Stock, 2003, Beckman and Rosenfield, 2008) R8. The size of the product tolerances (Fredriksson et al., 2014) R9. The availability of raw materials (Kraljic, 1983) R10. The extent to which the manufacture of products is complete prior to the customer order (Fredriksson et al., 2014) R11. Customer demand-certainty and production volume-certainty (Fredriksson et al., 2014) R12. Facility to protect the IP (Grant and Gregory, 1997)	The transferred object consisted of three product groups; each with three relatively simple products that were not part of the sender's other products. However, their production required many machines and tools that had to be either purchased or transferred from the sender. The demand was relatively certain; there was a good market for these products in Spain. Further, since it was rather difficult to protect the IP, the sender did not grant the receiver access to the document handling system, and little documentation had been transferred before the sender's representatives visited the receiver and saw that the material development process was promising. Because of the scarce information and the receiver's rush to start the production, the new layout at the purchased facility deviated from what the production required and had to be modified after the sender's visit. Moreover, during one assessment conducted a short time after kick-off, the sender's employees identified a certain risk of IP loss during the transport of the acoustic technology to the receiver, but actions were soon implemented to ensure that only qualified logistics suppliers were used.	3
3. Tacitness R13. The facility to codify and document the tacit knowledge about the object (Tatikonda and Stock, 2003, Grant and Gregory, 1997) R14. The transfer object's maturity (e.g. with well-defined processes) (Tatikonda and Stock, 2003, Grant and Gregory, 1997) R15. The relevance of the documentation (e.g. updated and representative) (Tatikonda and Stock, 2003, Grant and Gregory, 1997)	The transferred products were mature, but the documentation was not completely updated, and a certain amount of tacit knowledge could not be codified. Thus, the receiver's operators had to travel several times more than expected to the sender for hands-on and face-to-face training provided by the sender's operator and engineers. This possibly increased the transfer time.	2
4. Adaptability R16. The facility to find alternatives when adapting the production process to the receiver's environment (Grant and Gregory, 1997)	The production could not be changed and adapted to receiver's environment.	3

Literature	Case (1—low/ 2—medium/ 3—high contribution to increased transfer risk)	
R17. The facility to pilot and test the adaptations at the sender prior to the transfer execution phase (Grant and Gregory, 1997) R18. The sender's capability and willingness to make adaptations (Grant and Gregory, 1997)		
5. Flexibility R19. The possibility to reserve resources at the sender for necessary tasks during transfer execution and start-up at the receiver (Fredriksson et al., 2014, Fredriksson et al., 2015) R20. The possibility to plan the transfer as a gradual transfer, volumes being only gradually decreased as outputs at the receiver are increased (Fredriksson et al., 2014, Fredriksson et al., 2015)	The receiver was seeking a rather high transfer pace, because of the unutilised expensive equipment they had bought. Nonetheless, during the preparations phase, it became increasingly clear that a gradual transfer was necessary. To cope with the uncertainty, the sender decided to continue producing for a couple of months, until the receiver achieved a stable production. Moreover, since one of the reasons for the transfer was to release resources for innovation (the sender's core competency), the amount of resources the sender was willing to invest in the transfer was moderate. Yet, the sender assigned significant resources to travel to Spain and assist the receiver during transfer execution and start-up.	1
II. Related to the receiver		
6. Subsuppliers R21. The quality, cost, flexibility, service level, reliability and proximity of local and international subsuppliers (Grant and Gregory, 1997, Chopra and Meindl, 2013)	The subsuppliers' performance is evaluated as moderate. In addition, during one workshop, the receiver's personnel identified a certain risk that subsuppliers could unexpectedly stop their supply and thereby, it was decided to establish a long-term partnership with critical vendors and have available secondary subsuppliers for standard items.	2
7. Transfer market R22. The appropriateness of the receiver's market for the transferred production (e.g. if any product redesign is needed to satisfy the demand) (Grant and Gregory, 1997)	The transfer parties benefited from a strong and stable customer demand in Spain, without having to change the products.	1
8. Infrastructure R23. The appropriateness of the quality, cost and availability of local utilities (Grant and Gregory, 1997) R24. The appropriateness of the space and format of buildings (Grant and Gregory, 1997) R25. The appropriateness of telecommunications, road, rail, shipping and airfreight infrastructure (Grant and Gregory, 1997, Chopra and Meindl, 2013)	The infrastructure at the Spanish receiver was evaluated as very good.	1
9. Legal requirements R26. The appropriateness of import duties (Grant and Gregory, 1997, Chopra and Meindl, 2013) R27. The appropriateness of quotas, labour law, government emission regulations, planning permission regulations, approval and license requirements and other legal demands (Grant and Gregory, 1997)	The sender realised during preparations that it would be more expensive to sell products made in Spain to countries where the EU had less favourable trade agreements than Norway. Nonetheless, the Euro was more stable than the currency at their Chinese subsidiary and it was more advantageous to purchase from subsuppliers within the EU. Further, during one assessment early in the preparations phase, personnel with experience from previous transfers stressed the need to ensure comprehensive documentation for the transferred equipment and inventory in order to avoid being stopped at the customs office, so several actions were implemented to reduce this risk.	2
10. Financing R28. The appropriateness of the cost of capital, land, and inventory (Grant and Gregory, 1997)	The cost of capital and land are evaluated as high, whereas the cost of inventory and the foreign exchange requirement are moderately appropriate.	3

Literature	Case (1—low/ 2—medium/ 3—high contribution to increased transfer risk)	
11. Geographical environment R29. The appropriateness of the local temperature range, humidity level, air quality (Grant and Gregory, 1997), and geo-risk (e.g. if area is prone to natural disasters) (Kraljic, 1983)	The temperatures, humidity, air quality and geo-risk at the Spanish site are evaluated as moderately appropriate for electronics production.	2
12. Socio-political environment R30. The level of governmental stability (Kraljic, 1983)	The area benefits of high governmental stability.	1
13. Labour force R31. Employee's productivity, educational level, language homogeneity and turnover (Grant and Gregory, 1997)	Workers' productivity and educational level at Receivers are evaluated as high and respectively moderate. Receiver's area was known for its material technology expertise and the labour force turnover was low. Yet, the workers' English skills were modest and this could be especially challenging during videoconferences.	2
14. Culture R32. The closeness between job positions (e.g. manager-operator) (Grant and Gregory, 1997) R33. The individuals' willingness to assume responsibility and the appropriateness of the receiver's approach to problem solving and quality perception (Grant and Gregory, 1997)	Workers are willing to assume responsibility and have an appropriate quality perception and problem-solving approach. The relational closeness between job positions is moderate.	1
15. Production environment R34. The production and packaging rooms; testing, production and packaging equipment; inventory control mechanisms; documentation; absence of banned substances; waste management (WHO, 2011), and other HSE aspects (Alfnes and NTNU, 2006) R35. Layout and material flow; efficiency of space usage; levels of inventory and work-in-process; quick changeover; installation and maintenance protocols; planning and control, value chain information sharing and other ICT systems (e.g. level of integration between the systems); order management; quality management (e.g. TQM); Visual management (Alfnes and NTNU, 2006, WHO, 2011) R36. Workers' technical capabilities (e.g., to adapt the production process to own environment and the use of leading technology); organisational practices (e.g., customer focus, housekeeping) (Alfnes and NTNU, 2006, Grant and Gregory, 1997) R37. Level of teamwork and worker empowerment and flexibility (Alfnes and NTNU, 2006)	The receiver possessed the ISO 9001: 2008 certification within Quality management and achieved a good score when the sender conducted a Lean audit at their premises. Moreover, they were very receptive to new technologies and best practices. Nonetheless, when the sender's representatives visited them two months after kick-off, both parties realised how important it was to implement the sender's quality management systems and procedures in the new supply chain (for Change control, FIFO, tracing parts, the reception of sourced items, and for correct storage). In addition, they agreed on and took the first actions to implement the sender's ERP production module at Receiver. Receiver's personnel had to travel several times to Norway for training and the process required a trial period at Receiver, which could prolong the start-up and delay the steady state.	2
III. Related to supplier relationships		
16. Distance R38. The physical proximity between related processes (e.g. the development and manufacturing units) after the transfer execution (Fredriksson et al., 2014, Terwiesch et al., 2001) R39. The relationship closeness between the sender and receiver (Fredriksson et al., 2014, Terwiesch et al., 2001) R40. The relationship closeness within the value chain (e.g. the receiver has close subsuppliers that deliver high quality items) (Alfnes and NTNU, 2006) R41. The similarity of the transfer parties' perception of their relation (Oosterhuis et al., 2011)	The sender and receiver were part of the same corporation, yet the supply agreement they had was a buyer-supplier contract similar to the ones the sender had with external suppliers. This generated certain confusion among personnel. Sometimes, sender's workers were hesitant to share information, whereas receiver's workers expected more openness. The physical distances between the development and manufacturing of the core technology and the moulding material were small, since the processes were collocated at sender and respectively, receiver. Yet, the fact that the two sites were located far from each other posed some characteristic challenges to their collaboration (e.g. if they will have to adapt technology to the Spanish market).	3

Literature	Case (1—low/ 2—medium/ 3—high contribution to increased transfer risk)	
17. Power balance R42. The sender's and receiver's negotiating power (Kraljic, 1983)	The competition between receiver and other 'receivers' that sender could have selected is moderate, and the same applies for the sender's and their competitors.	2
18. Motivation R43. Employees' motivation for transfer, at both locations (e.g. high when no lay-offs) (Fredriksson et al., 2014)	Some of sender's employees were afraid to lose their jobs in the future.	2
IV. Related to Profit Impact		
R44. The size of the sourced volume compared to the receiver and sender's remaining portfolios (Kraljic, 1983, Fredriksson et al., 2014) R45. The proportion of the sender's total sourcing cost that the sourced items stand for (Kraljic, 1983) R46. The positive impact of the sourced items on quality and business growth (Kraljic, 1983)	The product volume is rather low, compared to sender's other products. The products require a high amount of manual labour and are one of sender's most price sensitive. Thus, the sender hopes to decrease the costs in the future due to the cheaper workforce (1/3 the cost at sender) and to improve the products' robustness due to the new moulding material. The outbound logistics could also decrease due to higher market proximity, but the inbound logistics could increase as long as the sender's original Norwegian suppliers are used.	2

suppliers in the absence of a signed formal agreement. Because of several engineering changes, part of the expensive material that Receiver.NO purchased became obsolete, and it was unclear how Sender.Co would compensate them for this. In addition, Receiver.NO did not have any agreement with Sender.Co on future volumes. This posed a significant risk for Receiver.NO, as they were making significant investments in the transfer. Therefore, Sender.Co and Receiver.NO reflected that they should always sign a comprehensive formal agreement prior to transfers, specifying who bares the risk of obsolete material. Furthermore, the transfer-parties had little experience with the transfer process (see R1) and did not have any established transfer procedures. Thus, neither they prepared a transfer plan, nor did they conduct a transfer risk identification and analyse at the beginning of the process. For instance, since Receiver.NO had not produced the same products before and they did not have test equipment for this, it was decided that Sender.Co's test equipment would be transferred to them. However, when the product development-department at Sender.Co found this out, they realised that if the equipment would be transferred, they would not be able to run spot-checks on the final products anymore, losing the control over the quality of their deliveries. Thus, only a copy of the test equipment was eventually transferred to Receiver.NO. The earlier literature supports these findings, showing that production processes that are novel and with a great level of tacit knowledge tend to be more difficult to transfer, increasing considerably the overall transfer risk level (Stock and Tatikonda, 2000, Galbraith and Galbraith, 1990, Malm et al., 2016). For both Transfer B in Paper 1 and the case in Paper 2, the transferred processes were rather novel for the receivers and the transferred products were modified, thus implying a high amount of tacit knowledge. Nonetheless, while Malm et al. [2016] acknowledges the significant impact of the receivers' experience on the transfer risk level they also emphasise that the senders' ability to frame the transfer knowledge in a way that other people can understand it accurately and put it into practice, is equally important.

To conclude, the main contributions of Paper 2 include a framework of transfer risk sources based on the literature. Primarily, the framework can be used when assessing the transfer risk in the early phase of a production transfer. Secondarily, it can be applied when the transfer object is selected (especially the 'factors related to transfer object') and when the location and receiver are selected ('factors related to the receiver'). A team with experienced members from key disciplines could jointly analyse possible disruptions generated by each risk source and rank them. Risk mitigation-actions should be considered for the risk sources in descending priority i.e., first for risk-sources with high scores, etc. Furthermore, as Gelderman and Van Weele (2003), Norrman and Jansson (2004) and ISO (2009) recommend, a cost-benefit evaluation should be conducted before selecting the actions. Thus, if the risk level is high, it is worth making high investments in e.g. expensive training, provided the profit impact is also high. Here companies should also consider that it is recommended to rather prevent disruptions and performance deviations than to correct them.

4.2. What are the facilitators of efficient production transfers?

The second research question is addressed in Papers 3 and 4. In Paper 3, the co-authors and I propose a framework of facilitators of efficient production transfers, based on the literature.

Paper 4 derives a set of lessons learned about transfer management (including risk management) and potential facilitators of efficient production transfers, based on a transfer that I studied in-depth for over two years.

4.2.1. Paper 3: Prerequisites for Successful Production Transfers

The main objectives of this study were to identify potential facilitators of efficient production transfers in the existent research, develop a literature-based production transfer procedure based on the facilitators, and compare the procedure with empirical findings from production transfer studies. To this end, the co-authors and I capitalised on the systematic literature review that I presented in Subchapter 3.1.

We structured the identified facilitators according to typical categories of production transfer actions (based on Madsen, 2009, Fredriksson et al., 2015, and Momme and Hvolby, 2002): (i) preparation, (ii) execution, (iii) start-up, and (iv) supplier relationship management. Moreover, to increase the readability of the paper we divided them into two parts: potential facilitators of efficient production transfers during the (i) preparations phase, and (ii) Execution, start-up & Supplier Relationship Management, respectively (Table 10 and Table 11).

Furthermore, as Table 10 and 11 show, the preparations and execution were further divided into the subcategories: 'organization and project management' (based on WHO, 2011 and Galbraith, 1990), 'pilot production at sender' and 'pilot production at receiver' (both based on Terwiesch et al., 2001), as well as 'knowledge transfer', 'transfer of administrative systems' and 'supply chain transfer' (based on Fredriksson and Wänström, 2014). The knowledge transfer consists of actions that are necessary for transferring tacit and uncodified knowledge, whereas the transfer of administrative systems consists of actions necessary for transferring explicit and codified knowledge (Fredriksson and Wänström, 2014). The supply chain transfer consists of actions that are needed for establishing relations to subsuppliers of raw materials, components and parts (Aaboen and Fredriksson, 2016).

Next, we compared the literature-based procedure (Table 10 and 11) with empirical findings from the studies of the two production transfers between Sender.Co and Receiver.NO, andwith findings from a follow-up workshop with Sender.Co about the improvement programs with relevance for transfer (risk) management, which they were implementing. We presented challenges during the two production transfers and discussed how those challenges could have been avoided or more easily dealt with if some of the identified facilitators had been in place. The facilitators revealed by both the literature and the empirical findings are marked with (*) in Table 10 and Table 11.

To conclude, the main contributions of Paper 3 include a framework of facilitators of efficient production transfers that are identified in the production transfer-literature. Primarily, the procedure can inform the transfer plan in the beginning of the production transfer process. Secondarily, it can be used as an example of what actions a production transfer process may require, when the relocation decision is taken, and when the appropriate transfer object, production location and receiver are selected.

*Table 10: Facilitators of efficient production transfers during the preparation phase (*also revealed by the case findings)*

Id.	Facilitators	References
	Organisation and project management	
P1*	Project start-up meeting. Executive level commitment	e.g., (Dudley, 2006, McBeath and Ball, 2012)
P2*	Multidisciplinary transfer team with project managers from both parties	(Madsen, 2009)
P3	Product Development team	(Madsen, 2009, Terwiesch et al., 2001, Rudberg and West, 2008, WHO, 2011, Fredriksson et al., 2015)
P4	Supplier Development team	e.g., (Modi and Mabert, 2007)
P5*	Multidisciplinary team for Risk Management	(Manuj and Mentzer, 2008b, WHO, 2011)
P6*	Formal agreement between the transfer parties	(Danilovic and Winroth, 2005, Zhu et al., 2001, Franceschini et al., 2003)
P7	Address the impact of IP on communication of technical matters	(Danilovic and Winroth, 2005, WHO, 2011)
P8*	Up-to-date and easily accessible Transfer Protocol comprising all the transfer documents (i.e. a transfer plan and checklist)	(Terwiesch et al., 2001, WHO, 2011, Ferdows, 2006)
P9	Evaluate the receiver's readiness (by e.g. Gap Analysis)	(McCormack et al., 2008, WHO, 2011, Modi and Mabert, 2007)
P10*	Risk identification and assessment for the transfer object (by e.g., FMEA, FTA, or ETA analyses)	(McCormack et al., 2008, WHO, 2011)
P11*	Assess the transferability of the production system. Codify tacit knowledge. Replace obsolete equipment	(Grant and Gregory, 1997, McBeath and Ball, 2012, Hilletofth et al., 2015, Madsen, 2009)
	Pilot production at the sender (if suitable)	
P12	Set the performance targets to be achieved prior to the Physical Transfer (e.g. first pass yields)	(Terwiesch et al., 2001)
P13	Robust forecasts (of physical transfer, start-up time, new lead times, etc.)	(Fredriksson et al., 2015, Hilletofth et al., 2015)
P14	Early problem solving for the production system (incl. recalibration) and for the supplied components/raw materials (by e.g., RCA, or FTA)	(Terwiesch et al., 2001)
P15*	Define the Change Control process	(Terwiesch et al., 2001)
P16	Implement preventive actions (e.g. safety stock and safety capacity). Ensure redundancy	(Fredriksson et al., 2015, McCormack et al., 2008)
	Knowledge transfer	
P17	Send personnel from the receiver to the sender (including FMEA specialists)	(McBeath and Ball, 2012, Grant and Gregory, 1997, Terwiesch et al., 2001, Galbraith and Galbraith, 1990, Madsen, 2009)
P18	Video-taped review of the production process	(Galbraith and Galbraith, 1990)
P19	Multidisciplinary training based on non-standard events. A repository of solutions	(McBeath and Ball, 2012, Madsen, 2009)
P20	Perform audits at the receiver to verify knowledge transfer. Test personnel	(McBeath and Ball, 2012)
P21*	Perform activities to enhance the receiver's performance (e.g., FMEA, RCA, VSM, Lean, Six sigma, and APQP)	(Modi and Mabert, 2007)
P22	The sender and receiver jointly review and update the transfer documentation and the planning and control systems	e.g., (McBeath and Ball, 2012, Terwiesch et al., 2001, Fredriksson et al., 2015)
	Transfer of administrative systems	
P23*	The sender and receiver develop a Communication Plan (part of the Transfer Protocol)	(McCormack et al., 2008, WHO, 2011)

Id.	Facilitators	References
P24	The sender transfers documentation. The receiver reviews the documentation from the sender, identifies any gaps (in facilities, systems, etc.), and develops operating procedures and other necessary documentation. Provides the sender feedback on the transferred documentation	(WHO, 2011)
P25*	Use a common software for managing information flows	(Malm, 2013, Terwiesch et al., 2001)
	Supply chain transfer	
P26	Establish relationships to subsuppliers of necessary raw materials and components	(Aaboen and Fredriksson, 2016)

*Table 11: Facilitators of efficient production transfers during execution and start-up (*also revealed by the case findings)*

Id.	Facilitators	References
	Execution	
P27	Upgrade, test, and burn-in the equipment to be transferred	(Madsen, 2009)
P28	Temporary send personnel from the sender to receiver (including FMEA specialists)	(Terwiesch et al., 2001, Ferdows, 2006)
	Pilot production at receiver (if suitable)	
P29	Early problem solving for the production system (including recalibration) and the supplied components/raw materials (by e.g., RCA, or FTA). Full speed testing	(Terwiesch et al., 2001, Almgren, 1999)
	Start-up	
P30	Parties meet to review the Transfer Protocol and met/unmet performance targets	(Terwiesch et al., 2001)
P31*	Gradual Production Transfer with secondary supply sources (not 'clear-cut'). Transfer production during periods with low demand	(Fredriksson, 2011, Terwiesch et al., 2001, Hilletofth et al., 2015, Madsen, 2009)
P32	Parallel experimental line at the receiver and a dedicated process improvement team	(Terwiesch et al., 2001)
P33	Qualify vendors. 'Vendor matrix' for components that can be used together	(Terwiesch et al., 2001)
P34	Continuous monitoring of the start-up progress, demand, and safety stock level	(Fredriksson et al., 2015, McCormack et al., 2008)
P35	Decide on corrective actions (subcontracting, expediting part delivery, etc.)	(Fredriksson et al., 2015)
P36	Adapt the documentation and the planning and control systems	(Fredriksson et al., 2015, Grant and Gregory, 1997)
P37	Decide on when to transfer component/ raw material ordering responsibility to the receiver	(Fredriksson et al., 2015)
P38*	Production verification. Post-transfer audit. Compare the costs before and after the transfer	(Hilletofth et al., 2015, Zhu et al., 2001)
P39*	Transfer summary report including deviations, actions and lessons learned	(Zhu et al., 2001, WHO, 2011, Stock and Tatikonda, 2000)
P40*	Continuous performance improvement and monitoring (including conducting audits at the receiver)	(Gero and Stefan, 2009, Madsen, 2009)
	Supplier relationship management	
P41*	High communication, collaboration, and coordination requirements for novel, complex, and/or tacit transfer object. Leveraging each other's strengths	(Stock and Tatikonda, 2000, McCormack et al., 2008, Vitasek and Manrodt, 2012)

Id.	Facilitators	References
P42*	The receiver informs sender about any process conflict. The transfer-parties have regular status meetings	(Hilletofth et al., 2015, Rehme et al., 2013)
P43	Long-term commitment. Invest in supplier development	(Modi and Mabert, 2007, Bocquet, 2011)

4.2.2. Paper 4: Investigating Relationships between Production Transfer Management and Transfer Success

The purpose of Paper 4 was to increase the knowledge about transfer risk mitigation by exploring the relationships between risk sources and the potential disruptions and losses that the risk sources may trigger. Moreover, the paper explored the effect of preventive and corrective actions on the risk level and on the efficiency of the production transfer. This paper's findings are summarised in Table 12. The table presents the seven key relationships that were identified during the longitudinal field study of a production transfer that was studied in-depth for 26 months (the same as in Subchapter 4.1.2), as well as the lessons learned about facilitators of efficient production transfers that were gained from the process of conducting the transfer project (potential preventive actions). The empirical data was collected and analysed based on the analytical framework from Figure 9. The dimensions in the analytical framework are further operationalised in detailed lists of potential transfer risk sources, disruptions, losses-, and preventive and corrective actions (see Paper 4). Table 12 (left column) includes examples from these five lists.

Risk sources	Preventive actions	Disruptions	Corrective actions	Losses
Related to Transfer-object: Product and production process Planning and control **Related to Sender:** Disseminative capacity **Related to Receiver:** Absorptive capacity Physical location **Related to Sender-Receiver Relation:** Earlier relation and physical proximity Power balance	**Organisation & Project Management** actions **Quality Management** actions **Knowledge Transfer** actions **Administrative Transfer** actions **Supply Chain Transfer** actions	**Internal to Supply Chain:** Supply disruptions Operational disruptions Demand disruptions HSE disruptions **External to Supply Chain:** Natural disasters Labour strikes Security disruptions Macroeconomic disruptions Policy disruptions	To mitigate: **Supply/operational/demand disruptions** To mitigate: **HSE/security/macroeconomic/policy disruptions, natural disasters, and labour strikes**	**Human and Health** losses **Material** losses **Environmental** losses

Figure 9: The analytical framework that was used to collect and analyse the empirical data

The lessons learned can be divided into two categories: (lessons learned) (i) related to the cross-locational management of the production transfer project at the sender and receiver (Relationship 1–3 and Relationship 7 in Table 12), and (ii) the power balance between the sender and receiver with regards to production adaptation and sub-supplier selection (Relationship 4–6).

The existing production transfer-literature shows that dedicating personnel at the sender to the production transfer (Fredriksson et al., 2015) and having a project manager at the receiver's site (Terwiesch et al., 2001) has a positive impact on the transfer-outcome. However, surprisingly, the production transfer-scholars have so far payed little attention to the

Table 12: Key empirical findings and lessons learned (PT=production transfer)

No.	Relationships between risk sources, disruptions, corrective actions and losses	Preventive actions to mitigate the risk of disruptions and losses (lessons learned)
1	A long geographical distance can lead to supply disruptions (such as significant schedule disruptions), corrective actions such as the repeated rescheduling of activities and overtime, and eventually, to material losses.	The transfer parties should name a cross-locational project manager (preferably with PT experience) in the early phase of a PT, and his/her role and responsibilities should be clarified during general meetings. The manager should organise monthly general meetings with the entire transfer team to review the project milestones and more frequent (e.g. every two weeks) detail meetings with each department to review the actions.
2	Risk sources related to the receiver's absorptive capacity (e.g. when new equipment has to be integrated into the receiver's production system) in combination with demand disruptions (e.g. the sender's demand changes after agreeing on the PT scope) can lead to excessive equipment capacity, excessive inventory, and eventually, to significant material losses.	By signing a comprehensive formal agreement and freezing the modification of the PT scope after signing the agreement, the transfer parties are likely to avoid considerable losses caused by the sender's demand changes after agreeing on the PT scope.
3	Risk sources related to the receiver's absorptive capacity (e.g. when the receiving production site is greenfield), can lead to significant schedule disruptions, to corrective actions such as the repeated rescheduling of activities and overtime, and eventually, to material losses.	The transfer parties should collaborate closely when the layout plan of the receiver's premises is prepared and freeze the layout design after agreeing on the final version.
4	Risk sources related to the product & production process and the receiver's absorptive capacity (e.g. modifying the object of the transfer before PT execution in combination with the receiver's modest experience with the transferred production), can lead to supply disruptions (e.g. significant schedule disruptions) and operational disruptions (e.g. nonconformances), to corrective actions such as the repeated rescheduling of activities, and to material losses.	The more significant the changes applied to the transferred production, the higher the risk level and the longer the PT-process.
5	Risk sources related to the receiver's absorptive capacity (e.g. the receiver's modest experience with the transferred production), can lead to supply disruptions (such as significant schedule disruptions), operational disruptions (such as nonconformances), corrective actions such as the repeated rescheduling of activities, and, eventually, to significant material losses.	Extensive learning-by-doing training of the receiver's operators at the sender can significantly mitigate the PT risk level and reduce the start-up time.
6	Risk sources related to the receiver's physical location (e.g. introducing new subsuppliers) can lead to supply disruptions (e.g. material shortages or supplier bankruptcy), and eventually, to material losses.	Keep the existing subsuppliers until production is steady-state to avoid introducing additional risk sources such as suboptimal quality, flexibility, service level, or reliability of the new subsuppliers.
7	The lack of thorough planning and monitoring of the PT can enhance all the risk sources and significantly increase the overall PT risk level and transfer time.	Applying a thorough PT procedure right from the start of the transfer and implementing it by help of an action plan is likely to considerably mitigate the PT risk and reduce the transfer time. The action plan could be uploaded to a joint cloud platform and must be kept updated.

role played by the cross-locational project management (connecting the sender and receiver's organisations) during transfers. The findings in the previous section show that this topic requires increased focus in future research. Furthermore, this study's results are similar to the findings of Zhu et al. (2001), which highlight that it might be appropriate to hold weekly and well-documented status meetings during production relocations, and that meeting notes should be distributed to each action owner. However, this would require a substantial amount of resources, increasing the production transfer cost. The case findings indicate that to economise working hours, the transfer-parties could consider organising two types of status meetings: weekly (or every two weeks) detail meetings with each department to review their actions, and monthly general meetings with the entire transfer team, to review the project milestones (see Relationship 1, Table 12).

The case findings also show that by signing a comprehensive formal agreement and freezing the modification of the transfer scope after signing the agreement, the transfer parties are likely to avoid considerable losses caused by the sender's demand changes after agreeing on the transfer scope (see Relationship 2, Table 12). The agreement can include specifications about the business relationship between the sender and receiver (Zhu et al., 2001), project timeline, expected performance targets, ways to address any controversy, the risk assumed by each party, the ownership of the transferred product(s), forms of termination (Danilovic and Winroth, 2005, Franceschini et al., 2003, Zhu et al., 2001), specifications about who may have access to confidential information (Danilovic and Winroth, 2005), etc.

Furthermore, the in-depth study indicates that the transfer parties should collaborate closely when the layout plan is prepared. Apparently small omissions (cable trays, the location of pillars, utility connections, etc.) can lead to significant schedule disruptions (Kowalski et al., 2018). Transfer parties might have to transfer and integrate at the receiver's premises a high number of items, such as when production lines are transferred. Thus, preparing and agreeing on a comprehensive, updated, and timely layout plan and other necessary documentation ahead of the layout work can be of paramount importance (see Relationship 3, Table 12). Moreover, in line with WHO (2011), Zhu et al. (2001) and Terwiesch et al. (2001), this study's findings shed light on the importance of a thorough transfer procedure that should be implemented right from the start of the production transfer (see Relationship 7, Table 12).

Compared to Grant and Gregory's (1997) study about the advantages of applying changes to the transferred production process to improve its 'transfer fitness' (e.g. replacing complex systems with systems that are more user-friendly to the receiver), this study shows that the transfer-parties should be aware that any type of change can introduce new risk-sources. The more significant the changes applied to the transferred production, the higher the risk-level and the longer the production transfer-process. Nonetheless, in line with a plethora of earlier 'knowledge transfer' studies, e.g. Galbraith's (1990) and Terwiesch et al. (2001), ensuring that the receiver's personnel have the appropriate competency for the transferred production through an extensive learning-by-doing training at the sender, can significantly mitigate the transfer risk level and reduce the start-up time. Moreover, McBeath and Ball (2012) argue that whenever possible, the training must take place at the sender's production facility, prior to the transfer execution. In addition, to overcome any nondisclosure of tacit knowledge, the training should be repeated with different experienced personnel. (See Relationship 4 and 5 in Table 12.)

Furthermore, Gant and Gregory (1997) argue that the receivers are usually the ones that are best fit to adapt the transferred production to match their own production environment. For instance, the receiver may know local subsuppliers that deliver cheaper and high-quality components or raw materials. Conversely, Fredriksson et al. show that often receivers do not have enough competency to take charge of issues such as the qualification of new subsuppliers in the early phase of a production transfer (Fredriksson et al., 2019). This study's results add to these findings, indicating that despite higher inbound logistics costs and other short-term disadvantages, it may pay off to only change the subsuppliers after the production steady-state, in order to avoid introducing additional risk-sources to an already risky transfer process (see Relationship 6, Table 12). Nonetheless, Aaboen and Fredriksson (2016) acknowledge that if receivers are not given enough mandate during the transfer process, they may not integrate the transferred production well enough into their own production environment. Thus, the question of how much and when the sender should empower the receiver to adapt the production to their own environment and to select new subsuppliers is an intriguing avenue of further research.

To conclude, the main contributions of Paper 4 include an increased knowledge about the relationships between the risk sources, disruptions, and the losses that the senders and receivers may experience during transfers. Furthermore, the paper arguably contributes to an increased understanding of the effect of preventive and corrective actions on the risk level and the relocation outcome. Finally, the paper derives a set of lessons learned about facilitators of efficient transfer management (including risk management) from a production transfer, which I studied in-depth for over two years.

4.3. What are the main actions in a production transfer procedure that aids the transfer risk mitigation?

The third research question is addressed in Papers 5 and 6. In Paper 5, the co-authors and I propose a validated procedure for the preparation of production transfers that is based on risk management principles. The procedure should help companies mitigate the risk of disruptions during transfers, and achieve their production relocation goals. Moreover, the paper attempts to enhance the production transfer literature by clarifying the meaning of transfer-risk management. Paper 6 presents how the literature-based transfer procedure from Paper 3 can be integrated into one of the possible relocation processes, the production outsourcing.

4.3.1. Paper 5: A Transfer Procedure Based on Risk Management Principles

Based on findings from the literature review, the Action Research during the transfer to Spain and the survey during the international workshop with production transfer-practitioners, the authors developed the basic framework in Figure 10. Its aim is to foster a mutual understanding among the academia and transfer practitioners, of the main categories of preventive actions in a transfer preparation procedure (based on Fredriksson and Wänström (2014), Madsen (2009) and WHO (2011)), and the relation between these. Each of the five

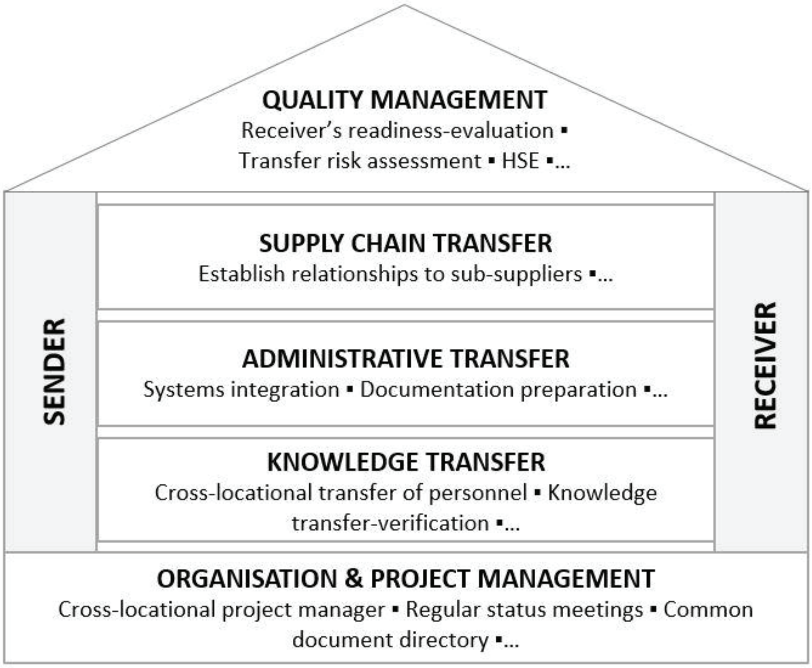

Figure 10: Main types of preventive actions in a transfer-preparation procedure based on risk management principles, and the relation between these

preventive action categories includes a few examples of keywords from the literature-based transfer procedure (Tables 10 and 11, Subchapter 4.2.1). It should provide a basic structure that can be easily used to introduce the transfer preparation procedure in the early phase of a production transfer.

Furthermore, this paper proposes a validated procedure for the preparation of production transfers, which is based on the literature-based transfer procedure (see Subchapter 4.2.1), as well as on risk management principles. This procedure informs the risk mitigation during the transfer-risk management process and is presented in Table 13. To reduce the likelihood of potential disruptions with an unacceptable risk level, transfer practitioners should implement all the preventive actions in the procedure which they deem relevant (e.g. based on a cost-benefit analysis), in the early phase of production transfers. The procedure suggests that the preventive actions should be implemented in a certain sequence. However, this is the result of the refinement process during the action research, when the procedure was adapted to the transfer to Spain during which it was implemented. Thus, the exact sequence of the actions is expected to vary from transfer to transfer.

The transfer preparation procedure was refined and validated by the sender and receiver's personnel involved in the transfer to Spain, and by international transfer-practitioners, who applied it to three transfers with which they had worked (see Subchapter 3.3.1 and 3.2). The three selected transfers belonged to different industries (food, maritime technology and aerospace production) and had been conducted between different countries. While all the

Table 13: The refined production transfer-preparation procedure based on risk management principles ("An." - the transfer parties' ID)

Preventive actions in the refined procedure
Organisation and project management:
A1. Establish a project team with project managers and representatives from all disciplines affected by the transfer and from both the sender and receiver. Assign a general project coordinator. Clarify the role and responsibilities of each member
A2. Establish a Process Improvement team with representatives from all relevant disciplines and from both the sender and receiver
A3. Establish a Risk Management team with representatives from all relevant disciplines and from both the sender and receiver
A4. Organise a project start-up meeting with the sender's and receiver's personnel involved in the transfer. Announce the object of the transfer, reasons for the transfer, the relationship between the sender and receiver, expected performance targets, etc.
A5. Sign a formal agreement. Include in the agreement specifications about expected performance targets and how to monitor them, profit and cost sharing, the rights to access confidential information, product ownership, request for proposal, etc.
A5.1. The sender and receiver agree on performance targets (KPIs) and their continuous monitoring
A5.2. The receiver's personnel with access to confidential information sign a nondisclosure agreement
A6. The sender and receiver hold regular status meetings and send meeting notes to all the affected personnel
A7. Create a common directory that includes all the transfer documentation and is easily accessible to all the sender and receiver's personnel involved in the transfer. The directory should be kept updated
A8. The sender and receiver prepare a crisis management procedure and address the impact of confidentiality on the open communication of technical matters
A9. Plan for overproduction at the sender to cover the needs during the execution and start-up phases
Sourcing:
A10. Evaluate the regulatory requirements in the sender's and receiver's countries and in any countries to which the product is to be supplied: exchange rates for equipment and inventory (e.g. parts and components) from the sender and the subsuppliers, import duties, land codes and the new origin of finished products
A10.1. Verify transportation requirements (e.g. customs requirements and trade agreements applicable when delivering goods from the receiver vs. the sender)
A11. Establish relationships with subsuppliers of raw materials, components, parts, etc.
Quality management:
A12. Involve the sender in the design and approval of the layout, if this is modified
A13. Evaluate the receiver's readiness with regards to facilities, equipment, and support services (e.g. by a gap analysis)
- purchasing (the selection and development of the subsuppliers through the Change Control procedure)

Preventive actions in the refined procedure
- storing (FIFO, serial and version control, and ESD) - reception structure (routines and equipment for reception control and tolerance control) - nonconformance handling - Total Preventive Maintenance for the equipment **A14.** Validate the receiver’s facilities (after the implementation of any sub-actions for improving the receiver’s ‘readiness’ for transfer) A14.1. Validate the purchasing, storing and reception structure **A15.** Identify and assess the transfer risk. Address customs clearance and material supply risks **A16.** Identify and implement preventive actions to mitigate the risk of supply shortages (e.g. safety stock and safety capacity). Identify corrective actions to mitigate the risk of supply shortages (e.g. overtime and express transports) **A17.** Define and implement a Change Control process at the receiver **A18.** Conduct activities to enhance the receiver’s performance level (e.g., VSM, RCA, FMEA, Lean, Six Sigma and APQP) **A19.** Prepare a list of items and documentation to be transferred. Specify transfer means, costs if purchases are required, and lead-times to the receiver **A20.** Review, update and create missing documentation. Translate documentation, if necessary **A21.** Ensure that the equipment to be transferred is registered and marked with the sender’s property **A22.** Verify if the actions in the Preparations phase are closed prior to the Execution phase **Process technology:** **A23.** The receiver to pilot and validate the new material in the process technology to identify any necessary adaptations **A24.** The sender and receiver to prepare the documentation for the new material **Test:** **A25.** Verify the readiness of the test system for the transfer (software, equipment, documentation, access rights to the sender’s systems, etc.) **A26.** Update/create documentation about the tests **A27.** Send personnel from the sender to the receiver to perform training on testing methods **Production:** **A28.** The sender and receiver to jointly develop a training plan **A29.** Train the receiver’s personnel. Send personnel from the receiver to the sender for training, and to improve the transferability of the production-system **A30.** Verify the knowledge transfer at the receiver (e.g. check the transfer documentation and test the personnel)

Preventive actions in the refined procedure
A31. The sender transfers all the necessary documentation to the receiver. The transfer parties review this documentation and identify if there are any gaps between the facilities, systems, capabilities, testing methods, etc. at the sender and receiver' sites. Thereafter the receiver should develop documentation (e.g. operating procedures) based on this information A31.1. Transfer photographs and a video review of the production process to the receiver **Plan for ERP set-up:** **A32.** Implement the ERP system at the receiver. Train the receiver's personnel on the ERP use A32.1. Verify that the ERP is functional at the receiver **A33.** Make robust forecasts (of start-up time, new lead times, new quality levels, etc.) **A34.** Update the ERPs at the sender and receiver A34.1. Update the sales forecasting and planning **Health, safety and environment:** **A35.** Ensure documented procedures and routines for hazardous materials (e.g. for purchase, reception, storage, handling and disposal) **A36.** Ensure HSE visual management **A37.** The sender to provide the receiver information on all the HSE issues associated with the transfer object, such as material safety data sheets, risk mitigation actions, emergency planning (e.g. in case of fire) and waste management

senders were located in Nordic countries, the receivers were located in three distinct geographical areas (Estonia, China and India). Furthermore, two of the transfers were part of offshoring processes and one was part of an outsourcing. In addition, the complexity of the transfer object varied across the production transfers, including both ‘simple’ transfer objects (a production line for bread) and complex (aircraft production). Nevertheless, despite these differences between the transfer examples, each transfer practitioner evaluated 94.62% of the actions as highly and moderately relevant. Of the preventive actions, 74.19% were highly relevant for the food production transfer, 64.52% for the maritime technology transfer, and 77.42% for the aerospace production transfer. This indicates that the transfer-preparation procedure should be useful for different types of production relocations and production industries. Furthermore, the procedure can also be useful during the Relocation-decision and the Supplier-selection phases as an illustration of what the preparation of a production transfer implies (e.g. the amount of actions that senders and receivers must implement and what they consist of). For instance, the procedure could inform a holistic cost evaluation of producing in-house vs. at a supplier (Fredriksson, 2011). If the cost of the production transfer exceeds the benefits, it may not be worth proceeding with the relocation process. Note that the preventive action categories in Table 13 deviate from the literature- based categories in Figure 10 as a result of the procedure refinement process during the action research, when the case company adapted the procedure to their needs.

Furthermore, Paper 5 emphasises the importance of managing organisation, project and quality during production transfers (also illustrated in Figure 10). During the transfer to Spain, most of the preventive actions related to *organisation and project management* that were initially regarded as highly relevant were assigned a medium risk in the action plan; the transfer parties did not consider them as indispensable for the ability to produce during the start-up phase. However, at the end of the action research several of those actions turned out to be more important than thought earlier, for example, holding regular cross-locational status meetings, and collecting all the transfer documentation in an electronic directory that is easily accessible to the entire transfer organisation and is continuously updated. When the transfer practitioners evaluate the ‘organisation & project management’ actions, they should be aware that even though these actions might not be regarded as indispensable for the ability to produce during start-up, they could facilitate the execution of those actions that are indispensable. For instance, an electronic directory that contains all the necessary transfer documentation and is rigorously used by all the transfer personnel should be a minimum requirement for a smooth transfer of administrative systems. It can significantly mitigate the risk of schedule disruptions and of needless costs caused by, for example, late or missing documentation. Finally, the findings also indicate that practitioners should revisit the transfer preparations procedure several times as the relevance of the actions may change throughout the production transfer.

The Action Research also showed that the preventive actions related to *quality management* enable or facilitate the achievement of transfer performance targets. Based on his experience with the transfer to Spain and with another large offshoring to Asia, the QA & risk manager (employee at Sender.Co) recommended that before starting with knowledge transfer actions such as training, the transfer parties should verify that an appropriate quality management system is in place at the receiver. This should be done by conducting a gap analysis at the very beginning of the production transfers in order to identify risk sources connected to the readiness of the receiver's facilities, equipment and support services (e.g. HSE management, and purchasing and inventory control mechanisms). After identifying the 'gaps', a risk identification and assessment should be conducted together with the receiver, and appropriate risk mitigation actions should be implemented.

Furthermore, the action research showed that the *administrative transfer*, and in particular the integration of the sender and receiver's relevant ICT systems (e.g. ERP and test systems) could be a complex endeavour; hence, it should be initiated as early as possible during the preparation phase. In an era of increasing digital transformation, the integration of the sender and receiver's relevant ICT systems is expected to become more and more critical for the transfer parties' competitive edge. Moreover, by carefully reviewing and preparing the transfer documentation ahead of the receiver's training, the senders could streamline the knowledge transfer and significantly reduce expenses.

According to Fredriksson et al. (2014), if the senders and receivers regard the administrative, supply chain, knowledge and physical transfers as four distinctive parts of any production transfer, they are likely to allocate more resources to ensure each of these transfers. Similarly, the authors contend that if the senders and receivers are aware of the role played by the preventive actions related to the organisation, project and quality management areas during production transfers, it will be easier to invest in them.

To conclude, Paper 5 proposes a thoroughly validated procedure for the preparation-phase of the production transfer based on risk management principles. Primarily, the procedure can be used to prepare for the execution and start-up phases of the transfer and preventively mitigate the risk of disruptions. Secondarily, it can be used as an example of a transfer preparation process when the appropriate transfer object, production location and receiver are selected.

4.3.2. Paper 6: A Proposed Outsourcing Procedure

As seen in Subchapter 4.2.1, Paper 3 proposed a literature-based procedure, including facilitators of efficient production transfers for each of the transfer phases: preparation, execution and start-up. However, the production transfer is part of a larger process, that is, the production relocation. Thus, while Paper 5 focused on the critical transfer preparation phase, and showed how the literature-based procedure was implemented and adapted to a specific case, in this paper, the co-authors and I presented how the procedure can be integrated into one of the most common relocation processes, the production outsourcing. To this end, we synthesised outsourcing frameworks from the research literature and the production transfer procedure into one holistic outsourcing procedure that is presented in Table 14. Moreover, we applied the procedure to two outsourcing cases (transfers 1–2 in Table 5, Subchapter 3.2), and reflected on the relevance of the procedure actions for transfer risk mitigation, and for achieving the performance outcomes that the transfer parties expected. Note that for the preparation phase (O13–O34), one should consider the detailed procedure in Paper 5.

Table 14: Proposed outsourcing procedure

Outsourcing policy: **O1.** Identify the amount of cost-driven, strategy-driven and politically-driven outsourcing (Kremic et al., 2006, Brandes et al., 1997) **O2.** Analyse whether benefits and risks will strengthen or weaken the decision to outsource (Kremic et al., 2006) **O3.** Establish policy document (Kremic et al., 2006) **O4.** Communicate the company's outsourcing policy to employees (Kremic et al., 2006) **Outsourcing candidate selection:** **O5.** Identify possible candidates for outsourcing (functions, products or processes) (Kremic et al., 2006) **O6.** Evaluate identified candidates (Kremic et al., 2006, Semini et al., 2013) **O7.** Select candidate(s) (Kremic et al., 2006) **Supplier selection:** **O8.** Prequalify suppliers (Cousins et al., 2008) **O9.** Agree on measurement criteria (Cousins et al., 2008) **O10.** Obtain relevant information (Cousins et al., 2008) **O11.** Select the supplier (Cousins et al., 2008) **O12.** Contract negotiation (Danilovic and Winroth, 2005) **Transfer preparation:** **O13.** Establish Project team (Madsen, 2009, WHO, 2011) **O14.** Kick-off meeting (Dudley, 2006) **O15.** Establish other teams (Terwiesch et al., 2001, WHO, 2011) **O16.** Sign formal agreement (Danilovic and Winroth, 2005, Zhu et al., 2001) **O17.** Plan as Stepwise Transfer during low demand season (if possible) (Fredriksson et al., 2015) **O18.** Ensure interaction with the receiver. Higher uncertainty, higher requirements (Stock and Tatikonda, 2000) **O19.** Develop training plan (Andre and Peter, 2012) **O20.** Create transfer register. Include transfer plans and checklist, Change Control procedure, etc. (WHO, 2011) **O21.** Evaluate the receiver's readiness (premises, equipment, support services) (WHO, 2011) **O22.** Perform transfer risk identification, assessment and mitigation. Implement risk mitigation actions (Fredriksson et al., 2015) **O23.** Problem solving/upgrading/recalibration/test of production system (Terwiesch et al., 2001, Madsen, 2009) **O24.** Define Engineering Change process (Terwiesch et al., 2001) **O25.** Train the receiver's personnel (Terwiesch et al., 2001, Andre and Peter, 2012) **O26.** Update/create documentation with the receiver (Terwiesch et al., 2001, Andre and Peter, 2012, Fredriksson et al., 2015)	**O27.** Improve the receiver's performance (Modi and Mabert, 2007) **O28.** Update the planning & control system (Fredriksson et al., 2015) **O29.** Develop Communication plan (WHO, 2011) **O30.** Transfer information (WHO, 2011) **O31.** The receiver reviews information and identifies gaps (WHO, 2011) **O32.** Ensure joint information sharing platform (Terwiesch et al., 2001) **O33.** Establish relations to subsuppliers (Aaboen and Fredriksson, 2016) **O34.** Verify preparations (Fredriksson et al., 2015) **Physical transfer:** **O35.** Transfer production equipment (Madsen, 2009) **O36.** Send personnel to the receiver (Terwiesch et al., 2001) **O37.** Install and test production equipment (Madsen, 2009) **Production start-up:** **O38.** Sender temporary transfers personnel (Terwiesch et al., 2001) **O39.** Set up experimental line (Terwiesch et al., 2001) **O40.** Involve all affected personnel (Madsen, 2009) **O41.** Qualify raw material/component sub-suppliers (Terwiesch et al., 2001) **O42.** Decide when to transfer responsibility to order raw material/components to the receiver (Fredriksson et al., 2015) **O43.**Adapt processes to the receiver's environment (Grant and Gregory, 1997) **O44.** Problem solving of parts/materials (Madsen, 2009) **O45.** Verify production (Hilletofth et al., 2015) **O46.** Continuously monitor performance. Consider shutdown when the output is lower than the targets to solve problems (Terwiesch et al., 2001)). Implement mitigation actions (Fredriksson et al., 2015, McCormack et al., 2008). **O47.** Adapt the documentation and the planning & control systems (Fredriksson et al., 2015) **O48.** Conduct post-transfer audit. Evaluate transfer (Hilletofth et al., 2015, Zhu et al., 2001) **O49.** Generate summary report (lessons learned, etc.) (WHO, 2011) **Production steady state:** **O50.** Continuously monitor and improve production (Madsen, 2009). Consider maintaining experimental line (Terwiesch et al., 2001)

According to Kremic et al. (2006), three classes of motivators can drive outsourcing: cost, strategy and politics. The sender should have a conscious attitude towards these (O1, Table 14). For instance, the outcome of an outsourcing is often more successful if the decision is based on strategic motivators rather than solely on financial considerations (Brandes et al., 1997). Next, the sender should analyse whether the benefits and risks of the outsourcing either strengthen or weaken the decision (O2). Thereafter, the resulting outsourcing policy should be documented (O3) and communicated (O4) to the employees. Next, the sender should identify (O5), evaluate (O6) and select (O7) what production activity (if any) to outsource, based on strategic, financial, functional and environmental factors, and on the outsourcing policy (Kremic et al., 2006). Moreover, Semini et al. (2013) suggest paying careful attention to logistics, equipment utilisation, proximity to product development and IP.

When the company has selected the functions, products, or processes to be outsourced, the next stage is to select an appropriate receiver and transfer location. First, suppliers are prequalified (O8, Table 14). Prequalification criteria will vary among companies and industries; however, suppliers' production capabilities and financial viability will typically be evaluated. Often, companies keep a record of prequalified suppliers, enabling them to skip this phase. Next, the company should agree on performance measurement criteria (O9) that are suitable for the outsourced product (e.g. unit price, lead-time, and supplier flexibility). Third, detailed information about suppliers' capabilities should be obtained (O10), for example through requests for proposal, and ultimately, the receiver should be selected (O11). Danilovic and Winroth argue that the production relocations must be supported by legal agreements (O12) regardless of the level of integration in a manufacturing network (Danilovic and Winroth, 2005). Examples of issues that should be addressed in the agreement are risk allocation, security issues and renegotiation/termination rules (Fredriksson et al., 2014).

To conclude, only when the outsourcing decision and supplier selection phases (and the corresponding actions) are completed can the production transfer commence, and the procedure proposed in Paper 3 can be applied.

5. Discussion

The overall purpose of this PhD research has been to investigate how production transfer processes can be conducted in order to mitigate the transfer risk. The final goal of the research has been to develop a procedure for efficient production transfers based on risk management principles. To this end, I addressed the research questions: *What are the potential risk sources when transferring production?*; *What are the facilitators of efficient production transfers?*; and *What are the main actions in a production transfer procedure that aids transfer risk mitigation?* This chapter discusses the theoretical and practical contributions of the research, showing how production transfer processes and risk management during these processes should be conducted based on the PhD results.

5.1. Contributions to Research

The main theoretical contributions of the research include an increased knowledge of potential transfer risk sources, as well as an increased knowledge of facilitators of efficient production transfer processes. Moreover, the research provides a thoroughly validated procedure that supports transfer risk mitigation and facilitates an efficient management of the transfer process, from initialisation to full-scale and stable production. These contributions are positioned within the field of operations management of multisite production networks. Table 15 provides an overview of key contributions from each paper.

The first contribution in Table 15 is the description of the 'production transfer' phenomenon as the distinctive process of implementing production relocation decisions such as offshoring and outsourcing. This contributes to the vast literature on operations management of multisite production networks, and in particular to the production relocation area (e.g., Fredriksson, 2011, Madsen, 2009). Based on Fredriksson and Wänström (2014), this thesis defines the production transfer as the process of relocating production activities (including the knowledge, equipment, inventories, administrative systems and subsuppliers needed to perform the activities) between two production units, sender and receiver. The papers show that despite the fact that production transfers are a common phenomenon among production companies, there is a need to increase the knowledge about production transfer management, and in particular, about the systematic actions (including risk management actions) that are important for efficient transfer processes. Considering the significant amount of resources that companies invest in production relocations and the risk to which they expose themselves, these were surprising findings, providing intriguing research opportunities.

Second, Papers 4 and Paper 5 describe and explain the phenomenon of 'risk management during production transfers', adding to the knowledge on supply chain risk management (e.g., Manuj and Mentzer, 2008, Norrman and Jansson, 2004) and risk management during production relocations (e.g., Cheng et al., 2010, Fredriksson et al., 2015).

Third, Paper 2 presents a framework of potential risk sources during production transfers, which is further refined in Paper 4. The framework includes risk sources related to the

Table 15: Summary of the key contributions from the six included papers

Contribution / Paper	#1	#2	#3	#4	#5	#6
1. Codification of the phenomenon 'production transfer'	X		X			
2. Codification of the phenomenon 'production transfer risk management'				X	X	
3. A framework of potential risk sources during production transfers		X		X		
4. A framework of facilitators of efficient production transfers during all three phases of a transfer process			X			
5. A set of lessons learned about production transfer (risk) management				X		
6. A procedure for the preparation phase of the production transfer, based on Risk Management principles					X	
7. Illustrating that a production transfer not only depends on the physical, knowledge, administrative and supply chain transfer, as presented in earlier research; it also depends on the organisation, project and quality management during the production transfer					X	
8. Presents the relationship between the production transfer process and one of the possible relocation processes, the production outsourcing						X

transfer object, sender, receiver, and risk sources surrounding the relationship between the sender and the receiver. This adds to the knowledge on risk management during production relocations (e.g., Fredriksson et al., 2014, Tatikonda and Stock, 2003, Grant and Gregory, 1997).

Fourth, Paper 3 presents a framework of facilitators of efficient production transfers for all three phases of a transfer process, that is, preparation, execution, and start-up. The framework contains a detailed overview of recommended actions during a production transfer process (overseen in earlier offshoring/outsourcing procedures and frameworks), and is based on the most comprehensive frameworks that were identified in the production relocation literature (Fredriksson et al., 2015, Madsen, 2009, WHO, 2011).

The fifth contribution of this dissertation is the set of seven propositions that Paper 4 advances, which contain insights about production transfer management. The propositions were developed based on the analysis of a series of disruptive scenarios that occurred during the production transfer studied longitudinally for over two years. The propositions arguably contribute to an increased knowledge base about how to mitigate the risk during production transfers and about the cross-locational management of the production transfer at the sender and receiver. Moreover, the propositions contribute to increased knowledge about the power balance between the sender and receiver with regards to production adaptation and sub-supplier selection.

The procedure proposed in Paper 5 is arguably the first transfer preparation procedure that is based on risk management principles, and addresses the organisation, project and quality management, knowledge transfer, supply chain transfer and administrative transfer. Moreover, the procedure was validated by the sender and the receiver at the main case company. Both the sender and receiver evaluated that the procedure had a positive impact on the efficiency of the production transfer during which it was implemented. In addition, transfer practitioners outside the main case company confirmed that the procedure was useful for production transfers within other types of industries with contrasting characteristics. The goal of this procedure is to aid the prevention of disruptions during transfers and thereby facilitate efficient transfer processes. Although several production transfer scholars have acknowledged the importance of a thorough preparation phase and recommended relevant preparatory actions (e.g., Madsen, 2009, Terwiesch et al., 2001), to the authors' knowledge, none have yet proposed a validated transfer preparation procedure. The co-authors and I argue that this paper contributes to the production transfer literature by providing a detailed and systematic description of the preventive actions that senders and receivers can implement in order to prepare for the transfers and reduce the amount of disruptions. Furthermore, although some of the production transfer scholars acknowledge the importance of managing the risk during transfers, Fredriksson et al. (2015) is the only identified paper that explicitly recommends preventive actions during production transfers. Nevertheless, this paper focuses on the preventive actions that may be necessary to avoid shortages of raw materials and components, which relates to the supply chain transfer and part of the transfer of administrative systems. Thus, the proposed transfer preparation procedure supplements the procedure of Fredriksson et al. (2015) with preventive actions related to organisation, project and quality management, knowledge transfer and with other relevant administrative transfer actions from the production transfer literature.

Last, Paper 6 presents how the production transfer procedure described in Paper 3 can be integrated into one of the possible relocation processes, the production outsourcing. Thus, the proposed procedure in Paper 6 also addresses the outsourcing decision-making and the supplier selection processes. The facilitators for these two processes are based on two frameworks from the production relocation literature, that is, Kremic et al. (2006) and Cousins et al. (2008).

These contributions can be discussed in light of the following theories with relevance for the field of operations management of multisite production networks: transaction cost economics, agency theory, resource-based view, knowledge based-view, task interdependence theory, eclectic theory and the organisational learning theory (introduced in Subchapter 2.4).

In line with the transaction cost economics theory (Williamson, 1975, Tsay et al., 2018), the research results highlight the importance of a close relationship between the sender and receiver during the production transfer process, with high levels of communication, collaboration and coordination between the two sites during both offshoring and outsourcing processes. Facilitators of a close sender-receiver relationship, which the informants (see Paper 5, 'A transfer procedure based on risk management principles') unanimously evaluated as highly relevant for production transfers with contrasting traits, include assigning a cross-locational project coordinator and transfer project managers at both sites, as well as establishing a project team with representatives from all the disciplines affected by the transfer, and from both transfer parties. Each team member should have clear roles and responsibilities. Furthermore, the informants unanimously evaluated the project start-up meeting with the sender and receiver's transfer personnel as a highly relevant facilitator of efficient transfer processes. The object of the transfer, reasons for the transfer, the relationship between the transfer parties and expected performance targets should be announced at the start-up meeting. This would, for instance, reduce the information asymmetry between the transfer parties with regards to their roles and responsibilities and the transfer goal. Furthermore, both the longitudinal study of the production offshoring to Spain and the two studies of production offshoring to the Norwegian receiver shed light on the importance of signing a formal agreement with the receiver, that is, even when the receiver is owned by the sender.

In accordance with the agency theory (Eisenhardt, 1989a), the research results showcase the importance of performance monitoring and of conducting audits at the receiver. For instance, the formal agreement that the transfer parties sign should include specifications regarding performance targets and how to monitor them, profit and risk sharing, the rights to access confidential information and product ownership (see Paper 3, 'Prerequisites for successful production transfers', and Paper 5). Moreover, the facilitators that the informants unanimously evaluated as highly relevant for efficient transfers include making robust forecasts of indicators such as start-up time, new lead times and new quality levels (and monitoring them during the start-up and beyond), as well as conducting an audit at the receiver during the preparation phase to evaluate its readiness for transfer with regards to facilities, equipment and support services (e.g. by a gap analysis; see Paper 5). In addition, the informants recommended the validation of the receiver's readiness after the implementation of any necessary preventive actions and highlighted the importance of verifying the knowledge transfer prior to production start-up (e.g. by checking the transfer documentation and testing the receiver's personnel).

In consonance with the resource-based view theory (Barney, 1991, Penrose, 1959), the sender in the longitudinal offshoring study pursued enhancing their core competencies by capitalising on the material technology expertise at the receiver. This led to the replacement of one material in the transferred sub-assembly with a more performant one, and subsequently, to a significant delay of the start-up and considerable expenses. Thus, one of the lessons that the informants drew from this production transfer was that the more significant the changes applied to the transferred production, the higher the risk level and the longer the transfer-process appears to be (see Paper 4, 'Investigating Relationships between Production Transfer Management and Transfer Success'). It might have been more efficient to change the material after the production steady-state in order to avoid introducing a new risk source in an already complex process, and to retain the possibility to compare the sub-assembly produced by the receiver with the one produced by the sender.

In line with the knowledge-based view theory (Grant, 1996a, Grant, 1996b, Kogut and Zander, 1992) and task interdependence theory (e.g., Thompson, 1967, Van de Ven et al., 1976, Kumar et al., 2009), the research results highlight the importance of complete and updated transfer information, temporary employee transfers between sites, learning-by-doing training, and joint ICT systems for knowledge integration. For instance, the facilitators that the informants unanimously evaluated as highly relevant include 'reviewing, updating, translating and creating missing documentation', 'preparing a list of items and documentation to be transferred (as well as specifying transfer mechanisms, if purchases are required, and the costs and lead-times to the receiver)', and 'updating the planning and control systems' (see Paper 5). In addition, the informants highly recommended sending personnel from the sender to the receiver to provide training on testing methods, as well as an electronic repository that includes all the transfer documentation, is easily accessible to all the sender and receiver's transfer personnel and is kept updated. Furthermore, even though the receiver's facility was greenfield and the personnel had limited experience with the production of the transferred sub-assembly, the longitudinal offshoring study indicated that an extensive learning-by-doing training of the receiver's operators at the sender can significantly mitigate the transfer risk level and reduce the start-up time (see Papers 4 and 5).

As introduced in Subchapter 2.4, the risk sources in the framework from Papers 2 ('A production transfer risk assessment framework') and 4 are based on the knowledge-based view theory and task interdependence theory (particularly the risk sources related to the transfer object and the sender), the eclectic theory (particularly the risk sources related to the receiver), and on the transaction cost economics, agency theory and resource based-view (particularly the risk sources related to the relationship between the sender and receiver). In addition, Paper 3 ('Prerequisites for successful production transfers'), Paper 4, Paper 5 and Paper 6 ('A structured outsourcing procedure') provide examples of disruptions and losses, and preventive and corrective actions for risk mitigation, which, along with the risk sources framework, can inform a total cost analysis of producing in-house vs. at a receiver (Fredriksson, 2011); if the cost of the production transfer exceeds the benefits, it may not be worth proceeding with the relocation process. A better estimation of the transaction costs enables increasingly profitable relocation decisions.

Lastly, even though the sender in the longitudinal offshoring study had a broad production transfer experience (the studied transfer was their 20th), they were often experiencing excessively long start-ups and high scrap and inventory levels during the transfers. At the end of the longitudinal offshoring study, informants in both transfer parties reflected that applying a thorough production transfer procedure right from the start of the transfer and implementing it by help of an action plan appeared to considerably mitigate the transfer risk and reduce the transfer time. The action plan can be uploaded to a joint cloud platform and must be kept updated. In the light of the organisation learning theory (e.g. Levitt and March, 1988), which contends that companies learn from their own experience and from others, these findings indicate that the production transfer experience should be also supported by systematic and robust transfer methods and tools.

5.2. Implications for Practitioners

This subchapter presents the key practical implications of the papers, and how the research results can be applied. Figure 11 depicts the three main types of results that this PhD research produced, and the relationship between them. The figure includes examples of research

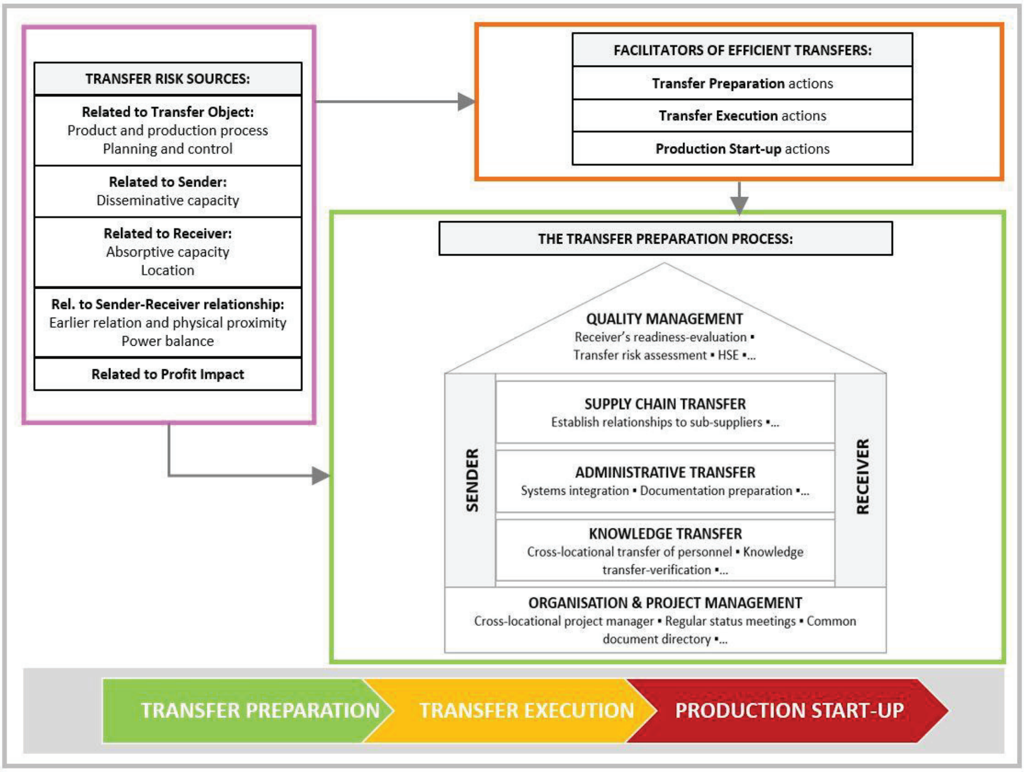

Figure 11: The relationship between the research questions (RQs) and selected research results

contributions and is based on the theoretical research framework in Subchapter 2.6 (in Figure 4).

First, this thesis proposes a framework of risk sources that may trigger disruptions and losses during production transfers. The risk sources in the framework are related to the transfer object, the receiver, the relation between the sender and the receiver and the profit impact. The framework should support the risk identification process during production transfers. A risk management team with members from both transfer parties, preferably with previous transfer experience, should identify potential risk sources during the transfer (by help of the framework), the disruptions that these risk sources may trigger and potential losses. In other words, they should address the question 'What can go wrong during the production transfer?'. Thereafter, the team should assess the risk level of the potential disruptions that they identified, based on estimations of the likelihood of each disruption and its negative impact on performance. This research indicates how the risk identification and assessment can be conducted, by applying the framework on an offshoring case. Note that the risk framework is introduced in Paper 2 and further developed in Paper 4 (about relationships between production transfer management and production transfer success), resulting in the risk source-categories presented in Figure 11. Moreover, this research also provides frameworks of potential disruptions and losses that can be used during the risk identification and assessment.

Second, after the risk identification and assessment, the risk management team should implement actions aimed at mitigating the risk of those disruptions that they assessed as having an unacceptable risk level. To this end, the PhD research proposes a framework of facilitators of efficient production transfers during each of the production transfer phases, that is, preparation, execution, and start-up. Risk mitigation strategies during production transfers include removing the risk source, implementing preventive actions to reduce the likelihood of disruptions, implementing corrective actions to reduce the losses caused by disruptions that could not be avoided, accepting the risk and sharing the risk. This research indicates how the facilitators of efficient production transfers can act as preventive actions, by applying the facilitators' framework in two outsourcing cases. In addition, the research also presents a framework of potential corrective actions along with examples from an electronics-transfer from Norway to Spain, part of an offshoring project that was studied over a two-year period. Finally, before implementing the mitigation actions, the risk management team can conduct a cost-benefit analysis with help from the factors related to the profit impact (see Paper 2 regarding the risk sources framework). For instance, if the risk level is high, it is worth making large investments in, for example, expensive training, provided the profit impact is also high. Finally, the research also provides a set of lessons drawn from the two-year offshoring study, which should be considered at the beginning of a production transfer.

Third, the PhD research focused on providing a detailed and validated procedure for the *transfer preparation* phase, as most of the abovementioned preventive actions will be implemented during this phase. The procedure was validated by implementing it during the transfer of electronics from Norway to Spain, and by iteratively refining it with the sender and receiver. Thus, the proposed procedure is based on both transfer parties' perspectives. To this end, I organised nineteen workshops with the transfer personnel. Moreover, at the end of the refinement process, I conducted an evaluation of the users' experience with the procedure. Key informants from both transfer parties reported that the transfer procedure and its implementation with the help of an action plan (see the action plan example in Table 6, Subchapter 3.3.1) were useful, and had a positive impact on the efficiency of the transfer. The sender's informants reported that the start-up phase had been shorter, and the on-time delivery and the percentage of quality nonconformances during the start-up had been better than during earlier transfers. The transfer procedure ensured that important preventive actions were implemented, reducing the amount of disruptions. The receiver's informants reported that the tempo of the transfer was considerably faster, and the sender's assistance was more substantial and timelier than during another transfer that they were conducting without applying the procedure. Finally, the procedure was validated by transfer practitioners outside the main case company, who applied it to transfers of food, maritime technology and aircraft production, with which they had worked. Despite differences between the transfer examples, each practitioner evaluated 94.62% of the actions as relevant.

The procedure should aid the senders and receivers when preparing the transfer action plan and should support transfer risk mitigation. Apart from an example of a transfer action plan, the research provides a model that can be used to introduce the production transfer process (depicted as a house in Figure 11). This model should foster a common understanding among the sender and receiver's personnel of the main types of preventive actions and the relationship between them, and is one of the results of the two-year study. For instance, the framework can be used to emphasise that the organisation and project management and quality management actions are fundamental for the success of a production transfer. Even though they might not be regarded as indispensable for the ability to produce during the start-up phase, they facilitate the execution of those actions that are considered as indispensable. Thus, the transfer parties should make sure to allocate sufficient resources to all the categories of preventive actions. For instance, an electronic repository that contains all the necessary transfer documentation and is rigorously used by the transfer personnel should be a minimum requirement for a smooth transfer of administrative systems. This can significantly mitigate the risk of schedule disruptions and of needless costs caused by, for example, late or missing documentation. Finally, the research presents how the production transfer procedure can be integrated into one of the possible relocation processes, the production outsourcing.

6. Conclusion

This chapter marks the end of this dissertation by presenting a summary of the main results and concluding remarks. Finally, the limitations of the research are highlighted, and intriguing avenues of future research are proposed.

6.1. Summary and Concluding Remarks

The purpose of this research has been to investigate how production transfer processes can be conducted in order to mitigate the transfer risk, and to develop a procedure for efficient production transfers. The research strategy has been design science, a strategy that is recommended both for the development of procedures with enhanced practical relevance and for the development of theory. As design science is a multi-method strategy, this research combined systematic literature reviews, production transfer studies, a longitudinal field study and action research. The main production transfer in the longitudinal field study is a transfer of electronics from a Norwegian producer to their subsidiary in Spain. The production transfer procedure was implemented during this ongoing transfer, and iteratively refined and validated together with both transfer parties, over a two-year period. Moreover, I organised an international workshop to validate the applicability of the procedure for other types of industries. Three practitioners reviewed and confirmed the applicability of the procedure for three transfers with which they had worked. In total, I studied eight transfers, including five transfers of electronics at the Norwegian electronics producer, one transfer of food production, one of maritime technology and one of aircraft production.

The main theoretical contributions of the research include an increased knowledge of potential transfer risk sources, as well as an increased knowledge of facilitators of efficient production transfer processes. Moreover, the research provides a thoroughly validated procedure that supports transfer risk mitigation and facilitates efficient management of the transfer process, from initialisation to full-scale and stable production. These contributions are positioned within the field of operations management of multisite production networks.

In response to the first research question—'What are the potential risk sources when transferring production?'—this thesis proposes a framework of transfer risk sources. This framework includes a set of 46 literature-based risk sources, which alone or in combination with other risk sources have the intrinsic potential to give rise to disruptions during production transfers. The transfer risk sources are divided into the following categories: (i) *transfer object* (e.g. the risk that the tacit knowledge about the production activities that are transferred is difficult to codify and document), (ii) *receiver* (e.g. the risk of high employee-turnover rate), (iii) *sender-receiver relationship* (e.g. the risk when the bargaining powers of the sender and receiver are unbalanced) and (iv) *the transfer's impact on the business profit* (e.g. the risk when the volume of goods that will be produced by the receiver is low compared to their remaining portfolio). This framework can be applied during the risk identification process. During the risk identification, a risk management team with members from both transfer parties should identify potential transfer risk sources, the disruptions that these risk sources may trigger and potential losses. This research indicates how the risk identification can be conducted by applying the framework in a production transfer during an offshoring project. Thereafter, the team should assess the risk level of the potential disruptions that they identified, based on estimations of the likelihood of each disruption and its negative impact on transfer performance. This research also provides an overview of potential disruptions and losses, and examples of disruption scenarios from the longitudinal field study, which the team can use during the risk identification and assessment.

In response to the second research question—'What are the facilitators of efficient production transfers?'—this research proposes a framework of facilitators of efficient production transfers. The framework includes a set of 40 facilitators that are divided into the three main transfer phases: (i) *preparation* (e.g. the receiver should review the documentation from the sender to identify any missing information), (ii) *execution* (e.g. the sender should temporarily transfer experienced production personnel to the receiver to facilitate the transfer of tacit knowledge) and (iii) *start-up* (e.g. the sender should transfer the production stepwise in order to enable the receiver to increase the production volumes incrementally). Moreover, the framework includes facilitators of efficient relationship management throughout the transfer (e.g. the sender and receiver should hold regular status meetings). This framework can be applied during the risk mitigation process. During this process, the risk management team should identify actions aimed at mitigating the risk of those disruptions that they assessed as having an unacceptable risk level. Risk mitigation strategies include implementing preventive actions to reduce the likelihood of disruptions and implementing corrective actions to reduce the negative consequences of those disruptions that could not be avoided. This research indicates how the facilitators of efficient production transfers can act as preventive actions by applying the framework in two transfers during outsourcing projects. In addition, the research also provides an overview of potential corrective actions and a set of lessons learned that should also be considered during risk mitigation, based on the longitudinal field study (e.g. 'The more significant the changes applied to the transferred production, the higher the risk level and the longer the transfer process.').

In response to the third research question—'What are the main actions in a production transfer procedure that aids transfer risk mitigation?'—the PhD research primarily provides a detailed and thoroughly validated procedure for the preparation phase that includes preventive actions. This procedure is based on the framework of facilitators of efficient production transfers, which was implemented during the ongoing electronics transfer from Norway to Spain, and iteratively refined with the transfer parties. This research focused on the preparation phase, as the actions implemented during this phase have a high potential to prevent the occurrence of disruptions and losses during the execution and start-up phases. At the end of the ongoing transfer, I conducted a user experience evaluation. The sender and receiver confirmed that the procedure had a positive impact on the efficiency of the transfer. The amount of disruptions was reduced, the start-up time was shorter, and both the on-time delivery and the product quality were better compared to earlier transfers. In addition, the practitioners at the international workshop that I organised confirmed that the procedure was useful for production transfers within other types of industries. The procedure includes 37 preventive actions that were refined with the transfer parties. The preventive actions are divided into the following categories: (i) *organisation and project management* (e.g. the transfer parties agree on transfer performance indicators and their continuous monitoring), (ii) *sourcing* (e.g. the transfer parties verify transportation requirements such as customs requirements and trade agreements that are applicable when delivering goods from the receiver vs. the sender), (iii) *quality management* (e.g. the sender evaluates the receiver's readiness with regards to facilities, equipment and support services), (iv) *process technology* (e.g. the receiver pilots and validates any design change on the process technology to identify any necessary adaptations), (v) *test* (e.g. the sender sends personnel to the receiver to perform training on testing methods), (vi) *production* (e.g. the sender verifies the knowledge transfer at the receiver, for instance by checking the transfer documentation and testing the personnel), (vii) *plan for ERP set-up* (e.g. the transfer parties update the bill of materials, inventory policies, capacities, etc., in their ERP systems) and (viii) *HSE* (e.g. the sender provides to the receiver HSE information about the transferred production activities, such as material safety data sheets, and information about risk mitigation actions and waste management). The procedure should aid the transfer parties during the risk mitigation process and when preparing the transfer action plan.

Based on the cases studied during the PhD research, examples of transfers when these contributions should be particularly important include (transfers) when the receiver is located far away from the sender, when the sender applies design changes to the products that are planned for transfer, when the transferred production activities involve a great amount of tacit knowledge, when the receiver has little experience with the transferred production activities, and when the receiver replaces the sender's sub-supplier with local subsuppliers. These types of transfers can lead to disruptions such as supply disruptions (e.g. material shortages and significant schedule disruptions), operational disruptions (e.g. quality nonconformances) and eventually significant material losses (e.g., scrap and excessive inventory). These contributions will aid practitioners at both senders and receivers to manage such situations, and production transfers in general, in a better way. Thus, this research can facilitate efficient production transfers during relocation processes such as offshoring and outsourcing.

6.2. Research Limitations

The production transfer procedure was implemented during a production transfer from the Electronics industry, which I studied in-depth for over two years (2016–2018). However, each production transfer is different; hence one of the main limitations of this research is that the procedure was implemented during only one production transfer, which restricts the extent to which the findings can be applied to settings other than the case. The findings from longitudinal studies cannot be generalised in the statistical sense. However, this is not the aim (Spencer and Dale, 1979). The ability to generalise rather depends on the quality of the corroboration process, and, particularly, on how well the collected empirical and theoretical evidence supports the findings (ibid.). The general value of the findings will increase if they can be supported by observations from existing theory and/or from other cases (Karlsson, 2009, Holmström et al., 2009). The research findings were systematically compared with the earlier research on the topic of production relocation, and significant similarities and differences were highlighted. In addition, as recommended by Holmström (in Kaipia et al., 2017), the co-authors and I paid attention to describing the design science research process and the results in a detailed manner, in order to support the researchers and practitioners who want to (further) validate or use the transfer preparation procedure in Paper 5, as well as the frameworks from Papers 2, 3, 4 and 6. Moreover, apart from the production transfer that was studied longitudinally, the sender at the main case company had conducted nineteen other production transfers, and on numerous occasions, the informants compared happenings during the longitudinal study with other production transfers with which they had worked, hence providing rich and interesting empirical evidence. Papers 1, 3, 4, 5 and 6 address four of these production transfers. These transfers include two outsourcing processes to a domestic electronics supplier in Norway with broad experience with the transferred production, and two offshoring processes to the same subsidiary in Spain as in the longitudinal study. The offshoring processes involved one completed transfer of a relatively simple sub-assembly and one ongoing transfer of an end-of-life product. In addition, during an international workshop, transfer practitioners corroborated that the production transfer procedure was relevant for different types of manufacturing industries and production relocations. For instance, the procedure can be useful for both offshoring and outsourcing projects, and for the transfer of both simple and complex production activities. However, this thesis only presents the results from the evaluation of the procedure for the preparation phase of a production transfer (see Subchapter 3.3).

Furthermore, the external validation of the transfer preparation procedure by only three practitioners outside the main case company can be also regarded as a limitation. A large survey study could have been conducted with transfer practitioners from different companies for a more extensive external validation and for the development of a formal representation of the procedure (as recommended by Holmström et al., 2009). Finally, the effects of the production transfer procedure on the transfer performance were only evaluated through a questionnaire and interviews of key transfer personnel, during a user experience evaluation and throughout the transfer. A set of performance indicators could have been continuously monitored along the entire production transfer, and compared to a reference level, for example, the performance during a similar production transfer.

6.3. Future Research

Future research can continue to investigate how production transfer processes should be conducted in order to mitigate the transfer risk and facilitate successful production relocations. Companies are expected to continue to relocate production in the future due to the increasingly shifting global conditions regarding access to advanced technology, skills, low production cost and markets in light of growing environmental requirements (Dachs et al., 2019, ManuFuture-EU, 2019, Heikkilä et al., 2017, De Backer and Flaig, 2017). Moreover, the digital transformation trend plays a central role in the future of production relocations.

Innovative communication and monitoring technologies facilitate the management of globally distributed activities within production networks.

(De Backer and Flaig, 2017, ManuFuture-EU, 2019)

This PhD research contributes to an increased knowledge of potential transfer risk sources, and of facilitators of efficient production transfers. Moreover, it provides a thoroughly validated and detailed transfer preparation procedure. The transfer procedure had a positive impact on the efficiency of the production transfer during which it was implemented and was validated as relevant for different types of transfers. I argue that this should motivate a series of studies of intriguing research areas in the future.

First, I have primarily conducted this research in the electronics industry. Future research should implement and further validate the transfer preparation procedure, and the proposed frameworks (i.e. the frameworks of transfer risk sources, disruptions, losses, preventive and corrective actions and the framework of facilitators of efficient production transfers for the execution and start-up phases), in other production contexts. The researchers can for instance explore whether certain types of preventive actions in the transfer preparation procedure are more relevant during transfers with high risk level and/or high profit impact than during production transfers with low risk level and/or low profit impact. Moreover, the transfer procedure can be implemented during outsourcing, offshore-outsourcing and reshoring projects, as well as in special cases such as when the sender's facility is to be closed down.

Second, the 'lessons learned' from Paper 4 also merit further investigation during different production transfers. For instance, future studies could investigate to what extent cross-locational project management is a facilitator of efficient production transfers. Another interesting question is whether adapting the transferred product/processes to the receiver's production environment is a facilitator or an inhibitor of efficient transfers.

Third, a large survey can be conducted with production transfer practitioners from various companies, who should further validate the relevance of the transfer preparation procedure and of the proposed frameworks.

Fourth, the benefits of advanced process simulation technologies should be investigated (e.g., Tao et al., 2018, Leng et al., 2019), as they provide opportunities for modelling, dynamically simulating and monitoring in real-time the impact of the production transfer on the production environment at the sender and the receiver.

Finally, I contend that the topic of pandemic and epidemic risk management prior, during and after production transfers is an extremely intriguing avenue for future research. Potential disruptions that can be addressed include supply shortages and price escalations, transportation disruptions, work force absenteeism, supplier and sub-supplier bankruptcy, schedule disruptions, ICT system disruptions and cyber-attacks.

References

AABOEN, L. & FREDRIKSSON, A. 2016. The relationship development aspect of production transfer. *Journal of Purchasing and Supply Management,* 22**,** 53-65.

ALFNES, E. & NTNU. 2006. *Enterprise Reengineering – A Strategic Framework and Methodology.* PhD thesis Norges Teknisk-Naturvitenskapelige Universitet, Fakultet for ingeniørvitenskap og teknologi.

ALMGREN, H. 1999. Start-up of advanced manufacturing systems - a case study. *Integrated Manufacturing Systems,* 10**,** 126-135.

ANDRE, M. & PETER, B. 2012. Towards a framework for transferring technology knowledge between facilities. *Strategic Outsourcing: An International Journal,* 5**,** 213-231.

ARGOTE, L., MCEVILY, B. & REAGANS, R. 2003. Managing knowledge in organizations: An integrative framework and review of emerging themes. *Management science,* 49**,** 571-582.

AWASTHI, A., GOVINDAN, K. & GOLD, S. 2018. Multi-tier sustainable global supplier selection using a fuzzy AHP-VIKOR based approach. *International Journal of Production Economics,* 195**,** 106-117.

BARNEY, J. B. 1991. The resource based view of strategy: Origins, implications, and prospects. *Journal of management,* 17**,** 97-211.

BECKMAN, S. L. & ROSENFIELD, D. B. 2008. *Operations strategy: competing in the 21st century,* Boston, McGraw-Hill/Irwin.

BOCQUET, R. 2011. Product and Process Innovations in Subcontracting: Empirical Evidence from the French "Sillon Alpin". *Industry and Innovation,* 18**,** 649-668.

BODE, C. & WAGNER, S. M. 2009. Risk and security–A logistics service industry perspective. *Managing risk and security. The safeguard of long-term success for logistics service providers***,** 1-30.

BRANDES, H., LILLIECREUTZ, J. & BREGE, S. 1997. Outsourcing—success or failure?: Findings from five case studies. *European Journal of Purchasing & Supply Management,* 3**,** 63-75.

BUSI, M. & MCIVOR, R. 2008. Setting the outsourcing research agenda: the top-10 most urgent outsourcing areas. *Strategic Outsourcing: An International Journal,* 1**,** 185-197.

CÁNEZ, L. E., PLATTS, K. W. & PROBERT, D. R. 2000. Developing a framework for make-or-buy decisions. *International Journal of Operations & Production Management*.

CHENG, Y., MADSEN, E. S. & JIRAPHA, L. 2010. Transferring knowledge in the relocation of manufacturing units. *Strategic Outsourcing: an International Journal,* 3**,** 5-19.

CHOPRA, S. & MEINDL, P. 2013. *Supply chain management : strategy, planning, and operation,* Boston, Pearson.

CHOPRA, S. & SODHI, M. 2004. Supply-chain breakdown. *MIT Sloan management review,* 46**,** 53-61.

COASE, R. H. 1991. The nature of the firm (1937). *The Nature of the Firm. Origins, Evolution, and Development. New York, Oxford***,** 18-33.

COUGHLAN, P. & COGHLAN, D. 2002. Action research for operations management. *International journal of operations & production management,* 22**,** 220-240.
COUSINS, P., LAMMING, R., LAWSON, B. & SQUIRE, B. 2008. *Strategic supply management: principles, theories and practice*, Pearson Education.
DACHS, B., KINKEL, S., JÄGER, A. & PALČIČ, I. 2019. Backshoring of production activities in European manufacturing. *Journal of Purchasing and Supply Management,* 25**,** 100531.
DACHS, B. & ZANKER, C. 2015. Backshoring of production activities in European manufacturing.
DANILOVIC, M. & WINROTH, M. 2005. A tentative framework for analyzing integration in collaborative manufacturing network settings: a case study. *Journal of Engineering and Technology Management,* 22**,** 141-158.
DE BACKER, K. & FLAIG, D. 2017. The future of global value chains: Business as usual or "a new normal"?
DE BACKER, K., MENON, C., DESNOYERS-JAMES, I. & MOUSSIEGT, L. 2016. Reshoring: Myth or reality?
DICTIONARY, C. 2020a. Cambridge University Press Available: https://dictionary.cambridge.org/dictionary/english/project [Accessed March 12th 2020].
DICTIONARY, O. 2020b. *Oxford Languages* [Online]. Available: https://www.oxfordlearnersdictionaries.com/definition/english/action_1?q=action [Accessed September 12th 2020].
DICTIONARY, O. E. 2020c. *Lexico* [Online]. Available: https://www.lexico.com/en/definition/facilitator [Accessed March 12th 2020].
DUDLEY, JR. 2006. Successful technology transfer requires more than technical know-how - Frequent and open communication is a necessity in successful technology transfer. *Biopharm. Int.,* 19**,** 68-+.
DUNNING, J. H. 1979. Explaining changing patterns of international production: in defence of the eclectic theory. *Oxford bulletin of economics and statistics,* 41**,** 269-295.
EISENHARDT, K. M. 1989a. Agency theory: An assessment and review. *Academy of management review,* 14**,** 57-74.
EISENHARDT, K. M. 1989b. Building theories from case study research. *Academy of management review,* 14**,** 532-550.
FAN, Y. & STEVENSON, M. 2018. A review of supply chain risk management: definition, theory, and research agenda. *International Journal of Physical Distribution & Logistics Management*.
FERDOWS, K. 2006. Transfer of Changing Production Know-How. *Production and Operations Management,* 15**,** 1-9.
FRANCESCHINI, F., GALETTO, M., PIGNATELLI, A. & VARETTO, M. 2003. Outsourcing: guidelines for a structured approach. *Benchmarking: an international journal*.
FRATOCCHI, L., DI MAURO, C., BARBIERI, P., NASSIMBENI, G. & ZANONI, A. 2014. When manufacturing moves back: Concepts and questions. *Journal of Purchasing and Supply Management,* 20**,** 54-59.
FREDRIKSSON, A. 2011. *Materials supply and production outsourcing*, Chalmers University of Technology.

FREDRIKSSON, A. & JONSSON, P. 2019. The impact of knowledge properties on international manufacturing transfer performance. *Production Planning & Control,* 30**,** 197-210.

FREDRIKSSON, A., MALM, A. & SKOV MADSEN, E. 2019. Technology transfer as a part of the business–inter-organizational transfer strategies based on experiences of aircraft production. *Journal of Global Operations and Strategic Sourcing,* 12**,** 151-171.

FREDRIKSSON, A. & WÄNSTRÖM, C. 2014. Manufacturing and supply chain flexibility–towards a tool to analyse production network coordination at operational level. *Strategic Outsourcing: An International Journal,* 7**,** 173-194.

FREDRIKSSON, A., WÄNSTRÖM, C., JOHANSSON, M. I. & MEDBO, L. 2015. A structured procedure for materials planning during production transfer. *Production Planning & Control,* 26**,** 738-752.

FREDRIKSSON, A., WÄNSTRÖM, C. & MEDBO, L. 2014. Assuring materials availability during the production transfer process; Critical characteristics of the materials planning environment. *Journal of Manufacturing Technology Management,* 25**,** 310-333.

GALBRAITH, C. & GALBRAITH, C. 1990. Transferring Core Manufacturing Technologies in High-Technology Firms. *California Management Review,* 32**,** 56-56.

GERO, W. & STEFAN, S. 2009. Performance measurement in business process outsourcing decisions; Insights from four case studies. *Strategic Outsourcing: An International Journal,* 2**,** 275-292.

GRANT, E. & GREGORY, M. 1997. Adapting manufacturing processes for international transfer. *International Journal of Operations & Production Management,* 17**,** 994-1005.

GRANT, R. M. 1996a. Prospering in dynamically-competitive environments: Organizational capability as knowledge integration. *Organization science,* 7**,** 375-387.

GRANT, R. M. 1996b. Toward a knowledge-based theory of the firm. *Strategic management journal,* 17**,** 109-122.

GREGOR, S. & HEVNER, A. R. 2013. Positioning and presenting design science research for maximum impact. *MIS quarterly,* 37.

HAMEL, G. & PRAHALAD, C. K. 1994. Competing for the future. *Harvard business review,* 72**,** 122-128.

HANDLEY, S. M. & GRAY, J. V. 2013. Inter-organizational quality management: The use of contractual incentives and monitoring mechanisms with outsourced manufacturing. *Production and Operations Management,* 22**,** 1540-1556.

HEIKKILÄ, J., OLHAGER, J., MARTINSUO, M., LAINE, T., SUOMALA, P., JOHANSSON, M., NENONEN, S., VALKONEN, T., SAUKKONEN, N. & CHAOJI, P. 2017. Relocation of Nordic Manufacturing. Tampere University of Technology. Industrial and Information Management.

HILLETOFTH, P., WLAZLAK, P., JOHANSSON, G. & SÄFSTEN, K. Challenges With Industrialization In a Supply Chain Network: A Supplier Perspective. Management, Knowledge and Learning-Joint International Conference 2015 Bari, Italy.

HOLMSTRÖM, J., KETOKIVI, M. & HAMERI, A. P. 2009. Bridging Practice and Theory: A Design Science Approach. *Decision Sciences,* 40**,** 65-87.

ISO. 2009a. *ISO 31000:2009 Risk management — Principles and guidelines* [Online]. Available: https://www.iso.org/standard/43170.html [Accessed January 31th 2016].

ISO 2018a. Risk Management - Guidelines. Switzerland: International Standard Organization.

ISO. 2018b. *Risk management - ISO 31000* [Online]. International Organization for Standardization. Available: https://www.iso.org/files/live/sites/isoorg/files/store/en/PUB100426.pdf [Accessed March 9th 2020].

ISO, I. 2009b. 31000: 2009 Risk management–Principles and guidelines. *International Organization for Standardization, Geneva, Switzerland*.

KAIPIA, R., HOLMSTRÖM, J., SMÅROS, J. & RAJALA, R. 2017. Information sharing for sales and operations planning: Contextualized solutions and mechanisms. *Journal of Operations Management,* 52**,** 15-29.

KARLSSON, C. 2009. Researching operations management. New York: Routledge.

KERN, D., MOSER, R., HARTMANN, E. & MODER, M. 2012. Supply risk management: model development and empirical analysis. *International Journal of Physical Distribution & Logistics Management,* 42**,** 60-82.

KINKEL, S. & MALOCA, S. 2009. Drivers and antecedents of manufacturing offshoring and backshoring-A German perspective. *Journal of Purchasing and Supply Management,* 15**,** 154-165.

KLEINDORFER, P. R., SINGHAL, K. & VAN WASSENHOVE, L. N. 2005. Sustainable operations management. *Production and Operations Management,* 14**,** 482-492.

KOGUT, B. & ZANDER, U. 1992. Knowledge of the firm, combinative capabilities, and the replication of technology. *Organization science,* 3**,** 383-397.

KOWALSKI, A., CHLEBUS, T. & SERWATKA, K. 2018. Technical aspects of relocation of production and assembly lines in automotive industry. *Topics in Intelligent Computing and Industry Design,* 1**,** 111-117.

KRALJIC, P. 1983. Purchasing must become supply management. *Harvard business review,* 61**,** 109-117.

KREMIC, T., ICMELI TUKEL, O. & ROM, W. O. 2006. Outsourcing decision support: a survey of benefits, risks, and decision factors. *Supply Chain Management: an international journal,* 11**,** 467-482.

KUMAR, K., VAN FENEMA, P. C. & VON GLINOW, M. A. 2009. Offshoring and the global distribution of work: Implications for task interdependence theory and practice. *Journal of International Business Studies,* 40**,** 642-667.

LENG, J., ZHANG, H., YAN, D., LIU, Q., CHEN, X. & ZHANG, D. 2019. Digital twin-driven manufacturing cyber-physical system for parallel controlling of smart workshop. *Journal of ambient intelligence and humanized computing,* 10**,** 1155-1166.

LEVITT, B. & MARCH, J. G. 1988. Organizational learning. *Annual review of sociology,* 14**,** 319-338.

LOERTSCHER, S. & RIORDAN, M. H. 2019. Make and buy: Outsourcing, vertical integration, and cost reduction. *American Economic Journal: Microeconomics,* 11**,** 105-23.

MADSEN, E. S. 2009. *Knowledge transfer in global production: The use of didactics and learning to transfer and to share tacit knowledge on the shop floor in a manufacturing environment*, Syddansk Universitet. Det Tekniske Fakultet.

MALM, A. 2013. *Important Factors in the Transfer of Aircraft Production: Challenges Related to Offset Business*, Linköping University.

MALM, A. 2016. *Technology Transfer within Related Offset Business: From an Aircraft Production Perspective.* Linköping University Electronic Press.

MALM, A. M., FREDRIKSSON, A. & JOHANSEN, K. 2016. Bridging capability gaps in technology transfers within related offsets. *Journal of Manufacturing Technology Management,* 27**,** 640-661.

MANUFUTURE-EU. 2019. *Strategic Research and Innovation Agenda 2030 (SRIA)* [Online]. Available: http://www.manufuture.org/wp-content/uploads/ManuFUTURE_SRIA_2030_Vfinal.pdf [Accessed May 2nd 2020].

MANUJ, I. & MENTZER, J. T. 2008. Global supply chain risk management. *Journal of business logistics,* 29**,** 133-155.

MCBEATH, A. & BALL, P. 2012. Towards a framework for transferring technology knowledge between facilities. *Strategic Outsourcing: An International Journal,* 5**,** 213-231.

MCCORMACK, K., WILKERSON, T., MARROW, D., DAVEY, M., SHAH, M. & YEE, D. 2008. Managing risk in your organization with the SCOR methodology. *The Supply Chain Council Risk Research Team***,** 1-32.

MCIVOR, R. 2000. A practical framework for understanding the outsourcing process. *Supply Chain Management: an international journal*.

MCIVOR, R. 2009. How the transaction cost and resource-based theories of the firm inform outsourcing evaluation. *Journal of Operations management,* 27**,** 45-63.

MIHALACHE, M. & MIHALACHE, O. R. 2016. A decisional framework of offshoring: Integrating insights from 25 years of research to provide direction for future. *Decision Sciences,* 47**,** 1103-1149.

MINSHALL, T. 1999. *Manufacturing mobility: a strategic guide to transferring manufacturing capability*, University of Cambridge Institute of Manufacturing.

MODI, S. B. & MABERT, V. A. 2007. Supplier development: Improving supplier performance through knowledge transfer. *Journal of Operations Management,* 25**,** 42-64.

MOHER, D., LIBERATI, A., TETZLAFF, J., ALTMAN, D. G. & GROUP, P. 2009. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *PLoS med,* 6**,** e1000097.

MOMME, J. & HVOLBY, H.-H. 2002. An outsourcing framework: action research in the heavy industry sector. *European Journal of Purchasing & Supply Management,* 8**,** 185-196.

MONOSTORI, L., KÁDÁR, B., BAUERNHANSL, T., KONDOH, S., KUMARA, S., REINHART, G., SAUER, O., SCHUH, G., SIHN, W. & UEDA, K. 2016. Cyber-physical systems in manufacturing. *CIRP Annals,* 65**,** 621-641.

MOSES, A. 2009. *Designing and managing cross-functional make or buy decision processes*, Chalmers University of Technology.

MUKHERJEE, D., LAHIRI, S., ASH, S. R. & GAUR, A. S. 2019. Search motives, local embeddedness, and knowledge outcomes in offshoring. *Journal of Business Research,* 103**,** 365-375.

MYKHAYLENKO, A., MOTIKA, Á., WAEHRENS, B. V. & SLEPNIOV, D. 2015. Accessing offshoring advantages: what and how to offshore. *Strategic Outsourcing: An International Journal,* 8**,** 262-283.

NORRMAN, A. & JANSSON, U. 2004. Ericsson's proactive supply chain risk management approach after a serious sub-supplier accident. *International Journal of Physical Distribution & Logistics Management,* 34**,** 434-456.

OOSTERHUIS, M., VAN DER VAART, T. & MOLLEMAN, E. 2011. Perceptions of technology uncertainty and the consequences for performance in buyer-supplier relationships. *International Journal of Production Research,* 49**,** 6155-6173.

PENROSE, E. 1959. The theory ofthe growth ofthe firm. *JohnW iley& Sons, New York*.

PLATTS, K., PROBERT, D. & CANEZ, L. 2002. Make vs. buy decisions: A process incorporating multi-attribute decision-making. *International Journal of Production Economics,* 77**,** 247-257.

PROBERT, D. R. 1996. The practical development of a make or buy strategy: the issue of process positioning. *Integrated Manufacturing Systems*.

RAUSAND, M. 2013. *Risk assessment: theory, methods, and applications*, John Wiley & Sons.

REHME, J., NORDIGÅRDEN, D., BREGE, S. & CHICKSAND, D. 2013. Outsourcing to a non-developed supplier market: The importance of operational aspects in outsourcing. *Journal of Purchasing and Supply Management,* 19**,** 227-237.

RINDFLEISCH, A. 2019. Transaction cost theory: past, present and future. *AMS Review***,** 1-13.

RUDBERG, M. & OLHAGER, J. 2003. Manufacturing networks and supply chains: an operations strategy perspective. *Omega,* 31**,** 29-39.

SEMINI, M., SJØBAKK, B. & ALFNES, E. 2013. What to Offshore, What to Produce at Home? A Methodology. *Advances in Production Management Systems. Competitive Manufacturing for Innovative Products and Services.* Springer.

SLACK, N., CHAMBERS, S. & JOHNSTON, R. 2010. *Operations management*, Pearson education.

SLEPNIOV, D. & WAEHRENS, B. V. 2008. Offshore outsourcing of production. *Strategic Outsourcing: An International Journal*.

SPENCER, L. & DALE, A. 1979. Integration and regulation in organizations: A contextual approach. *The Sociological Review,* 27**,** 679-702.

STENTOFT, J., MIKKELSEN, O. S. & JOHNSEN, T. E. Going local: a trend towards insourcing of production? Supply Chain Forum: An International Journal, 2015. Taylor & Francis, 2-13.

STOCK, G. N. & TATIKONDA, M. V. 2000. A typology of project-level technology transfer processes. *Journal of Operations Management,* 18**,** 719-737.

TAO, F., CHENG, J., QI, Q., ZHANG, M., ZHANG, H. & SUI, F. 2018. Digital twin-driven product design, manufacturing and service with big data. *The International Journal of Advanced Manufacturing Technology,* 94**,** 3563-3576.

TATIKONDA, M. & STOCK, G. 2003. Product technology transfer in the upstream supply chain. *J. Prod. Innov. Manage.,* 20**,** 444-467.

TERWIESCH, C., BOHN, R. E. & CHEA, K. S. 2001. International product transfer and production ramp-up: A case study from the data storage industry. *R and D Management,* 31**,** 435-451.

THOMPSON, J. D. 1967. Organizations in action. New York: McGraw-Hill. *ThompsonOrganizations in Action1967*.

TSAY, A. A., GRAY, J. V., NOH, I. J. & MAHONEY, J. T. 2018. A review of production and operations management research on outsourcing in supply chains: Implications for the theory of the firm. *Production and Operations Management,* 27**,** 1177-1220.

VAN AKEN, J. E. & ROMME, G. 2009. Reinventing the future: adding design science to the repertoire of organization and management studies. *Organization Management Journal,* 6**,** 5-12.

VAN DE VEN, A. H., DELBECQ, A. L. & KOENIG JR, R. 1976. Determinants of coordination modes within organizations. *American sociological review***,** 322-338.

VITASEK, K. & MANRODT, K. 2012. Vested outsourcing: a flexible framework for collaborative outsourcing. *Strategic Outsourcing: An International Journal,* 5**,** 4-14.

VON HIPPEL, E. 1994. "Sticky information" and the locus of problem solving: implications for innovation. *Management science,* 40**,** 429-439.

WEIMER, G. & SEURING, S. 2008. Information needs in the outsourcing lifecycle. *Industrial Management & Data Systems*.

WHO. 2011. *WHO expert committee on specifications for pharmaceutical preparations. Forti-fifth Report; Annex 7-WHO guidelines on transfer of technology in pharmaceutical manufacturing* [Online]. Available: http://apps.who.int/medicinedocs/documents/s18652en/s18652en.pdf [Accessed June 1st 2015].

WILLIAMSON, O. E. 1975. Markets and hierarchies. *New York,* 2630.

YIN, R. K. 2004. *The Case study anthology,* Thousand Oaks, Calif, Sage.

ZENG, A. Z. 2003. Global sourcing: process and design for efficient management. *Supply Chain Management: An International Journal,* 8**,** 367-379.

ZHEN, X., LI, Y., CAI, G. G. & SHI, D. 2016. Transportation disruption risk management: business interruption insurance and backup transportation. *Transportation Research Part E: Logistics and Transportation Review,* 90**,** 51-68.

ZHU, Z., HSU, K., LILLIE, J. & ZHU, Z. 2001. Outsourcing - a strategic move: the process and the ingredients for success. *Management Decision,* 39**,** 373-378.

ZSIDISIN, G. A., ELLRAM, L. M., CARTER, J. R. & CAVINATO, J. L. 2004. An analysis of supply risk assessment techniques. *International Journal of Physical Distribution & Logistics Management*.

Appendix 1

Seminal papers for the PhD research:

No	Year	Reference	Title	Journal/publisher	Research area	Method
1.	1990	Galbraith, C.	Transferring core manufacturing technologies in high-technology firms	*California Management Review*	Manufacturing strategy/ technology transfer	Survey
2.	1997	Grant, E. & Gregory, M	Adapting manufacturing processes for international transfer	*International Journal of Operations and Production Management*	Operations management; production transfer	Single case study
3.	1997	Grant, E. & Gregory, M	Tacit knowledge, the life cycle and international manufacturing transfer	*Technology Analysis & Strategic Management*	Operations management; production transfer	Multiple case study
4.	1999	Almgren, H.	Start-up of advanced manufacturing systems—a case study	*Integrated Manufacturing Systems*	Production management/start-up	Case study
5.	1999	Almgren, H.	Towards a framework for analyzing efficiency during start-up: an empirical investigation of a Swedish auto manufacturer	*International Journal of Production Economics*	Production management/start-up	Longitudinal field study
6.	1999	Minshall, T	Manufacturing mobility: a strategic guide to transferring manufacturing capability	*University of Cambridge*	Operations management/production transfer	Conceptual

No	Year	Reference	Title	Journal/publisher	Research area	Method
7.	2000	Stock, G.N., Tatikonda, M.V.	A typology of project-level technology transfer processes	*Journal of Operations Management*	Operations management/technology transfer	Conceptual
8.	2001	Terwiesch, C., Bohn, R.E. & Chea, K.S.	International product transfer and production ramp-up: a case study from the data storage industry	*R&D Management*	R&D management/production transfer	Longitudinal field study
9.	2003	Tatikonda, M. & Stock, G.	Product technology transfer in the upstream supply chain	*Journal of Production Innovation Management*	Operations management/technology transfer	Conceptual
10.	2003	Argote, L., McEvily, B. & Reagans, R.	Managing knowledge in organizations: an integrative framework and review of emerging themes	*Management Science*	Organisation management/knowledge transfer	Conceptual
11.	2007	Modi, S.B., Mabert, V.A.	Supplier development: improving supplier performance through knowledge transfer	*Journal of Operations Management*	Operations management/knowledge transfer	Conceptual
12.	2008	Madsen, E.S., Riis, J.O. & Waehrens, B.	The knowledge dimension of manufacturing transfers: a method for identifying hidden knowledge	*Strategic Outsourcing: An International Journal*	Operations management/knowledge transfer	Multiple case study
13.	2009	Madsen, E.S.	Knowledge transfer in global production	*Aalborg University*	Operations management/production transfer	Multiple case study
14.	2010	Cheng, Y., Madsen, E.S. & Jirapha, L.	Transferring knowledge in the relocation of manufacturing units	*Strategic Outsourcing: An International Journal*	Operations management/knowledge transfer	Multiple case study

No	Year	Reference	Title	Journal/publisher	Research area	Method
15.	2011	Fredriksson, A	Materials supply and production outsourcing	*Chalmers University of Technology*	Operations managements/supply chain management/production transfer	Multiple case study
16.	2011	WHO	WHO Expert Committee on Specifications for Pharmaceutical Preparations	*WHO Technical Report Series*	NA/ Production transfer	NA
17.	2012	McBeath, A. & Ball, P.	Towards a framework for transferring technology knowledge between facilities	*Strategic Outsourcing: An International Journal*	Operations management/knowledge transfer	Survey
18.	2013	Malm, A	Important factors in the transfer of aircraft production: challenges related to offset business	*Linköping University*	Operations management/production transfer	Longitudinal field study
19.	2014	Fredriksson, A. & Wänström, C.	Manufacturing and supply chain flexibility towards a tool to analyse production network coordination at operational level	*Strategic Outsourcing: An International Journal*	Operations management/production transfer	Longitudinal field study
20.	2014	Fredriksson, A., Wänström, C. & Medbo, L.	Assuring materials availability during the production transfer process	*Journal of Manufacturing Technology Management*	Operations management/production transfer	Single case study
21.	2015	Fredriksson, A., Wänström, C., Johansson, M.I. & Medbo, L.	A structured procedure for materials planning during production transfer	*Production Planning & Control*	Production management/production transfer	Multiple case study

No	Year	Reference	Title	Journal/publisher	Research area	Method
22.	2016	Aaboen, L. & Fredriksson, A.	The relationship development aspect of production transfer	*Journal of Purchasing and Supply Management*	Supply chain management/operations management/production transfer	Multiple case study
23.	2016	Malm, A, Fredriksson, A. & Johansen, K.	Bridging capability gaps in technology transfers within related offsets	*Journal of Manufacturing Technology Management*	Operations management/technology transfer	Multiple case study
24.	2018	Kowalski, A., Chlebus, T. & Serwatka, K.	Technical aspects of relocation of production and assembly lines in automotive industry.	*Topics in Intelligent Computing and Industry Design*	Production management/production transfer	Single case study

Other relevant papers that the PhD research is based on:

No.	Year	Reference	Title	Journal/publisher
25.	1983	Kraljic, P.	Purchasing must become supply management	*Harvard Business Review*
26.	2000	Dyer, J.H., Nobeoka, K., Gulati, R., Nohria, N. & Zaheer, A.	Creating and managing a high-performance knowledge-sharing network: the Toyota case	*Strategic Management Journal*
27.	2001	Zhu, Z., Hsu, K. & Lillie, J.	Outsourcing—a strategic move: the process and the ingredients for success	*Management Decision*
28.	2002	Momme, J., Hvolby, H.-H.	An outsourcing framework: action research in the heavy industry sector	*European Journal of Purchasing & Supply Management*
29.	2002	Momme, J.	Framework for outsourcing manufacturing: strategic and operational implications	*Computers in Industry*
30.	2002	Steenhuis, H.J. & De Bruijn, E.	Technology transfer and learning	*Technology Analysis & Strategic Management*
31.	2003	Zeng, A.	Global sourcing: process and design for efficient management	*Supply Chain Management*

No.	Year	Reference	Title	Journal/publisher
32.	2003	Franceschini, F., Galetto, M., Pignatelli, A., Varetto, M.	Outsourcing: guidelines for a structured approach	*Benchmarking: An International Journal*
33.	2005	Danilovic, M. & Winroth, M.	A tentative framework for analysing integration in collaborative manufacturing network settings: a case study	*Journal of Engineering and Technology Management*
34.	2006	Tibor, K., Oya Icmeli, T., Walter, O.R.	Outsourcing decision support: a survey of benefits, risks, and decision factors	*Supply Chain Management International Journal*
35.	2006	Dudley, J.R.	Successful technology transfer requires more than technical know-how: frequent and open communication is a necessity in successful technology transfer	*BioPharm International*
36.	2006	Ferdows, K.	Transfer of changing production know-how	*Production and Operations Management*
37.	2006	Alfnes, E.	Enterprise reengineering: a strategic framework and methodology	*Norwegian University of Science and Technology*
38.	2006	Winters, P.M.	Changing your outsourcing partner: how to survive the transition	*Journal of Facilities Management*
39.	2008	Rudberg, M., West, B.M.	Global operations strategy: coordinating manufacturing networks	*Omega-Int. J. Manag. Sci.*
40.	2008	Busi, M. & McIvor, R.	Setting the outsourcing research agenda: the top 10 most urgent outsourcing areas	*Strategic Outsourcing: An International Journal*
41.	2008	Beckman, S.L. & Rosenfield, D.B.	Operations strategy: competing in the 21st century	McGraw-Hill/Irwin
42.	2004	Norrman, A. & Jansson, U	Ericsson's proactive supply chain risk management approach after a serious subsupplier accident	*International Journal of Physical Distribution & Logistics Management*
43.	2004	Chopra & Sodhi	Managing risk to avoid supply-chain breakdown	*MIT Sloan management review*
44.	2008	McCormack, K., Wilkerson, T., Marrow, D.,	Managing risk in your organization with the SCOR methodology	The Supply Chain Council Risk Research Team

No.	Year	Reference	Title	Journal/publisher
		Davey, M., Shah, M. & Yee, D.		
45.	2008	Manuj, I. & Mentzer, J.T.	Global supply chain risk management strategies	*International Journal of Physical Distribution & Logistics Management*
46.	2008	Blackhurst, J., Sheibe, K. & Johnson, D.	Supplier risk assessment and monitoring for the automotive industry	*International Journal of Physical Distribution & Logistics Management*
47.	2008	Bode, C. & Wagner, S. M.	Risk and security: A logistics service industry perspective	*Business Logistics*
48.	2008	Manuj, I. & Menzer, J.T.	Global supply chain risk management	*Journal of Business Logistics*
49.	2009	ISO	ISO 31000: 2009 Risk management—Principles and guidelines	International Organization for Standardization
50.	2012	Kern, D., Moser, R., Hartmann, E. & Moder, M.	Supply risk management: model development and empirical analysis	*International Journal of Physical Distribution & Logistics Management*
51.	2013	Vikram, C.	Managing a supply chain′s web of risk	*Strategy & Leadership*
52.	2013	Rausand, M.	Risk assessment: theory, methods, and applications	John Wiley & Sons
53.	2013	Chopra & Meindl	Supply chain management: strategy, planning, and operation	Pearson
54.	2016	Dimase, D., Collier, Z.A., Carlson, J., Gray, R.B. & Linkov, I.	Traceability and risk analysis strategies for addressing counterfeit electronics in supply chains for complex systems	*Risk Analysis: An International Journal*
55.	2016	Arica, E, Haskins, C. & Strandhagen, J.O.	A framework for production rescheduling in sociotechnical manufacturing environments	*Production Planning & Control*

PART II. The Collection of Papers

Paper 1

Sjøbakk, B., Mogos, M. F. and Magerøy, K. (2016). "Transfer of production to strategic suppliers: a case study", *WIT Transactions on Engineering Sciences*, ISSN 1743-3533, Vol. 113, pp. 279-286.

This is an accepted manuscript of an article published in WIT Transactions on Engineering Sciences. The final authenticated version is available online at: https://www.witpress.com/Secure/elibrary/papers/IWAMA15/IWAMA15032FU1.pdf

Transfer of production to strategic suppliers: a case study

B. Sjøbakk[1], M. F. Mogos[2] & K. Magerøy[1]

[1]*SINTEF Technology and Society, Department of Industrial Management, Norway*
[2]*Department of Production and Quality Engineering, Norwegian University of Science and Technology (NTNU), Norway*
{maria.f.mogos, erlend.alfnes}@ntnu.no

Abstract

To remain competitive, Norwegian suppliers to the maritime industry need to improve the efficiency of their supply chains and production systems without compromising their products' high performance. To free capacity for product innovation and reduce their cost of production, companies may transfer parts of their production to strategic suppliers in their supply chains. However, many businesses do not carry out such transfer processes in a systematic manner owing to a lack of models and tools supporting them in the process. In this paper, insights into a case study are presented for two production transfer processes between a Norwegian supplier of advanced maritime monitoring systems and one of its strategic suppliers. A set of preliminary guidelines for carrying out production transfer processes is proposed based on the case study. The paper is the first step toward developing a model for systematic production transfer processes.

Keywords: *Transfer of production, ramp-up, operations strategy, supply chain collaboration, guidelines, case study.*

1. Introduction

Manufacturing of innovative and technologically advanced products is an area where, traditionally, Norway has been competitive, with a potential for growth. Through access to knowledge and focus on research, development, quality, and performance, Norwegian suppliers to the maritime industry have positioned themselves as leaders within the premium segments of their markets. Here, customers have been willing to pay a higher price than in the volume segments, where competitors in low-cost countries, traditionally, have dominated with less expensive products that have a lower performance. However, in recent years, competitors in low-cost countries have increased their product performance while keeping their costs lower. Consequently, Norwegian suppliers have been forced to lower their margins to remain attractive to their customers. This is not a sustainable solution. To secure the competitiveness of Norwegian suppliers of high-tech, knowledge-intensive products to the maritime industry, there is a need to improve the efficiency of their supply chains and production systems without sacrificing their high product performance.

Many Western companies choose to transfer parts of their production to suppliers to increase their competitiveness. This approach has many stated benefits, such as lower factor costs and access to new materials, distribution channels, and technologies; however, it is associated with substantial risk, and may lead to increased costs and loss of business if it is not carried out carefully and in a systematic manner (Kinkel and Maloca, 2009). Yet, there is a lack of established frameworks focusing on rapid and reliable production transfers.

In this paper, insights into a case study are presented for two production transfer processes between a Norwegian supplier of advanced maritime monitoring systems and one of its strategic suppliers within electronic manufacturing service (EMS). A set of preliminary guidelines for carrying out such transfer processes is proposed based on the case study. The purpose of the research is to help better understand production transfer processes, and the paper is a first step toward developing a model for systematic transfer processes.

2. Research method

When research is of an exploratory nature, and contemporary events are investigated without being able to manipulate behavioral events, case studies are a preferred research method (Yin, 2013). For this particular activity, where production transfer processes of a Norwegian supplier to the maritime industry are explored, the researchers were not able to manipulate any behavior – at least in the short term. Therefore, an instrumental case study approach is adopted. This approach provides insight into a particular issue and can be used to redraw generalizations or build theory (Stake, 2013). The case study has been designed as a single case study as access to adequate empirical data was limited to production transfers within one supplier-buyer relation. However, two transfer processes were followed as this gave multiple sources of evidence and enabled pattern matching, and thereby increased both construct and internal validity (Yin, 2013). The empirical data has been collected through workshops, semi structured interviews, and meetings with key representatives of the case companies, e.g. quality managers, product developers, key account managers, and process engineers.

3. Theoretical background

In this section, key concepts for the topic are defined and a brief overview of earlier studies is provided. Typical challenges for a production transfer process are highlighted.

Production transfer is hereby understood as the preparation, transfer, and start of relocated production, i.e. the relocation of the production of products and components from a sender (the buying company) to a receiver (a supplier). It comprises several types of transfer: transfer of knowledge, physical equipment, administrative systems, and transfer of relationships to different supply chain actors (Fredriksson and Wänström, 2014). The start-up phase, also known as ramp-up phase, lasts until a full-scale production is reached – at targeted levels of cost and quality. It succeeds the process engineering and pilot production phases (Terwiesch et al., 1999). Moreover, the production may be transferred to domestic (nearshore) or offshore suppliers, internally or externally owned (Monczka et al., 2005, Schniederjans et al., 2005).

Sourcing processes are not exempt from challenges, and to benefit from production transfers, one needs to reduce or cope with various types of risks, such as the inability to meet demand on time, the loss of intellectual property, or an increase in transaction costs. Thus, it is important to identify and implement measures to reduce risk level as much as possible (Chopra and Meindl, 2010). Two challenges emphasized by the literature and specific for the ramp-up phase are unforeseeable capacity and quality losses, which are likely to lead to delays and increased costs (Almgren, 1999). Their occurrence and frequency depend on factors like the sourcing experience of the supplier and the buyer; the size and pace of the transfer process; the amount of tacit knowledge to be transferred; the degree of adaptation of the production process or the product to the new context; the degree of technological complexity and maturity; and second-tier suppliers (Fredriksson, 2011).

Several studies about supplier relationships for the manufacturing of high-tech and core products highlight the advantages of a partnership model with strategic suppliers characterized by effective information sharing, close collaboration, and long-term commitments (e.g. Bensaou, 1999, Hadeler and Evans, 1994). Moreover, the early involvement of suppliers in the product development process is an increasing trend owing to several benefits seen with such a collaboration, i.e. improved product quality, improved manufacturability and logistics, shorter time-to-market and ramp-ups, reduced costs, and experience transfer (Chopra and Meindl, 2010). However, in spite of a diverse literature about the advantages of early supplier involvement and close collaboration with strategic suppliers, there is a lack of established frameworks focusing on rapid and reliable production transfers and ramp-ups through effective cooperation and information exchange in high-tech supply chains.

4. Case study

The case study describes key takeaways from two production transfer processes between a Norwegian supplier of advanced maritime monitoring systems (*Buyer*) and one of its strategic EMS suppliers (*Supplier*). First, the two products under consideration are introduced. Here Products A and B represent a mature and ongoing transfer, respectively. Thereafter, insights from the transfer processes are condensed into a set of preliminary guidelines for carrying out such transfer processes.

4.1. Introduction to the products

4.1.1. Product A

The production of Product A was the first to be transferred from the Buyer to the Supplier. The product somewhat differs from the Buyer's other products in that it is cheaper, less complex and produced in higher volumes (tens of thousands). All products are sold to one sole customer, which uses Product A to offer a monitoring service to which other companies can subscribe. The products operate in exposed areas, and often need to be replaced. This creates a yearly demand for Product A.

The product consists of a sensor, casing and of electronics. The assembly process consists of soldering the sensor and electronics together and molding it into the casing. Subsequently, the product is tested. For several years, the Buyer purchased the casing and electronics from two suppliers and assembled the products. However, two years ago, the Buyer approached the Supplier with an invitation to tender for the assembly of Product A. Currently, the Supplier receives sensors from the Buyer and casing and electronics from two other suppliers, and carries out the assembly and testing of Product A. All products are delivered to the Buyer, which still maintains communication with the customer of the product.

4.1.2. Product B

The production of Product B is currently being transferred from the Buyer to the Supplier. Product B, a signal converter used in combination with a range of the Buyer's other sensor products, replaces a previous product version with similar characteristics. It consists of a cabinet with different electronics, such as power supply, wiring, and circuit boards. For the previous version of the product, cabinets were produced by one supplier, shipped to another for installation of power supply and wiring, and then shipped to the Buyer, which installed circuit boards from the Supplier and tested the product. However, for Product B, the Supplier will become more integrated in the supply chain. It will receive cabinets from the cabinet producer (and eventually a subsidiary of the Buyer located in a low-cost country) and install all electronics including self-produced circuit boards before shipping the product to the Buyer. For the time being, testing will still be carried out by the Buyer.

4.2. The transfer process

In this section insights into the transfer processes are presented in the form of general requirements pertinent to the production transfer process.

First of all, there is a need to *involve relevant actors* from both companies early in the process. For the transfer of Product A, the purpose of the transfer was unclear to key personnel in the department that owned the product. It was rumored that it was a cost-saving measure, when the main driver was, in fact, the high volume and low complexity of the production not being consistent with the Buyer's core competence. Further, key personnel did not feel involved in the decision to transfer production. In fact, they saw the need to intervene in the transfer process two times to secure deliveries to the customer. Both the Buyer and the Supplier agreed that the transfer process should be marked by a formal kick-off.

Second, a *communications structure* needs to be established. This includes defining contact points at both the buyer's and the supplier's ends and agreeing on how relevant matters should be communicated. During the transfer of Product B, the Supplier had appreciated the fact that the contact person at the Buyer's end was same throughout the process. At the same time, the contact person at the Buyer's end felt that it had been challenging to know who to contact at the Supplier's end. She had also experienced that two contacts at the Supplier's end had different revisions of the bill-of-materials (BOM). According to the Buyer, their personnel quickly embarked on other projects after a transfer. Generally, it is important that a supplier has a contact point at the buyer's end even after the transfer, and vice versa.

Next, the parties should be conscious of *risk handling*. Early in the process of transferring Product B, the Supplier was asked to secure necessary material from second-tier suppliers without any formal agreements being put in place. Due to changes in the BOM, some of this material had become obsolete. The economic consequences for the parties were still not settled. Further, beyond what was indicated in the invitation to tender, no formal agreements regarding, e.g., future volumes existed. This posed a risk to the Supplier, which had invested in its processes based on the transfer.

The case study identified *transfer of equipment* from the Buyer to the Supplier as another area that should be taken into careful consideration. For the transfer of Product A, it was initially decided that all test equipment would be moved from the Buyer to the Supplier instead of duplicating the equipment. This was one of the decisions that the department that owned the product challenged. It envisaged that the Buyer would be unable to run spot checks, thereby losing control over the quality of its outgoing deliveries. Some of the Supplier's current test equipment had been duplicated and borrowed from the Buyer, whereas some were owned by the Supplier. This equipment was identical to the Buyer's other test equipment.

Next, the *ramp-up* needs further attention. For the transfer of Product A, the original plan was that the Buyer would produce the product up until Easter and the Supplier would produce everything subsequently. Both the Buyer and Supplier currently agree that this is not realistic; it is impossible to transfer years of competence "overnight". For Product B, some issues regarding product design that should have been sorted out during the pilot production phase were identified in the production phase. As such, some type of stage gate should be put in place between the pilot production and the production phase. Further, the buyer should maintain some production capacity to secure the supply chain's ability to deliver during a ramp-up.

Throughout the transfer process, many alterations take place that necessitate a consciousness toward *change handling*. This applies both between the buyer and the supplier and internally in the two companies. For the transfer of Product A, the Supplier came up with many suggestions for improvements in the production process, some of which were accepted, whereas some were dismissed by the Buyer. In the latter case, the Supplier felt that it had often been short of an explanation. For Product B, the Buyer experienced challenges with its own product life-cycle management system with respect to how changes should be registered. In any case, the current version data should be kept in one file, which is updated and validated at all times.

As described previously, the purpose of the production transfer needs to be clearly defined and communicated to relevant actors. The buyer should follow up on the *attainment of these objectives*. For product A, the department owning the product still has no clear overview of the economic consequences of the transfer. If perceived benefits are not realized, the buyer should consider to either transfer the production back or transfer it to another supplier.

During the research, the Buyer revealed that it was considering updating Product A to a new version. The Supplier had made a plan to further improve Product A's production process.

Many of these suggestions, including possible investments, will be futile if a new product version is launched. Hence, the supplier should, in some way, be kept updated about the *future prospect* of the product it produces. In the same way, the supplier should inform the buyer about relevant information concerning product components, such as last buy notifications from second-tier suppliers that may trigger product alterations.

A transfer of production may also trigger *new business opportunities* for the supplier. For Product B, the Buyer included the development of an assembly procedure in the order. According to the Buyer, the Supplier also had competence within test development that it could sell in conjunction with production transfers.

5. Conclusion

In this paper, insights into a case study are presented for two production transfer processes between a Norwegian supplier of advanced maritime monitoring systems and one of its strategic EMS suppliers. A set of preliminary guidelines for carrying out such transfer processes is proposed based on the case study. These are summarized in Table 1.

The purpose of the research is to help better understand production transfer processes, and the paper is a first step toward developing a model for systematic transfer processes. Such a model would help managers carry out such processes either from their own facilities to a supplier or from an existing supplier to another. A systematic approach is likely to reduce costs associated with such transfers.

Table 1: Guidelines for production transfer processes.

Requirement	Description
Involvement	Early in the transfer process, relevant actors need to be informed about its purpose and be involved in making decisions, which strongly influences the company's ability to deliver. The transfer process should be marked by a formal kick-off.
Communications structure	Contact points and modes of information sharing should be defined for the entire transfer process and the subsequent period to follow.
Risk handling	Both the buyer and the supplier should carry out risk assessments prior to the transfer process. Formal agreements need to be put in place where appropriate, e.g. for securing material and future deliveries.
Transfer of equipment	The timing and nature of the transfer (e.g., copy exactly) of equipment need to be decided.
Ramp-up	The transition from the pilot production phase to the maximum capacity production phase needs to be carefully planned with respect to, e.g., whether the product is ready for ramp-up and how any overlap in capacity should be organized.
Change handling	Suggestions for a change should be treated in a systematic manner, with decisions being supported by factual explanations and systems keeping track of valid documentation at all times.

Requirement	Description
Goal attainment	Effects of the transfer need to be measured and followed up. If perceived effects are not realized, this could trigger a transfer of production back to the buyer or to another supplier.
Future prospect	A supplier should be kept informed about the future prospect of the product it produces so that unnecessary investments and improvements are not made. At the same time, the supplier should keep the buyer informed about information that may trigger product alterations, such as last buy on key components.
New business opportunities	A transfer of production may trigger new business opportunities. The parties should consider what tasks are to be performed in connection with the production transfer.

Acknowledgments

This research has been conducted with support from the research projects Sound-Chain and Parabel supported by The Research Council of Norway. The authors would like to thank the participants of the projects for providing valuable empirical data.

References

ALMGREN, H. 1999. Towards a framework for analyzing efficiency during start-up:: An empirical investigation of a Swedish auto manufacturer. *International Journal of Production Economics,* 60**,** 79-86.

BENSAOU, M. 1999. Portfolios of buyer-supplier relationships. *Sloan management review,* 40**,** 35-44.

CHOPRA, S. & MEINDL, P. 2010. *Supply chain management. Strategy, planning & operation,* Boston, Person Education.

FREDRIKSSON, A. 2011. *Materials supply and production outsourcing.* PhD thesis, Chalmers University of Technology.

FREDRIKSSON, A. & WÄNSTRÖM, C. 2014. Manufacturing and supply chain flexibility–towards a tool to analyse production network coordination at operational level. *Strategic Outsourcing: An International Journal,* 7**,** 173-194.

HADELER, B. J. & EVANS, J. R. 1994. Supply strategy: capturing the value. *Industrial Management,* 36**,** 3-4.

KINKEL, S. & MALOCA, S. 2009. Drivers and antecedents of manufacturing offshoring and backshoring—A German perspective. *Journal of purchasing and Supply Management,* 15**,** 154-165.

MONCZKA, R. M., MARKHAM, W. J., CARTER, J. R., BLASCOVICH, J. D. & SLAIGHT, T. H. 2005. Outsourcing strategically for sustainable competitive advantage. Arizona: CAPS Research.

SCHNIEDERJANS, M. J., SCHNIEDERJANS, A. M. & SCHNIEDERJANS, D. G. 2005. *Outsourcing and insourcing in an international context,* New York, ME Sharpe.

STAKE, R. E. 2013. *Multiple case study analysis,* New York, Guilford Press.

TERWIESCH, C., CHEA, K. S. & BOHN, R. E. 1999. An exploratory study of international product transfer and production ramp-up in the data storage industry. *In:* CENTER, I. S. I. (ed.) *High-Technology Manufacturing.* San Diego: University of California.

YIN, R. K. 2013. *Case study research: Design and methods*, Sage publications.

Paper 2

Mogos, M. F., Sjøbakk, B. and Alfnes, E., (2017). "A Production Transfer Risk Assessment Framework", *IFIP International Conference on Advances in Production Management Systems*, Vol 514, pp. 29-39, Springer, Cham.

This is an accepted manuscript of an article published in IFIP International Conference on Advances in Production Management. The final authenticated version is available online at: https://doi.org/10.1007/978-3-319-66926-7_4

A Production Transfer Risk Assessment Framework

M. F. Mogos[1], B. Sjøbakk[2] & Erlend Alfnes[1]

[1]*Norwegian University of Science and Technology (NTNU), Trondheim, Norway*
{maria.f.mogos, erlend.alfnes}@ntnu.no
[2]*SINTEF Technology and Society, Department of Industrial Management, Trondheim, Norway*

Abstract

Many companies transfer production between them as part of relocation processes such as offshoring and outsourcing. Such production transfers (PT) are often associated with the risk of not achieving the expected performance results. Thus, many scholars and practitioners have acknowledged the importance of a thorough PT planning, based on risk management principles. One major principle is the assessment of PT risk in early stages of the process, in order to identify risk factors, analyze potential risk scenarios generated by the factors, implement risk-mitigation actions and improve PT performance. While several scholars have recommended conducting assessments early in the transfer process, which through the risk management lens, can be regarded as variants of risk assessment, there has not been published any recent review of the extant research on the risk assessment early in the PT process. Thereby, the main objectives of this paper are to identify and classify potential risk factors in the extant research, propose an assessment tool and test its utility on a longitudinal PT case. The paper also provides suggestions of how to apply the proposed tool to evaluate the requirements for resource intensive activities between the PT parties.

Keywords: *Production Relocation, Supply Chain Risk Management, Performance Management, Offshoring, Outsourcing.*

1. Introduction

Many companies carry out production transfers (PTs) as part of relocation processes such as offshoring or outsourcing (Fredriksson and Wänström, 2014). In line with (Fredriksson, 2011), a PT can be defined as the relocation of the manufacturing of products and components between a *sender* (original manufacturer) and a *receiver*. Further, it can be divided into three main phases: (i) *'PT preparation'*, (ii) the *'PT execution'* mainly consisting of the physical transfer of production equipment and inventories, and (iii) the production '*start-up'* at receiver. A PT is usually considered successful if a stable production is achieved at the expected performance objectives (e.g., cost and yield), in the start-up (Terwiesch et al., 2001, Almgren, 1999). The PT can be regarded as the final stage in a production relocation process, being usually preceded by the decision whether to relocate production or not, and the selection of suitable sourcing items, locations and suppliers (Momme and Hvolby, 2002). All the new risk factors introduced when transferring the production to a new production environment (e.g. a new workforce, production equipment and sub-suppliers) contribute to an increased risk level. For PTs, the '*risk factors'* can be defined as tangible and intangible elements which have the intrinsic potential to give rise to supply-disruptions(McCormack et al., 2008). Although they are a common phenomenon, PTs tend to take much longer time than companies anticipate (Madsen, 2009). Further, they do not always meet the expected performance objectives, and can even lead to losses (e.g. financial or intellectual property (IP) losses)(Chopra and Meindl, 2013). Thus, many scholars and practitioners have acknowledged the importance of thorough PT planning and control, based on risk management principles (e.g. (WHO, 2011, Terwiesch et al., 2001)).Two central risk management goals are the risk assessment and the risk mitigation process. For PTs, the assessment consists of the following activities: the identification of risk factors, potential supply-disruptions (e.g. a machine breakdown) generated by these factors and their effect on performance; an analysis to understand risk scenarios and estimate the level of risk, and an evaluation of whether risk-mitigation actions should be implemented or not (ISO, 2009). Several scholars (e.g. WHO, 2011, Grant and Gregory, 1997, Stock and Tatikonda, 2000) have recommended conducting assessments in the early stages of the PT process that, through the risk management lens, can be regarded as variants of risk assessment. Such assessments indicate potential sources of disruptions in the material and information flow (i.e. risk factors), and can aid in identifying risk-mitigation actions that should be included in the PT action plan. Nevertheless, to the authors' knowledge, there has not been published any recent review of the extant research on the risk assessment early in the PT process. Thus, the research problem this paper addresses is *'What are the risk factors during PTs?'* and the main objectives are to identify and classify potential PT risk factors in the extant research, and, thereby, propose a risk assessment tool. Moreover, the utility of the proposed tool is tested on a PT case.

2. Research Methodology

The research process has been conducted in two steps. First, we have carried out a literature review of peer-reviewed journal articles, dissertations, and best practices within the topics of *production-, knowledge-,* and *technology-transfer*, as well as about *manufacturing relocations and start-up, supplier assessment and audit*, and key *risk management* publications. The aim of the review was to identify potential PT risk factors. When synthesizing these factors into the proposed assessment tool, the most comprehensive frameworks found (WHO, 2011, Grant and Gregory, 1997, Stock and Tatikonda, 2000) were taken as a starting point. Second, a case study is used to test the utility of the tool. The case is the PT of electronics from a Norwegian company to a subsidiary in Spain. Rich empirical data has been collected during a period of 12 months. The case method was adopted because it allows the identification of PT risk factors during a real PT case and with a relatively full understanding of the nature and complexity of the PT process(Karlsson, 2009). The sender had conducted PTs several times before, including to the receiver. Yet, they were experiencing a series of challenges during PTs. This made the selected PT an interesting case to study and get a better understanding of how to identify areas where risk-mitigation actions could be implemented in order to improve supply performance. Further, the PT project owner and the sender's PT Quality & Risk manager applied the tool to the case, 6 months after the PT decision. Both had rich experience from similar PTs. A semi-structured interview was conducted with the informants, who jointly analyzed and ranked the impact of the risk factors on the overall risk level during the case. Responses were cross-referenced with documentation and extensive field notes.

3. Potential Risk Factors during Production Transfers

Supplier qualification assessments are widespread in the scientific literature. Grant and Gregory (Grant and Gregory, 1997), pioneers of the PT literature, argue that the PT success would not be only influenced by factors dependent on receiver but also by those inherent in the type of production transferred, and best controlled by sender. Thereby, based on (Grant and Gregory, 1997), we have established the two first categories of literature findings: *'potential risk factors related to the transfer object'* and *'to the receiver'* respectively (see framework in Table1). These factors have been further divided into five and nine areas respectively. The Risk factors related to the receiver can be encountered in the widespread supplier qualification assessments. Although these factors do not necessarily affect the selection of the receiver, they might still contribute to an increase in the PT risk level, and should therefore not be overseen. Moreover, WHO (WHO, 2011) recommends visiting the receiver early in the transfer process, in order to assess the new production environment at a more detailed level, and shed light on the capability gaps between the receiver and the sender. Thus, the 'production environment' area was added, and several factors in this area can be also encountered in Lean audits (i.e. R35, R36, R37 in Table 1).

Next, according to (Terwiesch et al., 2001, Stock and Tatikonda, 2000) the PT outcome will be also influenced by the physical distance and the relationships within the supply chain. Thus, a third category was added to our classification, *'factors related to supplier relations'*. Finally, based on the widely used Kraljic model (Kraljic, 1983), the *'factors related to the profit impact'* a sourcing activity has, should be always considered along with the risk factors. According to (Kraljic, 1983), these factors stand out and have a moderating impact on the risk level. If the risk level is high, it is worth making high investments in the sourcing, provided the profit impact is also high. The 4 categories of risk factors are presented in Table 1. The factors have been divided into 18 distinctive areas. (WHO, 2011, Grant and Gregory, 1997, Stock and Tatikonda, 2000) were taken as a starting point for the framework.

4. Case Description and Analysis

The case we have studied is a PT of one acoustic sensor product family from the domestic production site of a major Norwegian corporate group (*Sender*) to a financially autonomous subsidiary in Spain (*Receiver*). The production was offshored in order to get better access to the developed customer market and to the material technology expertise at Receiver, as well as to reduce labor cost and delivery time. Sender was transferring all the production activities

Table 1. Framework for production transfer risk assessment

I. Risk factors related to the transfer object	
1. Novelty **R1.**Degree of experience sender and receiver have with transferring production between them (Tatikonda and Stock, 2003, Fredriksson et al., 2014) **R2.** Receiver's experience with similar production (Tatikonda and Stock, 2003, Fredriksson et al., 2014) **R3.** The similarity of the transfer object produced by receiver to the object produced by sender (Tatikonda and Stock, 2003) **R4.** The similarity of the transfer object produced by receiver to other production at receiver (e.g. if receiver's equipment can be used) (Fredriksson et al., 2014) **R5.** Production site's maturity (e.g. greenfield or brownfield) (Cheng et al., 2010) ***2. Complexity*** **R6.** Degree of internal and external modularity (e.g. the object is part of a larger system) (Tatikonda and Stock, 2003, Beckman and Rosenfield, 2008) **R7.** Amount of elements, configurations and functions the object has (e.g. BOM complexity) (Tatikonda and Stock, 2003, Beckman and Rosenfield, 2008) **R8.** The size of the product tolerances (Fredriksson et al., 2014) **R9.** Availability of raw materials (Kraljic, 1983) **R10.** The extent to which the manufacture of products is complete prior to customer order (Fredriksson et al., 2014) **R11.** Customer demand- and volume-certainty	(Fredriksson et al., 2014) **R12.** Facility to protect IP (Grant and Gregory, 1997) ***3. Tacitness*** **R13**.The facility to codify (document) the tacit knowledge about the object (Tatikonda and Stock, 2003, Grant and Gregory, 1997) **R14.** The transfer object's maturity (e.g. with well-defined processes) (Tatikonda and Stock, 2003, Grant and Gregory, 1997) **R15.** The relevance of the documentation (e.g. updated and representative) (Tatikonda and Stock, 2003, Grant and Gregory, 1997) ***4. Adaptability*** **R16.** Facility to find alternatives when adapting the production process to receiver's environment (Grant and Gregory, 1997) **R17.** Facility to pilot and test the adaptations at sender prior to transfer execution phase (Grant and Gregory, 1997) **R18.** Sender's capability and willingness to make adaptations (Grant and Gregory, 1997) ***5. Flexibility*** **R19.** The possibility to reserve resources at sender for necessary tasks during transfer execution and start-up at receiver (Fredriksson et al., 2014, Fredriksson et al., 2015) **R20**. The possibility to plan the transfer as a gradual transfer, volumes being only gradually decreased as outputs at receiver are increased (Fredriksson et al., 2014, Fredriksson et al., 2015)
II. Risk factors related to the receiver	
6. Sub-suppliers **R21.** The quality, cost, flexibility, service level, reliability and proximity of local and international sub-suppliers (Grant and Gregory, 1997, Chopra and Meindl, 2013) ***7. Transfer market*** **R22.** The appropriateness of receiver's market for the transferred production (e.g. if product redesign is needed to satisfy demand) (Grant and Gregory, 1997) ***8. Infrastructure*** **R23.** The appropriateness of the quality, cost and availability of local utilities (Grant and Gregory, 1997) **R24.** The appropriateness of the space and format of buildings (Grant and Gregory, 1997) **R25.** The appropriateness of tele-communications, road, rail, shipping and airfreight infrastructure (Grant and Gregory, 1997, Chopra and Meindl, 2013) ***9. Legal requirements*** **R26.** The appropriateness of import duties	(Grant and Gregory, 1997, Chopra and Meindl, 2013) **R27.** The appropriateness of quotas, labor law, government emission regulations, planning permission regulations, approval and license requirements, and other legal demands (Grant and Gregory, 1997) ***10. Financing*** **R28.** The appropriateness of the cost of capital, land, inventory, and the foreign exchange requirement (Grant and Gregory, 1997) ***11. Geographical environment*** **R29.** The appropriateness of the local temperature range, humidity level, air quality (Grant and Gregory, 1997) and of geo-risk (e.g. if area is prone to natural disasters) (Kraljic, 1983) ***12. Socio-political environment*** **R30.** The level of governmental stability (Kraljic, 1983) ***13. Labour force*** **R31.** Employee's productivity, educational level, language homogeneity and turnover (Grant and Gregory, 1997)

14. Culture **R32.** The closeness between job positions (e.g. manager-operator) **R33.** Individuals' willingness to assume responsibility and the appropriateness of receiver's approach to problem solving and quality perception (Grant and Gregory, 1997) *15. Production environment* **R34.** Production and packaging rooms, the testing, production and packaging equipment, inventory control mechanisms, documentation, the absence of banned substances, waste management (WHO, 2011) and other HSE aspects (Alfnes and NTNU, 2006)	**R35.** Layout and material flow; efficiency of space usage; levels of inventory and work-in-progress; quick changeover; installation and maintenance protocols; planning and control, value chain information sharing and other data systems (e.g. level of integration between systems); order management; quality management (e.g. TQM); Visual management (Alfnes and NTNU, 2006, WHO, 2011) **R36.** Workers' technical capabilities (e.g., to adapt the production process to own environment and the use of leading technology); organizational practices (e.g., customer focus, housekeeping) (Grant and Gregory, 1997, Alfnes and NTNU, 2006) **R37.** Level of teamwork and worker empowerment and flexibility (Alfnes and NTNU, 2006)
III. Risk factors related to supplier relations	
16. Distance **R38.** Physical proximity between related processes (e.g. the development and manufacturing units) after transfer execution (Fredriksson et al., 2014, Terwiesch et al., 2001) **R39.** The relationship closeness between sender and receiver (Fredriksson et al., 2014, Terwiesch et al., 2001) **R40.** The relationship closeness within the value chain (e.g. receiver has close sub-suppliers that de	liver high quality items) (Alfnes and NTNU, 2006) **R41.** The similarity of transfer parties' perception of their relation (Oosterhuis et al., 2011) *17. Power balance* **R42.** Sender's and receiver's negotiating power (Kraljic, 1983) *18. Motivation* **R43.** Employees' motivation for transfer, at both locations (e.g. high when no lay-offs) (Fredriksson et al., 2014)
IV. Risk factors related to profit impact	
R44. The size of the sourced volume compared to sender's and receiver's other products (Kraljic, 1983, Fredriksson et al., 2014) **R45.** The proportion of sender's total sourcing	cost the sourced items stand for (Kraljic, 1983) **R45.** The positive impact of the sourced items on quality and business growth (Kraljic, 1983)

to Receiver, apart from the acoustic technology, which contained a high IP level. Thus, Receiver was required to assemble the acoustic technology into housings from vendors, and mold, assemble, test and deliver final products. The PT decision was taken in spring 16', the Preparations started in September and the Start-up is estimated to start in June 17'. Further empirical findings are presented in Table 1. As explained in Section 2, the Project owner and Sender's Quality & risk manager for the PT analyzed and ranked the risk factors according to their contribution to increased PT risk level; the assessment was conducted 6 months after the PT decision. In the table, we have only displayed an average of all the factors' rankings in each area. Risk-mitigation actions could be implemented for the risk factors (or areas) in descending priority i.e., first for factors with 3- high contribution to increased risk, etc.

5. Discussion and Conclusion

In the previous section, we applied a conceptual framework developed from literature on a PT case. The framework was able to capture all the risk factors that had arisen during the PT process, suggesting its usefulness as a simple checklist for identifying and evaluating risk factors. When performing the assessment together with the Project owner and Sender's

Table 2. Risk factors in the case (1-low/ 2-medium/ 3-high contribution to increased risk)

Related to the Transfer Object	**Novelty:** Sender had transferred production several times before, but Receiver had initially only carried out sale and service operations for Sender and did not have much production experience. However, they had successfully undertaken production from Sender before (the assembly of a simple component), and they had been having a good collaboration for 20 years. Moreover, Receiver had employed a researcher with a PhD in material technology who was developing a new molding material, a process that could delay the transfer. Most of the machines had to be purchased and there were certain distinctions between this equipment and the original one at Sender. In addition, Receiver had bought these expensive machines too early (more than one year before start-up). Finally, because of increasing production activities, Receiver also had to buy a facility to move to before start-up, and its layout had to be changed. The constructors they contracted for the 1st part of the building project submitted a too costly offer for 2nd part, and the process of contracting new ones delayed the start-up with weeks.	3
	Complexity: The transferred object consisted of three product groups; each with three relatively simple products that were not part of Sender's other products. However, their production required many machines and tools that had to be either purchased or transferred from Sender. The demand was relatively certain; there was a good market for these products in Spain. Further, since it was rather difficult to protect the IP, Sender did not grant Receiver access to the document handling system, and little documentation had been transferred before Sender's representatives visited Receiver and saw that the material development process was promising. Because of the scarce information and Receiver's rush to start the production, the new layout at the purchased facility deviated from what the production required, and had to be modified after Sender's visit. Moreover, during one analysis conducted short time after kick-off, Sender's employees identified a certain risk of IP loss during the transport of the acoustic technology to Receiver, but actions were soon implemented to ensure that only qualified logistics suppliers are used.	3
	Tacitness: The transferred products were mature, but the documentation was not completely updated and a certain amount of tacit knowledge could not be codified. Thus, Receiver's operators had to travel several times than expected to Sender for hands-on and face-to-face training provided by Sender's operator and engineers. This could increase the transfer time.	2
	Adaptability: The production could not be changed and adapted to Receiver's environment.	3
	Flexibility: Receiver was seeking a rather high transfer pace, because of the unutilized expensive equipment they had bought. Nonetheless, during the preparations phase, it became increasingly clear that a gradual transfer was necessary. To cope with the uncertainty, Sender decided to continue producing for a couple of months, until Receiver achieved a stable production. Moreover, since one of the reasons for the transfer was to release resources for innovation (Sender's core competency), the amount of resources Sender was willing to invest in the transfer was moderate. Yet, Sender assigned significant resources to travel to Spain and assist Receiver during transfer execution and start-up.	1
Related to the Receiver	**Sub-suppliers:** The subsuppliers' performance is evaluated as moderate. In addition, during one workshop, Receiver's personnel identifies a certain risk that sub-suppliers could unexpectedly stop their supply and thereby, it is decided to establish a long-term partnership with critical vendors and have available secondary sub-suppliers for standard items.	2
	Transfer market: The transfer parties benefited of a good and stable customer demand in Spain, without having to change the products.	1
	Infrastructure: The infrastructure at the Spanish receiver is evaluated as very good.	1
	Legal requirements: Sender realized during Preparations, that it would be more expensive to sell products Made in Spain to countries where EU had less favorable trade agreements than Norway. Nonetheless, Euro was more stable than the currency at their Chinese subsidiary and it was more advantageous to purchase from sub-suppliers within EU. Further, during one analysis early in the preparations phase, personnel with experience from previous transfers stressed the need to ensure comprehensive documentation for the transferred equipment and inventory, in order to avoid being stopped at the customs office, so several actions were implemented to reduce this risk.	2
	Financing: The cost of capital and land are evaluated as high, whereas the cost of inventory and the foreign exchange requirement are moderately appropriate.	3

	Geographical environment: The temperatures, humidity, air quality and geo-risk at the Spanish site are evaluated as moderately appropriate for electronics production.	2
	Sociopolitical environment: The area benefits of high governmental stability.	1
	Labor force: Workers' productivity and educational level at Receivers are evaluated as high and respectively moderate. Receiver's area was known for its material technology expertise and the labor force turnover was low. Yet, the workers' English skills were modest and this could be especially challenging during videoconferences.	2
	Culture: Workers are willing to assume responsibility and have an appropriate quality perception and problem-solving approach. The relational closeness between job positions is moderate.	1
	Production environment: Receiver possessed the ISO 9001: 2008 certification within Quality management and achieved a good score when Sender conducted a Lean audit at their premises. Moreover, they were very receptive to new technologies and best practices. Nonetheless, when Sender's representatives visited them two months after kick-off, both parties realized how important it was to implement Sender's quality management systems and procedures in the new supply chain (for Change control, FIFO, tracing parts, the reception of sourced items, and for correct storage). In addition, they agreed on and took the first actions to implement Sender's ERP production module at Receiver. Receiver's personnel had to travel several times to Norway for training and the process required a trial period at Receiver, which could prolong the start-up and delay the steady state.	2
R. to Supplier Relations	**Distance:** Sender and Receiver were part of the same corporation, yet the supply agreement they had was a buyer-supplier contract similar to the ones Sender had with external suppliers. This generated certain confusion among personnel. Sometimes, Sender's workers were hesitant to share information, whereas Receiver's workers expected more openness. The physical distances between the development and manufacturing of the core technology and the molding material were small, since the processes were collocated at Sender and respectively, Receiver. Yet, the fact that the two sites were located far from each other posed some characteristic challenges to their collaboration (e.g. if they will have to adapt technology to the Spanish market).	3
	Power balance: The competition between Receiver and other 'receivers' that Sender could have selected is moderate, and the same applies for Sender and their competitors.	2
	Motivation: Some of Sender's employees were afraid to lose their jobs in the future.	2
R. to Profit	**Profit impact:** The product volume is rather low, compared to Sender's other products. The products require a high amount of manual labor and are one of Sender's most price sensitive. Thus, Sender hopes to decrease the costs in the future due to the cheaper workforce (1/3 the cost at Sender) and to improve the products' robustness due to the new molding material. The outbound logistics could also decrease due to higher market proximity, but the inbound logistics could increase as long as Sender's original Norwegian suppliers are used.	2

Quality & Risk manager, it was revealed that Sender and Receiver had identified some of the risk factors during the PT, and implemented actions for those on the way. For instance, as presented in Table 2, during one analysis early in the preparations phase, personnel who had been retained at the customs office for more than one day because of incomplete documentation stressed the need to validate the transportation documentation for equipment and inventory before transfer. Thereby, several actions were taken to avoid this scenario again. However, the PT parties had also encountered a series of unexpected events during the PT, which might negatively affect the performance results. For instance, a long time after the initial PT decision, Sender realized that there would be less favorable trade agreements when selling Made-in-Spain products to major customers overseas, compared to Made-in-Norway. The Receiver purchasing capital-intensive equipment more than one year prior to actual use is another example. If the PT parties had conducted the risk assessment early in the process, they could have implemented actions and avoided some of the pitfalls encountered.

Moreover, we propose that the suggested assessment tool could be applied on several occasions, such as when the transfer object is selected (especially the 'factors related to transfer object'), when the location and receiver are selected ('factors related to receiver'), and when the PT plan is created (the entire list). A team with experienced members from key disciplines could jointly analyze possible unwanted events generated by each risk factor and rank them. Risk-mitigation actions should be considered for the factors in descending priority i.e., first for factors with high scores, etc. As (Kraljic, 1983, ISO, 2009) recommend, a cost-benefit evaluation should be conducted before choosing the actions. Thus, if the risk level is high, it is worth making high investments in e.g. expensive training, provided the profit impact is also high. Here one should also consider that it is recommended to rather prevent performance deviations than to correct them (Fredriksson et al., 2014).

To conclude, we argue that the theoretical contribution of this study is the development of a conceptual framework based on a range of factors identified in literature, which seen through the risk management lens can be regarded as potential common risk factors in PTs. Moreover, the framework has been tested on a PT case together with experienced managers. Although a single case impedes the generalizability of the framework to other companies and industries, the empirical data is thoroughly collected during a period of 1 year, and it is reasonable to expect that part of the findings are applicable to other electronics producers and offshoring cases. Nonetheless, several types of PT cases should be studied, and the PT risk assessment framework could be validated through a survey. In this paper, the empirical data indicates that a structured assessment of risk factors during the early stages of PTs can aid practitioners in mitigating the PT risk, and thereby improve future performance.

Acknowledgments

This research has been conducted with support from a research project funded by The Research Council of Norway. The authors would like to thank the project participants for providing valuable empirical data.

References

ALFNES, E. & NTNU. 2006. *Enterprise Reengineering – A Strategic Framework and Methodology.* PhD thesis Norges Teknisk-Naturvitenskapelige Universitet, Fakultet for ingeniørvitenskap og teknologi.

ALMGREN, H. 1999. Start-up of advanced manufacturing systems - a case study. *Integrated Manufacturing Systems,* 10**,** 126-135.

BECKMAN, S. L. & ROSENFIELD, D. B. 2008. *Operations strategy: competing in the 21st century,* Boston, McGraw-Hill/Irwin.

CHENG, Y., MADSEN, E. S. & JIRAPHA, L. 2010. Transferring knowledge in the relocation of manufacturing units. *Strategic Outsourcing: an International Journal,* 3**,** 5-19.

CHOPRA, S. & MEINDL, P. 2013. *Supply chain management : strategy, planning, and operation,* Boston, Pearson.

FREDRIKSSON, A. 2011. *Materials supply and production outsourcing*, Chalmers University of Technology.

FREDRIKSSON, A. & WÄNSTRÖM, C. 2014. Manufacturing and supply chain flexibility towards a tool to analyse production network coordination at operational level. *Strategic outsourcing : an International journal,* 7**,** 173-194.

FREDRIKSSON, A., WÄNSTRÖM, C., JOHANSSON, M. I. & MEDBO, L. 2015. A structured procedure for materials planning during production transfer. *Production Planning & Control***,** 1-15.

FREDRIKSSON, A., WÄNSTRÖM, C. & MEDBO, L. 2014. Assuring materials availability during the production transfer process; Critical characteristics of the materials planning environment. *Journal of Manufacturing Technology Management,* 25**,** 310-333.

GRANT, E. & GREGORY, M. 1997. Adapting manufacturing processes for international transfer. *Int. J. Oper. Prod. Manage.,* 17**,** 994-&.

ISO, I. 2009. 31000: 2009 Risk management–Principles and guidelines. *International Organization for Standardization, Geneva, Switzerland*.

KARLSSON, C. 2009. Researching operations management. New York: Routledge.

KRALJIC, P. 1983. Purchasing must become supply management. *Harvard business review,* 61**,** 109-117.

MADSEN, E. S. 2009. *Knowledge transfer in global production,* Aalborg, Danmark, Aalborg University.

MCCORMACK, K., WILKERSON, T., MARROW, D., DAVEY, M., SHAH, M. & YEE, D. 2008. Managing risk in your organization with the SCOR methodology. *The Supply Chain Council Risk Research Team***,** 1-32.

MOMME, J. & HVOLBY, H.-H. 2002. An outsourcing framework: Action research in the heavy industry sector. *European Journal of Purchasing and Supply Management,* 8**,** 185-196.

OOSTERHUIS, M., VAN DER VAART, T. & MOLLEMAN, E. 2011. Perceptions of technology uncertainty and the consequences for performance in buyer-supplier relationships. *International Journal of Production Research,* 49**,** 6155-6173.

STOCK, G. N. & TATIKONDA, M. V. 2000. A typology of project-level technology transfer processes. *Journal of Operations Management,* 18**,** 719-737.

TATIKONDA, M. & STOCK, G. 2003. Product technology transfer in the upstream supply chain. *J. Prod. Innov. Manage.,* 20**,** 444-467.

TERWIESCH, C., BOHN, R. E. & CHEA, K. S. 2001. International product transfer and production ramp-up: A case study from the data storage industry. *R and D Management,* 31**,** 435-451.

WHO. 2011. *WHO expert committee on specifications for pharmaceutical preparations. Forti-fifth Report; Annex 7-WHO guidelines on transfer of technology in pharmaceutical manufacturing* [Online]. Available: http://apps.who.int/medicinedocs/documents/s18652en/s18652en.pdf [Accessed June 1st 2015].

Paper 3

Mogos, M. F., Alfnes, E. and Swahn, N. (2016). "Prerequisites for Successful Production Transfers in the Electronics Industry", *Lecture Notes in Business Information Processing*, Vol. 262, pp. 168-181.

This is an accepted manuscript of an article published in Lecture Notes in Business Information Processing. The final authenticated version is available online at: *https://doi.org/10.1007/978-3-319-73758-4_12*

Prerequisites for Successful Production Transfers in the Electronics Industry

Maria Flavia Mogos[1], Erlend Alfnes[1], Natalia Swahn[1]*

[1] *Norwegian University of Science and Technology (NTNU)-Department of Mechanical and Industrial Engineering, Trondheim, Norway*
{maria.f.mogos, erlend.alfnes}@ntnu.no

Abstract

The purpose of this paper is to identify prerequisites for successful production transfers i.e. for achieving a stable production at the receiver at targeted supply-performance levels. The research findings consist of a collection of 43 prerequisites identified in the extant literature and structured according to the main transfer phases. Moreover, the authors present the challenges encountered during two transfers of electronics production and discuss how those challenges could have been avoided or easily dealt with if some of the identified prerequisites had been in place. The paper provides a detailed overview over recommended activities when transferring production. In addition, risk-mitigation measures are highlighted along the transfer process, and there are suggested methods and tools for supply-chain risk management. Practitioners can use the collection of prerequisites as a checklist when preparing the transfer plan. These results represent a first step towards configuring a project development model for systematic production transfer management.

Keywords: *Production transfer. Outsourcing. Operations management. Supply chain risk management. Case research*

1. Introduction

The transfer of production is common among companies nowadays as part of relocation processes such as outsourcing and offshoring (Fredriksson and Wänström, 2014). Companies relocate production as the products and the industry matures (Beckman and Rosenfield, 2008), or in order to cope with market trends e.g., decreasing product life cycles, more and more frequent introductions of novel technologies, and increasing competition from low-cost countries. For instance, by focusing on innovativeness and quality the Norwegian producers of electronics for the maritime industry have positioned themselves as leaders in an industrial area that has a significant growth potential. On these markets, customers have been typically willing to pay higher prices in exchange for higher performance. However, in recent times, competitors from low-cost countries have been improving the performance of their products. Therefore, the Norwegian electronics producers have been urged to streamline their supply chains and production systems, yet without compromising their core capabilities (i.e. innovativeness and quality). Hence, in order to achieve an increased cost-effectiveness and at the same time release more resources for product innovation, one major Norwegian electronics producer has started to transfer parts of the production to strategic suppliers in their supply chains. In recent years, they have transferred high demand products with little intellectual property (IP) to domestic series electronics producers, in order to achieve better economies of scale. In addition, they have transferred the production of mechanical parts to a subsidiary in a low-cost country. Other examples of benefits that companies pursue when transferring production are, the access to novel technologies not available internally, lower investments costs, better performance results due to the competition between suppliers, and access to new distribution channels (Beckman and Rosenfield, 2008). Nevertheless, achieving these benefits depends on the success of the transfer.

By *production transfer* (PT) there is hereby meant the relocation of production activities between two facilities, a *sender* and a *receiver* (Fredriksson, 2011). The PT can be divided into three main phases: (i) the preparation for the transfer, (ii) the transfer execution mainly consisting of the physical transfer of equipment and inventories (if necessary), and (iii) the start-up of production at the Receiver (Fredriksson, 2011). Further, in line with (Almgren, 1999, Terwiesch et al., 2001), a PT is typically considered *successful* if a stable production is achieved during the scheduled Start-up phase (the *steady state*) at the expected performance outcomes (e.g., cost, volume and yield). The PT can be considered as the third stage in the production relocation process (e.g. outsourcing and offshoring), succeeding the decision to relocate or not and the selection of suppliers (Momme and Hvolby, 2002) (see Figure 1).

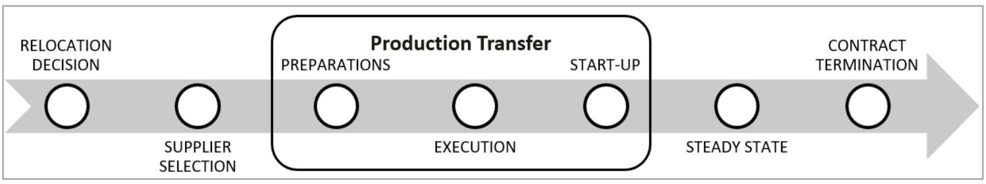

Fig. 1. The production relocation process (adapted after (Momme and Hvolby, 2002, Fredriksson, 2011))

One major challenge is that PT projects are often associated with an increased risk level in the supply chain (SC) (Aaboen and Fredriksson, 2015). When companies transfer production from one environment to another, a series of new risk sources are introduced (e.g., new equipment, or new sub-suppliers). These risk sources may lead to SC disruptions (e.g., machine breakdowns or defective components), performance deviations and eventually, to significant losses (McCormack et al., 2008). Examples of losses during PTs are the inability to meet the demand on time, the loss of IP, excessive transaction costs, and even a reduction in brand value and the loss of business (Kinkel and Maloca, 2009, Chopra and Meindl, 2013, Vikram, 2013). Therefore, many scholars and practitioners have acknowledged the importance of SC risk management (SCRM) during PTs (e.g. (WHO, 2011, Fredriksson et al., 2014, Malm, 2013)).

Next, although several frameworks for systematic production relocation exist, many of them focus solely on the decision to relocate or not (Tibor et al., 2006), by e.g. discussing possible relocation benefits and risks (literature review by (Fredriksson, 2011)). Moreover, most of these frameworks end before the physical transfer of equipment and inventory (literature review by (Fredriksson, 2011)). Relocation frameworks addressing the PT process either provide only a coarse overview over PT activities (e.g., (Momme and Hvolby, 2002),(Madsen, 2009) and (Zeng, 2003)), or they only focus on certain There is a lack of knowledge about the PT management in different production industries, and in particular, about the systematic activities (including SCRM activities) that are important for the success of PTs.

The question that arises based on the described research context is, *'What are the prerequisites for successful PTs?'*. The research will focus on this topic from an Operations Management and SCRM point of view. The research results represent a first step towards developing a project development model for systematic PT management.

1.1. Research Methodology

The research process has been conducted in two steps. First, there was carried out a systematic literature review of peer-reviewed journal articles, dissertations, and best practices within *production-*, *knowledge-*, and *technology-transfers* in manufacturing industries, as well as about *outsourcing*, *production start-up*, *ramp-up*, and key publications within the area of SCRM. The aim of the literature study was to identify potential prerequisites for successful PTs. When structuring these measures, the most comprehensive frameworks and guidelines found in the literature were taken as a starting point (WHO, 2011, Fredriksson et al., 2015, Madsen, 2009). Second, in order to get a better understanding of the phenomenon of PT in the electronics industry (Yin, 2004), two cases of PTs were studied. In both cases, the production was transferred from a Norwegian producer of electronics for the maritime industry ('*Sender*') to one of its strategic Norwegian suppliers ('*Receiver*'). Both cases illustrate challenges that might have been minimized if some of the prerequisites derived from the extant literature had been in place. The empirical data was collected and triangulated by taking field notes and by performing semi-structured interviews during one tour of Receiver's facilities, two workshops (one at Receiver and one at Sender), as well as during a follow-up meeting with Sender's representatives. During the workshops, key representatives from the case companies (i.a., quality managers, product developers, key account managers, and process engineers) were interviewed about their views on how the PTs had been carried out. Relevant internal documents from Sender were also reviewed. The empirical data was collected during 2015. In order to increase the validity, key informants at both companies reviewed the case report. A paper based on the data collected during the second workshop was published as (Sjøbakk et al., 2016) last year.

2. Literature Review

In this section, first, we explain how the SCRM theory can be applied during PTs. Second, we provide a brief overview over interesting findings in the reviewed literature, highlighting the prerequisites (i.e. required conditions) for achieving the expected performance outcomes, and ultimately successful PTs.

2.1. Supply Chain Risk Management during Production Transfers

According to the SC Council, the SC risk should be managed in three main steps. First, one should proactively identify potential SC disruptions and their corresponding risk sources (addressing the question *'What can go wrong?'*). Second, the likelihood of these disruptions and their impact on performance should be evaluated. Third, measures aimed at mitigating the likelihood or the impact of serious disruptions (i.e. 'preventive' and 'corrective actions' in the PT literature (Fredriksson et al., 2015)) should be identified and implemented. Moreover, the risk level should be continuously monitored throughout the PT (McCormack et al., 2008).

Figure 2 depicts relevant concepts from the SCRM literature and the causal relation between them during a supply disruption scenario. The '*risk source'* represents a tangible or intangible element, which alone or in combination with other risk sources has the intrinsic potential to give rise to a SC disruption (ISO, 2009). A '*SC disruption'* is the abnormal situation leading to negative deviations from certain performance measures and resulting in *'losses'* for the focal firm. The *'preventive'* and *'corrective actions'* are risk-mitigating actions acting as barriers between the SC risk source(s) and the unwanted SC disruption, and between the disruption and the losses, respectively. For instance, during PTs, the likelihood of SC disruptions linked to defective or even counterfeit components (Dimase et al., 2016) could be mitigated by maintaining Sender's sub-suppliers until a steady state is achieved (Fredriksson et al., 2015) (as a preventive action). Furthermore, the impact of such disruptions on supply performance could be mitigated by having alternative sub-suppliers able to deliver the same components (Manuj and Mentzer, 2008) (as a corrective action).

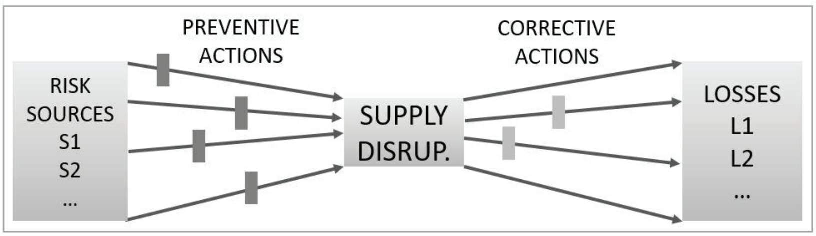

Fig. 2. Central SCRM concepts and their causality during a supply disruption scenario

Potential SC disruptions can occur either within the SC (e.g. machine breakdown) or outside the SC (e.g. natural disasters). Furthermore, the SC disruptions can be related to the sourcing process ('*source risks'* upstream the supply chain), operations ('*make risk'* at the focal firm), to delivery or to product return (downstream the supply chain) (McCormack et al., 2008, Manuj and Mentzer, 2008). The PT literature (e.g. (Fredriksson et al., 2015, Minshall et al., 1999)) primarily addresses Source risks (e.g. disruptions in the material and information flow between the Sender and the Receiver (Norrman and Jansson, 2004)) and Make risks (e.g. production disruptions at the Receiver (Almgren, 1999)).

2.2. Prerequisites for Successful Production Transfers

Based on (Momme and Hvolby, 2002) and (Madsen, 2009), the identified prerequisites in the reviewed literature have been structured according to typical categories of activities during PTs: (1) *'Preparation'*, (2) *'Execution'*, (3) *'Start-up'* and (4) *'Supplier Relationship Management'*. Moreover, the Preparations and Start-up include the subcategories *'Organization and Project Management'* (activities for organizing the PT teams and for planning the PT project (WHO, 2011, Galbraith and Galbraith, 1990)), *'Pilot Production at Sender'*, and respectively, '*Pilot Production at Receiver'*. According to (Momme and Hvolby, 2002), the Supplier Relationship Management category would succeed the PT phases, but it is worth specifying that this phase might be concurrent with other relocation phases, as it will be shown below.

Furthermore, apart from the earlier mentioned Physical transfer, a PT will comprise three other types of transfers: *knowledge* (for transferring tacit, uncodified knowledge (Fredriksson and Wänström, 2014)), *administrative* (for transferring explicit, codified knowledge (Fredriksson and Wänström, 2014)), and *supply chain transfer* (for establishing relations to vendors of raw materials, components and parts (Aaboen and Fredriksson)).

Finally, the identified prerequisites are not explicitly related to the management of SC risk during PTs. Nevertheless, in the light of the SCRM literature, we argue that several of them are closely related to SCRM, as it will be explained in the remainder of this sub-section. Examples of methods and tools for conducting SCRM will be also provided. Table 1 presents 26 identified prerequisites for the Preparations phase.

Several of the above prerequisites can be related to SCRM theory. Ensuring executive level commitment (P1, Table 1), and constituting teams dedicated to the PT with representatives from all the affected disciplines (P2, P3, P4, P5 in Table 1) and with clear roles, are not only important conditions for the success of the PT project, but also for SCRM and a sustained supply performance (McCormack et al., 2008, Manuj and Mentzer, 2008). Constituting multidisciplinary Risk management teams at both PT parties is considered essential for SCRM (McCormack et al., 2008). In addition, according to the SC Council, one should also establish a coordinating team dedicated to aligning Sender's and Receiver's risk-mitigation measures with the overall RM process (McCormack et al., 2008). This would facilitate the SCRM coordination between parties, and ultimately the effectiveness of SCRM.

Next, SCRM should be addressed right from the start. Thus, the formal agreement could include specifications about the risk assumed by each party, expected performance targets (Danilovic and Winroth, 2005, Franceschini et al., 2003, Zhu et al., 2001) and about product ownership (e.g., the Sender can maintain the ownership of equipment with high IP values

Table 1. Prerequisites for successful production transfers during the Preparations phase

Id.	Prerequisites	References
	Organization and Project Management	
P1	Project startup meeting. Executive level commitment	e.g., (Dudley, 2006, Andre and Peter, 2012)

Id.	Prerequisites	References
P2	Multidisciplinary transfer team with project managers from both parties	(Madsen, 2009)
P3	Product Development team	(Fredriksson et al., 2015, Madsen, 2009, Terwiesch et al., 2001, Rudberg and West, 2008, WHO, 2011)
P4	Supplier Development team	e.g., (Modi and Mabert, 2007)
P5	Multidisciplinary team for Risk Management	(Manuj and Mentzer, 2008, WHO, 2011)
P6	Formal agreement between transfer parties	(Danilovic and Winroth, 2005, Franceschini et al., 2003, Zhu et al., 2001)
P7	Address impact of IP on communication of technical matters	(Danilovic and Winroth, 2005, WHO, 2011)
P8	Up-to-date and easily accessible Transfer Protocol comprising all the transfer documents (i.a. a transfer plan and checklist)	(Terwiesch et al., 2001, WHO, 2011, Ferdows, 2006)
P9	Evaluate Receiver's readiness (by e.g. Gap Analysis)	(McCormack et al., 2008, WHO, 2011, Modi and Mabert, 2007)
P10	Risk Assessment for the transfer object (by e.g., FMEA, FTA, or ETA analyses)	(McCormack et al., 2008, WHO, 2011)
P11	Assess the transferability of the production system. Codify tacit knowledge. Replace obsolete equipment	(Grant and Gregory, 1997a, Andre and Peter, 2012, Madsen, 2009, Hilletofth et al., 2015)
	Pilot production at Sender (if suitable)	
P12	Set the performance targets to be achieved prior to the Physical Transfer (first pass yields, etc.)	(Terwiesch et al., 2001)
P13	Robust forecasts (of physical transfer, start-up time, new lead times, etc.)	(Fredriksson et al., 2015, Hilletofth et al., 2015)
P14	Early problem solving/recalibration on production system/supplied components or materials (by e.g., RCA, or FTA)	(Terwiesch et al., 2001)
P15	Define the Change Control process	(Terwiesch et al., 2001)
P16	Implement Preventive actions (e.g. safety stock and safety capacity). Ensure redundancy	(Fredriksson et al., 2015, McCormack et al., 2008)
	Knowledge Transfer	
P17	Send personnel from Receiver to Sender (including FMEA specialists)	(Andre and Peter, 2012, Grant and Gregory, 1997b, Terwiesch et al., 2001, Madsen, 2009, Galbraith and Galbraith, 1990)
P18	Video-taped review of production process	(Galbraith and Galbraith, 1990)
P19	Multidisciplinary training based on non-standard events. A repository of solutions	(Andre and Peter, 2012, Madsen, 2009)
P20	Perform audits at Receiver to verify Knowledge Transfer. Test personnel	(Andre and Peter, 2012)

Id.	Prerequisites	References
P21	Perform activities to enhance Receiver's performance (FMEA, RCA, VSM, Lean, Six sigma, APQP, quality control, etc.)	(Modi and Mabert, 2007)
P22	Parties jointly review and update documentation and the planning and control systems	e.g., (Andre and Peter, 2012, Fredriksson et al., 2015, Terwiesch et al., 2001)
	Transfer of Administrative Systems	
P23	Sender and Receiver develop a Communication Plan (part of the Transfer Protocol)	(McCormack et al., 2008, WHO, 2011)
P24	Sender transfers information. Receiver reviews information from Sender, identifies gaps (in facilities, systems, etc.) and develops operating procedures and documentation. Provides Receiver information	(WHO, 2011)
P25	Use a common software for managing information flows	(Malm, 2013, Terwiesch et al., 2001)
	Supply Chain Transfer	
P26	Establish relationships to sub-suppliers of necessary materials and components	(Aaboen and Fredriksson, 2015)

(Chopra and Meindl, 2013)). The agreement could also include specifications about information-sharing frequency and formats, technologies used for this, information access rights for the PT participants (P7), and the communication processes (i.a. whom to contact and how). Details about information-sharing could be included in the Communication Plan (P23), along with a crisis procedure to ensure a prompt and appropriate response to disruptions (McCormack et al., 2008). Moreover, certain types of agreement can reduce the Source risk. For instance, strategic agreements can ensure a continued service in the event of capacity constraints, and 'joint product design and delivery' (with suppliers) could reduce the risk of material non-performance and shortages (McCormack et al., 2008). Details from the agreement could be part of the Transfer Protocol (P8), along with a Change Control system (Terwiesch et al., 2001, WHO, 2011, Ferdows, 2006), a PT checklist, and a flow diagram with the sequential stages of the PT, milestones and action owners (Terwiesch et al., 2001, WHO, 2011). A simple audit checklist can be also used for evaluating Receiver's readiness (P9). Evaluating Receiver's readiness (P9) relates to the 1st step of the SCRM process, i.e. the proactive identification of Make risks at Receiver's facility (e.g., risks related to capacity, quality management and to IP). The SCOR mapping, VSM, or looking at historical problems, are some of the most common Risk Identification methods applied (McCormack et al., 2008).To perform the Risk Assessment in P10 (i.e. the 2nd step of SCRM), one could use tools such as qualitative and quantitative electronic spreadsheets. One Risk assessment method that can be applied is the Failures Modes and Effects Analysis (FMEA) (McCormack et al., 2008). As seen in Table 1, the FMEA is also frequently emphasized in the PT literature. Further, for those PT disruptions assessed as critical, there should be identified preventive and corrective actions. Then, these actions should be evaluated based on cost-benefit criteria (McCormack et al., 2008, Dimase et al., 2016), and the optimal ones should be implemented- either before (preventive actions) or after disruptions (corrective) (McCormack et al., 2008).

During the Pilot production at Sender (if suitable), parties could meet and set performance targets to be achieved before Execution (P12). Apart from first-pass yield, they could monitor the rework yield, process induced failures, test time, and tact time (Terwiesch et al., 2001). A 'watch-out' list of precursor events could be also used for monitoring, and the monitoring of Make risks could be done automatically through a data system such as the ERP. Moreover, as mentioned in the previous sub-section, the monitoring should be a continuous process, and the focus should lie on indicators warning in the beginning of a risk event or even before the event occurs (McCormack et al., 2008).

Table 2 presents 17 additional prerequisites for the remainder of the PT process. While the Execution phase should be kept as short as possible (Madsen, 2009), there are several strategies that could be applied during Pilot production at Receiver and Start-up, many of them related to SCRM. For instance, P30 and P40 are related to Monitoring. Production monitoring should be a continuous activity along PTs, yet the target levels might vary. The targets during Start-up are often higher than during Pilot production (e.g., the first pass yield, process induced failures, test time, tact time, downtime, and overall equipment effectiveness) (Terwiesch et al., 2001). In line with the SC Council, by continuously monitoring the performance, it would be easier to react promptly after supply disruptions and implement corrective actions. Further, planning the PT as a gradual transfer (P31) is related to ensuring supply continuity during PTs- one of the SCRM goals- by maintaining a secondary supply source (i.e. the Sender) in case of shortages (Fredriksson et al., 2014, Almgren, 1999). Full-speed testing (in P29) is running the system at a speed equaling the balanced capacity, to solve as many problems as possible (by e.g., Root Cause Analysis (RCA)) and speed up the Start-up (Almgren, 1999). Having a parallel experimental line at Receiver with a dedicated process improvement team (P32) is related to the continuous improvement of supply performance- including after the steady state. Furthermore, the improvement solutions should be shared with other production units (Madsen, 2009). For P34, one related mitigation action could be to shut down a production line or a test station any time the yield is lower than a certain limit, and assess the problems (Terwiesch et al., 2001). P38 is a verification of the performance targets at the end of the PT, preventing later much more costly corrections and obsolete material (Hilletofth et al., 2015).

For Supplier Relationship Management, a good coordination and collaboration with Receiver is an important success factor for both PTs and SCRM. It is at the basis of the 'shared risk' approach, as the Receiver is the only one which can directly act on most of the Make risks (McCormack et al., 2008) during the Start-up. In addition, it mitigates the likelihood of Source risks (Norrman and Jansson, 2004) during both Execution and Start-up. Finally, (Beckman and Rosenfield, 2008) state that the degree of organizational interaction and thereby the requirements for information processing capability, will depend on the degree of uncertainty within the transfer object. Further, the degree of uncertainty would depend on

Table 2. Prerequisites for successful PTs during Execution, Start-up, and Supplier Relationship Management

Id.	Prerequisites	References
	Execution	
P27	Upgrade, test, and burn-in the equipment to be transferred	(Madsen, 2009)
P28	Temporary send personnel from Sender to Receiver (including FMEA specialists)	(Terwiesch et al., 2001, Ferdows, 2006)
	Pilot production at Receiver (if suitable)	
P29	P14 and full speed testing	(Terwiesch et al., 2001, Almgren, 1999)
	Start-up	
P30	Parties meet to review Transfer Protocol and met or not-met performance targets	(Terwiesch et al., 2001)
P31	Gradual Production Transfer with secondary supply sources (not 'clear-cut'). Transfer production during periods with low demand	(Fredriksson, 2011, Terwiesch et al., 2001, Hilletofth et al., 2015, Madsen, 2009)
P32	Parallel experimental line at Receiver and a dedicated process improvement team	(Terwiesch et al., 2001)
P33	Qualify vendors. 'Vendor matrix' for components that can be used together	(Terwiesch et al., 2001)
P34	Continuous monitoring of start-up progress, demand, and safety stock level	(Fredriksson et al., 2015, McCormack et al., 2008)
P35	Decide on Corrective actions (subcontracting, expediting part delivery, etc.)	(Fredriksson et al., 2015)
P36	Adapt the documentation and the planning and control systems	(Fredriksson et al., 2015, Grant and Gregory, 1997a)
P37	Decide on when to transfer component/ material ordering responsibility to Receiver	(Fredriksson et al., 2015)
P38	Production verification. Post-transfer audit. Compare the outsourcing costs before and after the transfer	(Hilletofth et al., 2015, Zhu et al., 2001)
P39	Transfer summary report including deviations, actions and lessons learned	(Zhu et al., 2001, WHO, 2011, Stock and Tatikonda, 2000)
P40	Continuous performance improvement and monitoring (including conducting audits at Receiver)	(Madsen, 2009, Gero and Stefan, 2009)
	Supplier Relationship Management	
P41	High communication, collaboration, and coordination requirements for novel, complex, and/or tacit transfer object. Leveraging each other's strengths	(Stock and Tatikonda, 2000, McCormack et al., 2008, Vitasek and Manrodt, 2012)
P42	Receiver informs Sender about any process conflict. They have regular status meetings	(Hilletofth et al., 2015, Rehme et al., 2013)
P43	Long-term commitment. Invest in Supplier Development	(Modi and Mabert, 2007, Bocquet, 2011)

three dimensions: novelty (e.g. higher uncertainty when the PT parties have no previous experience with PTs (Fredriksson, 2011)), complexity (e.g. higher when transferring a subassembly that is part of a non-modular product than one in a modular one (Beckman and Rosenfield, 2008)), and ‘tacitness’ (e.g. higher when there is a high amount of unwritten production knowledge). Thus, PTs with a low degree of uncertainty would require less information processing capability, hence lower costs (Stock and Tatikonda, 2000).

3. Case Research

The findings from the Case Research on two PTs between a Norwegian producer of maritime monitoring systems (Sender) and one of its strategic suppliers (Receiver) are presented in Table 3.

As shown in Table 3, the transfer parties experienced a number of unwanted events during both PTs, which could have been avoided or more easily handled if some of the prerequisites from tables 1 and 2 had been in place.

In Case A, constituting a transfer management team (P2, Table 1) with representatives from all the relevant departments, including Product design and Purchasing, could have contributed to a better collaboration between Sender’s and Receiver’s personnel (Dudley, 2006). All the members should have clear roles and responsibilities and both parties should assign project managers to lead the transfer team and its activities at the two locations. Moreover, the motives behind the PT could have been explained to all the affected personnel, during a kickoff meeting early in the PT process (P1, Table 1). Further, receivers need a significant amount of documentation to start up the production and even more documentation is generated by the end of the PT. Thus, during both PTs, the transfer parties could have created an electronic transfer protocol to include all the documentation (P8, Table 1). The protocol should be continuously accessible to all the affected personnel and up-to-date (Terwiesch et al., 2001, WHO, 2011). Two of the important documents that should be included in the protocol are a plan for the entire PT and a transfer risk assessment. For instance, all the activities in the transfer plan could be assessed by the project team or a dedicated team for risk management (P5, Table 1), and for all the critical activities, preventive and corrective actions should be identified and implemented whenever necessary (P10-P11, Table 1). Had the transfer parties assessed the risk, they could have identified the risk implied by the transfer of the test equipment to Receiver earlier. Furthermore, as several studies argue, a transfer with only a gradual reduction in the production output at the Sender, synchronized with the output at the Receiver, would have helped the transfer parties to avoid some of the disruptions. In addition, the PTs could be planned during seasons with low customer demand (Madsen, 2009) (P31, Table 2). Examples of corrective actions that the transfer parties could implement in case of supply-disruptions are building up safety stock and ensuring safety capacity (Fredriksson et al., 2015).

During both cases, Sender and Receiver experienced a number of miscommunication

Table 3. Overview of the studied production transfers and their main activities

Case A- Completed Transfer	Case B- Ongoing Transfer
Sender: Norwegian electronics producer. No previous experience with transfers. Transfer object: Acoustic sensor. Mature and not too complex product. High volumes. Little IP. **Receiver:** Norwegian series producer of electronics. Strategic supplier. After transfer, they assembled and tested final products and sent them to Sender. Asked to come with suggestions for cost reduction. **Preparations:** No kick-off meeting. Sender collaborated little with their product, purchasing, and test teams and in general, their personnel had unclear roles in the transfer. The Product team did not know the motives behind the transfer and they were reluctant to support Receiver and provide essential information. The parties had not prepared any plan or risk assessment early in the project. Thus, the original decision of transferring the test equipment to Receiver had to be overridden by Product team, when they became aware of it, in order to safeguard their capability to quality-assure their deliveries. Another decision that proved to be inappropriate was planning the transfer as a clear-cut transfer, with Sender producing the entire volume until Easter and Receiver everything after that. For Knowledge transfer, the parties conducted a VSM at Sender and 3 of Receiver's operators were sent to Sender for process training. Some of Sender's suppliers of parts were transferred to Receiver. **Physical Transfer:** A copy of the test equipment was transferred. **Start-up:** Receiver came with several process improvement suggestions that were rejected by Sender without a clear explanation. During the workshops, it was disclosed that Sender was about to replace the product with a new variant but had not informed Receiver. Receiver also disclosed that the transfer had not been profitable for them, whereas Sender could not tell if the post-transfer costs were lower, only that the start-up had been long with high scrap rates and stock levels. The parties were considering to transfer	**Sender:** The same as in Case A **Transfer object:** Signal converter, part of several of Sender's products. New product version, more complex than Product A. **Receiver:** Same as in Case A. Transfer planned as a co-development of the new variant with Receiver. Receiver installed electronics (i.a. own PCBs) in cabinets; Sender tested the final products. **Preparations:** The transfer started in Sept. '14 with a kick-off, when prior to any formal agreement, Receiver was asked to order long lead-time material from vendors. Sender sent 4 BOM changes after the Pilot phase. Thus, a considerable amount of this material became obsolete, and during the April 15' workshop, Receiver revealed that they had not received yet a confirmation that Sender would compensate them for their expenses. In terms of Administrative transfer, the documentation about several changes was sent late in the process, and some of the changes had not even been properly recorded. This was according to Sender, partially because Sender's Change Control system did not allow purchasing materials for prototypes before design-freeze. With respect to Knowledge transfer, this time Receiver din not sent any personnel to be trained at Sender. With respect to the Supply chain transfer, Receiver had to use Sender's cabinet suppliers in the beginning. Next, while Receiver appreciated relying on the same key contact person at Sender throughout the process (the Product developer), Sender's Prod. Developer experienced that it had been unclear whom to contact at Receiver. She had also found two of Receiver's employees working with different BOM revisions. **Physical Transfer:** None. **Start-up:** The status during the workshop in April '15, was that Receiver had just transferred the production from their Development to their Production department.

the assembly to one of Receiver's suppliers in a low-cost country.	
Follow-up meeting with Sender: The sender had launched 3 programs with dedicated teams for each of them: (1) a Supplier Development program for Lean implementation (Receiver audited by Sender), (2) a program for Product Development with strategic suppliers, and (3) a Supplier Quality program. The Quality program included the implementation of a Change Control system, and a Statistical Process Control (SPC). They had purchased the CAPA-8D software for managing corrective and preventive actions and the integrated change control (with a dedicated multidisciplinary team). The software applies the RCA method. Moreover, Sender had an increased focus on performance monitoring. They were now using 3 performance indicators (KPIs) for monitoring suppliers: quality non-conformance ≤1%, a delivery performance ≥99%, and a cost reduction of 5% per year. They were also planning to monitor the time-to-market. Scorecards based on the 3 first indicators were used for suppliers' self-assessment, and for Sender's own assessment of these suppliers. All strategic suppliers were expected to implement the above-mentioned systems (i.e., Change Control, CAPA, SPC, KPI's monitoring, and Lean).	

incidents, e.g. production improvement suggestions rejected without a clear justification, contact persons not clearly specified, or Receiver's personnel following two different BOMs. Therefore, in addition to assigning project managers to the PT at each location, the parties could have included a communication plan in the transfer protocol, specifying whom the personnel should contact for assistance when problems arise (P23, Table 1). The communication plan is a central prerequisite for a coordinated SCRM between the Sender and the Receiver.

Finally, in order to minimize the stock levels, waste, and start-up time during the PT in Case A, Sender and Receiver could have implemented knowledge transfer measures for supplier development and continuous improvement of supply performance, e.g. VSM, Six sigma, RCA, FMEA and Lean (P21, Table 1). Moreover, as emphasized in the extant research, at the end of any PT, the senders should perform a post-transfer audit, in order to evaluate if the cost and other performance targets had been reached (P38, Table 2). In addition, the performance could be continuously monitored throughout the PT (P40, Table 2). Finally, Receiver's results together with a description of process changes, disruptions, actions and lessons learned should be documented in a summary report (WHO, 2011) (P39).

During Case B and in general during any PT, signing a thorough formal agreement (P6, Table 1) before or in the beginning of the transfer could significantly reduce the amount of unwanted and possibly very costly incidents. The agreement could specify the expected performance targets, ways to address any controversy, information access rights, forms of termination, and the risk assumed by each party (e.g., the cost of the obsolete material) (Terwiesch et al., 2001). Moreover, agreements for longer-term commitment between the two PT parties could enhance Receiver's willingness to open its facilities for the scrutiny of the Sender (Modi and Mabert, 2007), facilitating the risk monitoring (McCormack et al., 2008). Further, in order to avoid BOM and other changes too late in the process, the PT parties could have prepared a flow diagram with milestones (WHO, 2011). One recommended milestone is the production verification prior to continuous production (P38, Table

2). In addition, preparing and following a clear Change control process is also highly recommended during PTs (P15).

The follow-up meeting revealed that the Sender had been implementing several measures i.a., as a result of the challenges during PTs (Table 3). All of Sender's strategic suppliers were expected to implement these measures. However, in line with (Stock and Tatikonda, 2000), the closeness between a sender and a receiver and the required investments in data processing systems, would depend on the degree of uncertainty within the PT (i.e., novelty, complexity, and 'tacitness') (P41,Table 2). For instance, in Case B, the production process of the new variant had a relatively high degree of novelty, complexity and amount of tacit knowledge. Thus, the implementation of a program for systematic product development with the Receiver, and purchasing a software for an integrated control of engineering changes, could indeed be suitable in this context. In addition, the PT parties could have invested in a common information management system (P25, Table 1), and could have hold regular and more frequent meetings (P42, Table 2). In any case, a tighter and more coordinated collaboration between the PT parties is important for a shared risk approach and has a positive impact on supply performance (McCormack et al., 2008).

4. Conclusion

The purpose of this paper has been to identify prerequisites for achieving the expected supply performance outcomes, and thereby successful PTs - a topic addressed from an Operations Management and a SCRM point of view. Thus, a number of such prerequisites have been identified in the extant literature and structured according to the main PT phases. Moreover, the challenges during two PTs have been presented and we have discussed how they could have been avoided or more easily dealt with, if some of the identified prerequisites had been in place. The prerequisites revealed by both the literature and the empirical findings are displayed in Table 4.

We argue that the originality of this paper resides in the detailed overview over recommended activities for the entire PT process, which has not been found elsewhere. In addition, we have shed light on the potential of the SCRM approach to aid in managing unwanted events during PTs, we have highlighted possible risk-mitigation measures and suggested SCRM methods and tools. The practitioners can use the list of prerequisites as a checklist when preparing the PT plan. Nevertheless, the utility of the proposed overview of prerequisites should be tested in PT cases of various characteristics. The authors' plan for the future is to configure a project development model based on the validated prerequisites. The model will include important transfer activities, milestones, as well as suggestions of methods and tools for high supply performance during PTs.

Table 4. Prerequisites for successful PTs revealed by both the literature and the cases

Id.	Prerequisites
P1	Project startup meeting early in the transfer process where i.a. the reason for the transfer is clarified to all the affected workers
P2	Multidisciplinary transfer team with project managers and other representatives from all the affected disciplines, both transfer parties, and with clear roles
P6	Formal agreement signed as early as possible (including the risk assumed by each party)
P8	Up-to-date and easily accessible electronic Transfer Protocol containing all the transfer documentation (including a transfer plan and a transfer risk assessment)
P5,10,11	Transfer risk assessment
P15	Define and implement a clear Change Control process
P21	Perform activities to enhance Receiver's performance
P23	Sender and Receiver jointly develop a Communication Plan (including contact points for assistance and their roles)
P25	Use a common platform for information management
P31	Gradual production transfer planned during a season with low customer demand
P38	Production verification and a post-transfer audit. Compare the outsourcing costs before and after the transfer
P39	Transfer summary report including a description of process changes, disruptions, actions, and lessons learned
P40	Continuous monitoring and performance improvement at Receiver
P41	High communication, collaboration, and coordination between transfer parties for novel, complex, and/or tacit transfer object
P42	Regular and frequent status meetings

Acknowledgements

This research has been conducted with support from a research project funded by The Research Council of Norway. The authors would like to thank the project participants for providing valuable empirical data.

References

AABOEN, L. & FREDRIKSSON, A. 2015. The relationship development aspect of production transfer. *Journal of Purchasing and Supply Management*.

ALMGREN, H. 1999. Start-up of advanced manufacturing systems - a case study. *Integrated Manufacturing Systems,* 10**,** 126-135.

ANDRE, M. & PETER, B. 2012. Towards a framework for transferring technology knowledge between facilities. *Strategic Outsourcing: An International Journal,* 5**,** 213-231.

BECKMAN, S. L. & ROSENFIELD, D. B. 2008. *Operations strategy: competing in the 21st century,* Boston, McGraw-Hill/Irwin.

BOCQUET, R. 2011. Product and Process Innovations in Subcontracting: Empirical Evidence from the French "Sillon Alpin". *Industry and Innovation,* 18**,** 649-668.

CHOPRA, S. & MEINDL, P. 2013. *Supply chain management : strategy, planning, and operation,* Boston, Pearson.

DANILOVIC, M. & WINROTH, M. 2005. A tentative framework for analyzing integration in collaborative manufacturing network settings: a case study. *Journal of Engineering and Technology Management,* 22**,** 141-158.

DIMASE, D., COLLIER, Z. A., CARLSON, J., GRAY, R. B. & LINKOV, I. 2016. Traceability and Risk Analysis Strategies for Addressing Counterfeit Electronics in Supply Chains for Complex Systems. *Risk Analysis,* 36**,** 1834-1843.

DUDLEY, JR. 2006. Successful technology transfer requires more than technical know-how - Frequent and open communication is a necessity in successful technology transfer. *Biopharm. Int.,* 19**,** 68-+.

FERDOWS, K. 2006. Transfer of Changing Production Know-How. *Production and Operations Management,* 15**,** 1-9.

FRANCESCHINI, F., GALETTO, M., PIGNATELLI, A. & VARETTO, M. 2003. Outsourcing: guidelines for a structured approach. *Benchmarking: An International Journal,* 10**,** 246-260.

FREDRIKSSON, A. 2011. *Materials supply and production outsourcing*, Chalmers University of Technology.

FREDRIKSSON, A. & WÄNSTRÖM, C. 2014. Manufacturing and supply chain flexibility towards a tool to analyse production network coordination at operational level. *Strategic outsourcing : an International journal,* 7**,** 173-194.

FREDRIKSSON, A., WÄNSTRÖM, C., JOHANSSON, M. I. & MEDBO, L. 2015. A structured procedure for materials planning during production transfer. *Production Planning & Control***,** 1-15.

FREDRIKSSON, A., WÄNSTRÖM, C. & MEDBO, L. 2014. Assuring materials availability during the production transfer process; Critical characteristics of the materials planning environment. *Journal of Manufacturing Technology Management,* 25**,** 310-333.

GALBRAITH, C. & GALBRAITH, C. 1990. Transferring Core Manufacturing Technologies in High-Technology Firms. *California Management Review,* 32**,** 56-56.

GERO, W. & STEFAN, S. 2009. Performance measurement in business process outsourcing decisions; Insights from four case studies. *Strategic Outsourcing: An International Journal,* 2**,** 275-292.

GRANT, E. & GREGORY, M. 1997a. Adapting manufacturing processes for international transfer. *Int. J. Oper. Prod. Manage.,* 17**,** 994-&.

GRANT, E. & GREGORY, M. 1997b. Tacit knowledge, the life cycle and international manufacturing transfer. *Technol. Anal. Strateg. Manage.,* 9**,** 149-161.

HILLETOFTH, P., WLAZLAK, P., JOHANSSON, G. & SÄFSTEN, K. Challenges With Industrialization In a Supply Chain Network: A Supplier Perspective. Management, Knowledge and Learning-Joint International Conference 2015 Bari, Italy.

ISO, I. 2009. 31000: 2009 Risk management–Principles and guidelines. *International Organization for Standardization, Geneva, Switzerland*.

KINKEL, S. & MALOCA, S. 2009. Drivers and antecedents of manufacturing offshoring and backshoring-A German perspective. *Journal of Purchasing and Supply Management,* 15**,** 154-165.

MADSEN, E. S. 2009. *Knowledge transfer in global production,* Aalborg, Danmark, Aalborg University.

MALM, A. 2013. *Important Factors in the Transfer of Aircraft Production: Challenges Related to Offset Business*, Linköping University.

MANUJ, I. & MENTZER, J. T. 2008. Global supply chain risk management strategies. *International Journal of Physical Distribution & Logistics Management,* 38**,** 192-223.

MCCORMACK, K., WILKERSON, T., MARROW, D., DAVEY, M., SHAH, M. & YEE, D. 2008. Managing risk in your organization with the SCOR methodology. *The Supply Chain Council Risk Research Team***,** 1-32.

MINSHALL, T., UNIVERSITY OF CAMBRIDGE INSTITUTE FOR, M., STORBRITANNIA DEPARTMENT OF, T. & INDUSTRY 1999. *Manufacturing mobility : a strategic guide to transferring manufacturing capability,* Cambridge, University of Cambridge, Institute for Manufacturing.

MODI, S. B. & MABERT, V. A. 2007. Supplier development: Improving supplier performance through knowledge transfer. *Journal of Operations Management,* 25**,** 42-64.

MOMME, J. & HVOLBY, H.-H. 2002. An outsourcing framework: Action research in the heavy industry sector. *European Journal of Purchasing and Supply Management,* 8**,** 185-196.

NORRMAN, A. & JANSSON, U. 2004. Ericsson's proactive supply chain risk management approach after a serious sub-supplier accident. *International Journal of Physical Distribution & Logistics Management,* 34**,** 434-456.

REHME, J., NORDIGÅRDEN, D., BREGE, S. & CHICKSAND, D. 2013. Outsourcing to a non-developed supplier market: The importance of operational aspects in outsourcing. *Journal of Purchasing and Supply Management,* 19**,** 227-237.

RUDBERG, M. & WEST, B. M. 2008. Global operations strategy: Coordinating manufacturing networks. *Omega-Int. J. Manage. Sci.,* 36**,** 91-106.

SJØBAKK, B., MOGOS, M. & MAGERØY, K. 2016. Transfer Of Production To Strategic Suppliers: A Case Study. *WIT Transactions on Engineering Sciences,* 113**,** 279-286.

STOCK, G. N. & TATIKONDA, M. V. 2000. A typology of project-level technology transfer processes. *Journal of Operations Management,* 18**,** 719-737.

TERWIESCH, C., BOHN, R. E. & CHEA, K. S. 2001. International product transfer and production ramp-up: A case study from the data storage industry. *R and D Management,* 31**,** 435-451.
TIBOR, K., OYA ICMELI, T. & WALTER, O. R. 2006. Outsourcing decision support: a survey of benefits, risks, and decision factors. *Supply Chain Management: An International Journal,* 11**,** 467-482.
VIKRAM, C. 2013. Managing a supply chain's web of risk. *Strategy & Leadership,* 41**,** 39-45.
VITASEK, K. & MANRODT, K. 2012. Vested outsourcing: a flexible framework for collaborative outsourcing. *Strategic Outsourcing: An International Journal,* 5**,** 4-14.
WHO 2011. WHO Technical Report Series 961: WHO Expert Committee on Specifications for Pharmaceutical Preparations, Forty-fifth Report. *In:* ORGANIZATION, W. H. (ed.).
YIN, R. K. 2004. *The Case study anthology,* Thousand Oaks, Calif, Sage.
ZENG, A. 2003. Global sourcing: process and design for efficient management. *Supply Chain Manag.,* 8**,** 367-379.
ZHU, Z., HSU, K., LILLIE, J. & ZHU, Z. 2001. Outsourcing - a strategic move: the process and the ingredients for success. *Management Decision,* 39**,** 373-378.

Paper 4

Mogos, M. F., Fredriksson, A., Alfnes, E., Strandhagen, J.O., (2020). "Investigating Relationships between Production Transfer-Management and Transfer Success", under review at *Journal of Manufacturing Technology Management*.

This article is awaiting publication and is therefore not included

Paper 5

Mogos, M. F., Fredriksson, A. and Alfnes, E., (2019). "A production transfer procedure based on risk management principles", *Journal of Global Operations and Strategic Sourcing,* Vol.12(1), pp.103-150.

This is an accepted manuscript of an article published in Journal of Global Operations and Strategic Sourcing. The final authenticated version is available online at: https://doi.org/10.1108/JGOSS-01-2018-0001

A Production-Transfer Procedure Based on Risk Management Principles

Maria Flavia Mogos[1], Anna Fredriksson[2], Erlend Alfnes[1]*

[1]Norwegian University of Science and Technology (NTNU)-Department of Mechanical and Industrial Engineering, Trondheim, Norway
[2]Linköping University-Department of Science and Technology, Construction Logistics, Linköping,
{maria.f.mogos, erlend.alfnes}@ntnu.no

Abstract

The Purpose – This paper aims to develop a procedure for preparing production transfers based on risk management principles. The procedure should help companies reduce the amount of supply chain disruptions during transfers and achieve their outsourcing/offshoring objectives.

Design/methodology/approach – The procedure was developed during a three-year Design Science study. First, a literature review and case studies were conducted to frame the research problem. Second, a preliminary procedure was developed based on preventive risk mitigation actions from the production transfer literature. Third, the procedure was implemented during an electronics-offshoring case and refined during workshops with the sender and receiver's transfer personnel. Fourth, during a seminar, transfer practitioners verified the procedure by applying it to outsourcing/offshoring cases with which they had experience.

Findings – Most of the preventive actions were evaluated as relevant for the transfers the procedure was applied to, regardless of industry and relocation type. Moreover, the electronics-offshoring case showed that the success of a production transfer not only depends on the physical, knowledge and supply chain transfers, as presented in earlier research, but also on the administrative transfer and on the organisation, project and quality management actions. This paper also attempts to enhance the production transfer literature by clarifying transfer risk management.

Practical implications – The procedure can be used during the production transfer phase as a preparation procedure. Moreover, it informs the decision-making process during the relocation-decision and supplier-selection phases.

Originality/value – To the authors' knowledge, this is the first production-transfer-preparation procedure based on risk management principles.

Keywords Manufacturing Relocation; Production Transfer; Supply Chain Risk Management

Paper type Research paper

1. Introduction

Nowadays, the relocation of production activities is a common phenomenon among manufacturing companies, which in the pursuit of higher competitiveness try to reap the benefits that different locations and suppliers provide (De Backer et al., 2016). Companies relocate production to external suppliers (*production-outsourcing*) or to suppliers in foreign and often low-cost countries (*production-offshoring*) (Jahns et al., 2006). Furthermore, relocation decisions can be motivated by goals such as reducing production costs, pursuing an emergent customer market and accessing new technologies or materials (Mykhaylenko et al., 2015, Beckman and Rosenfield, 2008). Nevertheless, the supply chain management-literature recognises that production relocations lead to an increased risk in supply chains; hence, the achievement of pursued goals may be challenging (Vikram, 2013, Chopra and Meindl, 2013). The existing literature reports a number of production relocations that failed, and e.g., led to unexpectedly high costs, reshoring or even factory close down (e.g. (Kinkel and Maloca, 2009, Fratocchi et al., 2014, De Backer et al., 2016)).

The success of production-relocations not only depends on companies' ability to select the most suitable production for relocation and the right supplier but also on how well the relocation decision is implemented (Aaboen and Fredriksson, 2016), which refers to the *production transfer* (PT). Figure 1 depicts the main phases of a production-relocation process.

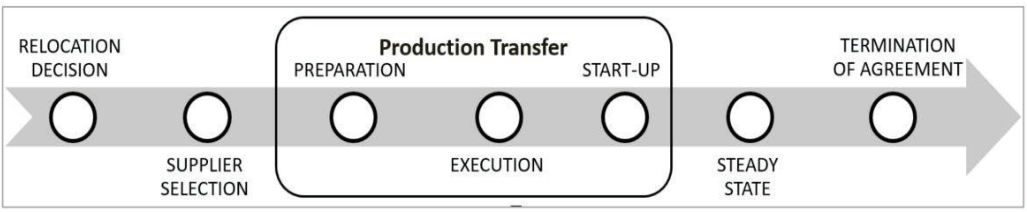

Figure 1: The production-relocation process (adapted after (Fredriksson, 2011, Madsen, 2009))

As shown in Figure 1, the PT is divided into three main phases: (i) *Preparation*, (ii) *Execution*, and (iii) the *Start-up* of production at supplier's site (Madsen, 2009). The Execution phase usually consists of a *physical-transfer* of equipment and inventory from the production site (hereafter denoted as *sender*) to the supplier (hereafter denoted as *receiver*).

A PT is considered successful if the receiver achieves a full-scale and stable production output (*Steady state* in Figure 1) according to schedule and at targeted levels of performance, which can be indicated by the cost and the yield level (Terwiesch et al., 2001, Almgren, 1999). However, production-relocations are often associated with an increased risk of supply chain disruptions, such as quality non-conformances (Dachs and Zanker, 2015, Manuj and Mentzer, 2008) and material shortages (Manuj and Mentzer, 2008). Furthermore, companies may experience different types of losses e.g., the loss of flexibility to respond quickly to demand changes, excessive transportation costs (Dachs and Zanker, 2015), a reduction in brand value, the loss of intellectual property and even the loss of their entire business (Vikram, 2013, Chopra and Meindl, 2013, Kinkel and Maloca, 2009). The European Manufacturing Survey from 2012 shows that between 2010 and mid-2012, ca. 25% of the 3500 participating firms reshored production to their home countries (Dachs and Zanker, 2015) because they incurred these types of losses. Moreover, an analysis of 39 German companies that relocated production highlights that on average, start-up times were 2.5 times longer than originally planned, and the period between Start-up and Steady state ranged in almost all cases from two to three years (Kinkel and Maloca, 2009).

In line with the Supply Chain Risk Management literature (e.g. (McCormack et al., 2008)), to avoid costly disruptions and losses during later process stages (i.e. Execution and Start-up), companies should focus on identifying and implementing preventive actions during earlier process stages (i.e. Preparation). The PT scholars also acknowledge the importance of preparing PTs thoroughly (Grant and Gregory, 1997a, Minshall et al., 1999, Terwiesch et al., 2001, Madsen, 2009) and based on risk management principles (Cheng et al., 2010, Malm, 2013, Fredriksson et al., 2015). However, to the best of the authors' knowledge, a detailed procedure for preparing PTs carefully and based on supply chain risk-management principles is lacking within the literature. Taking into account the significant amount of resources that companies invest in production relocations and the risk to which they expose themselves, this is a surprising finding, providing an intriguing research opportunity. By PT procedure is meant a series of PT actions, which are conducted in a certain order and are necessary to achieve production relocation goals (based on Fredriksson [2011]).

Although many production relocation procedures exist, only few of them address the PT process. Furthermore, those procedures either provide a rather vague overview of PT activities (e.g. (Zeng, 2003, Momme, 2002)) or they only focus on certain parts of the PT process (e.g. the physical transfer during the Execution phase in (Kowalski et al., 2018) or the materials planning and control during Preparation and Start-up in Fredriksson et al. [2015]).

Furthermore, although some of the PT scholars acknowledge the importance of managing the risk during PTs, they do not provide clear guidelines for this (e.g. Madsen [2009] and Malm [2013]). Malm (2013) presents a PT risk analysis performed by SAAB Aeronautics. This is an interesting example of how PT risk management is performed in practice. However, Malm does not describe the preventive actions implemented by SAAB to prepare for the studied PT. In 2015, Fredriksson et al. published the first paper explicitly recommending preventive actions during PTs. This paper has a focus on the preventive actions that might be necessary to avoid shortages of raw materials and components (e.g. forecast the start-up time and new lead times, update the planning and control systems, and prepare a safety stock and safety capacity) and on actions that are necessary to avoid incomplete or irrelevant transfer-documentation. However, there are additional risk-areas during PTs that should be handled by practitioners, such as the management of the PT project (Terwiesch et al., 2001, Madsen, 2009), receiver's training (e.g. McBeath and Ball [2012] and Cheng et al. [2010]) and the transfer of sub-suppliers (Aaboen and Fredriksson, 2016). Finally, World Health Organisation has published detailed guidelines for the preparation of PTs in the pharmaceutical industry (WHO, 2011). However, similar to the other publications, WHO (2011) acknowledges the importance of risk management during PTs, without clearly describing how it should be performed. In addition, WHO (2011) provides mainly practitioner-based and not research-based guidelines, and a significant amount of the recommended preparatory activities are arguably only applicable to the pharmaceutical industry (e.g. activities related to active pharmaceutical ingredients and the contamination of the pharmaceutical products).

In 2008, Busi and McIvor published a comprehensive literature review on the topics of outsourcing and offshoring. The review highlights that hitherto, the literature payed little attention to the PT preparation process and to PT risk management, and only few outsourcing/offshoring frameworks were developed by applying theoretical frameworks in a practical setting (Busi and McIvor, 2008). Nevertheless, the knowledge transfer, an important PT area, and the outsourcing/offshoring risks are presented as emergent themes, whereas the implications of applying well-known operations management techniques, such as change management, knowledge management and performance management during outsourcing/offshoring are proposed as future avenues of research. Implementing such techniques during PT projects is highly relevant, as will be shown later.

As presented above, the PT preparation process and the PT risk management continued to receive limited attention in the following decade, despite their importance for the success of production relocations. However, through the Supply Chain Risk Management lens, several of the preparation activities recommended in the PT literature can aid in avoiding supply chain disruptions. Therefore, the purpose of this research is to identify potential preventive actions in the PT literature and synthesise them into a procedure for preparing PTs and for preventively mitigating the risk of supply chain disruptions during PTs. The procedure should aid companies in meeting their targeted performance outcomes during production-relocations.

2. Methodology

To develop the PT-preparation procedure, the design science research strategy, as described by Holmström et al. (2009), was adopted. This strategy is recommended both for the development of procedures with enhanced practical relevance and for theory development (e.g. Holmström et al. [2009] and Van Aken and Romme [2009]). Moreover, according to the design science strategy, the cross-disciplinary nature of this paper is an advantage when developing procedures (Holmström *et al.*, 2009).

Table 1 presents the four phases of this study's research process: Problem framing, Procedure incubation, Procedure refinement and Explanation. The last three phases are based on Holmström et al.'s (2009) recommendations. the first phase is inspired by Van Aken and Romme's (2009) recommendations for design science and its purpose is to present how the field problem was identified.

The remainder of this section presents the methods of data collection and analysis during the Problem framing, Procedure incubation and Procedure refinement phases, as well as the rationale behind the case selection. The Explanation phase discusses the empirical findings collected during the previous research phases, in the light of the PT-literature, and is presented in Section 5. The empirical data was collected during a period of 3 years, between April 2015 and April 2018.

Phase 0: Field-problem framing. According to Van Aken and Romme (2009) *"a field problem is a problematic state in a social or material reality".* To gain an in-depth understanding of the field-problem the research was initiated with two exploratory case studies (Yin, 2004). The multiple case study enabled a fruitful cross-case analysis and a higher internal and external validity (Eisenhardt, 1989). The cases were recent transfers of electronics production from the domestic site of a Norwegian multinational producer (hereafter denoted as *Sender*) to a domestic electronics supplier. The empirical data was collected in April 2015, through semi-structured interviews conducted during one workshop at the supplier and one at Sender. During the workshops, key transfer-personnel (managers, purchasers, product-developers, process engineers and operators) from both companies were interviewed about the challenges they experienced during the PTs and possible causes of these. Thereafter, the interview data was triangulated with field notes taken during a tour of the supplier's factory, and with relevant internal documents from Sender. The authors prepared a case-report based on the collected data, and to increase the accuracy of the empirical findings and the construct validity, this report was reviewed by informants (Karlsson, 2009).

Table 1: The research process (based on (Holmström et al., 2009) and (Van Aken and Romme, 2009))

Research Type	**Exploratory Research**			**Explanatory Research**
Research Phase	0.Field-problem framing	1.Procedure Incubation	2.Procedure Refinement	3.Explanation
Objective	Identify, understand, frame the field-problem	Develop an initial transfer-preparation procedure	Refine the transfer-preparation procedure; solve the field- problem	Develop substantive theory; establish theoretical relevance
Means	Collecting and triangulating empirical data by taking field notes during site tours at both transfer-parties, performing semi-structured interviews and reviewing company documents and secondary data	Identification of potential preventive actions in the production-transfer literature, through the lens of supply-chain risk management. The review included: peer-reviewed journal articles, dissertations, best-practices within the topics of ‘production transfer’, ‘knowledge transfer’ and ‘technology transfer’, as well as publications about different types of production-relocations, ‘start-up’ and ‘ramp-up’. Moreover, seminal supply chain risk management publications were studied	• Implementation of the proc dure during a production offshoring case • 7 iterations between procedure implementation, evaluation and refinement during 19 workshops with the case-sender and receiver • Confirmation of intended consequences; co-optation of unintended consequences • By help of a questionnaire, transfer practitioners applied the procedure on 3 production transfer examples with which they had broad experience and verified it. The examples were from distinct industries	• Analysing the refined procedure in light of the literature findings from Phase 1 • Addressing the theoretical and practical implications of the procedure
Research approach in this paper	Exploratory Case Research on 3 retrospective production transfers	Literature review, conceptual analysis	Action Research, survey	Discussion

The logical approach employed during the Field-problem framing phase was abductive (as described by Karlsson [2009, p.30]). The starting point was the field-problem, which was the suboptimal supply performance during the studied PTs (e.g. long start-ups). Thereafter, it was identified that one of the potential root-causes for the field-problem was the lack of a PT-preparation procedure, which could be implemented by practitioners in order to mitigate the PT risk (see Section 1). Thus, the authors decided to develop a PT-preparation procedure based on risk management principles, and implemented it during an ongoing PT to study its effect on supply performance.

Phase 1: Procedure Incubation. This phase focused on developing a preliminary version of the PT-preparation procedure. First, the authors conducted a systematic literature review (as recommended by Karlsson [2009, p.48]) to identify potential preventive actions in the PT literature. The authors studied peer-reviewed journal and conference articles, dissertations, monographs, books and guidelines on the topics of *production-*, *knowledge-* and *technology-transfers* in manufacturing industries, as well as about *production relocations*, *start-up*, *ramp-up*, and key publications in the area of Supply Chain Risk Management. The literature search was conducted on a university’s internet library (Oria), which provides access to the main databases for peer-reviewed literature, and on Google Scholar. Second, the identified preventive-actions were synthesized into a preliminary procedure (Table 2, Section 4). To this end, the most comprehensive frameworks and guidelines found in the literature were taken as a starting point (Fredriksson et al., 2015, Terwiesch et al., 2001, WHO, 2011). Third, the preliminary procedure was presented and discussed at a major Operations Management conference (EurOMA 2016).

Phase 2: Procedure Refinement. In this phase, the PT-preparation procedure developed in Phase 1 was implemented and iteratively evaluated and refined during a PT of acoustic sensors from Sender to their Spanish subsidiary (hereafter denoted as *Receiver*). Figure 2 depicts the organisation chart of this PT and the personnel that was involved in the procedure refinement process. As recommended by Holmström et al. (2009), this phase applied an action research approach, and for this, the strategy described by Coughlan and Coghlan (2002) was followed. The action research approach allowed the authors to both implement the procedure at the case company in order to solve the field problem and affect the way the procedure was modified by the case company (Coughlan and Coghlan, 2002).

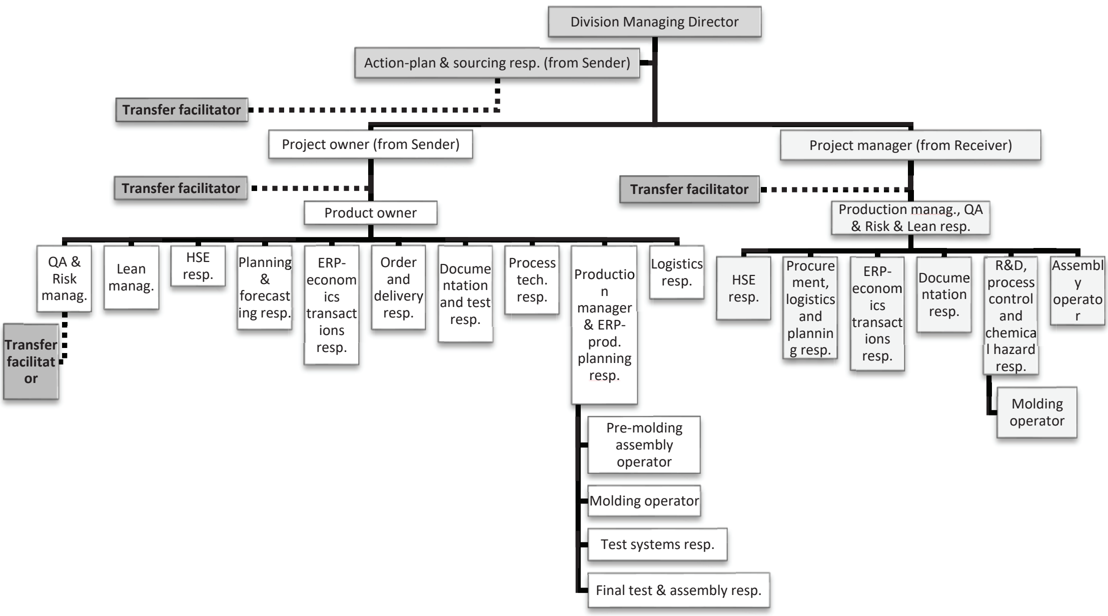

Figure 2- The organisation chart of the production transfer to Spain

As indicated in the organisation chart (Figure 2), the lead author was part of Sender and Receiver's PT organisation and had the role of Transfer Facilitator. However, the lead author was not employed by the transfer-parties (i.e. the author was an 'outside agent'). Thus, it was relatively easy to analyse not only the progress of the PT but also the research itself (Coughlan and Coghlan, 2002). Moreover, the lead author had a steering committee with members from Sender and Receiver, who enabled the author to build insider knowledge. The committee members were the Action-plan & Sourcing responsible, Project Owner, Quality-assurance & Risk Manager and the Project Manager.

Furthermore, after implementing the procedure developed in Phase 1 during the PT to Spain, the authors verified its external validity during an international one-day seminar on the topic of PT. The seminar was organised by the lead author's research group in March 2017. The main purpose of the verification was to corroborate how relevant the procedure was for PTs with contrasting characteristics compared to the PT to Spain. During the seminar, three international PT practitioners applied the procedure on a PT (each on a different one) and verified it. The practitioners were an external PT consultant who applied the procedure on an offshoring-PT of food production (with 8 years of PT experience), a PT manager who applied the procedure on an offshoring-PT of thruster production (6 years of PT experience) and a PT facilitator who applied the procedure on an outsourcing-PT of aircraft production (7.5 years of PT experience). Table 2 presents the PT experience and degree of involvement of all the informants during the Procedure Refinement phase. Although only three PT practitioners tested the utility of the procedure, the introduction of a potential solution in several contexts is a significant step toward theory development (Holmström et al., 2009). Moreover, according to Gregor and Hevner (2013), when a researcher has expended significant effort in developing the solution design in a project, often with much formative testing, the final testing should not necessarily be expected to be as full or as in-depth as evaluation in a research project where someone else developed the solution design (Gregor and Hevner, 2013).

Table 2: The experience and involvement of the informants during the Procedure Refinement phase

Informant (transfer role)	Transfer experience (years)	Participations at workshops/meetings
Action Research during a production transfer from Norway to Spain:		
From Sender:		
Division Managing Director	2	N = 3
Action Plan and Sourcing responsible	2	N = 8
Project Owner	3	N = 14
Product Owner	0.5	N = 5
QA and Risk manager	2.5	N = 12
Lean Manager	1	N = 2
HSE responsible	0.5	N = 1
Planning and Forecasting responsible	0.5	N = 2
ERP Economics Transactions responsible	0.5	N = 1
Order and Delivery responsible	1	N = 2
Documentation and test responsible	1	N = 2
Process Technology responsible	1	N = 3
Production Manager and ERP-Production Planning responsible	2	N = 4
Pre-moulding Assembly operator	0.5	N = 1
Moulding operator	0.5	N = 3
Test System responsible	0.5	N = 1
Final Test and Assembly responsible	0.5	N = 1
Logistics responsible	1	N = 1
From Receiver:		
Project manager	2.5	N = 7
Production Manager and QA& Risk& Lean responsible	2	N = 5
HSE responsible	1	N = 1
Procurement, logistics and planning responsible	2	N = 2
ERP Economics Transactions responsible	2	N = 2
Documentation responsible	2	N = 2
R&D, process control and chemical hazard responsible	0.5	N = 4
Moulding operator	0.5	N = 4

Informant (transfer role)	Transfer experience (years)	Participations at workshops/meetings
Assembly operator	1	N = 4
Survey at an international seminar:		
Production Transfer consultant	8	N = 1
Production Transfer manager	6	N = 1
Production Transfer facilitator	7.5	N = 1

First, each participant presented her/his selected PT. Thereafter, the lead author presented the PT procedure and administered an electronic questionnaire to the PT practitioners. The questionnaire was prepared in Google Forms and it consisted of several closed-questions with space for open-ended comments. The authors applied the Likert scale, with three alternatives: (the action has) 'no or low relevance', 'medium relevance' and 'high relevance'. Further details about the data collection and analysis during Phase 2 are provided in subsections 5.2 and 5.3, respectively.

Case Selection: According to a survey of 847 Nordic companies with over 50 employees, 48% of the surveyed production companies had relocated production (Heikkilä et al., 2017). Production relocations are arguably more frequent among Nordic companies than among other European companies. For instance, only 21% of the companies participating in the European Manufacturing Survey relocated production in the period 2000-2012 (Dachs and Zanker, 2015). Moreover, in Heikkilä et al.'s (2017) study, electronic companies were among those that relocated production most frequently. Consequently, based on these findings and on Karlsson's recommendations about sample representativeness (2009, p. 172), the main case company (a Nordic electronics company) and the selected cases during Phase 0 and the Action Research in Phase 2 can be regarded as representative.

As earlier mentioned, the survey-PTs belonged to different industries and to both offshoring and outsourcing processes, because the main purpose of the survey in Phase 2 was to verify the external validity of the procedure. Moreover, while the senders were all located in Nordic countries, the receivers were located in three distinct geographical areas (Estonia, China and India). In addition, the complexity of the transfer object varied across the PTs, including both 'simple' transfer objects (a production line for bread) and complex (aircraft production). Finally, the number of survey-PTs was a result of a trade-off between 'adequate' external validity and study depth, in the context of a one-day seminar. The authors decided that three cases should be sufficient to achieve both goals.

3. Research Phase 0- Field-problem Framing

This section briefly presents how the field problem and its potential causes were identified during the first phase of the design science research process. As already mentioned, during this research phase we studied two PTs of electronics from the domestic site of a Norwegian multinational producer (Sender) to a domestic electronics supplier. During the workshop-interviews (see Section 2), the informants from Sender and the supplier agreed that during the two studied PTs they experienced sub-optimal supply performance results in the form of excessive start-ups, scrap-rates and inventory levels (i.e. the field problem). During the first PT, which was also the first PT project between Sender and the Norwegian supplier, as the Norwegian supplier could not achieve a steady state of production, Sender had to re-relocate the production to a supplier in a low-cost country. The supplier's informants reported that they accepted to participate in the first PT because they were willing to initiate a close collaboration with Sender, but eventually the transferred production turned out to be excessively labour-intensive and unprofitable for them. Overall, the informants' responses indicated that the challenges they had experienced were caused by the lack of thorough preparation of the PTs and of risk management, because of a lack of established PT procedures that they could apply. Moreover, as the existing research shows (see Section 1), the challenges described by the informants are common for many companies. In addition, just as the informants reported, there is a lack of established PT-preparation procedures in the literature, based on which the production can be adapted to the receiver's environment (i.e. not 'copy exactly'). Thus, it determined that a PT-preparation procedure based on risk management principles could address both the field problem and the literature gap. Note that a detailed description of the two PT cases is provided in the authors' earlier papers (Sjøbakk et al., 2016, Mogos et al., 2016).

4. Research Phase 1- Procedure Incubation

This section presents the preliminary version of the PT-preparation procedure based on risk management principles. First, it is shown how the supply chain risk management theory can be applied during PTs. Second, there are presented the potential preventive actions identified in the PT literature and it is explained how these actions have been synthesized into the preliminary procedure.

4.1. The Relationship between the Supply Chain Risk Management Theory and PTs

The Supply Chain Risk Management literature shows that in general a risk management process is organized into three steps: risk identification, risk assessment, and risk mitigation (Kern et al., 2012, Bode and Wagner, 2009, Kleindorfer et al., 2005). The risk management process depicted in Figure 3 is used as the starting point for how the preventive risk mitigation during PTs is viewed in this research.

First, one should proactively identify potential supply chain disruptions, as well as the risk sources triggering these disruptions and their consequences (*losses*) (McCormack et al., 2008) (*step 1- risk identification*, Figure 3). In other words, one should address the question *'What can go wrong?'* A *supply chain disruption* is an abnormal situation in comparison to every-day business, which leads to negative deviations from certain performance targets and can result in losses for the affected companies (McCormack et al., 2008). Examples of possible supply chain disruptions during PTs are material shortages (Fredriksson et al., 2015), fires (Norrman and Jansson, 2004), machine breakdowns and quality non-conformances (Almgren, 1999). *Risk sources* are tangible or intangible elements, which alone or in combination with other risk sources have the intrinsic potential to give rise to supply chain disruptions (Norrman and Jansson, 2004). Examples of risk sources during PTs are the transfer-parties experience with PTs, receiver's experience with similar production, the complexity and maturity of the transfer object (Tatikonda and Stock, 2003), the relation and geographical closeness between the transfer-parties (Terwiesch et al., 2001), and the motivation of the sender's personnel (Fredriksson et al., 2014). For instance, a risk-source such as a receiver's inexperience with the transferred production equipment can trigger machine breakdowns and consequent capacity deviations. Furthermore, these breakdowns may eventually lead to significant losses, such as the receiver's inability to deliver on time (Chopra and Meindl, 2013, Fredriksson et al., 2015).

Second, the risk level should be assessed qualitatively or quantitatively, based on the likelihood of each potential supply chain disruption and its negative impact on performance (*step 2- risk assessment*,

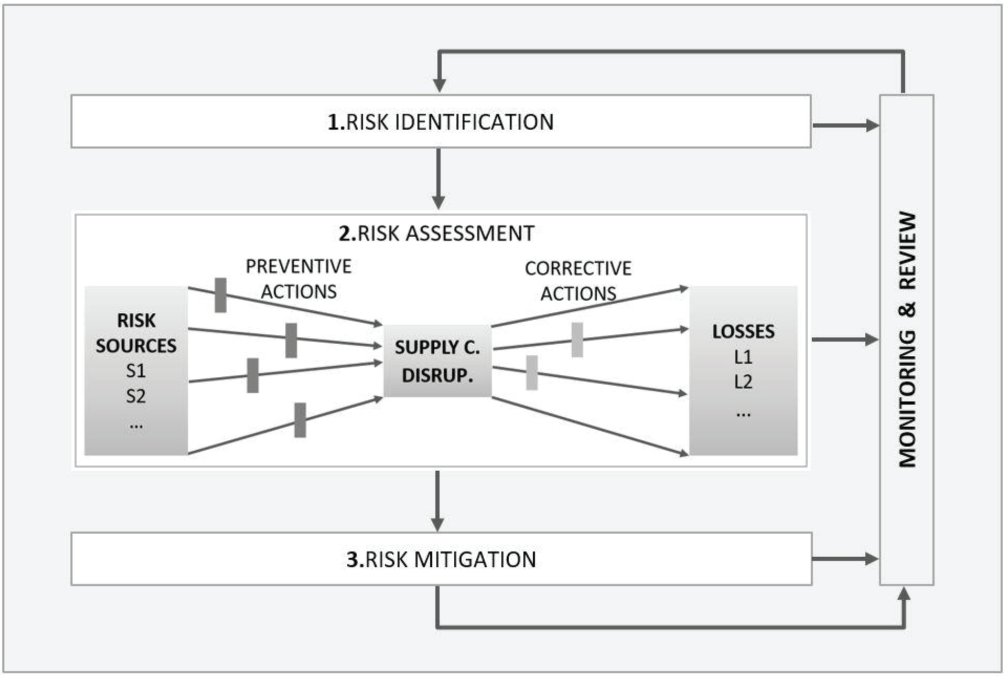

Figure 3: The risk management process during production transfers (based on Kern et al. [2012] and McCormack et al. [2008])

Figure 3). The supply chain disruptions can be visualised in a risk matrix with the dimensions probability of occurrence and negative impact. The matrix should clearly display supply chain disruptions with the risk level that is unacceptable for the companies (McCormack et al., 2008).

Third, actions aimed at mitigating the risk of those supply chain disruptions with an unacceptable risk level should be identified and implemented (*step 3- risk mitigation*, Figure 3). However, this should be only done after a cost-benefit analysis for the alternative risk-mitigation actions. Risk mitigation strategies during PTs include:

i) removing the risk source (e.g. by not changing sub-suppliers during Start-up to avoid the increased risk of quality deviations, as seen in Aaboen and Fredriksson [2016]);

ii) implementing *preventive actions* to reduce the likelihood of supply chain disruptions (as seen in Minshall et al. [1999]);

iii) implementing *corrective actions* to reduce the losses caused by supply chain disruptions that could not be avoided (as seen in Madsen [2009]).

iv) accepting the risk (Zhu et al., 2001);

v) sharing the risk (Zhu et al., 2001).

As illustrated in Figure 3, the preventive- and corrective actions are barriers between risk source(s) and the unwanted supply chain disruption, and between the disruption and losses. Finally, the performance level should be continuously monitored to promptly identify deviations and implement risk-mitigating actions (Kern et al., 2012, McCormack et al., 2008).

4.2. Potential Preventive Actions during PTs

The potential preventive actions (referred to as *A'no.'* in Appendix 2) identified in the PT literature are synthesized into the preliminary version of the PT-preparation procedure, as presented in Appendix 2. All the preparatory actions can mitigate the likelihood of supply disruptions (Norrman and Jansson, 2004, ISO, 2009) during the Execution and Start-up phases of the PT (see Figure 1). Thus, all the preparatory actions identified in the PT literature were included in the procedure. The actions are classified into the following categories: Organisation and Project Management (C1, Appendix 2), Quality Management (C2), Knowledge Transfer (C3), Transfer of Administrative Systems (C4) and Supply Chain Transfer (C5). C3, C4 and C5 are based on Fredriksson and Wänström's (2014) classification of PT activities, whereas C1 and C2 are added based on WHO's (2011) recommendations. The procedure suggests a certain sequence of the actions which is based on descriptions of the PT process from the literature. Nevertheless, the exact sequence of the actions is expected to vary from case to case. The preventive actions from each category are described below.

Organisation and Project Management (C1). This category comprises two types of actions that senders and receivers should implement. The first type are actions for establishing the PT organisation (i.e. creating a project-team and any other necessary sub-teams). The project-team should include a general coordinator for the entire project, and both transfer-parties should assign one project manager to the transfer (A1, Appendix 2). Moreover, all the disciplines affected by the PT should be represented, and the team members should have clear roles and responsibilities. According to the Supply Chain Council, these factors are essential for risk management (McCormack *et al.*, 2008). Moreover, the PT process adds new responsibilities to existing job positions. This should be clearly communicated to the affected personnel, and appropriate skills and capacity levels should be ensured (McCormack *et al.*, 2008).

WHO (2011) recommends creating a cross-locational risk management team with representatives from both PT parties (A4). In line with the Supply Chain Council, if the sender and receiver have two separate risk management teams, their risk activities should be always aligned (McCormack *et al.*, 2008).

The second type of actions in the Organisation and Project Management category (C1) are related to project management. A project start-up meeting should be organized as early as possible during the PT process and should include representatives from both transfer-parties and all the affected disciplines (A5). During this meeting, the transfer-parties should explain the reason for the transfer, discuss what performance outcomes are expected and clarify the business relationship between them (Dudley, 2006, McBeath and Ball, 2012).

Furthermore, if the transfer parties had not signed a formal agreement prior to the PT process, they should do this during Preparations. For this, the transfer-parties should evaluate the regulatory requirements (e.g. import duties and quotas) in their countries and in any country where the product is to be delivered (A6). Some of the issues that the agreement should include are emphasized in the Supply Chain Risk Management literature, including the specifications about profit sharing, the risk assumed by each transfer party (e.g. who pays for obsolete and scrapped materials), the PT personnel's rights to access information containing 'intellectual property' (IP) and the specifications about product ownership (McCormack et al., 2008, Chopra and Meindl, 2013). For instance, the sender could maintain ownership of the transferred equipment with a high IP value (Chopra and Meindl, 2013).

Other elements that the transfer-parties should agree on are the expected performance targets (e.g. key performance indicators [KPIs]) and how to continuously monitor them at the receiver (A7). Examples of performance indicators that could be monitored during Start-up are measures of first pass yield, process induced failures, test time, tact time, downtime and overall equipment effectiveness (OEE) (Terwiesch et al., 2001, Almgren, 1999). The continuous monitoring of performance is also important according to the Supply Chain Risk Management literature, as it facilitates the detection of supply disruptions and the prompt implementation of corrective actions (Blackhurst *et al.*, 2008). The monitoring of the production risks during the Start-up could be done through the ERP planning system. In addition, the transfer-parties can use a 'watch-out' list of precursor supply disruptions (McCormack *et al.*, 2008). Furthermore, certain types of agreements can reduce the supply risks. For instance, strategic agreements could ensure a continuous supply in the event of capacity constraints at the receiver, and a 'joint product design and delivery' with the receiver could reduce the risk of quality non-conformities and supply shortages (McCormack *et al.*, 2008).

Other Project Management actions are to prepare a thorough PT plan and to hold regular status meetings with the project team (A9-A10). Furthermore, whenever possible, PTs should be carried out during periods with lower customer demand (A14), and the production volume at the sender should be only gradually decreased as outputs increase at the receiver (A13). This implies having parallel production activities at the sender and receiver for a certain period. In this way, the sender would act as a secondary supply source in case of shortages (McCormack *et al.*, 2008).

Apart from the Project management plan, the PT parties should prepare a Communication plan (A12). By providing information about whom to contact when problems arise and how, this plan facilitates a prompt response to disruptions. In addition, the Communication plan should describe crisis scenarios, the media-relations strategy during crisis events and the corrective actions identified when performing the risk assessment (McCormack *et al*., 2008). When preparing the Communication plan, the impact of confidentiality on the open communication of technical and risk matters should be addressed (Danilovic and Winroth, 2005, WHO, 2011).

All the PT documents should be gathered into one common directory, also known as Transfer Protocol (A11), and the directory should be continuously updated.

Quality Management (C2). First, the sender should evaluate the receiver's readiness (A15, Table 3), which is highly relevant for risk identification (step 2, Figure 3). Examples of risk-sources are the qualification of the manufacturing and packaging rooms and of the equipment, the quality-control procedures (WHO, 2011) and the personnel's production-capability (Malm et al., 2016). One method that could be useful for this evaluation is the Gap Analysis, as it highlights the capability gaps between the transfer-parties (Malm et al., 2016, WHO, 2011). Other risk-identification methods are SCOR-mapping, Value Stream Mapping (VSM), surveys, site visits at supply-chain partners, the Delphi-method with experts from the organisation, a review of historical problems with a high risk of recurrence and a review of supply disruptions from other organisations (McCormack *et al.*, 2008). Useful tools include checklists of risk-sources and Gantt charts, which help identify bottleneck processes (McCormack *et al.*, 2008).

The second action in this category, the Transfer risk-assessment (A16), is related to the Risk-assessment steps in Figure 3 (steps 2–4). As Figure 3 indicates, the risk-sources identified when evaluating the receiver's readiness (see A15) should inform the Risk-analysis, together with any other relevant risk-sources. For instance, the PT parties should assess the risk related to the customs clearance e.g. to ensure that shipments are allowed outside or inside the receiver's country (Minshall et al., 1999). Suggested tools for the risk-assessment are qualitative and quantitative electronic spreadsheets that contain information about risk-sources, risk-analysis and evaluation, as well as mitigation actions and their impact (McCormack *et al.*, 2008).

Risk-mitigation, the last step in Figure 3, involves the identification and implementation of preventive and corrective actions to mitigate risks of supply shortages (A17). Prior to PT Execution, the transfer-parties should select and implement preventive actions to avoid material shortages. Such actions include building up safety-stock, arranging safety capacity, over-planning and adjusting safety lead-times. Preferably, more than one preventive action should be implemented. Corrective actions that the transfer-parties could plan during Preparations and implement in case of material shortages are sub-contracting, expediting part delivery, re-scheduling, overtime and express transports. (Fredriksson *et al.*, 2015)

The last action in the Quality Management category, improving the transferability of the transfer object (A18), is also related to the Risk-mitigation step in Figure 3. Several scholars recommend mitigating the PT risk by adapting the production system (i.e. production technologies, methods and processes) to the receiver's production environment (e.g. (Madsen, 2009, Grant and Gregory, 1997a). The adaptations can span from minor changes, such as translating documentation, to more significant changes, such as changing components to cope with the new sub-suppliers' capabilities. After significant adaptations, the sender should pilot the new processes to ensure appropriate performance levels (Minshall et al., 1999).

Knowledge Transfer (C3). This category includes preventive actions related to training and other interactive activities between the PT parties. Naturally, the sender and receiver should start by preparing a training plan (A19), whose starting point should be the receiver's evaluation (see A15) (Malm et al., 2016). The training should include the transfer of personnel from the receiver to the sender's site for 'hands-on' training and the fine-tuning of the production processes (Terwiesch *et al.*, 2001) (A20). For certain types of knowledge, one could use lower-cost training means, such as videotaped reviews of the production processes and photographs (A21). Other activities that could improve the receiver's performance include VSM or Root Cause analyses (RCA) (A23).

Furthermore, a Change Control process by which proposed engineering and other changes are validated should be always implemented at the receiver (A22). Finally, Knowledge Transfer is a cornerstone of the PT; hence, it is recommended to verify its outcomes (A24). This could be ensured by probing the receiver's knowledge about the processes and by requiring the receiver to run the operation autonomously for a defined period prior to Start-up (McBeath and Ball, 2012).

Transfer of Administrative Systems (C4). This category includes preventive actions related to the transfer of necessary documentation from the sender to the receiver and the preparation of the planning and control systems (A28, A30). Before transferring the documentation, overviews of what documentation is needed for the production and of required items, means of transfer and lead times should be prepared. One should also specify if any equipment purchase is required and its approximate cost. Thereafter the documentation should be updated and translated, and missing documentation should be created (A25). Furthermore, the sender should provide required HSE information to the receiver, such as the information needed for emergency planning (A27).

The receiver should always review received information and notify the sender about any incongruences with their production environment (i.e. their facilities, systems, capabilities, testing methods and equipment) (A28). Then, operating procedures and other necessary documentation should be prepared based on the sender's documentation (WHO, 2011). Moreover, the planning and control systems, such as the ERP, should be updated based on robust forecasts and other data (A29-A30).

Supply-chain Transfer (C5). The main action in this category is to ensure the necessary relationships to sub-suppliers of materials, parts, etc. (A31). This often means that new agreements are signed with both existing and new sub-suppliers. Sometimes, the transfer-parties change the sub-suppliers to more advantageous ones (e.g. to suppliers near the receiver) to reduce logistics and other production costs. However, it is also common that transfer-parties maintain existing sub-suppliers during the PT to avoid introducing new risk-sources connected to the quality of the supplies (Aaboen and Fredriksson, 2016).

5. Research Phase 2- Procedure Refinement

This section describes how the PT-preparation procedure from Appendix 2 was refined with the case-company into the final procedure presented in Appendix 3. First, the offshoring PT case is introduced. Second, it is described how the procedure was implemented during the PT-phase of the studied off-shoring and refined during workshops with PT personnel from both Sender and Receiver. Finally, it is presented how PT practitioners from other companies and industries verified the procedure by applying it to three distinct PT examples with which they had broad experience.

5.1. Introduction of the PT case

Sender was the same as in the two exploratory cases in Phase 0 (Section 3), the domestic production site of a large Norwegian producer. Receiver was the Spanish site of a subsidiary of the Norwegian producer. The case company is briefly described in Table 3.

Table 3: A description of the case company

Main case company	Norwegian technology company
Industry	Maritime supply
Area served	Global
No. of employees	Ca. 4000
Revenue	Ca. 1000 million EUR
Sender	Production site in Norway
Products	Electronics
Core competency	Innovative products
Product variety	Ca. 1000
Product volumes	Usually less than 1000 items
Receiver	The Spanish production site of a subsidiary
Transfer object	Acoustic sensors

The companies were part of and international technology group, which was a market leader within the production of advanced maritime electronics. Sender and Receiver had been experiencing good collaboration for over 20 years and had transferred one assembly process between them before. In the spring of 2016, Sender and Receiver decided to offshore the manufacturing of a product family with

4 acoustic sensors and 9 variants from Norway to Spain.

Over the years, Receiver had developed a large customer network that Sender wanted to access. By transferring the production to Receiver, the customer delivery time was expected to decrease. The labour costs in Spain were lower than those in Norway, which was an advantage for the transferred products, as they required a high level of manual labour. Nonetheless, Sender only expected moderate profit margins and thus had to manage their resources carefully.

Moreover, because Receiver's area was known for its Material Technology specialists, Sender also transferred part of the development activities, and Receiver was commissioned to develop a new material for the transferred products. To this end, Receiver employed a Material Technology researcher. Moreover, to cope with the increasing amount of production activities, Receiver needed to move to a larger building, and this building's layout had to be modified. In addition, Sender's ERP production module had to be implemented at Receiver before Start-up. These processes added several extra actions to the PT procedure (further details in Section 5.4).

Although Sender had transferred production several times before, they had yet not achieved satisfactory start-up times, inventory levels and scrap-levels during PTs (see Section 3). Therefore, together with Receiver, Sender decided to participate in the Procedure Refinement process and develop a thorough procedure for PT preparation.

5.2. The Refinement of the Procedure during the PT to Spain

The preliminary procedure from Appendix 2 was implemented during the above-described PT, and it was evaluated, tailored to the PT-case and refined 7 times in total. For this purpose, 19 workshops were organised in which Sender and Receiver's PT personnel participated either live or via video. The Procedure Refinement process is presented in detail in Appendix 1, along with data collection methods, the date when the data was collected, main events during the Procedure refinement activities and workshop participants.

Prior to the first workshop with Sender and Receiver's personnel, the preventive actions from Appendix 2 were transferred to an Action plan prepared in Excel (Id.2, Appendix 1). The headlines of the Action plan are presented in Figure 4, with an example of how the actions were evaluated during the workshops. During both the live-workshops and the videoconferences, the Action plan was projected to a common screen. The workshop-participants were asked to evaluate whether the preventive actions had low, medium or high-relevance for the studied PT. Consensus was achieved on each action before proceeding to the next. For those actions evaluated as having low relevance, the participants were asked to provide explanations. For medium or highly relevant preventive actions, the participants were asked if the actions had been implemented (*Status*) and whether any sub-actions were needed to implement them (*Open* action) or not (*Closed* action). If necessary, new sub-actions were identified, together with their action-responsible (*Owner*), start date, end date, amount of working days and Gantt chart. Sender and Receiver's personnel easily embraced this meeting format, maintaining it throughout the entire Procedure Refinement process.

As seen in Appendix 1 (Id.8-10), the procedure inspired Sender's personnel to schedule a Transfer risk-assessment (see Figure 3). For this, the lead author added two tools to the Action plan: one to assess the risk and one to plan the communication during the PT (A12 and A16, Table 2). Based on the Job Safety Analysis (as in (Rausand, 2013) and on Supply Chain Council's recommendations (McCormack *et al.*, 2008), the Sub-action column (see Figure 4a) was replaced with a number of new columns (the columns from Figure 4b). The risk-assessment columns (light grey columns in Figure 4b) contained items that were meant to aid in breaking down the preventive actions into sufficiently detailed sequences of steps, as well as in identifying what could go wrong during each step (i.e. supply disruptions), including risk-sources, potential losses, the risk-level and the residual risk after implementing the identified sub-actions (Rausand, 2013). The items in the Communication plan columns (darker columns in Figure 4b) were aimed at helping the Risk-assessment participants identify what information was necessary to implement the sub-actions, where the information could be found, and if the information did not exist, when it had to be ready (McCormack *et al.*, 2008).

Eventually, Sender's personnel transferred the data in the Action plan to an Excel template (presented in Figure 4c) they had prepared (Id. 14, Appendix 1). It can be seen that Sender's personnel assigned risk levels to the preventive actions (*activities* in this template). Actions evaluated as indispensable for the ability to produce during Start-up were assigned a high-risk level, whereas other actions were assigned medium- or low-risk levels. Moreover, a Plan-Do-Check-Act tool was included in the template, indicating to what extent the actions had been implemented (i.e. planned, executed, checked, or completed and documented). Several documents were also included in the template as separate Excel sheets, which contained user-instructions, an overview of the transferred product-variants, the PT organisation chart, a record of the status-meetings, as well as project milestones and their deadlines.

The milestones included central actions for the PT project that needed to be implemented in a certain order. Sender and Receiver identified three project milestones as the most important:

- Milestone 1
    - Verify shipping requirements
    - Plan for overproduction to cover needs during Execution and Start-up phases
    - Make robust forecasts (of start-up time, new lead times, new quality levels, etc.)
    - Update the Planning and Control systems (ERP)
    - Verify the readiness of the test system for the transfer (software, equipment, documentation, access rights to the sender's systems, etc.)
    - Verify Knowledge Transfer at Receiver (e.g. check documentation)
- Milestone 2
    - Sender and Receiver jointly develop a training plan
    - Prepare documentation for the newly developed material
    - Establish relationships to sub-suppliers of raw materials and parts
- Milestone 3
    - Validate Receiver's facilities
    - Validate the purchasing, warehousing and receiving structure at Receiver

Furthermore, as shown in Appendix 3, two separate sheets with the actions during the Execution and Start-up phases were added to the template. These Excel sheets had a similar structure to the Action plan for the Preparation phase. The Execution and Start-up processes were developed by the lead author during the same 3-year research project as the Preparations process. The new template with all the different sheets was given the name 'TAP' (*Transfer Action Plan*).

The first time the Action plan-responsible (from Sender) used TAP during status-meetings with the PT organisation, the plan worked smoothly and helped the company to prepare the PT thoroughly.

4a.

Id	Area	Action	Relevance	Status	Open/ Closed	Sub-action	Owner	Start date	End date	Duration [working days]	Gantt chart
1	Organisation & Project Management	Organize a project start-up meeting with representatives from both Sender and Receiver and all affected disciplines. Announce the transfer object, reasons for the transfer, the relationship between Sender and Receiver, expected performance targets, etc.	High	We have not organized the kick-off meeting yet	Open	**1a.** Organize a kick-off at Sender with Sender's transfer personnel	NN	NN	NN	NN	NN
						1b. Organize a kick-off at Receiver with Receiver's transfer personnel	NN	NN	NN	NN	NN

4b.

How is the action performed? (steps)	INFORMATION REQUIREMENTS (Communication plan)			What can go wrong (supply disruptions)?	Causes (human/ technological/ organizational errors)	Losses	Risk level			Sub-actions	Residual risk		
	What	Why	Where to get it				Likelihood (L:1-low to 4-high)	Impact (I:1-low to 4-high)	Risk level (=L+I)		Likelihood (L:1-low to 4-high)	Impact (I:1-low to 4-high)	Risk level (=L+I)
Sender organizes a kick-off with their transfer personnel	-	-	-	Relationship, profit and risk sharing, and the KPIs are not clear for all transfer personnel at Receiver; may lead to Steady state delay	Organizational	Cost overrun	4	3	7	**1a.** Organize a kick-off with both Sender and Receiver's trans- fer- personnel	1	3	4
Sender announces the transfer object …	Transfer Strategy and Goals document	To present transfer reasons, targets…	Transfer Protocol							**1b.** Announce transfer object and clarify t. reason, relationship, risk-sharing…			
Receiver organizes kick-off with their personnel	-	-	-							**1c**. Present Sender's existing KPIs			
Receiver announces the transfer object…	-	-	-							**1d.** Define transfer KPIs			

4c.

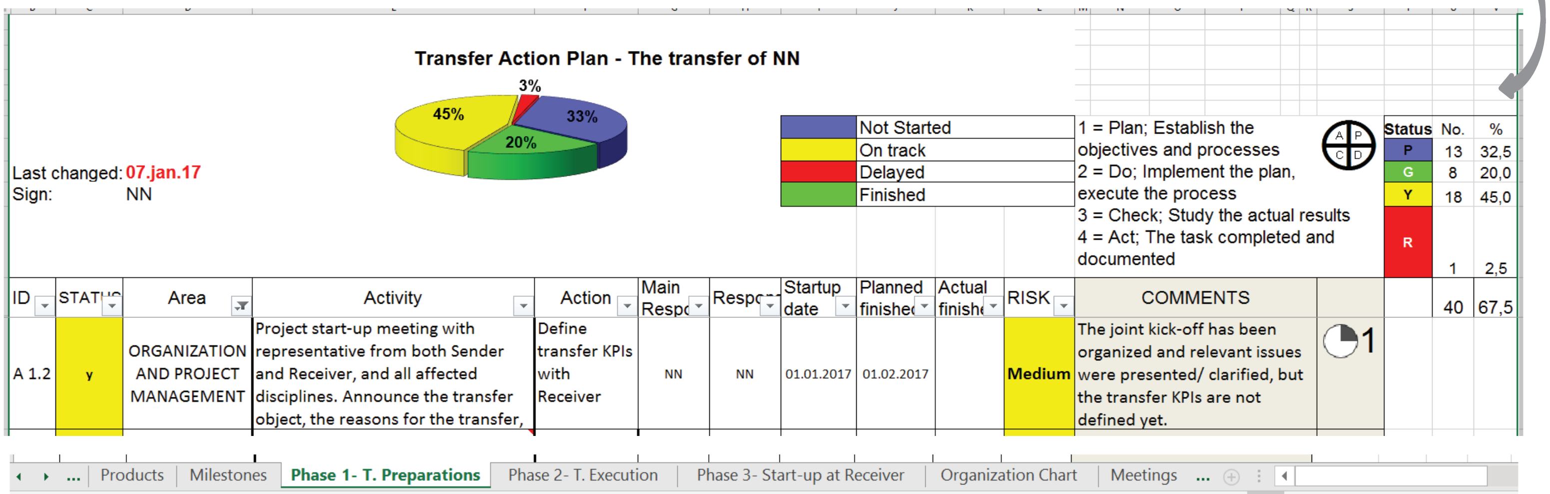

Figure 4: The Transfer Action plan used during the Procedure Refinement process (with an example) (4a). The columns that replaced the Sub-action column in the Transfer Action plan, in order to break down the actions into necessary steps, assess the risk and plan the communication during the transfer (with an example) (4b). The Transfer Action Plan, as implemented by the case company (with an example) (4c)

Moreover, the plan continued to do so for the next year when the lead author followed the PT (Id. 17-19, Appendix 1). In April 2018, at the end of the in-depth study the authors conducted an evaluation of the users' experience (Id. 20, Appendix 1). Key informants from Sender and Receiver were interviewed about their experience with the PT-preparation procedure and its implementation. Prior to the interviews, the authors sent a questionnaire to the informants and their answers were used as a starting point for the interview discussions. In the questionnaire, the informants were mainly asked to evaluate the utility of the procedure and its implementation (in the form of an action plan), as well as the Start-up time and delivery precision compared with the two transfers to the Norwegian supplier (see Section 3) and to the previous transfer to Receiver (see Subsection 5.1).

The Project Owner (from Sender) reported the following: *"There is no doubt that the methodology we have followed during the transfer to Spain has been very useful and an appropriate procedure and method to follow. […] The activities in the procedure are very important and the production transfer processes benefit a lot of such process tools."* Furthermore, the Action plan-responsible (Sender) and the QA & Risk Manager (Sender) reported that the PT procedure ensured that important preventive actions were implemented, and it reduced the amount of disruptions. Moreover, Sender's key informants reported that the Start-up had been relatively short, compared to earlier PTs, and the on-time delivery better.

Receiver's personnel expressed their satisfaction with how TAP worked, too. Receiver's Production Manager (also responsible for quality assurance, risk and Lean) wrote in an e-mail sent to the lead author: *"without the transfer plan, the sonars transfer would have been more complicated"*. The Project Manager (from Receiver) also made similar remarks on several occasions throughout the PT. Almost at the same time as the studied PT case, Receiver was taking on the production of another product offshored by Sender. According to the Project Manager and to the Production Manager, although the PT to Spain was more complex than the other PT, due to the use of the action plan, the tempo of the PT to Spain was considerably faster, and Sender's assistance was more substantial and timely.

5.3. The Verification of the Procedure

As described in Section 2, during a seminar in March 2017 three international practitioners with extensive experience with PTs (see Table 2) applied the PT-preparation procedure (Appendix 2) to three distinct PTs. Note that the preventive actions added by Sender and Receiver (in *italics* in Appendix 3) were appended to the procedure that the practitioners applied.

The verification process was conducted using an electronic questionnaire, which was administered to the practitioners. The questionnaire mainly consisted of questions related to the relevance of each preventive action for the selected PT-examples ('no or low relevance', 'medium relevance' or 'high relevance'). The practitioners' evaluations of the actions are included in Appendix 2 (the literature-based actions) and Appendix 3 (the actions added by Sender and Receiver). Based on the data in these appendices, the authors calculated the percentage of actions that were evaluated as having low/medium/high relevance per PT-example. The results are listed in Table 4, along with a brief description of the PT-examples. As this table shows, each PT-practitioner evaluated ca. 2/3 of the actions as highly relevant. In total, 94.62% of the actions were evaluated as highly- or at least medium relevant.

Table 4: The evaluation of the procedure actions' relevance for 3 distinct production transfers

	Example A	Example B	Example C
Production Transfer characteristics			
Sender	Swedish subsidiary of a large food company	Finish production site of a large technology producer	Swedish production site of a large aircraft producer
Transfer object	Production line for bread	Thruster production	Aircraft structural production
Receiver	Subsidiary in Estonia	Subsidiary in China	External supplier in India
Actions with low/medium/high relevance per production transfer [%]			
Low-relevance	6.45	3.22	6.45
Medium-relevance	19.35	32.26	16.13
High-relevance	74.19	64.52	77.42

5.4. The Refined Version of the Procedure

The final version of the PT-preparation procedure that emerged from the Procedure Refinement process (Section 4.2.) is presented in Appendix 3. Furthermore, Appendix 2 and Appendix 3 also presents how Sender and Receiver evaluated the potential preventive actions during the workshops and how they evaluated the risk of the actions in the TAP plan.

During the Refinement process, 18 new preventive actions were added to the procedure (in *italics* in Appendix 3). Several of these actions could be rather case-specific, such as the modification of the layout in the newly bought premises (A12*; Appendix 3) and the development of the new material (A23*, A24*; Appendix 3). The other actions that were added (e.g., A5.2*, A10.1*, A14*, A14.1*, A22* and A22.2*; Appendix 3) and the two new action categories (*Test* and *HSE*) are of a rather general nature, and should be applicable to other PT cases. For instance, A22*, which refers to verifying that all the preparation actions are closed before preceding to the Execution phase, could be useful during any PT case.

Six of the potential preventive actions identified in the literature (Section 3.2) were not included in the TAP plan (A3, A9, A12, A13, A14, A18; Appendix 2), in most cases because they were addressed or replaced by other actions. For instance, A9 was removed because the TAP plan fulfilled the function of a project management plan.

In the same way as in Subsection 5.3, based on the data in appendices 2 and 3, the authors calculated the percentage of actions that Sender and Receiver evaluated as having low/medium/high relevance, and low/medium/high risk level. The results are listed in Table 5. During the earlier stages of the Procedure Refinement process, the participants evaluated most of the preventive actions in the PT-preparation procedure as having high-relevance for the transfer to Spain (77.41%, or 24 out of 31). However, later during the research process, when the TAP plan was created and the action owners were appointed, only 25.8% of the same actions were considered to be indispensable for the ability to produce during Start-up, and were thereby assigned a 'high-risk level' (see Subsection 5.2). Therefore, only 22 out of 31 actions were transferred to the TAP-plan and assigned risk levels.

As earlier mentioned, Sender and Receiver added 18 new preventive actions to the PT-preparation

Table 5: The evaluation of the relevance of the procedure actions for the in-depth case

Production Transfer characteristics	
Sender	Norwegian production site of a large electronics producer
Transfer object	Sensor production
Receiver	Subsidiary in Spain
Actions with low/medium/high relevance [%]	
Low- relevance	19.35
Medium- relevance	3.22
High- relevance	77.41
Actions with low/medium/high risk level [%]	
Low-risk level	0
Medium-risk level	45.16
High-risk level	25.8

procedure (see Appendix 3). The PT-practitioners evaluated all of these actions but two, as highly- or medium relevant for the PT-examples. The PT-manager evaluated A10.1* (verifying shipping requirements, e.g. customs requirements and trade agreements applicable when shipping from the sender vs. the receiver) and A21* (ensure that the equipment to be transferred is registered and marked with the sender's property) to be little relevant for the offshoring to China. For instance he evaluated A10.1* as little relevant because *"international shipping and customs are generally straightforward except for few special locations"*.

Finally, 77.55% (38 out of 49) of all of the preventive actions (the actions in Appendix 2 and those added by Sender and Receiver in Appendix 3) were evaluated to either have high- or medium-relevance for the four PTs studied. Sender, Receiver and the PT-practitioners unanimously evaluated 16 of these to have high-relevance (Table 6).

6. Research Phase 3- Explanation

In this section, the significance of the results from the Procedure Refinement phase are interpreted in light of the paper's purpose, and the results are compared with those of earlier research.

The purpose of this paper was to develop a procedure for a thorough preparation of PTs that should aid companies in preventively mitigating the risk of supply chain disruptions during PTs and thereby meeting their targeted performance results during production relocations. The PT-preparation procedure (Refined Procedure in Appendix 3) was developed during a 3-year design science study. First, a preliminary procedure was developed based on preventive actions from the PT literature. Through the supply chain risk management lens, all the salient preparatory actions in the PT literature were regarded as preventive actions and included in the procedure, as all of them can mitigate the likelihood of supply chain disruptions (Norrman and Jansson, 2004, ISO, 2009) during the Execution and Start-up phases. Thereafter, the procedure was thoroughly validated by both Sender's and Receiver's personnel involved in the PT to Spain and by international PT-practitioners.

Table 6: Actions that the informants unanimously evaluated to have high-relevance

Id.	Preventive actions
A1	Establish a project team with project managers and representatives from all the disciplines affected by the transfer and from both the sender and receiver. Assign a general project coordinator. Clarify the role and responsibilities of each member
A5	Organize a project start-up meeting with the sender's and receiver's personnel involved in the transfer. Announce the object of the transfer, reasons for the transfer, the relationship between the sender and receiver, expected performance targets, etc.
A9	Prepare a project management plan
A11	Create a Transfer Protocol that includes all the transfer documentation and is easily accessible to all the sender and receiver's personnel involved in the transfer. The protocol should be continuously updated
A15	Evaluate the receiver's readiness with regards to facilities, equipment and support services (e.g. by a Gap Analysis)
A16	Assess the transfer risk. Include customs clearance and material supply risks
A17	Identify and implement preventive actions to mitigate the risk of supply shortages (e.g. safety stock and safety capacity). Identify corrective actions to mitigate the risk of supply shortages (e.g. overtime and express transports)
A24	Verify Knowledge Transfer at the receiver (e.g. check documentation, test personnel)
A25	Prepare a list of items and documentation to be transferred. Specify transfer mechanisms, if purchases are required, costs and lead-times to the receiver
A26	Review, update and create missing documentation. Translate documentation, if necessary
A29	Make robust forecasts (of start-up time, new lead times, new quality levels, etc.)
A30	Update the planning and control systems (e.g. ERP)
A14*	Validate the receiver's facilities (after the implementation of sub-actions for improving the receiver's 'readiness' for transfer)
A27*	Send personnel from the sender to the receiver to perform training on testing methods
A32*	Implement ERP at the receiver. Train the receiver's personnel on ERP use
A32.1*	Verify that ERP is functional at the receiver

The PT-practitioners verified the procedure by applying it to three PTs with which they had worked (see Table 4). The main purpose of the verification was to corroborate how relevant the procedure was for PTs with contrasting characteristics compared to the PT to Spain. Thus, the three selected PTs belonged to different industries (food-, power technology- and aerospace-production) and had been conducted between different countries. While all of the senders were located in Nordic countries, the receivers were located in three distinct geographical areas (Estonia, China and India). Furthermore, PT-A and PT-B were part of offshoring processes, while PT-C was part of an outsourcing. In addition, the complexity of the transfer object varied across the PTs, including both 'simple' transfer objects (a production line for bread) and complex (aircraft production). As shown in Table 5, despite of these differences between the PT examples, each PT practitioner evaluated 94.62% of the actions as highly- and medium relevant. 74.19% of the preventive actions were highly relevant for the food production-PT, 64.52% for the power technology-PT, and 77.42% for the aerospace-production PT. This indicates that the PT-preparation procedure should be useful for different types of production-relocations and production industries.

The refined PT-preparation procedure informs the risk assessment during the PT-risk management process (step 2 in Figure 3). To reduce the likelihood of potential supply chain disruptions with an unacceptable risk level, PT-practitioners should implement all the preventive actions in the procedure, which they deem relevant (e.g. based on a cost-benefit analysis). The preventive actions should be implemented in the early phase of PTs. Moreover, based on the Procedure Refinement process (Subsection 5.2), practitioners should break down the actions as much as practically needed when applying the PT-preparation procedure.

Furthermore, the procedure developed in this paper should not only be used during PT Preparation but also during the Relocation-decision and the Supplier-selection phases (see Figure 1) as an example of what the preparation of a PT implies (e.g. the amount of actions the sender and receiver must implement). For instance, the procedure could inform a Total cost analysis of producing in-house vs. at a supplier (Fredriksson, 2011). If the cost of the PT exceeds the benefits, it may not be worth proceeding with the relocation process.

To the authors' knowledge, the procedure proposed in this study is the first PT-preparation procedure based on risk management principles, which arguably addresses all the risk areas during the Preparation phase. As earlier mentioned, although many production relocation procedures exist, only few of them address the PT process. The existing PT procedures either provide a rather vague overview of PT activities (e.g. Momme and Hvolby [2002], Zeng [2003]) or they only focus on certain parts of the PT process. The PT-scholars have hitherto focused on the physical transfer of equipment and inventory (e.g. Kowalski et al., [2018], and Tatikonda and Stock [2003]), on the knowledge transfer throughout all the PT phases (e.g. Madsen [2009], Malm et al. [2016], and Cheng et al. [2010]), and on the transfer of sub-suppliers (e.g. Aaboen and Fredriksson [2016], and Fredriksson and Wänström [2014]). The PT-literature only recently started to pay more attention to the transfer of administrative systems (Fredriksson and Wänström, 2014, Fredriksson et al., 2015), and to the organisation, project- and quality-management (WHO, 2011). The authors argue that these areas are as important for the success of the PTs and of production-relocations as the physical- and knowledge-transfers are. Furthermore, although some of the PT scholars acknowledge the importance of managing the risk during PTs, Fredriksson et al. (2015) is the only identified paper that explicitly recommends preventive actions during PTs. Nevertheless, this paper focuses on the preventive actions that may be necessary to avoid shortages of raw materials and components, which relates to part of the transfer of administrative systems. Thus, the proposed PT-preparation procedure supplements Fredriksson et al.'s (2015) procedure with the preventive actions related to organisation-, project- and quality-management, knowledge transfer, supply chain transfer, and with other relevant administrative transfer-actions from the PT-literature. Finally, this study addresses Busi and McIvor's (2008) call for production relocations frameworks developed by applying theoretical frameworks in a practical setting.

In the remainder of this section, there will be presented a few salient empirical findings for the Organisation & Project Management, Quality Management, and Transfer of Administrative Systems, as these preventive actions categories received limited attentions in the existing PT literature.

6.1. Organisation & Project Management

The Organisation & Project Management preventive actions resulted to be fundamental during the in-depth study, facilitating the execution of the other preventive actions in the PT-preparation procedure. Three salient examples are A1, A10 and A11 (Appendix 2).

Based on A1 in the PT-preparation procedure (Appendix 2), the transfer parties in the in-depth study established a project team, defined the roles of the team members in the action plan (the TAP-plan) and named a Project Owner at Sender and a Project Manager at Receiver. However, the transfer-parties did not name a cross-locational project manager, fearing that this additional management layer could backfire on the information flow. Although later, the transfer-parties did name an action plan administrator, his responsibilities were not clear to all the transfer-personnel. According to the administrator, *"many are thinking that I'm the captain of this ship because I update the TAP, but I'm just sitting with the map!"*. Sometimes, transfer-personnel believed that the administrator was the PT-manager while on other occasions action owners only closed their actions after he reminded them to do so, or they even disregarded closing them. At the end of the in-depth study, informants from both transfer parties acknowledged that a cross-locational project manager should have been named in the early phase of the PT. This would have accelerated the transfer considerably. Furthermore, A1 was unanimously evaluated as highly relevant by the PT-practitioners during the international seminar.

The existing PT-literature shows that dedicating employees to the PT (Fredriksson et al., 2015) and having a project manager at the receiver's site (Terwiesch et al., 2001) has a positive effect on the PT-outcome. However, surprisingly, the PT-scholars have so far payed little attention to the role played by the cross-locational project manager during PTs.

During the Procedure Refinement workshops, the participants evaluated that holding regular cross-locational status meetings and sending meeting notes to all affected personnel after those meetings was highly relevant for the transfer to Spain (see A10, Appendix 2). However, in a later phase of the refinement process, Sender's personnel assigned a 'medium risk' to this action, as it was not considered indispensable for the ability to produce during Start-up (see Subsection 5.2). At the end of the in-depth study, Sender's and Receiver's informants reported that meetings had not been held regularly, notes had not been sent to affected personnel and the tasks had not been sufficiently well coordinated. The Action Plan-responsible (Sender) and QA & Risk Manager (Sender) reflected that during future PTs, the action plan-responsible should meet the action owners (one department at a time) weekly or every other week to update the plan. The meetings could be either physical or via videoconferences. QA & Risk Manager and Project Owner (Sender) reported that holding frequent and regular meetings with the receiver accelerated the transfer tempo and it was one of the success factors during an earlier PT to an Asian subsidiary. Moreover, on several occasions Action Plan-responsible experienced that the action-owners postponed their actions because other action-owners were late. Thereby, at times it was difficult to comply with the PT schedule. Therefore, according to him, during future PTs the action plan-responsible should hold general status meetings with the transfer-team once a month. During these meetings, the team should review whether relevant milestone actions (see Subsection 5.2) are closed or not, and if the project is on track. As shown in Appendix 2, the PT-practitioners also evaluated A10 as relevant. It was evaluated as highly relevant for the food industry- and aircraft transfers and medium relevant for the thruster transfer. For the thruster-transfer, the PT-manager explained that the sender relied heavily on expats working at their Asian subsidiary throughout the PT, one of them being the manager himself. Thus, the cross-locational status meetings were less critical during this PT.

These results provide support to Zhu et al.'s study (2001), which emphasizes that it might be appropriate to hold weekly status meetings during production relocations, and that meeting notes should be sent to each action owner. In addition, the in-depth study shows that the transfer-parties could consider organising two types of status meetings in order to economize working hours: weekly (or bi-weekly) detail meetings with each department to review all their actions, and monthly general meetings with the entire transfer team, to review the milestone actions.

Creating a directory (also known as Transfer Protocol) for all the transfer documentation, which is easily accessible to the entire transfer organisation and is continuously updated (A11, Appendix 2), is one of the actions that was evaluated as highly relevant by both the Sender and Receiver's informants and the PT-practitioners. However, Sender's personnel assigned a medium risk to A11 in the TAP-plan, as they did not regard this action as indispensable for the ability to produce during Start-up. Even though Sender's personnel prepared an electronic directory and required the transfer-personnel to store all the relevant documentation in that directory, later, informants from both parties reported that the transfer personnel did not actively use this directory. Moreover, on several occasions, Receiver's informants reported late or missing documentation that lead to significant schedule disruptions. For Production Manager (Receiver), the main challenge during the PT to Spain was to *"receive the correct information at the correct time"*. Furthermore, apart from the Transfer Protocol, Sender used a product lifecycle management-system for document handling. Nevertheless, Sender could not grant Receiver the permission to access the transfer documentation in this system, as Sender could not protect the IP connected to the documentation that was not related to the PT.

This empirical evidence supports WHO (2011) and Zhu et al.'s (2001) findings. According to these authors, the PT directory should, among other things, include the PT's objective and scope, a cost-sharing agreement, the roles and responsibilities of the transfer personnel, the project management plan, systematic instructions for all the tasks, a change control procedure, and an assessment of the finished products. Furthermore, the in-depth study shows that Organisation & Project Management activities such as A11 have a clear impact on the outcome of the administrative transfer, and of the entire relocation project. A common directory with all the necessary transfer documentation that is rigorously used by the sender and receiver's personnel is a minimum requirement for a smooth transfer of documentation and for systems integration (e.g. the sender and receiver's production planning and control systems). Moreover, it can significantly mitigate the risk of schedule disruptions and futile costs.

6.2. Quality Management

Similar to the Organisation & Project Management actions, the *Quality Management* actions resulted to be fundamental during the transfer to Spain. Moreover, the authors argue that these actions enable or facilitate the achievement of expected supply performance targets during PTs. Two salient examples are A15 and A16 (Appendix 2).

Evaluating the readiness of the receiver's facilities, equipment and support services (A15, Appendix 2), was assessed as highly relevant by both the Sender and Receiver's informants and the PT-practitioners. Moreover, Sender's personnel assigned a high-risk level to A15, as they considered that it was an indispensable action for the ability to produce during Start-up.

According to QA & Risk Manager (Sender), in the beginning of both the transfer to the Spanish subsidiary and to the Asian one, Sender's personnel focused very much on the knowledge transfer connected to the transferred products. In his opinion, before starting with the knowledge transfer, Sender should make sure that an appropriate quality management system is in place at the receiver; Sender and their receivers need to have a positive *"quality and safety culture"*. Even though Sender evaluated Receiver's readiness for transfer soon after the kick-off, part of the necessary preventive actions were implemented late during the Preparation phase (e.g. the warehouse routines). Thus, QA & Risk Manager stressed that during future PTs, Sender should conduct a Gap analysis and implement necessary actions in the very beginning of the PTs. Furthermore, Sender and Receiver's personnel added one related milestone action to the TAP-plan. This was A14* and it refers to the validation of the receiver's facilities after the implementation of necessary sub-actions for improving Receiver's 'readiness' for transfer. The PT-practitioners at the international seminar unanimously evaluated A14* as highly relevant (see Appendix 3).

These results are in line with Malm et al. (2016) and WHO's (2011) recommendations about conducting a Gap Analysis in order to identify potential risk-sources at the receiver (the Risk Identification step in Figure 3). According to WHO (2011), the risk-sources can be, among others, connected to the manufacturing- and packaging-rooms, to the equipment and to the quality-control procedures.

Similar to A15, assessing the transfer risk (A16, Appendix 2) was evaluated as highly relevant by all the informants. As earlier mentioned, A16 is related to the Risk Assessment step in Figure 3 and the risk-sources identified when evaluating the receiver's readiness (A15) should inform the assessment, together with any other relevant risk-sources. During the transfer to Spain, both Sender and Receiver conducted PT-risk assessments and added a series of sub-actions to the TAP-plan, to mitigate the risk of potential disruptions. For instance, Sender's personnel who had the experience of being retained at the customs office *"for two days"* because they did not possessed all the required documentation for the shipped equipment, stressed the need to carefully validate the transportation documentation of all the equipment and inventory prior to the physical transfer. This payed off as no goods were stopped at the customs office during the transfer to Spain.

Furthermore, Sender's personnel added a separate category for the HSE actions and sub-actions in the refined procedure (see Appendix 3), and the HSE actions were evaluated to pose a high risk for the ability to produce during Start-up. To ensure that all the critical HSE risk-sources were identified and the associated risk was properly mitigated, Receiver contracted an accredited HSE consultancy company to perform a comprehensive HSE assessment of the premises. No HSE disruptions (e.g. occupational accidents or chemical hazardous events) occurred during the construction project at the new premises, the relocation from the old premises to the new ones, or otherwise during the in-depth study.

The findings are in line with Fredriksson et al. (2015) and WHO's (2011) recommendation about ensuring a thorough risk assessment and mitigation (step 2 and 3 in Figure 3) during production relocations. Moreover, the results provide additional support to Minshall et al.'s (1999) findings about the importance of assessing the risk related to customs clearance.

6.3. Transfer of Administrative Systems

The in-depth study showed that the administrative transfer actions should have received more attention during the transfer to Spain. The authors argue that the integration of the sender and receiver's systems and the transfer of documentation is getting more and more critical in an era of increasing digitalisation.

During the transfer to Spain, the transfer-parties decided to implement Sender's ERP at Receiver, as Receiver's planning and control system could not cope with the increasing production activities. Half a year after signing the PT agreement, Sender started to implement the ERP at Receiver and provide a thorough training to Receiver's personnel on ERP use. Receiver's informants reported that the ERP implementation was a complex endeavour and one of the greatest challenges during the transfer to Spain. Several of them meant that Sender and Receiver should have allocated more time to the implementation and initiated it earlier. Furthermore, the informants during this study unanimously evaluated the ERP related actions as highly relevant. Both the literature-based actions (A29 and A30 in Appendix 2) and the actions added by the Sender and Receiver (A32* and A32.1*; Appendix 3) were evaluated as highly relevant for the food-, thruster- and aircraft-PTs alike. This can indicate that the implementation, update and verification of the ERP system, as well as the training of the receiver's personnel on ERP use are important and commonplace actions during production relocations of various types.

These results are in line with Fredriksson et al. (2015) and Minshall's (1999) findings about the importance of updating the production planning and control systems during PTs. The transfer parties can for instance update the customer order fulfilment strategy (e.g., made-to-order or made-to-stock), materials planning method (e.g., reorder point or Kanban), as well as the planning frequency, time fences, and the planning periods (Fredriksson et al., 2015). Moreover, the planning data should be also updated based on robust forecasts of e.g., start-up time, new lead times, and new quality levels (Fredriksson et al., 2015, Minshall et al., 1999).

Apart from the ERP system, Sender implemented their test system at Receiver. Thereby, the transfer parties added the Test category to the refined preparation-procedure. The actions included in this category (A25*-A27*; Appendix 3) were related to the verification of the readiness of the test system for transfer (software, equipment, documentation, access rights to Sender's Test Data Management system, etc.), the test update and the test training. The implementation of the test system only started at the end of the Preparation and the informants reported that this led to a delay of several weeks. Thus, similar to the ERP implementation, the Sender and Receiver's informants acknowledged that the implementation of the test should have been initiated in the earlier phase of the Preparation; the test system was only to a limited extent dependent on the other preparatory activities. Furthermore, the PT-practitioners during the international seminar evaluated the test actions as having high or medium relevance for the three PT-examples. Thus, other PT-practitioners could also take into account the Test actions during the Preparation phase, along with the actions related to the integration of the ERP or other relevant systems at the receivers.

Another example of administrative transfer action that should have received more attention, in particular from Sender, was A26 ("Review, update and create missing documentation. Translate documentation, if necessary"). All of the informants during this study evaluated A26 as highly relevant and Sender's personnel assigned it a 'high-risk' in the TAP-plan. However, as Sender only expected moderate profit margins and had to manage their resources with extra care, instead of assigning personnel to update the PT documentation prior to the training of the Receiver's personnel at their site, Sender decided to update it together with the Receiver's personnel. Consequently, part of Receiver's personnel had to travel to Norway frequently, and because of the relatively large distance between the sites, the travel expenses came to represent a significant portion of the total PT cost. Had the Sender carefully reviewed and prepared the transfer documentation ahead of Receiver's training, they could have incurred significantly lower expenses. These results provides support to Fredriksson et al. (2015) and Terwiesch et al. (2001) recommendations that the sender should update the transfer documentation prior to training. Examples of documents that could be updated are drawings, product tolerances, manuals, spare parts lists, and training aids (McBeath and Ball, 2012, Fredriksson et al., 2015, Terwiesch et al., 2001).

6.4. A Framework for the Preparation of Production Transfers

Based on the findings from literature, the in-depth study and the survey during the international seminar, the authors developed the basic framework in Figure 5. Its aim is to foster a common understanding between the sender and receiver's personnel, of the main types of preventive actions in the PT-preparation procedure (the literature-based procedure in Appendix 2) and the relation between them.

It should provide a basic structure that can be easily used to introduce the PT-preparation procedure in the early phase of a PT. Each preventive action category includes a few examples of keywords based on the PT-preparation procedure.

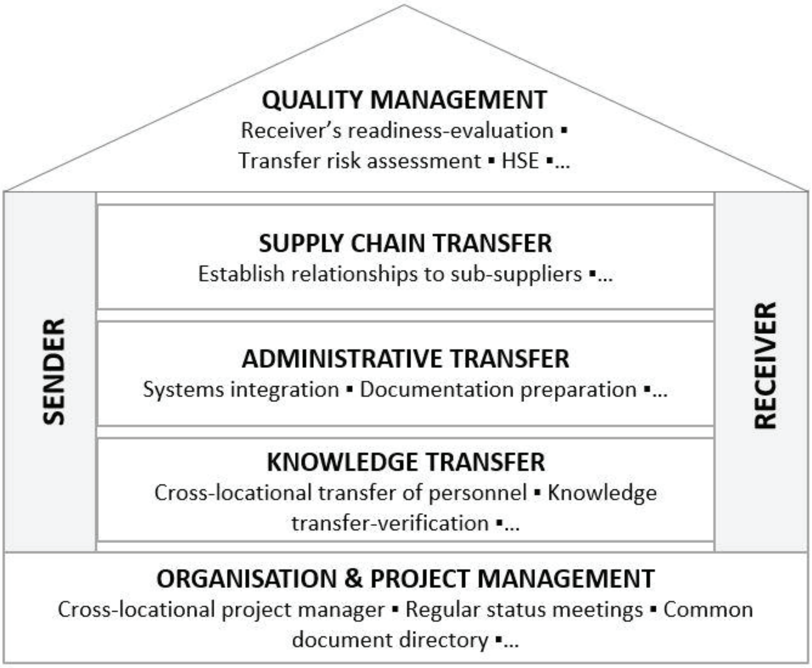

Figure 5: Production Transfer Preparation framework

As previously mentioned, the PT-scholars have hitherto focused on the physical transfer of equipment and inventory (the Execution phase), on the knowledge transfer and on the transfer of sub-suppliers. The PT-literature has only recently started to pay more attention to the transfer of administrative systems, and to the organisation-, project- and quality management. According to Fredriksson et al. (2014), if the senders and receivers regard the administrative-, supply chain-, knowledge- and physical transfers as four distinctive parts of any PT, they are likely to allocate more resources to ensure each and every of these transfers. Similarly, the authors argue that if the senders and receivers are aware of the role played by the organisation-, project- and quality-management areas during PTs, it should be easier for them to invest in these areas.

In the in-depth case study, most of the Organisation & Project Management preventive actions that initially were regarded as highly relevant, were assigned a medium risk in the action plan, as the transfer parties did not consider them as indispensable for the ability to produce during the Start-up phase (see appendices 2 and 3). However, at the end of the in-depth study several of those actions turned out to be more important than earlier though (e.g., holding regular cross-locational status meetings [A10] and collecting all the transfer documentation in an electronic directory that is easily accessible to the entire transfer organisation and is continuously updated [A11]). This suggests that when PT-practitioners evaluate the Organisation & Project Management actions, they should be aware that these actions could facilitate the execution of those actions that are indispensable for the ability to produce during Start-up. For instance, an electronic directory that contains all the necessary transfer documentation and is rigorously used by the transfer personnel should be a minimum requirement for a smooth transfer of administrative systems. Moreover, it can significantly mitigate the risk of schedule disruptions and of futile costs caused by e.g., late or missing documentation. Finally, the findings also indicate that practitioners should revisit the PT-preparations procedure several times as the relevance of the actions may change throughout PTs.

Similar to the Organisation & Project Management preventive actions, the Quality Management- and the Transfer of Administrative Systems actions emerged as key areas of attention during the PT to Spain. The in-depth study showed that the Quality Management actions enable or facilitate the achievement of expected supply performance targets during the PTs. Based on his experience with the transfer to Spain and with another large offshoring to Asia, QA & Risk Manager (Sender) even recommended that prior to knowledge transfer actions such as training, the transfer parties should verify that an appropriate quality management system is in place at receiver. This should be done by conducting a Gap analysis in the very beginning of the PTs in order to identify risk sources connected to the readiness of the receiver's facilities, equipment and support services (e.g. HSE management, and purchasing and inventory control mechanisms), as well as by risk assessment and risk mitigation. Furthermore, the in-depth study showed that the integration of the sender and receiver's administrative systems (e.g. ERP and test systems) could be a complex endeavour; hence, it should be initiated as early as possible during the Preparation phase. Moreover, by carefully reviewing and preparing the transfer documentation ahead of the receiver's training, the senders could streamline the knowledge transfer and significantly reduce expenses. In an era of increasing digitalisation, the integration of the sender and receiver's systems is expected to become more and more critical for the transfer parties' competitive edge.

The PT Preparation framework in Figure 5 can be related to McBeath and Ball's (2012) knowledge transfer framework, which comprises five required key themes for successful knowledge transfer from the senders to the receivers. These are the willingness to share information, willingness to receive information, explicit knowledge transfer, tacit knowledge transfer and verification. The authors argue that McBeath and Ball's framework is one of the 'detail views' of a PT, whereas the PT Preparation framework is a 'general view' of the PT-preparation phase. It highlights the four additional key areas of the PTs and the relation between them.

7. Conclusion

This paper proposes a procedure for a thorough preparation of PTs based on risk management principles. The goal is to reduce the amount of supply chain disruptions during PTs and thereby facilitate the achievement of the targeted performance results during production-relocations.

Although several PT scholars have acknowledged the importance of a thorough Preparation-phase and recommended relevant preparatory activities (e.g. Madsen [2009] and Terwiesch et al. [2001]) to the authors' knowledge, none has yet reviewed, summarized and structured the existing PT literature and proposed a validated procedure.

The authors argue that this paper contributes to the PT literature by providing a detailed and systematic description of the preventive actions that senders and receivers can implement in order to prepare the PTs and reduce the amount of supply chain disruptions (see Subsection 4.2 and Appendix 3).

Moreover, the in-depth study showed that the outcome of a PT and thereby of a production relocation not only depends on the *physical transfer* (the transfer of equipment and inventory), on the *knowledge transfer* (e.g. training) and on the *supply-chain transfer*, as presented in earlier research. It also depends on the *administrative transfer* (the transfer of documentation and the integration of operations management systems e.g., ERP at the receiver), as well as on the *organisation-, project-* and *quality-management* during the PT. Thus, the transfer parties should make sure to allocate sufficient resources to these categories of preventive actions, too. This study argues that although the organisation- and project management actions might not be regarded as indispensable for the ability to produce during the Start-up phase, they facilitate the execution of those actions that are considered as indispensable. Similarly, the Quality Management actions are fundamental during PTs and the PT-practitioners should intend to implement them at the beginning of the PT-preparation phase. These preventive actions facilitate the achievement of supply performance targets during the PTs and generally in the supply chain by e.g. mitigating the risk of supply chain disruptions and futile expenses. Furthermore, in an era of increasing digitalisation the integration of the sender and receiver's administrative systems is expected to become more and more critical for the success of the PTs and the supply chain collaboration in general. Thus, it should be also initiated in the early phase of PTs. Moreover, this paper argues that a careful preparation of the transfer documentation ahead of the receiver's training is worthwhile, and a minimum requirement for a smooth PT. Finally, the authors also attempt to enhance the PT literature by providing a clearer way of conceptualizing risk management during PTs.

Furthermore, it is argued that the refined PT-preparation procedure (Appendix 3) represents this paper's primary contribution to practice. The proposed procedure was developed by implementing the literature-based procedure (Appendix 2) during an offshoring case and continuously refining it with the sender and receiver. Thus, the proposed procedure is based on both transfer-parties' perspectives.

Practitioners can use the proposed procedure several times during the relocation process. First, they can use it during the Relocation-decision and Supplier-selection phases of relocation processes (see Figure 1) as an example of what a PT-preparation process implies. Second, they can apply the procedure in detail to thoroughly prepare for the PT. Finally, the procedure can be also used during post-transfer evaluations, to structure the sender and receiver's lessons learned.

In evaluating design science studies, criteria such as the validity (the artefact works and does what is meant to do) and utility (it has value outside the development environment) of the developed artefact are highlighted (Gregor and Hevner, 2013). Moreover, according to Holmström (2009), the success of a design science approach hinges on its ability to integrate itself with the theory-oriented mainstream research. At the end of the in-depth study, key-informants from both transfer parties reported that the PT procedure and its implementation by help of the TAP-action plan were appropriate and very useful. Receiver's key-informants reported that although the PT to Spain was more complex than during another transfer they were undertaking, its tempo was considerably faster, and Sender's assistance was more substantial and timelier. Sender's key-informants reported that the PT procedure ensured that important preventive actions were implemented, and it reduced the amount of disruptions. Moreover, they informed that the Start-up phase had been relatively shorter than during earlier PTs, and the on-time delivery precision better. Furthermore, the PT-practitioners during the international seminar evaluated most of the actions in the refined PT-preparation procedure as relevant, and the verification process indicated that the PT-preparation procedure should be useful for different types of production relocations and production industries. Finally, as recommended by Holmström (2009) the research findings were systematically compared with the earlier research on the topic of production relocation, and significant similarities and differences were highlighted. In addition, the authors payed attention to describing the research process and results in a detailed manner, in order to support actors that want to implement the PT-preparation procedure (Holmström in (Kaipia et al., 2017)).

In this paper, the proposed procedure was implemented during a PT in the electronics industry. However, each production relocation is different; therefore, the procedure should be adapted to different PT circumstances. Two factors that can have a significant influence on how the procedure is applied are the PT risk level and the strategic impact of the PT. The PT risk level depends on, e.g. the technological novelty of the transfer object (e.g. a product), the experience of the Receiver and on the cultural differences between the transfer parties. The strategic impact of a PT is contingent on the value of the transfer object and on how critical the transfer object is for the Sender and Receiver's profit. Further research should test the PT preparation procedure during PT cases with distinct characteristics and explore how the preventive actions in the procedure will be prioritised in different contexts. For instance, the researchers could explore if certain types of preventive actions are more relevant during PTs with high risk and/or high strategic impact than during PTs with low risk and/or low strategic impact. It would be also interesting to test the PT preparation framework from Figure 5 during distinct PTs and validate the action categories and the relation between them. Furthermore, the procedure-verification was carried out by only three PT practitioners. Hence, a large survey study is needed for a more extensive verification and for the development of a formal representation of the procedure (as recommended by Holmström et al. [2009]). Finally, the authors contend that the impact of digitalisation on the administrative transfer during PTs is an intriguing future avenue of research.

References

AABOEN, L. & FREDRIKSSON, A. 2016. The relationship development aspect of production transfer. *Journal of Purchasing and Supply Management*.

ALMGREN, H. 1999. Start-up of advanced manufacturing systems - a case study. *Integrated Manufacturing Systems,* 10**,** 126-135.

BECKMAN, S. L. & ROSENFIELD, D. B. 2008. *Operations strategy: competing in the 21st century,* Boston, McGraw-Hill/Irwin.

BLACKHURST, J., SCHEIBE, K. & JOHNSON, D. 2008. Supplier risk assessment and monitoring for the automotive industry. *Int. J. Phys. Distrib. Logist. Manag.,* 38**,** 143-165.

BODE, C. & WAGNER, S. M. 2009. Risk and security–A logistics service industry perspective. *Managing risk and security. The safeguard of long-term success for logistics service providers***,** 1-30.

BUSI, M. & MCIVOR, R. 2008. Setting the outsourcing research agenda: the top-10 most urgent outsourcing areas. *Strategic Outsourcing: An International Journal,* 1**,** 185-197.

CHENG, Y., MADSEN, E. S. & JIRAPHA, L. 2010. Transferring knowledge in the relocation of manufacturing units. *Strategic Outsourcing: an International Journal,* 3**,** 5-19.

CHOPRA, S. & MEINDL, P. 2013. *Supply chain management : strategy, planning, and operation,* Boston, Pearson.

COUGHLAN, P. & COGHLAN, D. 2002. Action research for operations management. *International journal of operations & production management,* 22**,** 220-240.

DACHS, B. & ZANKER, C. 2015. Backshoring of production activities in European manufacturing.

DANILOVIC, M. & WINROTH, M. 2005. A tentative framework for analyzing integration in collaborative manufacturing network settings: a case study. *Journal of Engineering and Technology Management,* 22**,** 141-158.

DE BACKER, K., MENON, C., DESNOYERS-JAMES, I. & MOUSSIEGT, L. 2016. Reshoring: Myth or reality?

DUDLEY, JR. 2006. Successful technology transfer requires more than technical know-how - Frequent and open communication is a necessity in successful technology transfer. *Biopharm. Int.,* 19**,** 68-+.

DYER, J. H., NOBEOKA, K., GULATI, R., NOHRIA, N. & ZAHEER, A. 2000. Creating and managing a high-performance knowledge-sharing network: the Toyota case. *Strategic Management Journal,* 21**,** 345-367.

EISENHARDT, K. M. 1989. Building theories from case study research. *Academy of management review,* 14**,** 532-550.

FERDOWS, K. 2006. Transfer of Changing Production Know-How. *Production and Operations Management,* 15**,** 1-9.

FRANCESCHINI, F., GALETTO, M., PIGNATELLI, A. & VARETTO, M. 2003. Outsourcing: guidelines for a structured approach. *Benchmarking: An International Journal,* 10**,** 246-260.

FRATOCCHI, L., DI MAURO, C., BARBIERI, P., NASSIMBENI, G. & ZANONI, A. 2014. When manufacturing moves back: Concepts and questions. *Journal of Purchasing and Supply Management,* 20**,** 54-59.

FREDRIKSSON, A. 2011. *Materials supply and production outsourcing*, Chalmers University of Technology.

FREDRIKSSON, A. & WÄNSTRÖM, C. 2014. Manufacturing and supply chain flexibility towards a tool to analyse production network coordination at operational level. *Strategic outsourcing : an International journal,* 7**,** 173-194.

FREDRIKSSON, A., WÄNSTRÖM, C., JOHANSSON, M. I. & MEDBO, L. 2015. A structured procedure for materials planning during production transfer. *Production Planning & Control***,** 1-15.

FREDRIKSSON, A., WÄNSTRÖM, C. & MEDBO, L. 2014. Assuring materials availability during the production transfer process; Critical characteristics of the materials planning environment. *Journal of Manufacturing Technology Management,* 25**,** 310-333.

GALBRAITH, C. & GALBRAITH, C. 1990. Transferring Core Manufacturing Technologies in High-Technology Firms. *California Management Review,* 32**,** 56-56.

GERO, W. & STEFAN, S. 2009. Performance measurement in business process outsourcing decisions; Insights from four case studies. *Strategic Outsourcing: An International Journal,* 2**,** 275-292.

GRANT, E. & GREGORY, M. 1997a. Adapting manufacturing processes for international transfer. *Int. J. Oper. Prod. Manage.,* 17**,** 994-&.

GRANT, E. & GREGORY, M. 1997b. Tacit knowledge, the life cycle and international manufacturing transfer. *Technol. Anal. Strateg. Manage.,* 9**,** 149-161.

GREGOR, S. & HEVNER, A. R. 2013. Positioning and presenting design science research for maximum impact. *MIS quarterly,* 37.

HEIKKILÄ, J., OLHAGER, J., MARTINSUO, M., LAINE, T., SUOMALA, P., JOHANSSON, M. & AHVONEN, P. 2017. Relocation of Nordic Manufacturing. *Tampere University of Technology. Industrial and Information Management*.

HOLMSTRÖM, J., KETOKIVI, M. & HAMERI, A. P. 2009. Bridging Practice and Theory: A Design Science Approach. *Decision Sciences,* 40**,** 65-87.

ISO, I. 2009. 31000: 2009 Risk management–Principles and guidelines. *International Organization for Standardization, Geneva, Switzerland*.

JAHNS, C., HARTMANN, E. & BALS, L. 2006. Offshoring: Dimensions and diffusion of a new business concept. *Journal of Purchasing and Supply Management,* 12**,** 218-231.

KAIPIA, R., HOLMSTRÖM, J., SMÅROS, J. & RAJALA, R. 2017. Information sharing for sales and operations planning: Contextualized solutions and mechanisms. *Journal of Operations Management,* 52**,** 15-29.

KARLSSON, C. 2009. Researching operations management. New York: Routledge.

KERN, D., MOSER, R., HARTMANN, E. & MODER, M. 2012. Supply risk management: model development and empirical analysis. *International Journal of Physical Distribution & Logistics Management,* 42**,** 60-82.

KINKEL, S. & MALOCA, S. 2009. Drivers and antecedents of manufacturing offshoring and backshoring-A German perspective. *Journal of Purchasing and Supply Management,* 15**,** 154-165.

KLEINDORFER, P. R., SINGHAL, K. & VAN WASSENHOVE, L. N. 2005. Sustainable operations management. *Production and Operations Management,* 14**,** 482-492.

KOWALSKI, A., CHLEBUS, T. & SERWATKA, K. 2018. Technical aspects of relocation of production and assembly lines in automotive industry. *Topics in Intelligent Computing and Industry Design,* 1**,** 111-117.

MADSEN, E. S. 2009. *Knowledge transfer in global production,* Aalborg, Danmark, Aalborg University.

MALM, A. 2013. *Important Factors in the Transfer of Aircraft Production: Challenges Related to Offset Business*, Linköping University.

MALM, A. M., FREDRIKSSON, A. & JOHANSEN, K. 2016. Bridging capability gaps in technology transfers within related offsets. *Journal of Manufacturing Technology Management,* 27**,** 640-661.

MANUJ, I. & MENTZER, J. T. 2008. Global supply chain risk management. *Journal of business logistics,* 29**,** 133-155.

MCBEATH, A. & BALL, P. 2012. Towards a framework for transferring technology knowledge between facilities. *Strategic Outsourcing: An International Journal,* 5**,** 213-231.

MCCORMACK, K., WILKERSON, T., MARROW, D., DAVEY, M., SHAH, M. & YEE, D. 2008. Managing risk in your organization with the SCOR methodology. *The Supply Chain Council Risk Research Team***,** 1-32.

MINSHALL, T., UNIVERSITY OF CAMBRIDGE INSTITUTE FOR, M., STORBRITANNIA DEPARTMENT OF, T. & INDUSTRY 1999. *Manufacturing mobility : a strategic guide to transferring manufacturing capability,* Cambridge, University of Cambridge, Institute for Manufacturing.

MODI, S. B. & MABERT, V. A. 2007. Supplier development: Improving supplier performance through knowledge transfer. *Journal of Operations Management,* 25**,** 42-64.

MOGOS, M. F., ALFNES, E. & SWAHN, N. 2016. Prerequisites for Successful Production Transfers in the Electronics Industry. *Lecture Notes in Business Information Processing,* 262**,** 168-181.

MOMME, J. 2002. Framework for outsourcing manufacturing: strategic and operational implications. *Computers in Industry,* 49**,** 59-75.

MYKHAYLENKO, A., MOTIKA, Á., WAEHRENS, B. V. & SLEPNIOV, D. 2015. Accessing offshoring advantages: what and how to offshore. *Strategic Outsourcing: An International Journal,* 8**,** 262-283.

NORRMAN, A. & JANSSON, U. 2004. Ericsson's proactive supply chain risk management approach after a serious sub-supplier accident. *International Journal of Physical Distribution & Logistics Management,* 34**,** 434-456.

RAUSAND, M. 2013. *Risk assessment: theory, methods, and applications*, John Wiley & Sons.

REHME, J., NORDIGÅRDEN, D., BREGE, S. & CHICKSAND, D. 2013. Outsourcing to a non-developed supplier market: The importance of operational aspects in outsourcing. *Journal of Purchasing and Supply Management,* 19**,** 227-237.

RUDBERG, M. & WEST, B. M. 2008. Global operations strategy: Coordinating manufacturing networks. *Omega-Int. J. Manage. Sci.,* 36**,** 91-106.
SJØBAKK, B., MOGOS, M. & MAGERØY, K. 2016. Transfer of production to strategic suppliers: a case study. *WIT Transactions on Engineering Sciences,* 113**,** 279-286.
TATIKONDA, M. & STOCK, G. 2003. Product technology transfer in the upstream supply chain. *J. Prod. Innov. Manage.,* 20**,** 444-467.
TERWIESCH, C., BOHN, R. E. & CHEA, K. S. 2001. International product transfer and production ramp-up: A case study from the data storage industry. *R and D Management,* 31**,** 435-451.
VAN AKEN, J. E. & ROMME, G. 2009. Reinventing the future: adding design science to the repertoire of organization and management studies. *Organization Management Journal,* 6**,** 5-12.
VIKRAM, C. 2013. Managing a supply chain's web of risk. *Strategy & Leadership,* 41**,** 39-45.
WHO. 2011. *WHO expert committee on specifications for pharmaceutical preparations. Forti-fifth Report; Annex 7-WHO guidelines on transfer of technology in pharmaceutical manufacturing* [Online]. Available: http://apps.who.int/medicinedocs/documents/s18652en/s18652en.pdf [Accessed June 1st 2015].
YIN, R. K. 2004. *The Case study anthology,* Thousand Oaks, Calif, Sage.
ZENG, A. 2003. Global sourcing: process and design for efficient management. *Supply Chain Manag.,* 8**,** 367-379.
ZHU, Z., HSU, K., LILLIE, J. & ZHU, Z. 2001. Outsourcing - a strategic move: the process and the ingredients for success. *Management Decision,* 39**,** 373-378.

Appendix 1. Research activities conducted in order to implement, evaluate and refine the PT Risk-mitigation procedure

Id	Data collection method	Date	Research activity purpose	Main events	Participants
1.	Video conference	Sept.'16	1st evaluation of the procedure	The lead author presents the initial procedure to the participants, who evaluate it as useful. Then, the lead author is invited to present it in detail during a live meeting	Project manager (Receiver), Production and quality & risk manager (Receiver), Lean manager (Sender), Lead author
2.	NA	Sept.'16	1st refined version based on feedback from previous research activity	The procedure activities are transferred to an Action plan prepared in Excel	Lead author
3.	2 meetings at Sender	Oct.'16	1st tailoring of the procedure to the transfer case; 2nd evaluation	Participants evaluate each procedure action as having low, medium or high relevance. The procedure inspires the participants to create an Organization chart presenting the transfer team, the role of each team member, as well as main contact points for each member at the other transfer-party. Moreover, it also inspires the participants to schedule a Risk-assessment for the transfer. To facilitate the implementation of medium and highly relevant actions, the participants plan several sub-actions. Several new preventive-actions are also recommended (A10*, A17*, A5.1*, A6.2*, A14.1*, A22.1* in Appendix 5)	Product owner (Sender), Project owner (Sender), Division managing director (Sender), Lead author
4.	NA	Oct.'16	2nd refined version based on feedback from previous research activity	The actions recommended by the participants are added to the Action plan. All the procedure activities (incl. the ones evaluated as having low relevance) and all the actions planned during the previous evaluation are kept in the Action plan for a new evaluation	Lead author
5.	1 meeting at Sender, 1 video conference	Oct.'16	2nd tailoring of the procedure to the transfer case; 3rd evaluation	The participant evaluates each procedure action as having low, medium or high relevance and plans an additional action (A20*, Appendix 5) and necessary sub-actions	Project manager (Receiver), Lead author
6.	NA	Oct.'16	3rd refined version based on feedback from research activities 3 and 5	A Risk-assessment tool and a Communication plan are added to the Action plan, to conduct the Transfer risk-assessment	Lead author
7.	Kick-off at Sender	Oct.'16	Presenting the procedure	-	All of Sender's transfer organization, Lead author

Id	Data collection method	Date	Research activity purpose	Main events	Participants
8.	1 meeting at Sender	Oct.'16	3rd tailoring of the procedure to the transfer case; 4th evaluation	The participants start conducting the Risk-assessment. First, they discuss the status of the previously identified sub-actions. Second, they break down each sub-action into sequences of steps. Third, they identify potential supply disruptions during Execution and Start-up and assess if the sub-actions they had planned are sufficient to mitigate the risk of disruptions. Moreover, the information necessary to implement the sub-actions is also identified by preparing the Communication plan. Action plan and sourcing responsible (Sender) provides a transfer template to the lead author. Where needed, several additional sub-actions are identified	Project owner (Sender), Quality assurance and risk manager (Sender), Action plan and sourcing responsible (Sender), Production manager and ERP production planning responsible (Sender), Documentation and test responsible (Sender), Planning and forecasting responsible (Sender), Order and delivery responsible (Sender), Lead author
9.	1 meeting at Sender, 2 video conferences	Nov.'16	Continue research activity 8	The participants evaluate the risk-assessment process as useful. Yet, the extra tools made the action plan cumbersome to use. Sender and Receiver decide to start using again the previous Action plan and to assign the Action owners with the responsibility to conduct risk-assessments for their actions. Two more new actions are recommended (A18*and A19*, Appendix 5). The actions are assigned to a newly created category, 'Test'.	Quality assurance and risk manager (Sender), Project owner (Sender), Lead author
10.	NA	Nov.'16	4th refined version based on feedback from research activities 8–9	The Risk-assessment tool and Communication plan are removed from the Action plan. Actions and sub-actions identified during the risk-assessment are kept in the plan	Lead author
11.	2 video conferences	Nov.'16	5th refined version based on feedback from research activity 8	The Action plan (containing the procedure actions) is compared with Sender's template for production transfer plans. It is found out that all but one of the actions in the template are already addressed by the procedure. The new action is added (A16*, Appendix 5). Moreover, the procedure included actions that although not found in template had been evaluated as relevant by Sender and Receiver. Nonetheless, the actions are regrouped following the structure of the template, i.e. according to the departments at the case company. It is easier to hold more frequent status meetings if only one department at a time is invited	Quality assurance and risk manager (Sender), Project owner (Sender), Lead author
12.	2 meetings at Receiver, in Spain	Nov.'16	4th tailoring of the procedure to the transfer case; 5th evaluation	Actions evaluated as having a low relevance are removed from the Action plan (see Appendix 5). Additional actions (A9*, A12*, A13*, A13.1*, A22.2*, A27.1*, A31.1*, Appendix 5) and corresponding sub-actions are planned with Receiver's representatives	All Receiver's transfer organization; Project owner (Sender), Quality assurance and risk manager (Sender), Lead author
13.	NA	Dec.'16	6th refined version based on feedback from previous research activity	At the suggestion of the Project manager (Receiver), the data in the Action plan is transferred from Excel to an MS Project, which is more appropriate for complex action plans	Lead author

Id	Data collection method	Date	Research activity purpose	Main events	Participants
14.	1 meeting at Sender	Dec.'16	5th tailoring of the procedure to the transfer case; 6th evaluation	Not all employees have access to the MS Project. Sender's representatives transfer the data in the Action plan to a new, more user-friendly Excel template prepared by Sender. All the actions are assigned a risk level depending on how indispensable they are to produce during Start-up. Moreover, a Plan-Do-Check-Act tool is implemented in the new template. The Organization chart and an overview of all the transferred product versions are also included in the Excel file as two separate sheets	Quality assurance and risk manager (Sender), Action plan and sourcing responsible (Sender), project owner (Sender), Lead author
15.	E-mails, 1 video conference	Dec.'16-Jan.'17	7th refined version based on feedback from previous research activity	Missing data from the previous Action plan is added to the new version. User instructions and a Meeting log are added to the file as two separate sheets. One new action category is created, 'HSE'	Lead author, Action plan and sourcing responsible (Sender)
16.	2 meetings at Sender	Jan.'17	6th tailoring of the procedure to the transfer case; 7th evaluation	The participants verify that all the relevant data from the previous Action plan had been transferred to the new version. An overview of project milestones is added as a separate sheet	Action plan and sourcing responsible (Sender), Lead author
17.	2 meetings at Sender	Jan.'17	The procedure is used for the 1st time by Sender to update the transfer status during status meetings	Transfer action plan responsible (Sender) uses the Action plan to update the actions' status. The Action plan works as intended	Action plan and sourcing responsible (Sender), Project manager (Receiver), Production and quality & risk manager (Receiver), R&D, process control and chemical hazard responsible (Receiver), Moulding operator (Receiver), Assembly operator (Receiver), Project owner (Sender), Quality assurance and risk manager (Sender), Process technology manager (Sender), Product owner (Sender), Production manager and ERP production planning responsible (Sender), Moulding operator (Sender), Lead author
18.	E-mails	Jan.-Feb.'17	7th tailoring of the procedure to the transfer case; 8th evaluation	The participants decide that the Action plan with the procedure actions manages to address potential supply disruptions in a satisfactory way. Thus, actions (A33* and A34*, Appendix 5) and sub-actions from a risk-assessment conducted by Receiver by using Sender's Risk-assessment tool are transferred to the Action plan. It is decided to continuously update the Action plan	Quality assurance and risk manager (Sender), Action plan and sourcing responsible (Sender), Lead author

Id	Data collection method	Date	Research activity purpose	Main events	Participants
19.	1 video conference, e-mails	Mar.'17-Apr.'18	Sender and Receiver's evaluation of the Action plan during the remainder of the in-depth study	Transfer action plan responsible (Sender) continues to use the Action plan to update the actions' status without notable incidents	The entire Transfer organization
20.	6 semi-structured interviews	Apr. '18	Sender and Receiver's evaluation of the Transfer-preparation procedure and its implementation at the end of the in-depth study	3 key informants from Sender and 3 from Receiver are interviewed about their experience with the Transfer-preparation procedure and its implementation. Prior to the interviews, the authors prepare and send a questionnaire to the informants and their answers are used as a starting point for the interviews. The informants are mainly asked to evaluate on a scale from 0 to 5 the utility of the procedure and its implementation (in the form of an action plan) as well as the Start-up time and delivery precision, compared with the two transfers to the Norwegian supplier (see Section 3) and to the previous transfer to Receiver (see Subsection 5.1). Moreover, they are asked to describe the main advantages and disadvantages of the procedure implementation.	Action plan and sourcing responsible (Sender), Project owner (Sender), Quality assurance and risk manager (Sender), Project manager (Receiver), Production and quality & risk manager (Receiver), Documentation responsible (Receiver), Lead author

Appendix 2. The literature-based Transfer Preparation procedure (H-high relevance, M-medium relevance, L-no or low relevance; PT-A, PT-B, PT-C are the examples of production transfers on which 3 transfer-experts applied the procedure to evaluate it)

Id.	Preventive Actions in the Literature-based Procedure	References	Sender & Receiver's evaluation	Transfer Risk in Sender & Receiver's Action plan	Transf. experts' evalu.		
					PT-A	PT-B	PT-C
	Organisation and Project Management	(WHO, 2011)					
A1	Establish a project team with project managers and representatives from all the disciplines affected by the transfer and from both the sender and receiver. Assign a general project coordinator. Clarify the role and responsibilities of each member	(Madsen, 2009, WHO, 2011)	H	*Closed action. Not included in the plan*	H	H	H

Id.	Preventive Actions in the Literature-based Procedure	References	Sender & Receiver's evaluation	Transfer Risk in Sender & Receiver's Action plan	Transf. experts' evalu.		
					PT-A	PT-B	PT-C
A2	Establish a Process Improvement team with representatives from all the relevant disciplines and from both the sender and receiver	(Fredriksson et al., 2015, Madsen, 2009, Terwiesch et al., 2001, Rudberg and West, 2008, WHO, 2011)	H	Medium risk	M	M	H
A3	Establish a Supplier Development team with representatives from all the relevant disciplines and from both the sender and receiver	(Modi and Mabert, 2007, Dyer et al., 2000)	L	NA. *Removed. Not relevant during the transfer. Supplier Development actions will be mostly implemented after Start-up*	M	H	H
A4	Establish a Risk Management team with representatives from all the relevant disciplines and from both the sender and receiver	(WHO, 2011)	H	Medium risk	M	M	H
A5	Organize a project start-up meeting with the sender's and receiver's personnel involved in the transfer. Announce the object of the transfer, reasons for the transfer, the relationship between the sender and receiver, expected performance targets, etc.	(Dudley, 2006, McBeath and Ball, 2012)	H	*Closed action. Not included in the plan*	H	H	H
A6	Evaluate regulatory requirements in the sender's and receiver's countries and in any countries to where the product is to be supplied	(WHO, 2011)	H	Medium risk	H	M	M
A7	The sender and receiver to agree on performance targets (e.g. KPIs) and their continuous monitoring	(Terwiesch et al., 2001, Almgren, 1999)	H	Medium risk	H	M	M
A8	Sign a formal agreement. Include in the agreement specifications about expected performance targets and how to monitor targets, profit and risk sharing, the rights to access confidential information, product ownership, Request for Proposal, etc.	(Danilovic and Winroth, 2005, Franceschini et al., 2003, Zhu et al., 2001)	H	High risk	H	L	H
A9	Prepare a project management plan	(Terwiesch et al., 2001, WHO, 2011)	H	NA. *Removed. For Sender and Receiver, this plan was the Transfer Action plan. Updated during status meetings*	H	H	H
A10	The sender and receiver to hold regular status meetings and send meeting notes to all the affected personnel	(Rehme et al., 2013, Zhu et al., 2001)	H	Medium risk	H	M	H

Id.	Preventive Actions in the Literature-based Procedure	References	Sender & Receiver's evaluation	Transfer Risk in Sender & Receiver's Action plan	Transf. experts' evalu.		
					PT-A	PT-B	PT-C
A11	Create a Transfer Protocol that includes all the transfer documentation and is easily accessible to all the sender and receiver's personnel involved in the transfer. The protocol should be continuously updated	(Terwiesch et al., 2001, Ferdows, 2006, WHO, 2011)	H	Medium risk	H	H	H
A12	The sender and receiver to prepare a Communication plan. To include a Crisis management procedure and to address the impact of confidentiality on the open communication of technical matters	(Danilovic and Winroth, 2005, Norrman and Jansson, 2004, WHO, 2011)	H	NA. *Replaced by A8*. Communication was addressed by the Organization chart document*	H	H	M
A13	Reduce the outputs at the sender only gradually, as the production stabilizes at receiver (if possible)	(Fredriksson, 2011, Terwiesch et al., 2001, Minshall et al., 1999)	L	NA. *Removed. Replaced by A9**	H	M	H
A14	Plan the transfer during a low customer-demand period (if possible)	(Madsen, 2009)	L	NA. *Removed. Sender will produce the products until the material developed by Receiver is approved. Also addressed by A9**	H	H	L
	Quality management	(WHO, 2011)					
A15	Evaluate the receiver's readiness with regards to facilities, equipment and support services (e.g. by a Gap Analysis)	(Malm et al., 2016, Modi and Mabert, 2007, WHO, 2011)	H	High risk	H	H	H
A16	Assess the transfer risk. Include customs clearance and material supply risks	(Minshall et al., 1999, Fredriksson et al., 2015, WHO, 2011)	H	Medium risk	H	H	H
A17	Identify and implement preventive actions to mitigate the risk of supply shortages (e.g. safety stock and safety capacity). Identify corrective actions to mitigate the risk of supply shortages (e.g. overtime and express transports)	(Fredriksson et al., 2015, Gero and Stefan, 2009)	H	High risk	H	H	H
A18	Improve the transferability of the transfer object (upgrade or replace obsolete equipment, codify tacit knowledge, etc.)	(Grant and Gregory, 1997a, McBeath and Ball, 2012, Madsen, 2009, Minshall et al., 1999)	NA	NA. *Removed. Sender does not want to change the transfer object, except for the material developed at Receiver. Tacit knowledge is codified during A26*	H	M	H

Id.	Preventive Actions in the Literature-based Procedure	References	Sender & Receiver's evaluation	Transfer Risk in Sender & Receiver's Action plan	Transf. experts' evalu.		
					PT-A	PT-B	PT-C
	Knowledge Transfer	(Fredriksson and Wänström, 2014)					
A19	The sender and receiver to jointly develop a training plan	(Madsen, 2009, WHO, 2011)	H	Medium risk. **Part of 2nd milestone**	M	H	H
A20	Train the receiver's personnel. Send personnel from the receiver to the sender for training and to improve the transferability of the production-system|	(McBeath and Ball, 2012, Grant and Gregory, 1997b, Terwiesch et al., 2001, Madsen, 2009, Galbraith and Galbraith, 1990, Minshall et al., 1999)	H	High risk	M	H	H
A21	Transfer photographs and a video-taped review of the production process to the receiver	(Galbraith and Galbraith, 1990, Minshall et al., 1999)	M *(Because of IP in processes)*	NA	L	M	L
A22	Define and implement a Change Control process at the receiver	(Terwiesch et al., 2001, WHO, 2011)	H	Medium risk	M	H	H
A23	Conduct activities to enhance the receiver's performance level (e.g., VSM, RCA, FMEA, Lean, Six sigma, APQP)	(Modi and Mabert, 2007)	H	Medium risk	L	M	M
A24	Verify Knowledge Transfer at the receiver (e.g. check documentation and test personnel)	(McBeath and Ball, 2012)	H	High risk. **Part of 1st milestone**	H	H	H
	Transfer of Administrative Systems	(Fredriksson and Wänström, 2014)					
A25	Prepare a list of items and documentation to be transferred. Specify transfer means, if purchases are required, costs and lead-times to the receiver	(Minshall et al., 1999, WHO, 2011)	H	High risk	H	H	H
A26	Review, update and create missing documentation. Translate documentation, if necessary	(McBeath and Ball, 2012, Fredriksson et al., 2015, Terwiesch et al., 2001, Minshall et al., 1999)	H	High risk	H	H	H
A27	The sender to provide the receiver information on all HSE issues associated with the transfer object: material safety data sheets, inherent risks (e.g. exposure limits), exposure-mitigation actions, emergency planning (e.g. in case of fire), waste management, etc.	(WHO, 2011)	H	High risk	H	M	M
A28	The sender to transfer all the necessary information. The receiver to review the information from the sender,	(WHO, 2011)	L	Medium risk	H	H	H

Id.	Preventive Actions in the Literature-based Procedure	References	Sender & Receiver's evaluation	Transfer Risk in Sender & Receiver's Action plan	Transf. experts' evalu.		
					PT-A	PT-B	PT-C
	identify gaps (in facilities, systems, capabilities, testing methods, etc.) and notify the sender. Thereafter the receiver should develop documentation (e.g. operating procedures) based on this information		*(This process will be carried out with Sender)*				
A29	Make robust forecasts (of start-up time, new lead times, new quality levels, etc.)	(Fredriksson et al., 2015, Minshall et al., 1999)	H	Medium risk ***Part of 1st milestone***	H	H	H
A30	Update the planning and control systems (e.g. ERP)	(Fredriksson et al., 2015, Minshall et al., 1999)	H	Medium risk **Part of 1st milestone**	H	H	H
	Supply-chain Transfer	(Fredriksson and Wänström, 2014)					
A31	Establish relationships to sub-suppliers of raw materials, components, parts, etc.	(Aaboen and Fredriksson, 2016)	L *(Transfer within the same company)*	Medium risk. **Part of 2nd milestone**	H	H	H

Appendix 3. The Transfer Preparation procedure after the Procedure Refinement process (H-high relevance, M-medium relevance, L-no or low relevance; PT-A, PT-B, PT-C are the examples of production transfers on which 3 transfer-experts applied the procedure to evaluate it; only the actions added by Sender and Receiver are evaluated)

New Id.*	Preventive Actions in the Refined Procedure	Sender & Receiver's evaluation	Transfer Risk in Sender & Receiver's Action plan	Transfer experts		
				PT-A	PT-B	PT-C
	Organisation and Project Management					
A1*	Establish a project team with project managers and representatives from all the disciplines affected by the transfer and from both the sender and receiver. Assign a general project coordinator. Clarify the role and responsibilities of each member					
A2*	Establish a Process Improvement team with representatives from all the relevant disciplines and from both the sender and receiver					

New Id.*	Preventive Actions in the Refined Procedure	Sender & Receiver's evaluation	Transfer Risk in Sender & Receiver's Action plan	Transfer experts		
				PT-A	PT-B	PT-C
A3*	Establish a Risk Management team with representatives from all the relevant disciplines and from both the sender and receiver					
A4*	Organize a project start-up meeting with the sender's and receiver's personnel involved in the transfer. Announce the object of the transfer, reasons for the transfer, the relationship between the sender and receiver, expected performance targets, etc.					
A5*	Sign a formal agreement. Include in the agreement specifications about expected performance targets and how to monitor targets, profit and cost sharing, the rights to access confidential information, product ownership, Request for Proposal, etc.					
A5.1 *	The sender and receiver to agree on performance targets (e.g. KPIs) and their continuous monitoring					
*A5.2 **	*The receiver's personnel with access to confidential information sign a Non-disclosure agreement*	*H*	*Medium risk*	*M*	*M*	*H*
A6*	The sender and receiver to hold regular status meetings and send meeting notes to all the affected personnel					
A7*	Create a common directory that includes all the transfer documentation and is easily accessible to all the sender and receiver's personnel involved in the transfer. The directory should be continuously updated					
A8*	The sender and receiver to prepare a Crisis management procedure and to address the impact of confidentiality on the open communication of technical matters					
A9*	*Plan for overproduction at the sender to cover the needs during the Execution and Start-up phases*	*NA*	*Medium risk.* ***Part of 1st milestone***	*M*	*M*	*M*
	Sourcing					
A10*	Evaluate regulatory requirements in the sender's and receiver's countries and in any countries to where the product is to be supplied *- exchange rates for equipment and inventory (e.g. parts and components) from the sender and the sub-suppliers, import duties, land codes and new origin on finished products*					
*A10. 1**	*Verify shipping requirements (e.g. customs requirements and trade agreements applicable when shipping from the receiver vs. the sender)*	*NA*	*Medium risk.* ***Part of 1st milestone***	*H*	*L*	*H*
*A11**	Establish relationships to sub-suppliers of raw materials, components, parts, etc.					
	Quality Management					
*A12**	*Involve the sender in the design and approval of the layout, if this is modified*	*H*	*Closed action. Not included in the plan*	*M*	*M*	*H*

New Id.*	Preventive Actions in the Refined Procedure	Sender & Receiver's evaluation	Transfer Risk in Sender & Receiver's Action plan	Transfer experts		
				PT-A	PT-B	PT-C
A13*	Evaluate the receiver's readiness with regards to facilities, equipment and support services (e.g. by a Gap Analysis) *- purchasing (the selection and development of the sub-suppliers through the Change Control procedure)* *- storing (FIFO, serial and version control, ESD)* *- receiving structure (routines and equipment for receiving control and tolerance control)* *- non-conformance handling* *- Total Preventive Maintenance for equipment*					
*A14**	*Validate the receiver's facilities (after the implementation of sub-actions for improving the receiver's 'readiness' for transfer)*	*NA*	*High risk* ***Part of 3rd milestone***	*H*	*H*	*H*
*A14.1**	*Validate the purchasing, warehousing and receiving structure*	*NA*	*High risk.* ***Part of 3rd milestone***	*M*	*M*	*H*
A15*	Assess the transfer risk. Include customs clearance and material supply risks					
A16*	Identify and implement preventive actions to mitigate the risk of supply shortages (e.g. safety stock and safety capacity). Identify corrective actions to mitigate the risk of supply shortages (e.g. overtime and express transports)					
A17*	Define and implement a Change Control process at the receiver					
A18*	Conduct activities to enhance the receiver's performance level (e.g., VSM, RCA, FMEA, Lean, Six sigma and APQP)					
A19*	Prepare a list of items and documentation to be transferred. Specify transfer means, if purchases are required, costs and lead-times to the receiver					
A20*	Review, update and create missing documentation. Translate documentation, if necessary					
*A21**	*Ensure that the equipment to be transferred is registered and marked with the sender's property*	*NA*	*Medium risk*	*M*	*L*	*H*
*A22**	*Verify if the actions in the Preparations phase are closed prior to the Execution phase*	*NA*	*High risk*	*H*	*M*	*M*
	Process Technology					
*A23**	*Develop, test, implement and validate the new material*	*NA*	*High risk*	*H*	*M*	*H*
*A24**	*The sender and receiver to prepare the documentation for newly developed material*	*NA*	*High risk.* ***Part of 2nd milestone***	*M*	*M*	*H*
	Test					
*A25**	*Verify the readiness of the test system for the transfer (software, equipment, documentation, access rights to the sender's systems, etc.)*	*NA*	*High risk.* ***Part of 1st milestone***	*M*	*M*	*H*

New Id.*	Preventive Actions in the Refined Procedure	Sender & Receiver's evaluation	Transfer Risk in Sender & Receiver's Action plan	Transfer experts		
				PT-A	PT-B	PT-C
*A26**	*Update/create documentation about tests*	*NA*	*Medium risk*	*H*	*M*	*H*
*A27**	*Send personnel from the sender to the receiver to perform training on testing methods*	*NA*	*High risk.* ***Training activities are concurrent***	*H*	*H*	*H*
	Production					
A28*	The sender and receiver to jointly develop a training plan					
A29*	Train the receiver's personnel. Send personnel from the receiver to the sender for training and to improve the transferability of the production-system					
A30*	Verify Knowledge Transfer at the receiver (e.g. check documentation and test personnel)					
A31*	The sender to transfer all the necessary information. The sender and receiver to review the information from the sender, identify gaps (in facilities, systems, capabilities, testing methods, etc.) and notify the sender. Thereafter the receiver should develop documentation (e.g. operating procedures) based on this information					
A31.1*	Transfer photographs and a video-taped review of the production process to the receiver					
	Plan for ERP set-up					
A32*	*Implement ERP at the receiver. Train the receiver's personnel on ERP use*	*NA*	*Medium risk.* ***Training activities are concurrent***	*H*	*H*	*H*
A32.1*	*Verify that ERP is functional at the receiver*	*NA*	*Medium risk*	*H*	*H*	*H*
A33*	Make robust forecasts (of start-up time, new lead times, new quality levels, etc.)					
A34*	Update the planning and control systems (ERP)					
A34.1*	*Sales order forecasting and planning*	*NA*	*Low risk*	*H*	*M*	*M*
	HSE					
*A35**	*Ensure documented procedures and routines for hazardous materials (e.g. for purchase, reception, storage, handling and disposal)*	*NA*	*High risk*	*H*	*M*	*H*
*A36**	*Ensure HSE visual management*	*NA*	*High risk*	*M*	*M*	*M*
A37*	The sender to provide the receiver information on all HSE issues associated with the transfer object: material safety data sheets, inherent risks (e.g. exposure limits), exposure-mitigation actions, emergency planning (e.g. in case of fire), waste management, etc.					

Paper 6

Mogos, M.F., Sjøbakk, B. and Alfnes, E., (2016). "A structured outsourcing procedure", *IFIP International Conference on Advances in Production Management Systems*, Springer, Cham, Vol. 488, pp. 739-747.

A structured outsourcing procedure

M. F. Mogos[1], B. Sjøbakk[2] & Erlend Alfnes[1]

[1]*Norwegian University of Science and Technology (NTNU), Trondheim, Norway*
{maria.f.mogos, erlend.alfnes}@ntnu.no
[2]*SINTEF Technology and Society, Department of Industrial Management, Trondheim, Norway*

Abstract

Outsourcing of production entails a vast amount of activities and decisions. Although it has many acknowledged benefits, it is associated with substantial risk, and may lead to increased costs and loss of business if it is not carried out carefully and in a systematic manner. The identified outsourcing literature mainly focuses on specific parts of the outsourcing process and often provides limited practical guidance. Therefore, the purpose of this paper is to synthesize existing research on outsourcing processes into one structured outsourcing procedure. This can guide companies in carrying out outsourcing activities in a systematic manner. The suggested procedure is discussed in light of a case study of two production transfers between a Norwegian supplier of advanced maritime monitoring systems and one of its strategic suppliers.

Keywords: *Outsourcing, Production transfer, Operations strategy*

1. Introduction

Many Western companies choose to transfer parts of their production to other actors in their supply chains. Such transfers are often denoted outsourcing or offshoring processes, depending on the ownership structure (internal or external) and target location (domestic or foreign) of the transfer (Monczka et al., 2005). Outsourcing generally refers to the handover of responsibility for certain activities across organizational borders, whereas offshoring indicates that the responsibility is transferred to a subsidiary or supplier in a foreign location. Due to its many stated benefits, such as lower factors costs, access to new materials, distribution channels and technologies, as well as increased capacity to focus on core competences, outsourcing has been a very popular strategy in many industries (Kinkel and Maloca, 2009). Still, it is associated with substantial risk and may lead to increased costs and loss of business if it is not carried out carefully and in a systematic manner – reflecting the high complexity of such transfer processes (Kinkel and Maloca, 2009).

Outsourcing of production entails a vast amount of decisions to be taken. Although several outsourcing frameworks and guidelines exist, only a few (e.g. Momme and Hvolby, 2002, WHO, 2011) describe all stages of the outsourcing process. These are typically rather general in their description of the activities that need to be carried out at the different stages. More detailed frameworks typically focus on the make-or-buy phase of the process, by e.g. discussing possible benefits and risks when outsourcing (Kremic et al., 2006), or they end before the physical transfer (Fredriksson, 2011). Frameworks that address the production transfer (PT), i.e. the actual relocation of manufacturing of products or components between two production facilities (*Sender* and *Receiver*), either focus on specific parts of the PT (Fredriksson, 2011), or provide only a general overview of interdependent activities important for supply performance (Madsen, 2009, Momme and Hvolby, 2002, Zeng, 2003). No comprehensive frameworks integrating all these aspects have been identified. Therefore, the purpose of this paper is to synthesize existing research on outsourcing processes into one structured outsourcing procedure. This can guide companies in carrying out outsourcing activities in a systematic manner. The procedure is discussed in light of an instrumental case study of two PTs between a Norwegian supplier of advanced maritime monitoring systems and one of its strategic suppliers within electronic manufacturing services (EMS).

2. Research Method

The structured outsourcing procedure is proposed on the basis of a thorough study of literature on *production-*, *knowledge-*, and *technology-transfers*, as well as more general literature on *outsourcing*, *production start-up* and *ramp-up*. When structuring the literature, the most comprehensive identified models and methods (Momme and Hvolby, 2002, WHO, 2011, Kremic et al., 2006) were taken as a starting point. During the structuring of the literature a need to add, rearrange and adjust phases emerged – more or less resulting in the proposed procedure. However, an *instrumental case study* approach (Baxter and Jack, 2008) has been selected to test and accomplish it. This was designed as a single case study as the access to adequate empirical data was limited to one supplier-buyer relation; however, two PTs were followed to increase the research quality. The empirical data was collected through workshops and semi-structured interviews with key representatives from both case companies, e.g. quality managers, product developers, key account managers and process engineers.

3. Structuring Outsourcing

In broad terms the production outsourcing process can be divided into three parts: (1) deciding what (if any) to outsource, (2) selecting and committing a supplier, and (3) transferring the production. Each of these contains a number of activities that a company needs to go through during an outsourcing process. These are briefly described and summarized below. IDs are assigned to the activities, in order to link them to the suggested outsourcing procedure at the end of the section.

3.1. The Outsourcing Decision

In describing the outsourcing decision, a framework by Kremic et al. (2006) is adopted. This depicts typical elements of the outsourcing decision, and shows where motivators, benefits, risks and other factors are typically encountered. The first step is to consider outsourcing in the first place. Here, the sender's motivation for outsourcing is weighed against general risks and benefits. According to (2006) (a combination of) three major categories of motivation drives outsourcing: cost, strategy, and politics. The sender should have a conscious attitude towards these (A1). For instance, the outcome of outsourcing is often more successful if the decision is based on strategic considerations rather than solely on financial problems (Brandes et al., 1997). Further, the sender should analyze whether common benefits and risks of outsourcing either strengthen or weaken the decision (A2). Although it is not explicitly stated in the literature, we suggest documenting (A3) and communicating (A4) the resulting outsourcing policy internally. Next, the sender should identify (A5), evaluate (A6) and select (A7) what, if any, to outsource based on strategic-, financial-, functional- and environmental factors of each candidate and on the outsourcing policy (2006). When production is outsourced, Semini et al. (Semini et al., 2013) suggest careful attention to aspects such as logistics, equipment utilization, proximity to product development and intellectual property.

3.2. Supplier Selection

When the company has selected which functions, products or processes it should outsource, the next stage is to select a target supplier and location for the transfer. Here, a four-stage supplier selection process by Cousins et al. (2008) is adopted. First, suppliers are prequalified (A8). Prequalification criteria will vary between companies and industries; however, suppliers' manufacturing capabilities and financial viability will usually be assessed. Often, companies keep a record of prequalified suppliers, enabling them to skip this phase. Otherwise, information about suppliers needs to be collected and evaluated. Next, the company should agree on measurement criteria (A9) that are specific to the product under consideration (e.g. unit price, lead time, supplier flexibility). Third, relevant information about suppliers should be gathered (A10), for example through requests for proposal or quotation. This information is used to make a selection in the fourth phase (A11). Danilovic and Winroth (Danilovic and Winroth, 2005) argue that no matter how hard management strives to have a high level of integration in collaborative networks, the integration must be supported by legal agreements (A12). Draft agreements would often need to be designed for each case. Examples of issues that need to be included are forms of decision making, risk allocation, security issues and renegotiation/termination rules (Danilovic and Winroth, 2005). As will be evident in the next section, the contract may need to specify responsibilities before, during and after the transfer.

3.3. Production Transfer

Finally, when the receiving supplier has been selected the PT can commence. Based on (Madsen, 2009), a PT process consists of four phases: the *preparation* for transfer, the *physical transfer* of equipment and inventories, the production *start-up* at Receiver, and the *steady state*. The Steady State starts after there has been reached a full-scale and stable production, at targeted levels of cost and quality (Terwiesch et al., 2001). Each of the PT related activities identified in the literature has been assigned to one of these four phases (Table 1).

Apart from the Physical Transfer, a PT consists of three additional types of transfers: *knowledge transfer (KT)* (of tacit knowledge), *administrative transfer (AT)* (of explicit/codified knowledge), and *supply chain transfer (SCT)* (by establishing relations to vendors of materials)(Fredriksson and Wänström, 2014). It is important to ensure all these types of transfers during a PT. In addition, transfer parties will have to perform certain project administrative activities, such as establishing a PT organization and manage the PT project (WHO, 2011).

Table 1. Outsourcing procedure with potential activities

Outsourcing policy:

A1. Identify the amount of cost-driven, strategy-driven and politically-driven outsourcing (Brandes et al., 1997, Kremic et al., 2006)

A2. Analyze whether benefits and risks will strengthen or weaken the decision to outsource (Kremic et al., 2006)

A3. Establish policy document

A4. Communicate the company's outsourcing policy to employees

Outsourcing candidate selection:

A5. Identify possible candidates for outsourcing (functions, products or processes) (Kremic et al., 2006)

A6. Evaluate identified candidates (Kremic et al., 2006, Semini et al., 2013)

A7. Select candidate(s) (Kremic et al., 2006)

Supplier selection:

A8. Prequalify suppliers (Cousins et al., 2008)

A9. Agree on measurement criteria (Cousins et al., 2008)

A10. Obtain relevant information (Cousins et al., 2008)

A11. Make selection (Cousins et al., 2008)

A12. Contract negotiation (Danilovic and Winroth, 2005)

Transfer preparation:

A13. Establish Project team (Madsen, 2009, WHO, 2011)

A14. Kick-off meeting (Dudley, 2006)

A15. Establish other teams (Terwiesch et al., 2001, WHO, 2011)

A16. Sign formal agreement (Danilovic and Winroth, 2005, Zhu et al., 2001)

A17. Plan as Stepwise Transfer during low demand season (if possible) (Fredriksson et al., 2015)

A18. Ensure interaction with Receiver. Higher uncertainty, higher requirements (Stock and Tatikonda, 2000)

A19. Develop training plan (Andre and Peter, 2012)

A20. Create transfer register. Include Transfer plans and checklist, Change Control procedure, etc. (WHO, 2011)

A21. Evaluate Receiver's preparedness (premises, equipment., support services) (WHO, 2011)

A22. Perform Transfer Risk Assessment. Implement measures (Fredriksson et al., 2015)

A23. Problem solving/upgrading/recalibration/test of production system (Madsen, 2009, Terwiesch et al., 2001)

A24. Define Engineering Change process(Terwiesch et al., 2001)

A25. Train Receiver's personnel (Terwiesch et al., 2001, Andre and Peter, 2012)

A26. Update/ create documentation with Receiver (Terwiesch et al., 2001, Fredriksson et al., 2015, Andre and Peter, 2012)

A27. Improve Receiver's performance (Modi and Mabert, 2007)

A28. Update Planning & Control system (Fredriksson et al., 2015)

A29. Develop Communication plan (WHO, 2011)

A30. Transfer information (WHO, 2011)

A31. Receiver reviews info. and finds gaps (WHO, 2011)

A32. Ensure joint info. sharing platform (Terwiesch et al., 2001)

A33. Establish relations to sub-suppliers (Aaboen and Fredriksson, 2015)

A34. Verify preparations (Fredriksson et al., 2015)

Physical Transfer:

A35. Transfer production equipment (Madsen, 2009)

A36. Send personnel to Receiver (Terwiesch et al., 2001)

A37. Install and test production equipment (Madsen, 2009)

Production Start-up:

A38. Sender temporary transfers personnel (Terwiesch et al., 2001)

A39. Set up experimental line (Terwiesch et al., 2001)

A40. Involve all affected personnel (Madsen, 2009)

A41. Qualify component vendors (Terwiesch et al., 2001)

A42. Decide when to transfer responsibility to order raw material to Receiver (Fredriksson et al., 2015)

A43. Adapt processes to a new environment (Grant and Gregory, 1997)

A44. Problem solving on parts/materials(Madsen, 2009)

A45. Verify production (Hilletofth et al., 2015)

A46. Continuously monitor performance. Consider shutdown when lower than targets to solve problems (Terwiesch et al., 2001)). Implement measures (Fredriksson et al., 2015, McCormack et al., 2008).

A47. Adapt docs and Plan. & Control syst. (Fredriksson et al., 2015)

A48. Conduct post-transfer audit. Evaluate transfer (Hilletofth et al., 2015, Zhu et al., 2001)

A49. Gen. sum. report (lessons learned, etc.) (WHO, 2011)

Production Steady State:

A50. Continuously monitor and improve production (Madsen, 2009). Consider maintaining experimental line (Terwiesch et al., 2001)

The *transfer preparation* phase includes the most identified activities. Here, KT activities are mainly related to the training (A25) and involvement of Receiver personnel in the preparation of documentation, the systems, and of the production equipment and processes

(A26). In addition, it might be necessary to implement KT activities for performance improvement at Receiver, such as six sigma or lean (Modi and Mabert, 2007) (A27). AT activities are related to e.g. updating of planning and control systems with data based on the estimated lead times and other performance indicators for the PT (Fredriksson et al., 2015) (A28), and the transfer of the updated information to Receiver (drawings, materials planning method, packaging procedures, etc.) (A30). SCT primarily concerns a possible transfer of suppliers to the Receiver (A33). Examples of project management (PM) activities are kick-off meeting (A14), signing of formal agreements (A16), and generating a transfer register with plans, flow diagrams, instructions and control procedures (accessible to both parties and up-to-date) (A20). The *physical transfer* mainly involves transfer of production equipment (A35), installation and testing of equipment (A36), but also certain KT by temporary transferring personnel from Sender to Receiver (A36) to provide support and report back to Sender (Terwiesch et al., 2001). Such a transfer can also take place during *start-up* (A38). Other KT activities during start-up imply setting up an experimental line for learning and for testing of performance improvement solutions at the Receiver (A39), and involving all the affected personnel along the process (A40). An AT task for the Receiver is to adapt documentation and systems to their own planning environment (A47). SCT activities during start-up are mainly related to qualification of component vendors (A41) and the decision about when to transfer the responsibility to order raw material to the Receiver (A42). As a PM activity, a summary report (A50) should be generated and stored in the transfer register.

4. Discussion and Conclusions

The empirical data collected during the case research is summarized in Table 2. As seen in Table 2, Sender and Receiver had a series of challenges with the two PTs that might have been reduced by some of the actions from Table 1. For instance, communicating the company's outsourcing policy internally (A4) and organizing a kick-off meeting where the reason for the PT is clarified (A14), could have increased the Product Team's motivation to share essential information with the Receiver in Case A (Dudley, 2006). The PT parties should have constituted a project team (A14), with PT managers and other members from all the affected disciplines and with clear roles (Terwiesch et al., 2001). Moreover, as stated by (WHO, 2011), PTs should be managed by help of a PM plan based on risk management principles (A20). Hence, all the activities with potentially negative consequences (e.g. transferring the test equipment to Receiver) should have been identified together with experienced personnel and measures should have been implemented (i.e. risk management) (A22). Further, some authors state that PTs, to the extent possible, should be planned as 'stepwise' transfers (A17) instead of 'clear-cut', as in Case A. Production at Sender should be gradually decreased as volumes increase at Receiver. Thus, in case of unexpected demand or major production disruptions during Start-up, one would have a secondary source of supply at the Sender (Fredriksson et al., 2015).

Furthermore, parties had several communication issues in both Case A and B. Thus, by preparing a communication plan (with e.g. points of contact and their roles) (A29), they could have minimized these challenges. This plan should be included in the PT register along with the PT plan and other tools, such as activities checklists, a change control system, and a flow diagram (Terwiesch et al., 2001, WHO, 2011). Moreover, the register should be

Table 2. Overview of the studied production transfers and their main activities

Completed transfer: Case A	Ongoing transfer: Case B
Transfer object: Acoustic sensor. Mature product. High volumes. Not too complex. Little IP. Original location: Sender's production facility in Norway. Before, Sender had been producing the sensors and assembled them with housings and electronics from two different suppliers. **New location:** After transfer, Receiver assembles tests and delivers final products to Sender. Receiver is expected to reduce unit cost over time. **Outsourcing policy:** Combination of cost and strategy. Need to reduce cost; aim to be a 'technology company' rather than manufacturing company. **Outsourcing candidate selection:** High volume product that requires higher efficiency and less competence than the Sender has. **Supplier selection:** The Receiver was prequalified and used to deliver electronics for the product. **Preparations:** Parties had no kick-off meeting. Key personnel in the Product Team, Sales, and Test were little involved in the preparations. Product Team was little informed about the reason for the transfer and their motivation to support Receiver was low. It had been unclear who was responsible for what at Sender and a transfer plan and risk assessment had not been prepared and conducted before transfer. Initially, it was decided that all test equipment would be moved from Sender to Receiver. When Product Team found this out, they realized that the Sender would not be able to run spot-checks, losing the control over the quality of their deliveries. Moreover, initially, Sender was to manufacture the product until Easter and Receiver everything after that (clean-cut). This turned out to be unrealistic. [*KT:*] Receiver participated in VSM at Sender and sent 3 operators to learn the process at Sender. [*SCT:*] Sender's original suppliers of housings and electronics were transferred to Receiver. **Physical Transfer:** Sender copied their test equipment and transferred the copy to Receiver. **Start-up:** Receiver experienced that several of their process improvement suggestions were rejected without a clear justification and the latest ones even turned out to be futile. During a workshop (April '15), the Product Team revealed, to the Receiver's surprise, their plans to update the product to a new version. Finally, Sender was unaware if the transfer had been profitable or not, but they said that the start-up was long with high scrap rates and stock levels.	**Transfer object:** Signal converter. New version of existing product. More complex than Product A. **Original location:** The same as in Case A. For previous version, Sender installed PCBs from Receiver in cabinets from one supplier, and power supply and wiring from another supplier. Sender tested the final products. **New location:** Same Receiver as in Case A. After transfer, Receiver installs electronics including own PCBs in cabinets. Sender still tests final products. **Outsourcing policy:** Same as in Case A. **Outsourcing candidate selection:** Product was selected due to the upcoming new version, 'now was the time'. Key components were already outsourced. **Supplier selection:** Same as in Case A. Their experience with product A was partly decisive. **Preparations:** The transfer started in Sept. '14, with a kick-off. Sender asked Receiver to secure material from sub-suppliers without any formal agreement. A significant amount of this material became obsolete because of BOM changes, and the financial consequences were unsettled for a long time. The transfer was planned with partially overlapped product development at Sender and process development at Receiver. Often, BOM and other product design changes came too late (e.g. during continuous production instead of the Pilot phase). 4 BOM changes were sent after Receiver had ordered material. Moreover, Sender had problems with own change control system that did not allow purchasing materials for prototypes before design-freeze. Thus, many changes were unrecorded until Product Developer started to collect them in a common excel-file. [*KT:*] No personnel from Receiver were transferred for training at Sender. Receiver appreciated having one contact person at Sender (Product Developer) whereas Sender's Prod. Developer felt that it had been challenging to know whom to contact at Receiver. She had also experienced that two contacts at the Receiver had different BOM revisions. [*SCT:*] Sender's original supplier of cabinets was transferred to Receiver. Later on, Sender may replace them by its own subsidiary in a low-cost country. **Physical Transfer:** None. **Start-up:** At the time of the workshop in April '15, the production had been transferred from Receiver's Development department to Manuf.

continuously updated and an easily accessible to both parties (A20). Finally, at the end of the Start-up in Case A, Sender could have conducted a post-transfer audit, comparing the pre- and post-outsourcing costs (Zhu et al., 2001) and evaluating whether the Steady-state had been achieved and whether the production should be relocated to other manufacturer or not (A48). In addition, Receiver's performance should be monitored along the entire PT and measures should be implemented (A50) (WHO, 2011). With respect to Case B, several authors stress the importance of a formal agreement (A12, A16) between parties, signed as early as possible during Preparations. The agreement should include each party's responsibilities along the process (e.g. who bears the cost of obsolete material), and desired performance targets (e.g. yield) (Terwiesch et al., 2001). Further, to effectively manage engineering changes, parties could also define the change control process (A24) during Preparations, and they could create a flow diagram of the PT with necessary decisions gates (WHO, 2011). For instance, before starting with the continuous manufacturing, the production should have passed a verification gate (A45). Finally, with higher uncertainty of the PT (i.e. novelty, complexity, and tacit knowledge) there are higher requirements of interaction between parties (A18). For Case B, the For Case B, the assembly of product B was novel for the Receiver; the product version was an innovation, and it had a high amount of uncodified knowledge. Thus, parties could have invested more in information management systems (e.g. a common IT platform) and could have drawn advantage from the domestic proximity by having regular and more frequent meetings with the Receiver (Hilletofth et al., 2015).

In this study, existing research on outsourcing processes is synthesized into one structured outsourcing procedure, comprising the *outsourcing decision*, the *supplier selection*, and the *PT* stage. We argue that one of the strengths of this procedure is providing a detailed overview of the PT specific activities, which are often overseen in earlier outsourcing procedures despite their impact on final performance results. The proposed procedure can guide practitioners in conducting production outsourcing processes in a systematic manner. Nevertheless, it should be validated in different manufacturing contexts and adapted to different types of production outsourcing. The authors objective for the future is to configure and validate a phase model comprising activities from the current procedure, decision gates, suggested disciplines for each activity, as well as appropriate methods and tools.

Acknowledgements

This research has been conducted with support from the research project SoundChain funded by The Research Council of Norway. The authors would like to thank the project participants for providing valuable empirical data.

References

AABOEN, L. & FREDRIKSSON, A. 2015. The relationship development aspect of production transfer. *Journal of Purchasing and Supply Management*.

ANDRE, M. & PETER, B. 2012. Towards a framework for transferring technology knowledge between facilities. *Strategic Outsourcing: An International Journal,* 5**,** 213-231.

BAXTER, P. & JACK, S. 2008. Qualitative case study methodology: Study design and implementation for novice researchers. *The qualitative report,* 13**,** 544-559.

BRANDES, H., LILLIECREUTZ, J. & BREGE, S. 1997. Outsourcing—success or failure?: Findings from five case studies. *European Journal of Purchasing & Supply Management,* 3**,** 63-75.

COUSINS, P., LAMMING, R., LAWSON, B. & SQUIRE, B. 2008. *Strategic supply management: principles, theories and practice*, Pearson Education.

DANILOVIC, M. & WINROTH, M. 2005. A tentative framework for analyzing integration in collaborative manufacturing network settings: a case study. *Journal of Engineering and Technology Management,* 22**,** 141-158.

DUDLEY, JR. 2006. Successful technology transfer requires more than technical know-how. *Biopharm. Int.,* 19**,** 68-+.

FREDRIKSSON, A. 2011. *Materials supply and production outsourcing*, Chalmers University of Technology.

FREDRIKSSON, A. & WÄNSTRÖM, C. 2014. Manufacturing and supply chain flexibility towards a tool to analyse production network coordination at operational level. *Strategic outsourcing : an International journal,* 7**,** 173-194.

FREDRIKSSON, A., WÄNSTRÖM, C., JOHANSSON, M. I. & MEDBO, L. 2015. A structured procedure for materials planning during production transfer. *Production Planning & Control***,** 1-15.

GRANT, E. & GREGORY, M. 1997. Adapting manufacturing processes for international transfer. *Int. J. Oper. Prod. Manage.,* 17**,** 994-&.

HILLETOFTH, P., WLAZLAK, P., JOHANSSON, G. & SÄFSTEN, K. Challenges With Industrialization In a Supply Chain Network: A Supplier Perspective. Management, Knowledge and Learning-Joint International Conference 2015 Bari, Italy.

KINKEL, S. & MALOCA, S. 2009. Drivers and antecedents of manufacturing offshoring and backshoring—A German perspective. *Journal of purchasing and Supply Management,* 15**,** 154-165.

KREMIC, T., ICMELI TUKEL, O. & ROM, W. O. 2006. Outsourcing decision support: a survey of benefits, risks, and decision factors. *Supply Chain Management: an international journal,* 11**,** 467-482.

MADSEN, E. S. 2009. *Knowledge transfer in global production,* Denmark, Aalborg University.

MCCORMACK, K., WILKERSON, T., MARROW, D., DAVEY, M., SHAH, M. & YEE, D. 2008. Managing risk in your organization with the SCOR methodology. *The Supply Chain Council Risk Research Team***,** 1-32.

MODI, S. B. & MABERT, V. A. 2007. Supplier development: Improving supplier performance through knowledge transfer. *Journal of Operations Management,* 25**,** 42-64.

MOMME, J. & HVOLBY, H.-H. 2002. An outsourcing framework: action research in the heavy industry sector. *European Journal of Purchasing & Supply Management,* 8**,** 185-196.
MONCZKA, R. M., MARKHAM, W. J., CARTER, J., BLASCOVICH, J. & SLAIGHT, T. 2005. Outsourcing strategically for sustainable competitive advantage. Tempe, Arizona: Center for Advanced Purchasing Studies.
SEMINI, M., SJØBAKK, B. & ALFNES, E. 2013. What to Offshore, What to Produce at Home? A Methodology. *Advances in Production Management Systems. Competitive Manufacturing for Innovative Products and Services.* Springer.
STOCK, G. N. & TATIKONDA, M. V. 2000. A typology of project-level technology transfer processes. *Journal of Operations Management,* 18**,** 719-737.
TERWIESCH, C., BOHN, R. E. & CHEA, K. S. 2001. International product transfer and production ramp-up: A case study from the data storage industry. *R and D Management,* 31**,** 435-451.
WHO 2011. WHO Technical Report Series 961: WHO Expert Committee on Specifications for Pharmaceutical Preparations, Forty-fifth Report. *In:* ORGANIZATION, W. H. (ed.).
ZENG, A. Z. 2003. Global sourcing: process and design for efficient management. *Supply Chain Management: An International Journal,* 8**,** 367-379.
ZHU, Z., HSU, K., LILLIE, J. & ZHU, Z. 2001. Outsourcing - a strategic move: the process and the ingredients for success. *Management Decision,* 39**,** 373-378.

ISBN 978-82-326-5132-0 (printed ver.)
ISBN 978-82-326-5133-7 (electronic ver.)
ISSN 2703-8084 (online)
ISSN 1503-8181 (printed ver.)

NTNU
Norwegian University of
Science and Technology