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Original Paper

Lean Cooperation: A Framework

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Abstract

While both concepts lean management and cooperation not only have received considerable attention in management literature but also have been combined e.g. in the field of supply chain literature, a comprehensive definition of lean cooperation is still missing. Whereas lean supply chain cooperation is only one aspect in a growing field, we aim at considering further forms of cooperation coming up and having consequences for the management of lean initiatives.

Based on an extensive literature review, we develop a framework addressing lean cooperation and thus, allowing for systematization. Furthermore we find out that current literature mainly focusses on lean cooperation along the supply chain. This paper presents other forms of cooperation focused on lean management. With a case study of lean cooperation within an industry cluster we will show the potential of knowledge-transfer on lean practices for individual firm´s implementation.

This paper provides a definition and a research framework for lean cooperation. Insights will be useful for further analysis of lean management roll-out within outlined forms of cooperation. Practitioners will learn about benefits and restrictions of lean cooperation. The paper also is of value for researchers giving a structured outline of lean cooperation and stating fields for further research.

Keywords

lean, cooperation, cluster, literature review, case study

1. Introduction

Lean thinking is one of the most important topics in operations (Cottyn et al., 2011; Hoss & Schwengber ten Caten, 2013; Lewis, 2000; Pilkington & Fitzgerald, 2006; Wu, 2003) and strategic management, especially when adapting the comprehensive understanding of lean management as an approach comprising strategic and operational levels (Hines et al., 2004). While today´s business environment is getting more global and dynamic, strategy formulation is getting even more complex and has to deal with the unpredictable nature of business environment (Acur & Englyst, 2006). Recognizing that there are four strategic determinants, namely corporate strengths, marketing strengths, technology strengths and operational strengths (Pun, 2004), it becomes obvious that focussing on the

five lean principles (Womack & Jones, 2003) solely within company boundaries is not sufficient for being competitive. One important aspect affecting strategy formulation is the increasing trend for cooperation within and across company boundaries (Karlsson, 1992). While there might be reasons for increasing cooperation stemming from corporate (e.g. regarding the availability of capital), marketing (e.g. regarding the company´s reputation in foreign markets) or technological perspectives (e.g. regarding R&D and innovation capabilities), using the determinants stated by Pun (2004), the impact of business cooperation will be comprehensive, also involving the operational perspective that is an original area of lean thinking.

One area in which the combination of lean thinking and cooperation is widely considered by researchers and practitioners is the field of supply chain management. Looking at lean thinking literature, the integration of upstream and downstream stages of the value chain is an essential step in implementing lean management (Liker, 2004). The integration of the supplier network is argued to be one of the critical factors for the success of the Toyota Production System (Hines, 1996). Accordingly, the simple transfer of costs along the supply chain is not enough for reaching a competitive advantage from a lean-perspective: focussing on customer value (Hines, 1994) means the implementation of a lean supply chain because shifting problems will generate disadvantages for the customer at the end of the value chain including dampening effects for all supply chain partners (Christopher, 2011). Hence, lean cooperation in supply chains has been widely considered, prominently e.g. by Hines (1994), Lamming (1993) and MacDuffie & Helper (1997).

However, due to the increasing dynamics for engaging within the spectrum of market and hierarchy as well as increasing mergers and acquisition activities (Bradach & Eccles, 1989; Smith et al., 1995; Sudarsanam, 2003), we assume that there is a great need for further lean cooperation. Assuming that lean thinking is understood as a comprehensive approach (Liker, 2004), firms will be aligned within and beyond operations—but at different levels of implementation and probably different forms of realization (e.g. Hines et al. (2004) argue that different tools on an operational level are able to realize lean-strategies). So, there is a need for understanding the different forms and designs of lean cooperation. While a lot of research has been done regarding supply chain cooperation, there still is a research-gap concerning other forms of lean cooperation that will have specific consequences for future lean implementation and the management of lean initiatives, as well as for an improved exploitation of cooperation initiatives. Therefore, we will first provide a generic definition of lean cooperation followed by a structured literature review covering relevant management and operations focused journals. In total, 38 peer-reviewed articles have been identified searching for keywords in paper abstracts and titles. After the exclusion of four articles that are not relevant four our research at all the 34 remaining articles have been analysed systematically. Thereby, we aim to develop a framework for possible forms of lean cooperation. Additionally, we will provide anexploratory clinical case study for an upcoming trend: using business clusters for lean cooperation. The case study, being very appropriate for in-depth research and often used for lean research interests, highlights the lean workshop project

within a German Aerospace Cluster. Thus, it gives detailed insights into lean cluster cooperation. Based on the findings of the literature review and the case study, we will close giving recommendations for management and showing fields of further research in the area of lean cooperation.

2. Theory: Towards a Generic Definition of Lean Cooperation

Due to the increasing importance of integrated and long-term relationships along the supply chain (e.g. Burgess et al., 2006; Christopher, 2011; Hines, 1994; Lamming, 1993; Van Nieuwenhuyse & Vandaele, 2006) focusing consequently on the value generated for end-users (e.g. Perez et al., 2010; Wu, 2003), the development of "lean" supply chains becomes inevitable. Lean supply models have the potential to manage the increasing complexity of innovation, interfacing components and systems as well as quality and design aspects (Nellore et al., 2001). Consequently, Perez et al. (2010) coin the term "lean collaboration" (p. 55) analysing the Catalan pork industry concerning the realization of lean principles along the supply chain. This paper argues that there are two main trends affecting industry nowadays. On the one hand, firms try to create customer value and to achieve efficiency with the help of lean principles (e.g. Hines et al., 2004; Lewis, 2000) and on the other hand, they increasingly strive for hybrid forms of organisations (e.g. Borgatti & Foster, 2003; Bradach & Eccles, 1989), whereas cooperation along the supply chain is only one form among numerous others. For developing a generic definition of lean cooperation in this section, we firstly expose the idea of lean thinking. Secondly, we define cooperation in contrast to other possible organisational forms.

2.1 Lean Thinking

Coming from the Japanese automotive industry in the 1950s,*lean* has influenced industry widely (Womack et al, 1991). The term *lean production* was coined by J. Krafcik during the International Motor Vehicle Program (Womack et al., 1991). But, surprisingly, there is still no common definition – and even no common understanding – of *lean* nowadays, and a lot of terms are used in literature and practice such as lean production, Japanese production system or world-class manufacturing (Hoss & Schwengber ten Caten, 2013). Based on the common objective of generating competitive advantage by improving productivity from the customer´s view (see Tab. 1) and the importance of comprehensive approaches (Liker, 2004, Sugimori et al., 1977; Womack & Jones, 2003), we will use the term *lean thinking* in the following. This is due to the fact that lean approaches do not only focus on cost reduction by eliminating waste (Sugimori et al., 1977; Womack & Jones, 2003) but also stress aspects like human-orientation (Sugimori et al., 1977) or a long-term philosophy (Liker, 2004). The term *lean thinking* seems useful regarding the significance of the comprehensiveness of successful lean approaches (Bernard, 1996). In this regard, Hines et al. (2004) state that any tool or method can be integrated within the company-specific lean approach as long as it pursues the target to "provide customer value" (Hines et al., 2004, p. 1006).

Table 1. Lean objectives in the literature

Objective	Realization	Source
Gaining competitive advantage by improving productivity	Cost reduction by elimination of waste / Exploitation of human potentials / Jidoka	Sugimori et al., 1977
Gaining strategic competitive advantage	Seven principles (beginning with "customer first")	Hines, 1994
Efficient value creation	Five principles (beginning with "defining customer value")	Womack & Jones, 2003
Manufacturing excellence as a strategic weapon	Four categories (long-term philosophy, process orientation, development of people and partners, organisational learning) including 14 principles	Liker, 2004
Standard global production system; efficiency, expertise, competitive advantage	Four principles (teamwork, communication, efficient use of resources and elimination of waste, continuous improvement)	Womack et al., 1991
Value creation	Just-in-time production system, pull production, respect for employees, employee problem solving and automated mistake proofing, elimination of waste	Hines et al., 2004
Efficiency, productivity	Elimination of overproduction, quality control/quality assurance/respect for humanity; just-in-time/autonomation, flexible workforce/originality/ingenuity	Monden, 2012

As a management approach understanding value creation as a process to increase perceived value to customers by adding valuable features and/or reducing waste and costs (Hines et al., 2004), lean thinking has the potential for firms to stay competitive. Therefore, the importance of lean thinking can be seen by the still widespread implementation in various industries and industry sectors. One of the latest examples focussing on lean thinking is the aerospace-industry that has been characterized by consolidation and transformation due to high competitive pressure (Murman et al., 2002; Akbulut-Bailey et al., 2012). Other prominent examples are the healthcare industry in order to reduce throughput time, to improve processes and to increase overall efficiency, which the industry has been forced to due to reduced public resources and low staff capacity (Edwards et al., 2012), or the service sector in general focussing on both efficiency and customer satisfaction. Therefore, service firms

increasingly transform lean thinking in a manner that considers their industry-specific characteristics such as intangibility, service heterogeneity, inseparability of delivery and consumption and service perishability (Bortolotti & Romano, 2012). Besides the implementation of lean principles in operations, many (manufacturing) firms consider lean administration to be a further milestone on their journey to becoming lean (Association for Manufacturing Excellence, 2007).

Lean thinking and its implementation can be seen as a permanent challenge for an organisation. While a lot of firms struggle with implementation – maybe because of misunderstandings presented by Liker (2004)—it is construed as an enduring and continuous transformation for the better that needs integration within the firm´s philosophy and people´s minds. Womack & Jones (2003) delineate only the implementation of lean thinking as a process comprising four stages within five years. Summing up, lean thinking is an adequate management approach coping with the complexity and dynamic of today´s competitive environment and is not just another project to be realized. Thus, it is a mind-set realised by tools and methods for reducing waste and improving customer value continuously.

2.2 Lean Thinking from a Cooperation Perspective

The statement of Hines et al. (2004) to focus lean thinking on providing customer value and not on the selective choice of lean-tools is crucial regarding the enduring transformation of firms within a complex and dynamic environment. One significant aspect affecting firms that serve the superior objective to provide customer value is the increasing trend of blurring company boundaries (Karlsson, 1992).

For explaining the blurring of firm boundaries, there are two helpful approaches, namely transaction cost theory and the resource-based view of the firm. Arguing from a transaction cost´s perspective, different forms of organisation are effective, thus serving customer value, given different degrees of task specificity (Bradach & Eccles, 1989; Williamson, 1981). Following Bradach & Eccles (1989), there are three categories of organisational forms: 1) market 2) hierarchy and 3) hybrid. Furthermore, taking a resource-based perspective, it can be argued that firms develop core competencies which provide access to a variety of markets, contribute to customer value significantly and are difficult to imitate (Prahalad & Hamel, 1990). Thus, core competencies are a precondition for competitive advantage. Basically, organizational forms can be distinguished depending on their contribution to the firm´s core competencies. Combining both views, there is on the one hand an efficiency-oriented perspective and on the other hand a perspective looking at competitive advantage, both considering customer value just like the lean thinking approach. In the following, we will differentiate between intra-firm cooperation, supply chain management as one hybrid-form and inter-firm cooperation as a second form of hybrid organization which is long-term oriented, but not necessarily a supplier or customer relationship. Thus, forms of inter-firm cooperation are e.g. industry cluster initiatives, joint ventures and strategic alliances. In Tab. 2 we have listed these organizational forms adding the market-form of organization and derived the need for lean cooperation. According to Smith et al. (1995), we use the term cooperation in this paper for both inter- and intra-organisational collaboration.

Table 2. Organisational forms and their need for lean cooperation

Organisational form	Characteristics	Need for Lean cooperation
Market (no focus in this paper)	▪ Specificity of tasks is low ▪ Lower level competencies	Because of short-term orientation and low-level or missing contribution to core competencies and value creation no reason for lean cooperation *(e.g. manufacturing firm orders office supplies)*
Hierarchy (here: intra-firm cooperation)	▪ Specificity of tasks is high ▪ Core competencies	Focal point for value creation and therefore, high need for intra-firm lean cooperation *(e.g. intra-firm teamwork, cooperation between business units and/or global sites)*
Supply chain (SC) management	▪ Level of task specificity is middle ▪ Competencies supporting core competencies	The partners contribute to value creation to a large extent. Therefore, high need for lean cooperation *(e.g. product development integrating upstream and downstream partners)*
Inter-firm cooperation	▪ Level of task specificity and contribution to value creation depend on type of inter-firm cooperation	The need for lean cooperation depends on type and objectives of cooperation. *(e.g. joint ventures or strategic alliances may contribute to future value creation in a large extent)*

The importance of integrating lean thinking within existing and rising partnerships is stated e.g. by Hines (1996, p. 2) regarding the supply chain cooperation: "*The success of Japanese manufacturing firms over a wide range of product categories is well established; however, one can argue that the success of an individual manufacturing system (such as the excellent Toyota Production System) has not been the causal factor. Rather, it is the thorough and speedy implementation of these systems throughout the complete supplier network that is crucial to manufacturing success.*"

Summing up, cooperation is an important aspect of both creating customer value and improving efficiency. Therefore, we consider cooperation to be an inherent part of lean thinking. Thus, we define *lean cooperation* as collaboration between firms that either cooperate in a lean manner or share their approach to lean management with each other. Consequently and also according to Smith et al. (1995), the term *lean cooperation* subsumes all kinds of cooperation discussed above, be it inter-firm or intra-firm collaboration. We suggest that engagement in lean cooperation holds the potential to learn from partners, to create value-generating relationships and to further improve lean thinking within the corporate network.

3. Research: Towards a Holistic Framework for Lean Cooperation

3.1 Literature Review Purpose and Methodology

It was only in 1990 that Womack et al. (1990) published their best-seller "The Machine That Changed the World" and thereby started the discussion among theorists and practitioners on the causes and effects of lean production and lean management respectively. This is why we systematically review the literature published after 1990. Intentionally, we used the literature review format instead of the meta-analysis format. While meta-analyses focus mainly on summarising relevant studies to statistically describe and compare the magnitude of effects (Cooper et al., 2009), a literature review aims for an overview of the research to date as well as the identification of further need for research.

Since this paper aims for the development of a framework for lean cooperation that clearly combines strategic, organizational and operational perspectives, we focus on academic articles published in Strategic Management Journal (SMJ), Academy of Management Journal (AMJ), Organization Studies (OS), Production & Operations Management (POM), Journal of Operations Management (JOM), International Journal of Production Economics (IJPE) as well as International Journal of Operations & Production Management (IJOPM). These peer-reviewed journals are regarded to be very appropriate for studies on cooperation (Oliver & Ebers, 1998; Kale et al., 2002; Hillebrand & Biemans, 2003) and lean (Da Silveira et al., 2001; Naim & Gosling, 2011) respectively.

This literature review contributes to the current body of research on lean cooperation by addressing the following questions:

- What kind of research in terms of methods and scope has been conducted?
- What is the focus of these studies in terms of content and subject of investigation?
- What conclusions can be drawn?
- What research gaps can be identified?

Using electronic databases such as EBSCO Host and Econis, we searched in paper abstracts and titles for a combination of the keywords "lean" AND "cooperation", "collaboration", "partner*", "supply chain", "supplier", "alliance", "network" OR "cluster". This extensive research enabled us to identify a total of 38 articles. Based on a detailed review of the abstracts, we excluded four of those papers since they did not deal with lean aspects in the context of cooperation. The main characteristics of the remaining 34 papers are summarised in Tab. 3. Furthermore, all articles have been briefly summarized with regard to findings on lean cooperation. The respective table can be obtained from the authors upon request.

Table 3. Main characteristics of analysed papers

Journal & Author(s)	Year	Type of paper	Country	Industry	Sample & unit of analysis
Organization Studies					
Lowe et al.	1997	Empirically qualitative	Worldwide	Automotive	71 plants
Production & Operations Management					
Kleindorfer et al.	2005	Conceptual	n/a	n/a	n/a
Journal of Operations Management					
Zhu & Sarkis	2004	Empirically quantitative	China	Various (manufacturing)	281 / 186 / 66% (companies)
Li et al.	2005	Empirically quantitative	USA	Various	3137 / 196 / 6% (companies)
International Journal of Production Economics					
Holmström	1994	Empirically quantitative	Worldwide	Automotive, radio/TV, office/computer	n/a
Warnecke & Hüser	1995	Conceptual	n/a	n/a	n/a
Panizzolo	1998	Empirically qualitative	Italy	Various (manufacturing)	27 plants / companies
Virolainen	1998	Conceptual	n/a	n/a	n/a
Naylor et al.	1999	Empirically qualitative	USA	Computer	1 supply chain
Alford et al.	2000	Conceptual	n/a	n/a	n/a
Holweg & Bicheno	2002	Empirically qualitative	UK	Automotive	1 supply chain
Herer et al.	2002	Conceptual	n/a	n/a	n/a
Stratton & Warburton	2003	Empirically qualitative	USA	Apparel	1 company
Bruun & Mefford	2004	Empirically qualitative	Worldwide	Various	9 companies or supply chains
Kainuma & Tawara	2006	Conceptual	n/a	n/a	1 decision maker to discuss concept with
Van Nieuwenhuyse & Vandaele	2006	Conceptual	n/a	n/a	n/a
Gosling & Naim	2009	Conceptual	n/a	n/a	n/a
Egan	2010	Conceptual	n/a	n/a	n/a
Demeter & Matyusz	2011	Empirically quantitative	Worldwide	Various (manufacturing)	4251 / 711 / 17%
Naim & Gosling	2011	Conceptual	n/a	n/a	n/a

Pool et al.	2011	Empirically qualitative	n/a	Consumer goods	1 plant
International Journal of Operations & Production Management					
Engström et al.	1996	Empirically qualitative	Sweden	Automotive	1 company
Lamming	1996	Conceptual	n/a	n/a	n/a
Niepce & Molleman	1996	Empirically qualitative	Sweden, NL, Japan	Automotive	1 partnership
Karlsson & Ahlstroem	1997	Empirically qualitative	Sweden	Machinery	1 company
Wu	2003	Empirically quantitative	USA	Automotive	143 / 103 /72% (plants)
Bruce et al.	2004	Empirically qualitative	UK	Textiles & apparel	4 companies
Cagliano et al.	2006	Empirically quantitative	Europe	Various (engineering)	425 / 297 / 70% (companies)
Pilkington & Fitzgerald	2006	Conceptual	n/a	n/a	n/a
Krishnamurthy &Yauch	2007	Empirically qualitative	North America	n/a (manufacturing)	1 company
Reichhart & Holweg	2007	Conceptual	n/a	n/a	n/a
Papadopoulos et al.	2011	Empirically qualitative	UK	Healthcare	1 hospital
Beelaerts et al.	2012	Empirically quantitative & qualitative	Worldwide	Aerospace	a) 100 / 41 / 41% (companies) b) Aircraft group of 8 companies
Moyano-Fuentes et al.	2012	Empirically quantitative	Spain	Automotive	216 / 84 / 39% (plants)

3.2 Literature Review Results

Research into lean cooperation has increased steadily in recent years. Two-thirds of the papers identified were published after 2000, and half of the papers between 2005 and 2012. However, consistent with Hoss & Schwengber ten Caten (2013), we found no relevant articles in the strategic management journals. This again confirms the necessity for a more integrated research of lean and strategic thinking.

In terms of the type of paper, the articles summarised in Tab. 3 can be divided into conceptual, empirically qualitative and empirically quantitative papers. In contrast to empirical papers, conceptual papers do not analyse primary or secondary field data but build theory on existing literature in the respective field of research. More than one-third of our papers identified (13 out of 34) belong to this group of conceptual papers. These articles mainly address questions regarding the further development

of lean thinking such as its compatibility with sustainable/green operations management (Kleindorfer et al., 2005; Kainuma & Tawara, 2006), mass customisation (Alford et al., 2000) or agility (Herer et al., 2002; Naim & Gosling, 2011). However, most of the publications (14 out of 34) follow an empirically qualitative research approach. That comes as no surprise, since (i) the research field of lean cooperation is a rather new and complex one and (ii) the causes and effects of lean cooperation are expected to be manifold and partly caused by social connections (Eisenhardt, 1989; Glaser and Strauss, 2009). By use of case studies, these papers' primary goal is to present specific examples for lean cooperation and to provide a basis for further, especially empirically quantitative, research. Descriptive or explanatory analyses on lean cooperation are still rare (7 out of 34) and mainly focus on supply chains (Wu, 2003; Li et al., 2005; Cagliano et al., 2006; Beelaerts et al., 2012; Moyano-Fuentes et al., 2012). Although buyer-supplier relationships have already been in the focus of research since the beginning of the 1990s, cooperation of supply chain partners jointly dealing with lean thinking obviously attracted research only in the last 10 years.

Overall, the empirical papers cover different industries. However, the automotive industry still seems to be preferred to other industries which probably is due to its' pioneering role within lean research. Industry representatives have an understanding of the topic and already dealt with its pros and cons over the last two decades, so that a high response rate for quantitative studies is typically ensured (Wu, 2003; Moyano-Fuentes et al., 2012). Having been focused mainly on mass production industries such as automotive and textiles so far, recent studies also explore lean cooperation aspects in service industries such as healthcare (Papadopoulos et al., 2011) and high technology industries such as aerospace (Beelaerts van Blokland et al., 2012). Lean cooperation in the aerospace industry also attracted our attention and will be further explored in this paper.

3.3 Framework for Lean Cooperation

Fig. 1 shows a holistic framework for the characterisation of lean cooperation. It has been developed based on concepts of lean management and cooperation as well as our literature findings with regard to lean cooperation. We propose to consider four aspects within discussion of lean cooperation: (a) form of cooperation, (b) characteristics of cooperation, (c) scope of cooperation and (d) level of impact.

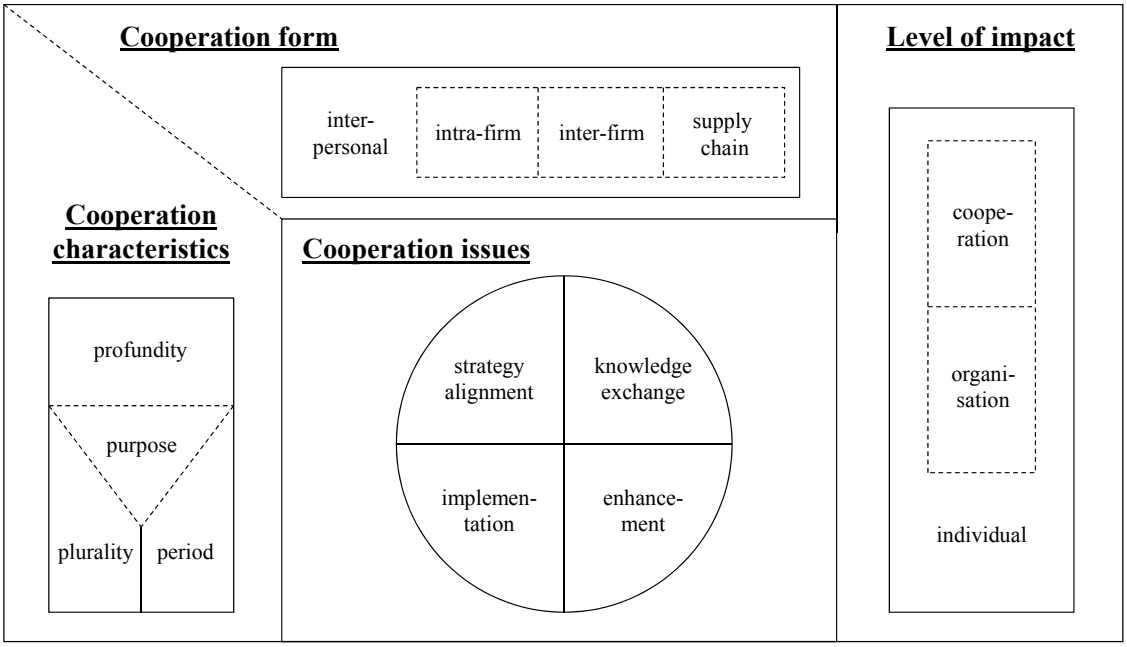

Figure 1. Framework for characterisation of lean cooperation

a) Lean cooperation form

Lean cooperation can be established in form of intra-firm, inter-firm and supply chain (SC) cooperation. However, being a people-centred approach, lean implementation on firm level always requires cooperation on individual level (Liker, 2004; Puvanasvaran et al., 2008). Thus, we understand inter-personal cooperation as another lean cooperation form.

Current research mainly focusses on SC lean cooperation analysing challenges firms have to manage when implementing integrated lean processes (Lamming, 1996; Cagliano et al., 2006), as well as advantages of a successful implementation such as a higher inventory turnover (Demeter & Matyusz, 2011), improved productivity (Holmström, 1994) or, in general, competitive advantages regarding different aspects of the logistics system (Wu, 2003). Intra-firm lean cooperation is of research interest as well, whereas different papers focus on different kinds of intra-firm cooperation such as the collaboration between a plant and its buying operating companies (Pool et al., 2011), between multiple business units (Krishnamurthy &Yauch, 2007) and within the internal value chain (Engström et al., 1996; Lowe et al., 1997).

Inter-personal lean cooperation is dealt with in only a few papers. One of these papers is the qualitative actor-network study by Papadopoulos et al. (2011) that highlights the role of employees and their relationship for introducing lean production. Papadopoulos et al. (2011) stress the importance of the employees who shape and are shaped by lean tools and methods. Another paper is the one by Niepce & Molleman (1996) that analyses the implementation of lean production and sociotechnical systems based on a case study. The authors focus on the role of the worker in the manufacturing process and conclude that cooperation on individual level is crucial for successful implementation. Beelaerts van

Blokland et al. (2012) emphasize the important role of the employee in leveraging value in the supply chain as well.

We found only two articles (Karlsson & Ahlstroem, 1997; Egan, 2010) that deal with lean cooperation on inter-firm level irrespective of an existing supply chain relationship. Karlsson & Ahlstroem (1997) analyse the applicability of lean thinking for small and medium-sized firms operating in global networks. Egan (2010) discusses challenges for public-private contracts to provide public goods or services in the context of vulnerability caused by thorough implementation of lean principles in the value chain. However, research into lean cooperation on individual level is rare, whereas especially the analysis of interdependencies between inter-personal cooperation and cooperation on overall firm-level offers further potential for research.

b) Lean cooperation characteristics

Thorough analysis of the identified papers on lean cooperation led us to the conclusion that not only level and form of collaboration offer starting points for characterisation of lean cooperation, but also their characteristics. Current literature known to us highlights four main characteristics that we call (i) purpose, (ii) profundity, (iii) plurality and (iv) period.

Purpose describes the intention of lean cooperation and thus, is basis for specification of the other three characteristics as well as for choice of cooperation form. Despite this fundamental necessity to clearly define the purpose of lean cooperation, none of the identified papers directly addresses this important aspect. Studies rather choose cooperation form and its implication for focal firms' performance as starting point for discussion. However, based on our literature review, we conclude that lean SC cooperation often follows lean cooperation on firm level, which first of all serves the purpose of increasing firms' manufacturing performance (Niepce & Molleman, 1996; Lowe et al., 1997; Pool et al., 2011). Following lean cooperation on supply chain level is then mainly for the purpose of integrating suppliers and ensuring sustainability of internally implemented lean practices (Cagliano et al., 2006; Reichhart & Holweg, 1997) or rather an effective management of the supply chain (Li et al, 2005). That is also why lean management is a much better wording than lean production (Warnecke & Hüser, 1995). Conversely, this means that suppliers also benefit if firms' purpose leads to lean SC cooperation (Wu, 2003).

Profundity, plurality and period are basically determined by the purpose. Profundity describes the depth of a lean cooperation and addresses e.g. the (non-)existence of an integrated coordination of processes and lean practices along the supply chain (Reichhart & Holweg, 2007; Moyano-Fuentes et al., 2012) or the usage of specific tools across cooperation partners to jointly implement or enhance lean management (Holweg & Bicheno, 2002). On the other hand, plurality refers to the frequency of communication or rather in general the degree of interaction between the cooperation partners. Period, as fourth parameter to characterise lean cooperation, deals with the time frame lean cooperation is set up for. However, we are not aware of any paper that explicitly addresses these characteristics and their implication for successful lean cooperation and in turn performance improvement.

c) Lean cooperation issues

Papers on lean cooperation cover different issues that arise in the context of cooperation involving a complex topic such as lean management. However, there is a clear tendency of current literature to either focus on

(i) implementation issues (Holmström, 1994; Warnecke & Hüser, 1995; Niepce & Molleman, 1996; Lowe et al., 1997; Panizzolo, 1998) or

(ii) enhancement of lean

- towards leagility (Naylor et al., 1999; Herer et al., 2002; Bruce et al., 2004; Stratton & Warburton, 2004; Naim & Gossling, 2011),
- regarding its compatibility with different decoupling points in the supply chain (e.g. mass customisation in Alford et al., 2000; engineer-to-order in Gosling & Naim, 2009),
- regarding its compatibility with sustainable/green supply chains (Zhu & Sarkis, 2004; Kleindorfer et al., 2005; Kainuma & Tawara, 2006).

Not surprisingly, this second group of papers, covering aspects of further development of the lean concept, date back only a few years whereas papers with focus on implementation issues were already published in the mid-1990s. However, the paper by Lamming (1996) provides an example of the analysis of enhancement of lean also in earlier years, although using another starting point for discussion. Coming from lean production and supply systems, Lamming (1996) argues that a prospective challenge lies in "squaring lean supply with supply chain management" (p. 183).

An interesting and content-wise rather unique paper regarding lean cooperation enhancement is the one by Bruun & Mefford (2004). Their paper discusses opportunities and implications for integration of the internet into lean production systems and thus, provides insights into one highly topical aspect of lean enterprise or rather lean intra-firm cooperation.

However, only Virolainen (1998), Naylor et al. (1999) as well as Pilkington and Fitzgerald (2006) consider a strategic perspective and highlight that lean is not a "stand-alone" approach but rather needs to be aligned with the procurement strategy, the supply chain strategy or even the firm's overall strategy. This is especially important if thinking about setting up a lean supply chain or lean inter-firm cooperation, since external partners will only share relevant knowledge and align their processes if a possible collaboration is strategically well thought-out regarding all relevant aspects of the relationship.

The paper by Holweg & Bicheno (2002) is an exception with regard to the fact that it deals with the question on how lean knowledge can be best shared and its effects can be transparently discussed. The paper presents a supply chain simulation that is supposed to be used for demonstration and discussion of supply chain improvements. Holweg & Bicheno (2002) emphasize that the usage of such a tool improves awareness for collaboration in the supply chain, especially when aiming at increased customer value and efficiency by implementation of lean practices that require alignment across (internal or external) firm boundaries.

d) Level of lean cooperation impact

The level of impact centres the question on "who is affected how and why by lean cooperation?". Research so far examined the impact on the firms involved, e.g. in terms of productivity, quality or inventory turnover (Lowe et al., 1994; Demeter & Matyusz, 2011), as well as on their overall cooperation, e.g. in terms of delivery reliability or lead time reduction (Holweg & Bicheno, 2002; Van Nieuwenhuyse & Vandaele, 2006). However, we argue that the lean approach is a people-centred approach, since it is the employees who jointly need to implement lean principles in an organisation or cross-firm cooperation. Therefore, we assume that every form of lean cooperation first and foremost has an impact on the individual level. Nevertheless, here again it is only the paper by Papadopoulos et al. (2011) that emphasises the individual level. In alignment with our view, this paper argues that only if individuals employ lean tools and methods, which in turn strongly influence their working habits and procedures, an impact on organisation or cooperation level is created.

To sum up, the literature review allows us to develop a holistic framework based on four main fields of interest: (a) form of cooperation, (b) characteristics of cooperation, (c) scope of cooperation and (d) level of impact. However, not all these aspects and their respective specifications have been analysed equally so far. Especially literature providing an insight into inter-firm lean cooperation and strategic questions is limited. Current research rather focuses on lean intra-firm and lean supply chain cooperation. Challenges and consequences of implementation are discussed thoroughly and proposals for enhancement are developed. Leagility or parallel manufacturing are solutions proposed to cope with the increasing demand for customised products while simultaneously ensuring efficiency and profitability. Therefore, future research on lean thinking increasingly needs to address antecedents of implementation such as the integration of lean management in a firm's overall strategy or the transparent communication with (potential) cooperation partners. An inter-firm lean cooperation might only exist for the purpose of temporary knowledge exchange and thus, forming the basis for an ensuing intra-firm lean cooperation. In general, the opportunities and consequences of inter-firm lean cooperation still offer a vast field of research. The same is true for inter-personal lean cooperation and the analysis of respective effects on the individual level.

4. Practice: Applying the Lean Cooperation Framework to a German Aerospace Cluster

Using the example of a German aerospace cluster, we present opportunities and consequences for firms that follow a structured approach of lean cooperation. We use an exploratory clinical case study in order to ensure an in-depth research that allows findings about the complexity our research object is embedded in (Eisenhardt, 1989; Yin, 2003). The clinical study has been shown to be a successful approach for this kind of research, especially regarding lean research interests (Ahlström & Karlsson, 2000; Karlsson & Ahlström, 1995; Karlsson & Ahlström, 1997). Due to the fact that two of the authors manage the Aerospace Cluster, we have full insight into our research object as well as access to the cluster firms and their representatives. Exploratory studies are best suited for building theory from

rich-context data (Eisenhardt & Graebner, 2007) and complement research in operations management by adding "richness of information and empirics, and improve the testing of theoretically-driven hypotheses"(Pilkington & Fitzgerald 2006, p. 1266). Our exploratory research is structured as followed: First, we describe the approach of industry clusters in general, quickly coming to the specific cluster we have studied. Secondly, we introduce the Lean Management Workshop Project (LMWP) and its prominent example—the lean aerospace initiative (Seifert Nightingale, 1998). Thirdly, we show the effects lean cooperation has on the one hand for the participating firms and on the other hand for the overall cluster development. We conclude with a discussion of our findings.

4.1 The Aerospace Cluster as Inter-Firm Lean Cooperation

"Clusters are geographic concentrations of interconnected companies and institutions on a particular field"(Porter, 1998, S. 78). Cooperation within an industry cluster enhances productivity and innovation of firms as e.g. for manufacturers, suppliers, logistical and IT services (Porter & Kramer, 2011). From a theoretical perspective, firms cooperating within clusters reach competitive advantages by the four potential sources stated in the relational view as an enhancement of the resource-based view focussing on relational-rents (Dyer & Singh, 1998): 1) relation-specific assets, 2) knowledge-sharing routines, 3) complementary resources and/or capabilities, and 4) effective governance. In a cluster, as we define it in the following, the effective governance is realized by a cluster management that initiates and manages cooperation within regional agglomerated companies and institutions within a given industry. Due to the commitment for collaboration of the partners involved and a limited access, the cluster investigated here can be defined as a cluster with network characteristics (Bode et al., 2010). Thus, we concentrate on the investigation of *inter-firm cooperation* (see Tab. 1).

The Aerospace Cluster is a cooperation of almost ten firms in aerotechnics and one university, located within a radius of some 30 kilometres in the south of Germany. The partners are suppliers for airplane manufactures settled at different stages of the supply chain. With their commitment to the cooperation in 2010 they started building different task forces (e.g. on human resources or quality topics) where they shared experiences, started joint projects and organised joint exhibition appearances. The two cluster managers are (former) researchers at a faculty for strategic management at the participating university.

4.2 Cooperation Issues and Characteristics of Cooperation

Lean management becomes increasingly important for aerospace industry notably because the business is going to be re-organised, driven by the airplane manufacturers. Airplane manufactures are sourcing out increasing bundles of value creation combined with a reduction of the total number of first-tier suppliers. Hence, first-tier suppliers will become value-integrators and have to coordinate value creation-bundles. Lower level suppliers will have to cooperate. The restructuring of the industry is accompanied by the SPACE Association that is an initiative for the improvement and sustainable development of industrial performance within civil aeronautical industry supported by an airplane manufacturer transferring lean management methods with this initiative (SPACE, 2013). Hence, lean

management is becoming more and more important for the industry partners in order to stay competitive and for the joint realization of value-creating projects.

In April 2013, the aerospace cluster started the so called Lean Management Workshop Project (LMWP). The idea for the LMWP was already born some months before in a conversation between a representative of a cluster firm and the cluster management about the cost-benefit ratio of the cluster-membership. The firms' representative argued that a new benefit would be required to further keep the firm as a paying cluster member. He then talked about the industry challenges and the conversation continued to lean management implementation efforts and difficulties. Following up this insightful meeting, cluster management developed the LMWP with the following objectives:

- creating a common understanding of lean management within the cluster firms,
- learning about existing tools and methods in theory and practice,
- learning about the origin and enhancement of lean approaches,
- transferring current research on lean management into practice,
- sharing experiences and lessons learned,
- getting to know other cluster-firms in-depth,
- enhancing the expert-network of individual participants,
- giving opportunities for bilateral projects and
- creating a highly attractive project which allows the acquisition of new cluster firms.

These objectives addressing mainly the cluster-firms can be complemented by the objectives addressing cluster-management which are predominantly:

- binding existing cluster-members,
- acquiring new cluster-members and
- reflecting current research with practitioners.

With this set of objectives the workshop project had been designed as shown in Fig. 2.

Six Modules	Lean Management - Basics	Implementation-Workshop	Lean Management: People & Partner	Processes I	Processes II	Best Practice
Contents	▪ training: lean basics ▪ expert key note ▪ benchmarking of cluster-members ▪ sharing of experiences	▪ training: implementing kean management using value stream analysis/ value stream design ▪ Doing first steps of value stream analysis in the shopfloor ▪ developing a lean implementation program	▪ training: tools and methods ▪ case studies from cluster-members ▪ structured sharing of experiences ▪	▪ „5S“-workshop ▪ short training: basics ▪ doing a real „5S“ workshop in shopfloor/ administration	▪ training: key performance indicators ▪ identification of key perfomance indicators in the shopfloor ▪ developing a standardized recording and visualization of key perfomance indicators	▪ visting a best practice firm (non cluster-member) ▪ expert key note ▪ discussion
Objective	▪ learning basic knowledge ▪ benefit from cluster-member benchmark ▪ benefit from other´s experiences	▪ learning the steps for implementing lean management ▪ benefit shopfloor-training ▪ benefit from other´s experiences	▪ learning tools and methods ▪ benefit from best practices	▪ learning and applying a simple lean-tool ▪ benefit from other´s experiences	▪ learning basic knowledge ▪ identification and visualization of key perfomance indicators in the shopfloor ▪ benefit from other´s experiences	▪ getting to know a best practice firm ▪ generating ideas for the own company
Date	at the site of cluster firm A 17. April, 2013	at the site of cluster firm B 25. June, 2013	at the site of cluster firm C 17. October, 2013	at the site of cluster firm D 18. February, 2014	at the site of cluster firm E 15. April, 2014	at the site of a non cluster-member 20. May, 2014

duration: every module one day: participants: fixed group of participants, guests are warmly welcome
workshops are accompanied by student´s theses

Figure 2. Lean Management Workshop Project—Design and realisation

The LMWP is inspired by the large-scale Lean Aerospace Initiative (LAI) that was formed in the 1990s by the U.S. Airforce, the Massachusetts Institute of Technology and additional actors from the defence industry (Murman et al., 2002; Seifert Nightingale, 1998). The objective of LAI was to accelerate the lean implementation, integrating government that acts as customer in military aerospace to some extent and supporting the research-practice transfer (Seifert Nightingale, 1998). By the cycle of learning that ensures that research and practice are aligned and the implementation of pilot projects is still part of the research, the LAI has a high value creating potential and the results show that the initiative has improved enterprise performance significantly (Seifert Nightingale, 1998). For more details and results, one can see the documentation where projects, activities, research results and participants of Lean Aerospace Initiative are listed (Lean Aerospace Initiative, 2005). We assume that positive effects as implemented within Lean Aerospace Initiative can also be realized within a regional inter-firm cooperation project. Thus, we will show effects of LMWP in the following.

4.3 Impact of Lean Cooperation

While the LMWP predominantly has a training-character, it is difficult to list direct improvements regarding quality, time, costs and flexibility. However, several indirect effects can be noted. Asking for the participants' feedback regularly at the end of the workshop-modules provides insights into potential benefits of LMWP. Even if there are different implementation levels, the cluster firms highlight the benefits of the exchange within the project modules. While smaller companies can learn from the mostly rich experiences of the larger companies, they in turn argue that they profit from pragmatic improvement experience of smaller firms. There are also challenges the smaller and the larger

companies have in common. For example, they all have leaders who should support improvement strongly and encourage staff in changing behaviour. This topic has been widely discussed by participants in the third workshop module. The structured sharing of experience has been increased since the participants prepare cases for presentation in the workshops. The discussion of the cases usually takes a large amount of time, but acts on the one side as a teaching input and on the other hand as an opportunity to discuss solutions reflecting other´s experience.

Another point that is highlighted by the cluster members is the benefit of the short-training modules that either transfer new knowledge or refresh existing knowledge. In any case, participants create ideas for their companies. All participants value the practice inputs which are, besides the firm-cases, the shop floor-training, the general case studies and the learning about good examples by the integrated plant tours. Through the resulting intimate contact and the discussion of firm-specific challenges the cluster-members get to know each other deeply. So the LMWP is a starting point for further, bilateral cooperation.

In addition to the single firm's perspective, there is a high benefit on cluster-level. Thus, potential new firms are interested in the LMWP because of the current relevance for aerospace industry. The enhancement of the cooperation is highly adored by the existing cluster-firms and can be improved with the LMWP and the positive experience the cluster-firms relate to their business partners. Furthermore, we can see that relationships between cluster-firms and also between cluster-firms and cluster-management get stronger. This is an important foundation for further cooperation because individual firm´s needs are continually identified and cluster activities can be adjusted accordingly.

One of the most important benefits of lean cooperation in the cluster is the enhanced cooperation between research and practice. During the identification of individual firm´s needs within the workshop discussions, some topics are identified that allow further research. Thus, so far five theses have been realized in close collaboration between cluster-firms and university within the LMWP. Since the results are publicly available for all cluster-firms, they all benefit from these research projects even if they are only realized at single cluster-firms. For the students, these investigations are often first-steps to job offers after graduation. These effects are very similar to Lean Aerospace Initiative and can also be realized within a small-scale, regional inter-firm cooperation.

4.4 Discussion of Case Study Findings

Our case study dealing with the LMWP in a German aerospace cluster shows that structured collaboration on lean thinking topics provides benefits for all firms involved. Whereas effects of SC lean cooperation, i.e. supply chain business partnerships, are already well researched, the same does not apply to inter-firm lean cooperation. We close this gap by analysing an inter-firm lean cooperation: a regional cluster in the aerospace industry. Applying our framework to this cluster, it becomes obvious that inter-firm cooperation has the potential to address all cooperation issues stated in Fig.1. Because of the industry development, lean cooperation becomes increasingly important and inter-firm cooperation forms like industry clusters are able to support strategy alignment. Furthermore, they offer an efficient

platform for knowledge and good practice exchange and the enhancement of lean initiatives within the industry. Therefore, as shown by our case study, inter-firm lean cooperation supports the implementation of lean thinking by learning from others, which indeed is the main purpose of such cooperation. The level of impact on the analysed inter-firm lean cooperation is twofold: on the one hand individual cluster firms benefit from knowledge exchange, implementation support and the strengthening of relationships and on the other hand the cluster (cooperation) itself improves usefulness of its activities and therefore increases attractiveness for existing as well as potential new members. Additionally, the participating firms further develop their individual competence which is essential for corporate learning. While the purpose of our lean cooperation is reasonable, the profundity of our analysed inter-firm lean cooperation is rather low, compared with SC lean cooperation often characterised by integrated processes. Therefore, plurality is also quite low, as shown in the timetable of the LMWP (see Fig. 2), but we observe an increasing communication with the participants beyond the organized workshops. The period, of course, is limited. A summary of this characterisation is provided by Fig. 3. Hence, the framework is an effective tool to characterise and analyse the rather new concept of lean cooperation.

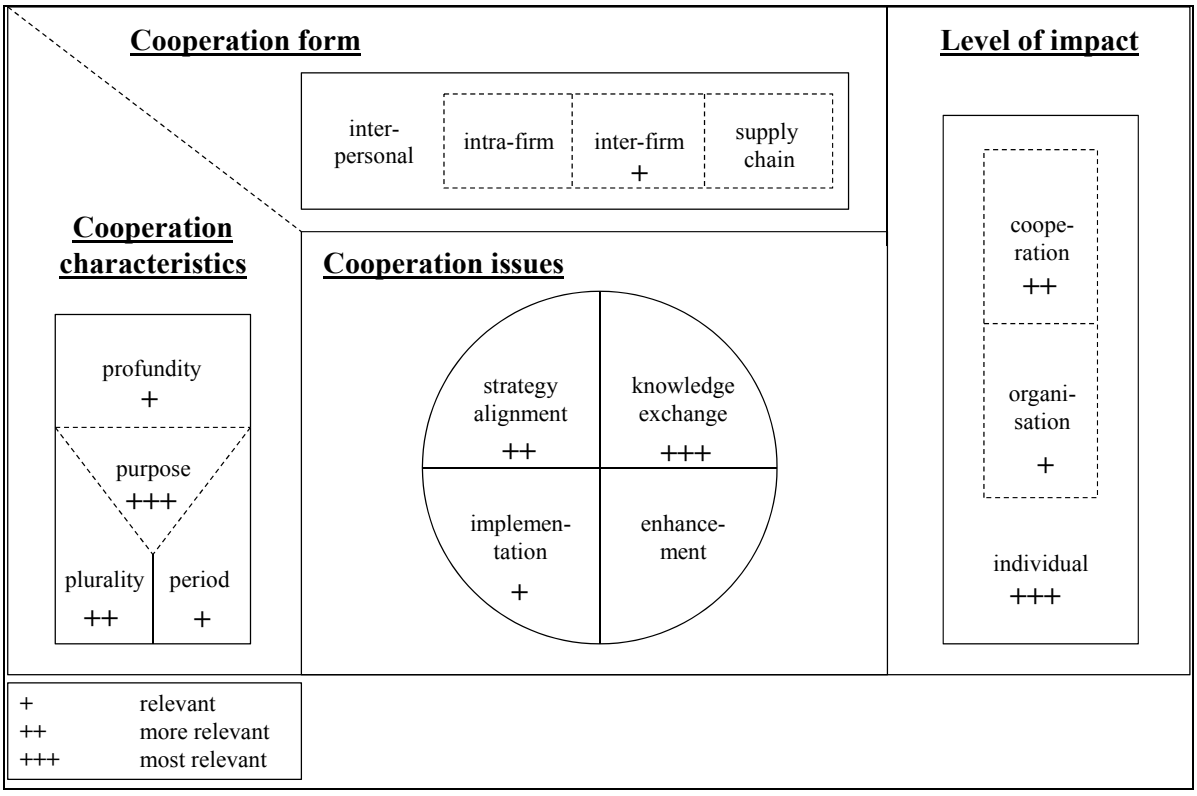

Figure 3. Characterisation of the lean cooperation in the Aerospace Cluster

5. Conclusion and Recommendations

With our paper we provide a generic definition of lean cooperation and develop a comprehensive framework addressing different aspects of lean cooperation. Our case study provides first evidence for a possible application of the framework. Case study results also give insights into how inter-firm lean cooperation can contribute to a lean industry roll-out and that cluster firms benefit from the exchange of knowledge and experience. Furthermore, the implementation of lean into cooperation has the potential to improve its attractiveness as it is the case in the introduced inter-firm lean cooperation of our case study.

However, we are aware of the limitations of our explorative research design. However, by applying our literature-based framework to a single case-study we have shown practicability. While generalisation from a single case study is not uncritical at all (Eisenhardt & Graebner, 2007; Siggelkow, 2007), we use this approach in addition to our well-founded literature findings. Combining empirical findings with existing theory enhances plausibility (Ahlström & Karlsson, 2000). Furthermore, the exclusive access to an inter-firm lean cooperation provides practical knowledge about lean cooperation. Accordingly, we recommend further research, qualitative and quantitative in nature, for developing and validating causal relationships using our framework. Nevertheless, current findings allow us to discuss first implications of lean cooperation focusing on theory and practice.

Theorists are provided with a holistic framework that allows for a clear characterisation of lean cooperation. We recommend further research investigating causal relationships between forms, characteristics and issues of lean cooperation considering the level of impact as well. Furthermore, we have shown the explanation of firm boundaries using transaction cost and resource-based perspective. Lately, with the relational view (Dyer & Singh, 1998), an enhancement of the resource-based view has established rooting in the analysis of Japanese supplier networks explaining four mechanisms for the realization of relational rents. These are, as shown before, 1) relation-specific assets, 2) knowledge-sharing routines, 3) complementary resources and/or capabilities, and) effective governance. We assume that the lean cooperation research framework can contribute to the further development of relational approaches in explaining why and how cooperation has the potential to create competitive advantages.

Practitioners benefit from our paper since it provides first insights into the relationship between different forms of lean cooperation, their benefits or rather their respective impact on firm and cooperation level. While SC lean cooperation is well established and recognized both in theory and practice, other forms bringing potential benefits have so far been neglected. Due to the increasing importance of cooperation, lean cooperation also has to be an issue for cooperation managers who are in charge of the alliance portfolio of a firm. This function has to be in close contact with the responsible lean officer reporting on the level of implementation, challenges, experiences, demanded inputs and so on for a systematic alignment with potential or existing cooperation partners. While the identification and matching of partners for lean cooperation is the first step, the realization of lean relationships might

be the next one. Another important issue regarding the strategic implementation is the roll-out of lean initiatives (e.g. Niepce & Molleman, 1996) between business units, locations and acquired or merged companies that is, basically, a lean intra-firm cooperation and has to be managed carefully.

Furthermore, practitioners learn from this paper that the implementation of lean thinking benefits from the exchange of knowledge and experiences. This is especially true for the operative realization of lean tools and methods where experience helps to find creative ideas and solutions and to realize a long-term continuous improvement going small steps with the whole team. Furthermore, benchmarking, trainings, exchanges and common projects together with partners enable these exchanges. Accordingly, we assume the development of skills and competencies for cooperation to be one the most important issues. Noting that a lot of cooperation initiatives fail or fall short of expectations, the individual cooperation skills are essential (Cousins, 2013; Lamming, 2013) and offer potential for further research.

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