LEAN MANAGEMENT OF IT ORGANIZATIONS: A LITERATURE REVIEW

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Abstract

Lean Management has been successfully applied by companies around the world, mainly in production/manufacturing functions. Recently, the interest to investigate a wider application of Lean Management especially in service functions increased. However, it is not clear how Lean Management can be applied to IT organizations. Therefore, this study aims to provide an overview on common characteristics and future research directions. A literature review on existing scholarly research from January 2004 to June 2014 is conducted. Using a database-driven search approach, a total of 1,206 research contributions are found of which 49 were identified as relevant. Results indicate a low theory grounding of mostly formulative and interpretative research items. This implies that research on Lean Management of IT organizations is still at its nascent state. Content-wise, five research themes emerge. The majority of research investigates IT organizations in a role to support Lean Management in production/manufacturing functions (determining "what to work on"), therefore more research on how Lean Management can be applied to IT organizations themselves (determining "how to work") could be beneficial. Future research could also try to build on Change Management theories, as the implementation of Lean Management is of transformational character.

Keywords: Lean Management, Lean, Lean IT, Information technology, Information systems, Lean knowledge work, Lean services, Application development, Application maintenance, Infrastructure services.

1 Introduction

Lean Management describes a set of management principles and methods in order to differentiate between "waste" and "value" in organizations (Stone 2012, p. 114). Waste can be defined as *"[…] any human activity which absorbs resources but creates no value"* (Womack & Jones 1996b, p. 15) and value as a *"[…] capability provided to a customer at the right time at an appropriate price, as defined in each case by the customer"* (Womack & Jones 1996b, p. 311). Examples for waste, e.g., include defects, extra processing, inventory, motion, overproduction, transport, and waiting (Ohno 1988, pp. 19–20).

Lean Management has been applied successfully by companies around the world, mainly in production/manufacturing functions (Arlbjørn & Freytag 2013, p. 175). The most famous example for the application of Lean Management is Toyota which was ranked as No. 1 manufacturer in global automotive deliveries in 2013 (Bloomberg 2014). Lean Management faces a research history spanning nearly four decades (Holweg 2007, p. 434; Stone 2012, p. 115) and finds itself also high on the agenda of various consultancies (Bain & Company 2014; McKinsey & Company 2014; The Boston Consulting Group 2014). Besides its success in production/manufacturing functions, the interest to investigate a wider application of Lean Management also in non-manufacturing functions increased (Arlbjørn & Freytag 2013, p. 174; Stone 2012, p. 120). In order to categorize and understand the evolution of Lean Management during the last decades a variety of mostly interdisciplinary research has been conducted (Arlbjørn & Freytag 2013; Hines, Holweg, & Rich 2004; Stone 2012). Related to IT organizations, the application of Lean Management to large-scale software systems development (Pernstål, Feldt, & Gorschek 2013) and to IT support services (Kumar Kundu & Bairi 2014) has been researched recently. However, both studies restrict their focus to only a small and specific part of Lean Management of IT organizations. To the best of our knowledge so far no systematic literature review has been conducted to analyze Lean Management of IT organizations. The study at hand addresses this research deficit. It conducts a systematic literature review of existing academic (peer-reviewed) research contributions regarding Lean Management of IT organizations from January 2004 to June 2014. Its main objectives are to identify relevant research contributions, categorize their theoretical foundations and research designs, understand emerging themes, and show implications for future research. It applies an IT managerial and business-oriented point of view. The interdisciplinary nature of this study is reflected through an integrated use of research methods originating in general management literature and more specific IS literature.

Several definitions of the term Lean Management exist (Carlborg, Kindström, & Kowalkowski 2013, p. 292; Shah & Ward 2007, pp. 785–786; Staats, Brunner, & Upton 2011, p. 377; Stone 2012, p. 113). For this study we understand Lean Management of IT organizations as an integrated socio-technical system whose main objective is to focus on customer value and eliminate waste by concurrently reducing or minimizing supplier, customer, and internal variability (Shah & Ward 2007, p. 791; Womack & Jones 1996b, pp. 15,311). Hereby "IT" is understood in a broad context, thus containing "change IT" and "run IT" including application development, application maintenance, infrastructure services as well as further IT functions (e.g., management or governance). "IT organization" comprises internal IT organizations, for example a company-internal IT department, as well as organizations delivering IT service to third parties, for example IT services for other companies and/or end-users.

Figure 1-1 conceptualizes the research focus. It views Lean Management from two perspectives (1) functions and (2) methods.

(1) Functions are about where to apply Lean Management. They include production/manufacturing, services and other functions (for instance finance or marketing). Thereby IT represents a sub-category of service functions. This segmentation is relevant because the transferability of research findings from production/manufacturing to service functions has been discussed intensively during the last years as knowledge work takes on a character more dynamic compared to manufacturing work (Staats et al. 2011, p. 377). For example (a) knowledge work is usually mainly driven by people and less depending on non-adaptable production assets (Staats et al. 2011, p. 377), and (b) processes in

knowledge work and their interdependencies are often invisible (Staats et al. 2011, p. 377). Both examples are also holding true for IT organizations. With respect to example (a), change requests in software implementation are usually easier to achieve compared with changes of a physical production unit. With respect to example (b), testing in software implementations can be difficult as problems with interdependencies can often only be recognized late in the process leading to an inefficient use of resources. In recent years however, most scholars have agreed that principles of Lean Management are indeed transferable to other functions than just production/manufacturing (Carlborg et al. 2013, p. 292; Haley 2014; Liker & Morgan 2006, p. 5; May 2005, p. 34; Staats & Upton 2011, pp. 101–103; Womack & Jones 1996a, pp. 140–141).

(2) Methods describe the most familiar management methods used in Lean Management. As Lean Management subsumes all types of management methods which focus on creation of value or elimination of waste, research investigating these methods in the context of IS organizations is of interest. There are numerous management methods which could qualify as "Lean Management methods". However, according to literature (Arlbjørn & Freytag 2013, p. 176; Näslund 2013, p. 88; Shah & Ward 2003, pp. 130–131) seven management methods are most pertinent to Lean Management: (1) Business Process Reengineering (BPR); (2) Human Resource Management (HRM); (3) Just In Time (JIT); (4) Six Sigma (SS); (5) Total Preventive Maintenance (TPM); (6) Toyota Production System (TPS); and (7) Total Quality Management (TQM).

With respect to other IT service management frameworks, for example the IT Infrastructure Library (ITIL), Lean Management is complementary. ITIL *"[…] consists of a set of guidelines that specify what an IT organization should do based on industry best practices. It does not, however, define how to do it.*" (Pillai, Pundir, & Ganapathy 2014, p. 485). Lean Management fills this gap by providing guidelines on how to deliver to a certain target.

The paper at hand tries to answer two questions: *RQ 1: What are common characteristics of research on Lean Management of IT organizations, RQ 2: What are future research implications?* Its main focus is the shaded area in Figure 1-1.

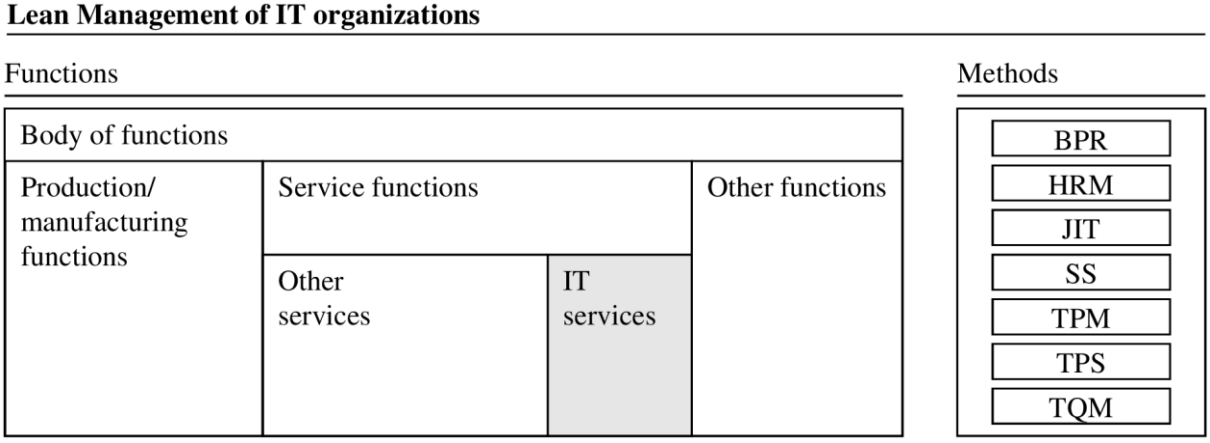

Figure 1-1: Conceptualization of research focus.

The rest of this paper is categorized as follows. Section 2 briefly introduces the research methodology. Section 3 provides a descriptive overview of results before section 4 discusses the results content wise. Section 5 ends the paper by discussing research limitations, learnings and opportunities.

2 Methodology

The analysis at hand applies a methodology consisting of five steps. The first three steps follow mainly Cooper and Hedges (2009) and Vom Brocke et al. (2009), step four is based on Mayring (2000, pp. 4–5). (1) Research items are retrieved, examined, and archived using a pre-defined keyword search in electronic databases; (2) Non-relevant research items are excluded from further analysis (as the da-

tabase-driven search approach might return non-relevant results); (3) Remaining research items are categorized; (4) Emerging themes of research are determined (section 4); and (5) The validity of research is described (section 5).

2.1 Literature Retrieval

This paper focused on peer-reviewed journals and conferences to identify and retrieve relevant research contributions by searching renowned electronic databases. A full list of searched databases is shown in Table 2-1.

Search focus	Searched items
Journals	EBSCO's Business Source Complete, ProQuest-ABI/INFORM Complete, Emerald Insight, Science direct
Conferences	AIS Electronic Library (AISeL): AMCIS, ECIS, ICIS, PACIS Digital Library at IEEE: HICSS

Table 2-1: Overview on electronic database search.

Even if electronic database search faces certain restrictions, for example regarding availability of journal issues in the database or record completeness, we decided for a database-driven approach for three reasons: (1) It covers a large number of peer-reviewed journals in various disciplines which reflects the presumed fuzziness and interdisciplinarity of Lean Management of IT organizations; (2) It appropriately reflects the perspective of an IT managerial and business-oriented point of view; (3) It assures repeatability of the search process for other scholars.

In a widely noted paper (Web of Science (2014): 139; Google Scholar (2014): 722) on Lean Management and its evolution, Hines et al. (2004, p. 1007) pointed out that future research for Lean Management should specifically include "*[...] under-researched sectors, such as low-volume manufacturing and service environments [...]"*. Therefore, the last 10 years since publication of the paper (from January 1st 2004 to June 30th 2014) served as relevant timeframe for searching literature items from journals and conferences. Article titles, subject terms as well as abstracts represented the relevant search fields for both journal and conference papers.

For the journal search the corresponding query string was derived in a pilot search over three iterations in order to balance comprehensiveness and precision of search results (see Table 2-2). EBSCO's Business Source Complete was used for the pilot search because it best reflects a managerial and business-oriented point of view. During the first iteration, we searched for Lean Management and all other associated management methods (c.f. Figure 1-1, methods) leading to 2,358 results of mostly non-relevant research contributions. For example results included items on foreign investments from Emerging Markets to Africa or completely different research disciplines. As a consequence, the query string was adapted in two ways: (1) Eliminating the used abbreviations "IT" for Information Technology and "IS" for Information Systems; (2) Eliminating all other management methods, leaving only Lean Management to search for. The adapted search resulted in 65 hits which were more precise. However, a more detailed look revealed, that the results barely reflected the IT organizational perspective, therefore the query string was adapted a third time by broadening the focus to include IT organizational units (e.g., application development, application maintenance etc.). A review of the resulting 234 hits in the pilot search revealed appropriate balance between search comprehensiveness and precision. After the search term was identified, the search was conducted in all four databases, leading to 1,163 journal articles in total (see Figure 3-1).

For the conference search, originally the same search strategy was applied. However, as there were nearly no results, a broader keyword search was used. Since the conferences searched already focus on

research in IT/IS, there is no necessity to further restrict the search term. That means only the keyword "Lean" was used[1], resulting in 43 items (see Figure 3-1).

Iteration	Keywords	Resulting hits (EBSCO only)
1	TI(("Lean" OR "JIT" OR "TPM" OR "TQM" OR "HRM" OR "Six Sigma" OR "BPR" OR "TPS") AND ("IT" OR "IS" OR "Information Technology" OR "Information Systems")) OR AB(("Lean" OR "JIT" OR "TPM" OR "TQM" OR "HRM" OR "Six Sigma" OR "BPR" OR "TPS") AND ("IT" OR "IS" OR "Information Technology" OR "Information Systems")) OR SU(("Lean" OR "JIT" OR "TPM" OR "TQM" OR "HRM" OR "Six Sigma" OR "BPR" OR "TPS") AND ("IT" OR "IS" OR "Information Technology" OR "Information Systems"))	2,358
2	TI(("Lean") AND ("Information Technology" OR "Information Systems")) OR AB(("Lean") AND ("Information Technology" OR "Information Systems")) OR SU (("Lean") AND ("Information Technology" OR "Information Systems"))	65
3	TI("Lean" AND ("Information technology" OR "Information systems" OR "Application maintenance" OR "Application development" OR "Infrastructure" OR "Support")) OR AB ("Lean" AND ("Information technology" OR "Information systems" OR "Application maintenance" OR "Application development" OR "Infrastructure" OR "Support")) OR SU("Lean" AND ("Information technology" OR "Information systems" OR "Application maintenance" OR "Application development" OR "Infrastructure" OR "Support"))	234

Table 2-2: Protocol of pilot search using EBSCO's Business Source Complete.

2.2 Literature Exclusion

The broad keyword search also returned some non-relevant research items, e.g., research on Lean Management without any connection regarding to IS/IT organizations or the usage of the term "Lean" in an opinionative ("leaning in one direction") context. Therefore, we needed to exclude non-relevant research items. This was done based on reading of title, subject terms, and abstract of each research item. A research item was considered non-relevant when at least one of the following criteria applied: (1) Its main focus is not on Lean Management in context of IS organizations; (2) Its main focus is not on IS organizations with sub-focus on Lean Management; (3) Its length is 4 pages or less; (4) It does not apply a managerial or business orientated point of view. (5) It has no original content (e.g., research agendas and proposals describing only planned research) or resulted in a journal article. After applying these criteria, 1,157 research contributions were excluded, leaving 49 research contributions in scope for the literature categorization (see Figure 3-1).

2.3 Literature Categorization

The relevant literature was categorized in four dimensions (1) Research methods; (2) Publication year; (3) Role of IT organization; and (4) IT services.

(1) In order to understand the used research methods, we follow Dibbern, Goles, Hirschheim, and Jayatilaka (2004) and categorize an item's (a) Reference theory; (b) Research approach; (c) Research type; (d) Data gathering approach; and (e) Data analysis. Figure 2-1 visualizes this. (2) To recognize trends and focus of the research community, the year of research publication was categorized. (3) To understand the role of IT organizations in Lean Management implementations, two possible roles (di-

[1] Within AISel "Lean" was searched in titles, subjects, and abstracts. Within the Digital Library at IEEE "Lean" was searched only in titles.

rect and indirect) were categorized. (4) Last also the affected IT services were categorized into application development and maintenance, infrastructure services or others.

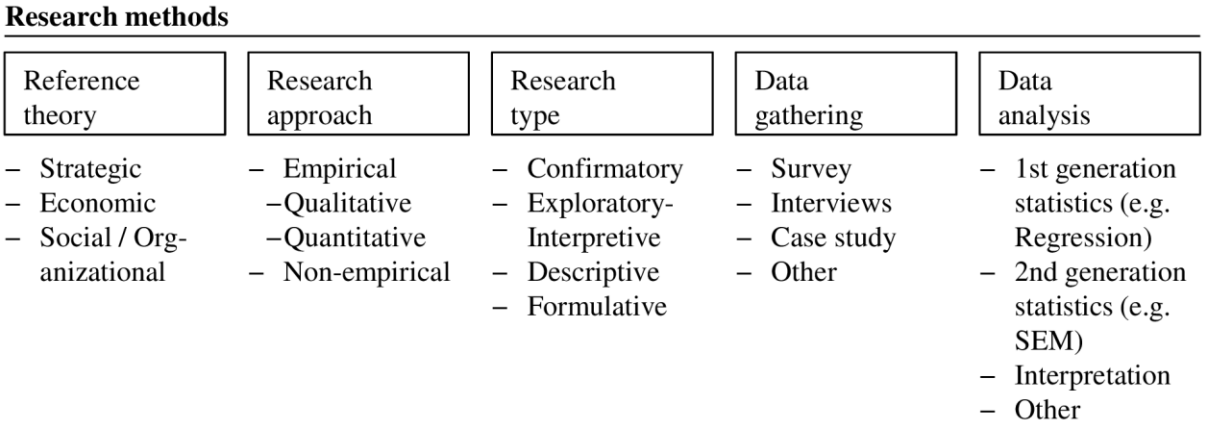

Figure 2-1: Dimensions of literature categorization framework (Dibbern et al. 2004).

3 Descriptive Analysis

3.1 Selection of relevant literature

The search resulted in a total of 1,163 journal articles and 43 conference contributions published between January 1st 2004 and June 30th 2014. This resulted in a total of 1,206 literature items initially in scope for the literature review. We examined these items, archived them, and analyzed their relevancy regarding Lean Management of IT organizations. 1,126 journal articles and 31 conference contributions were considered irrelevant. As a result, 37 journal articles and 12 conference papers remained, thus totalling 49 relevant literature items. Figure 3-1 visualizes the selection of relevant literature.

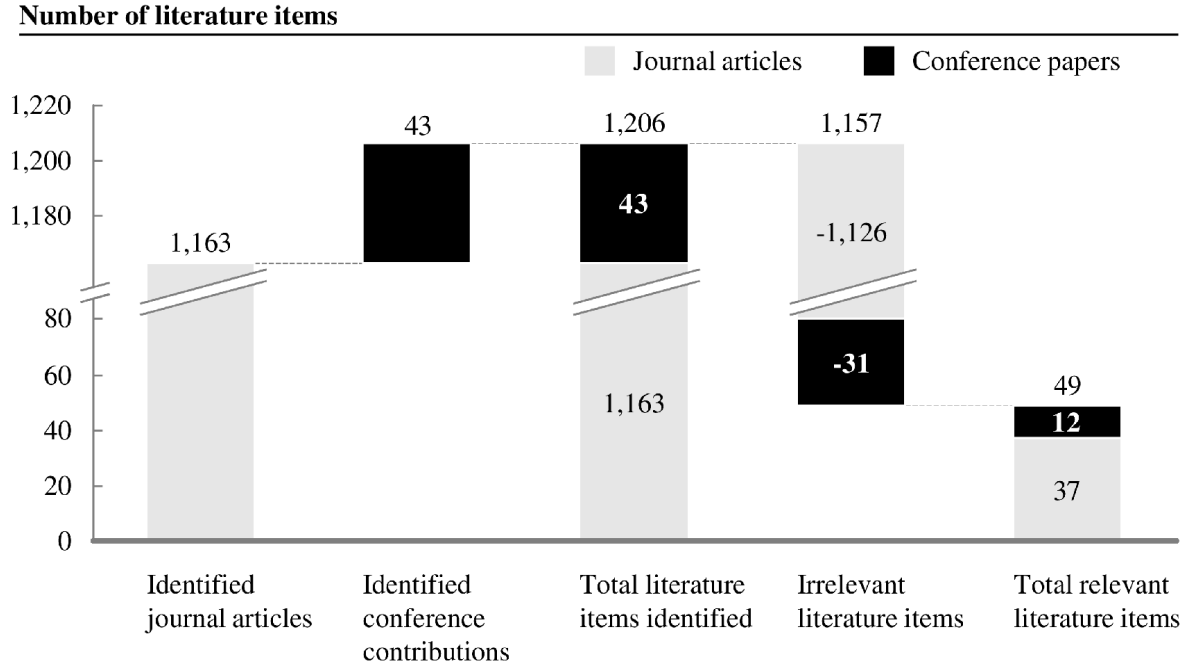

Figure 3-1: Selection of relevant literature items.

3.2 Publication Period

Figure 3-2 shows the publication years of the relevant literature items. Most research was published since 2009 and in the following years, indicating a higher research interest recently. An exception is 2010 but the reason for this gap in journal publications and conference papers remains unclear. The peak so far was reached in 2013 and 2014 with 11 published research items (however, for 2014 just January until June were reflected). The increasing number of results along the years matches to the historical developments of an increased interest of the application of Lean Management also to service functions.

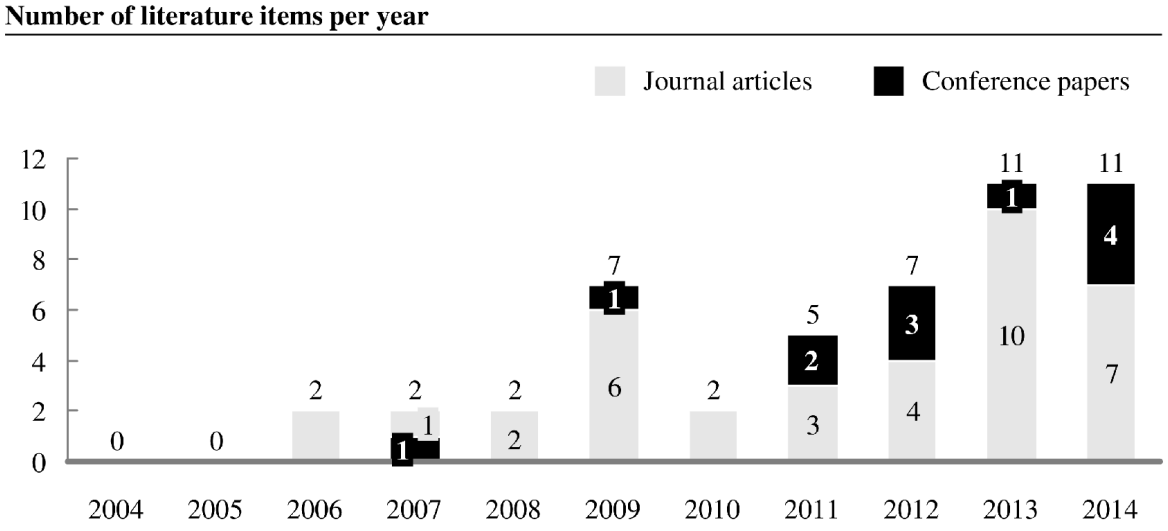

Figure 3-2: Publication period of relevant literature items.

3.3 Research methods

To understand applied research methods, the following categories were investigated (a) Reference theory; (b) Research approach; (c) Research type; (d) Data gathering; and (e) Data analysis (as shown in Figure 2-1). Figure 3-3 provides a detailed overview on the results.

(a) Most literature items do not draw on any explicit reference theory to conduct their research (42 items). If they apply a theoretical foundation, it is mainly Resource-Based-View or Information-Processing-Theory. (b) Non-empirical research dominates (26 items), however is nearly balanced by empirical research (total 23 items, thereof 9 quantitative and 14 qualitative). (c) Formulative (19 items) research is mostly applied, followed by descriptive research (12 items), explanatory/interpretative research (11 items) whilst confirmatory research (7 items) is not incisive. (d) Concerning data gathering mainly case study approaches (20 items) or other approaches (9 items) - mainly descriptive work based on literature reviews - are used. (e) The data gathered was predominantly analysed interpretively (30 items) or, in cases of survey research, with the help of 2nd generation statistics (9 items).

The low numbers of items referring to a theory as well as the high numbers of formulative and interpretative items indicate that research of Lean Management of IT organization is still at nascent state.

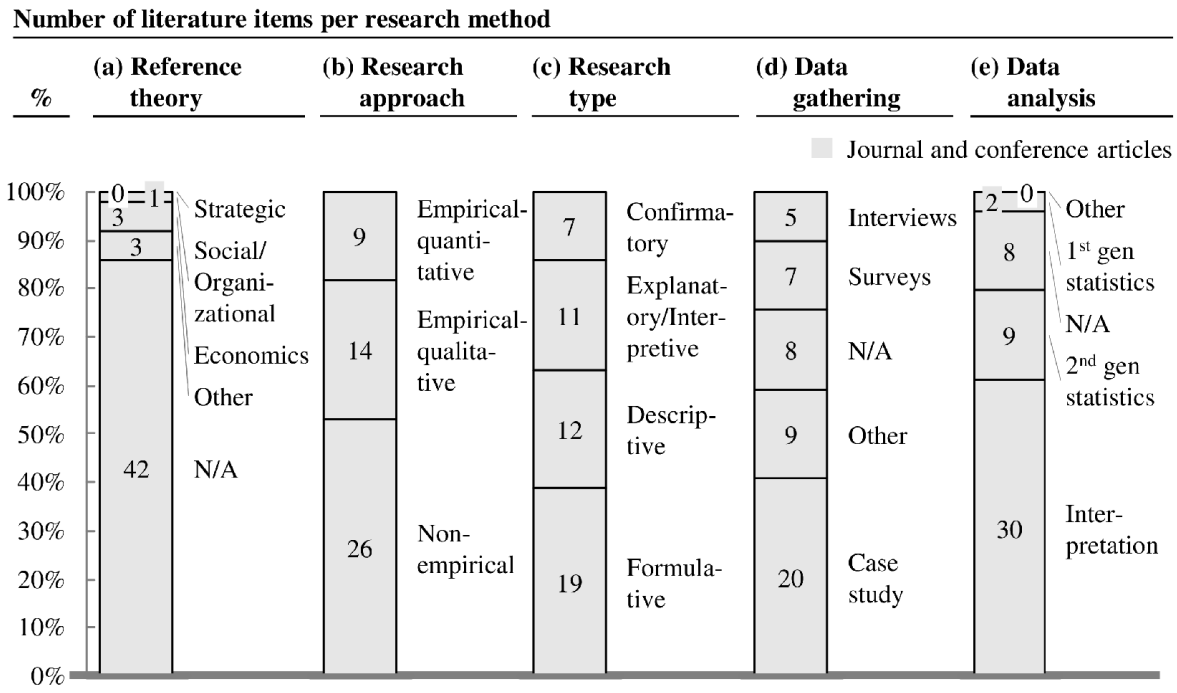

Figure 3-3: Categorization of research methods of relevant literature items.

3.4 Role of IT organizations

The role of IT organizations is described as twofold regarding the introduction of Lean Management: (1) Direct or (2) Indirect. (1) Direct: Lean Management is directly applied to IT organizations, meaning that it affects the way *how* the IT organization works. (2) Indirect: the IT organization is indirectly affected as IT tools are needed in order to support a Lean Management introduction in another corporate non-IT function. This affects *what* the IT organization is working on. The indirect role mostly consists of either the automation of a previous manual process step or a tool introduction which provides the necessary information for a Lean Management introduction, for example an Enterprise Resource Planning (ERP) system. Figure 3-4 illustrates the distribution of both roles. The direct role of Lean Management of IT organizations (11 items) is less important compared to the indirect role where IT organizations support a Lean Management introduction in other functions of a company (32 items).

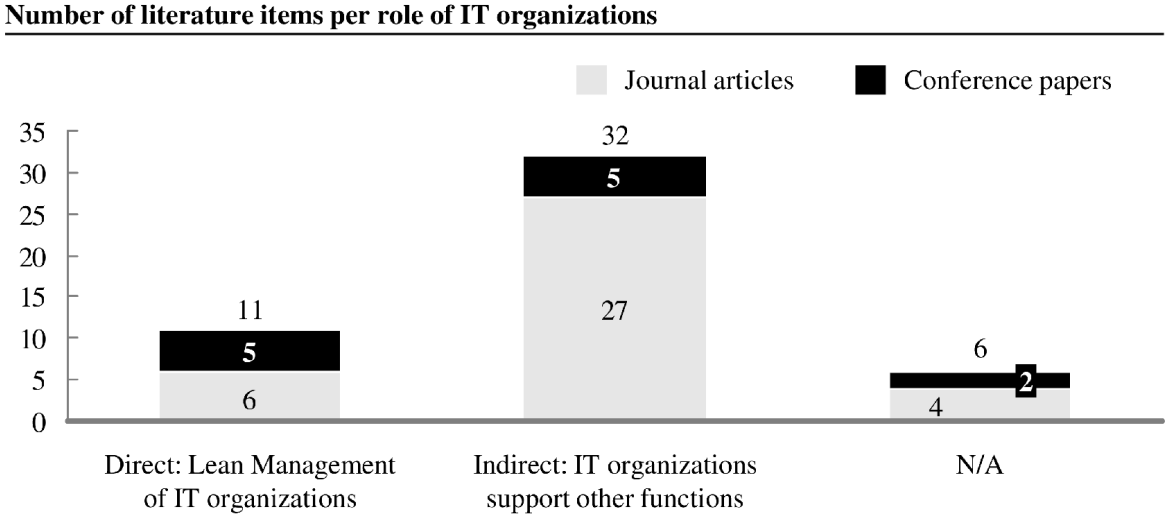

Figure 3-4: Role of IT organizations of relevant literature items.

3.5 IT services

Figure 3-5 provides an overview of involved IT service types. Most research items focus on infrastructure services (29 items) and application development and maintenance (15 items). 2 items focus on IT management in general. The total number of items in Figure 3-5 exceeds 49 because some papers focus on more than one IT service type.

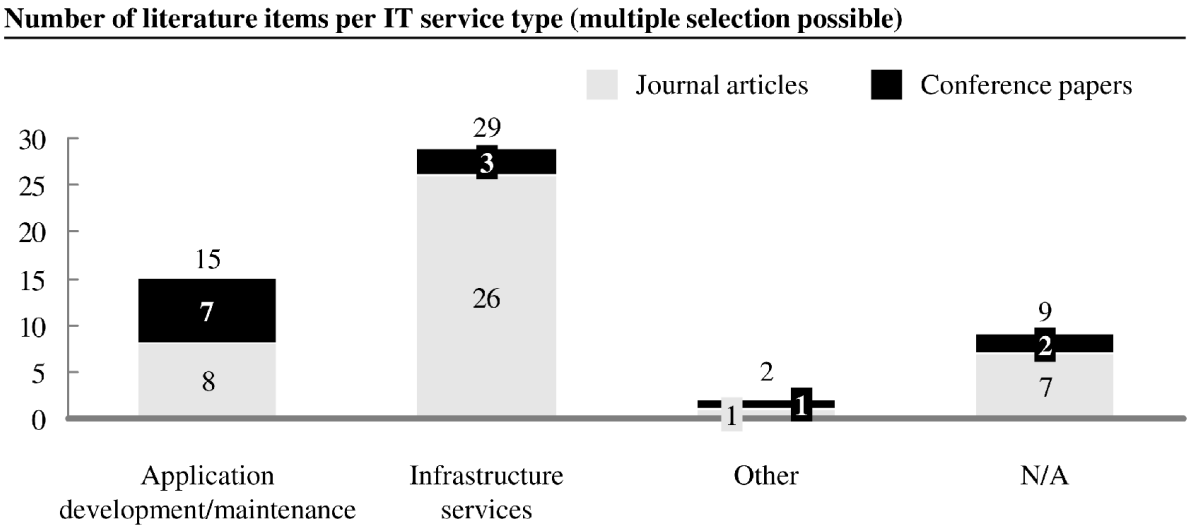

Figure 3-5: IT service types of relevant literature items.

The results of Figure 3-5 are consistent with previous findings. The large number of items in infrastructure services is related to the indirect, supporting role of IT organizations for Lean Management in other functions (see Figure 3-4). The reason for the rather high number on application development/maintenance is twofold and can be found in (1) The assessment of "Leanness" (meaning to assess the degree in which Lean Management has been successfully implemented); and (2) Decision support systems which should help practitioners to choose the right Lean Management tool at the right time. Research on these items needs application development and maintenance to implement developed algorithms.

4 Emerging themes

A content analysis based on Mayring (2000, pp. 4–5) was used in order to consolidate the research content and identify emerging research themes. In total, five emerging themes are identified. (1) Lean Management can be applied to service functions; (2) Lean Management has started to be applied to IT organizations mainly in application development and maintenance; (3) Infrastructure services play an important role in supporting Lean Management through process automation and information provisioning; (4) The implementation of Lean Management is a transformational journey; (5) The order of implementation of Lean Management and IT infrastructure modifications matters.

(1) Lean Management can be applied to service functions

The question if Lean Management is also applicable to service functions is of importance to scholars. Maleyeff (2006) investigates several service functions, e.g., IT and human resources, finding common problems including a lack of standard procedures, long service times, communication breakdowns, and poor personnel management which could be addressed by Lean Management. Bortolotti and Romano (2012) propose a framework for process streamlining and automation in pure service-providing companies. Kumar Kundu and Bairi (2014) investigate the applicability of Lean Management in IT support services finding that it can widely be applied. Another example is provided by Browning and Sanders (2012, p. 8) who summarize the main environmental characteristics of traditional production (stable and routine processes, high-volume production, stable workforce, traditional learning curve) and contrast them with the rather novel and complex environment of service functions (dynamic and

unfamiliar processes, low-volume production, workforce turnover, learning curve disruptions). A problem of the application of Lean Management to service functions is the more difficult identification of waste and the definition of value as it is less visible and more subjective (Hicks, 2007, p. 234). Hicks (2007, p. 235) therefore discusses waste and key principles of Lean Management in Information Management, and maps the value-flow model of production/manufacturing to an Information Management context (Hicks 2007, p. 238). In summary, there is agreement *that* Lean Management can be applied to service functions; however *how* exactly is still a research opportunity.

(2) *Lean Management has started to be applied to IT organizations mainly in application development and maintenance*

The application of Lean Management to application development and maintenance has been discussed in different dimensions. Lane, Fitzgerald, and Ågerfalk (2012) try to identify the underlying values which should be followed in Lean application development from an interdisciplinary lens (operations management, product development, and project management) and state that it is rather a management philosophy than only a specific methodology. Pernstål et al. (2013) investigate Lean Management in large-scale software system development. They conclude that research is still in its nascent state and that there is very little support for practitioners who want to introduce Lean Management. Durrani, Pita, Richardson, and Lenarcic (2014) investigate if the size of organizations in adaptable application development is important when introducing Lean Management. They conclude that Lean Management can be considered as helpful for all sizes of development organizations. Finally, Vartiainen and Siponen (2012) investigate quality problems in application development, mentioning also lean and agile development. They conclude that economic pressure is responsible that developers omit quality controls during the development process. In summary, Lean Management has started to be applied to application development and maintenance, however is still at a nascent state.

(3) *Infrastructure services play an important role in supporting Lean Management through process automation and information provisioning*

The enabling role of IT infrastructure services is a key emerging theme regarding Lean Management in production/manufacturing. In contrast to its American competitors, Toyota historically followed the paradigm, that IT is a contributor to waste and used simple and robust card systems (KanBan) for their production instead (Bortolotti & Romano 2012, p. 516; Cottyn, van Landeghem, Stockman, & Derammelaere 2011, p. 4401; Powell, Alfnes, Strandhagen, & Dreyer 2013, p. 324; Powell, Riezebos, & Strandhagen 2013, p. 395; Riezebos, Klingenberg, & Hicks 2009, p. 237). However, with increasing product complexity (Pernstål et al. 2013, p. 2798), the introduction of infrastructure support systems became appropriate. These systems can support internal IT, external IT, or a mix of internal and external IT by automating previously manual processes or by providing the infrastructure on which information transparency, exchange, access, or visualization is handled. Thereby, internal IT support focuses on company operations while external IT support focuses on the interaction with customers and suppliers (Moyano-Fuentes, Martinez-Jurado, Maqueira-Marín, & Bruque-Címara 2012, p. 135; Ward & Zhou 2006, pp. 181–182). Examples for a mix of internal and external IT and also the most important emerging theme in literature were ERP systems, which aim to support internal operations and usually have some sort of integration for customers/suppliers. Their use in Lean Management in production functions has become widespread (Packowski & Francas 2013, p. 132; Riezebos et al. 2009, p. 245) and is extensively reported regarding supply chain management (Lee, Olson, Lee, Hwang, & Shin 2008, pp. 981–982). Examples of ERP support include planning on dynamic buffers to improve handling of demand variability, flexible production cycle time, synchronization support (Packowski & Francas 2013, p. 135), and enablement of cost measuring for custom products (Webb, Budnick, & Middelkoop 2009, p. 222). There are also several other infrastructure support systems mentioned, e.g., Manufacturing Execution System (MES) (Cottyn et al. 2011, p. 4397), Manufacturing Resources Planning (MRP) (Riezebos et al. 2009, p. 242), Advanced Planning and Scheduling (APS) (Packowski & Francas 2013, pp. 131–132) as well as custom developed systems (Adamides, Karacapilidis, Pylarinou, & Koumanakos 2008, p. 36; Singer & Becker 2013, p. 83). In summary, infrastructure services are important for Lean Management in production/manufacturing as they provide appropriate information to forecast, plan, execute, and control production. Additionally and no less, infrastructure

support is also important for Lean Management in service functions as usually no physical good, but rather a transformation of information itself is provided (Bortolotti & Romano 2012, p. 520).

(4) The implementation of Lean Management is a transformational journey

From a managerial perspective the identified literature can be separated in three sub-themes: (a) Implementation examples of Lean Management regarding company transformations or process improvements; (b) Decision support systems; and (c) Application and assessment of Lean Management.

(a) Several research items provide implementation examples targeted at managers. Browning and Sanders (2012) investigate the application of Lean Management to a context of high novelty and complexity, finding that timing, scale, and extent of the Lean Management implementation are of critical importance. Smith and Watson (2013) report on a divestiture of an highly integrated IS support organization stating the importance of effective operation and providing guidelines on how to achieve this. Costello, Rochford, and Donnellan (2007) describe the role of innovation in an organizational transformation in the course of information system design. On a process level, Erdmann, Groot, and Does (2010) provide a possible guide in order to improve the invoicing process of a consulting company. Ker, Wang, Hajli, Song, and Ker (2014) describe the application of Lean Management to evaluate IT effectiveness in hospital pharmacies. Wen, Remus, and Mills (2011) investigate user resistance to the introduction of IS in a Lean Management context, confirming that it is not very different from regular IS implementations. (b) Since both IT and Lean Management can require significant investments of managerial attention, employees' qualifications, and budget (Ward & Zhou 2006, p. 178), it is of interest for management on how to best balance investment decisions. Jeffers (2010) provides a framework for guiding IT investments in order to enhancing firm performance. Ghobakhloo and Hong (2014) find that IT investment is a minimum requirement of a Lean Management implementation. Further decision support regarding the choice of Lean Management tools are given by Pullan, Bhasi, and Madhu (2013) who introduce a computer based Lean decision in a machine tool manufacturing company reporting a 50% lead-time decrease. Wan and Chen (2009) describe a web-based decision support tool to guide practitioners throughout the Lean Management journey stating that the application of the right tools at the right time on the right spot relies on extensive knowledge and experiences. (c) Shrestha, Cater-Steel, Tan, and Toleman (2014) propose the use of process assessment building on international standards for a consistent measurement of process capability. Zandi and Borchers (2012) provide a fuzzy linear programing technique to solve an optimization problem in e-health reference architectures. Vinodh and Dinesh Kumar (2012) provide a multi-grad fuzzy approach for a leanness assessment as does Vinodh and Balaji (2011). Iris and Cebeci (2014) measure the maturity of Lean Management implementation in Turkey stating that the application of Lean instruments is at an initial level. Costa et al. (2014) lists 43 Lean Management enabler in order to provide a framework for assessment. In summary, the implementation of Lean Management is complex and relies on extensive knowledge and experience. Research in current state does not provide a clear and justified answer to what makes the implementation of Lean Management of IT organizations successful. At least, however, it aims to help practitioners by providing success stories and instruments for decision and assessment support.

(5) The order of implementation of Lean Management and IT infrastructure modifications matters

Regarding the order of implementation, most scholars agree that it is better to first introduce Lean Management (Bortolotti & Romano 2012, p. 513; Mo 2009, p. 269; Nicoletti 2013, p. 184) and then implement supporting IT infrastructure changes. They see IT as a multiplier of the improvements the application of Lean Management brought and want to avoid, that a non-streamlined process is supported by IT systems as this can create even more waste in the longer term. However, one research item (Wen et al. 2011, p. 1) takes a perspective of user resistance. It argues that users need to get used to the new system before further changes in his daily work through Lean Management occur, otherwise they get overwhelmed by the amount of changes.

5 Research limitations, learnings and opportunities

5.1 Research limitations

The research approach used faces limitations concerning (1) Scope; (2) Selection bias; and (3) Extraction bias.

(1) Scope: The search approach chosen tried to balance comprehensiveness and precision of the results by testing alternative keywords and their combinations (see section 2.1). However, it cannot guarantee completeness. The timeframe (2004-2014) was selected based on a widely noted paper on Lean Management and its evolution of (Hines et al. 2004, p. 1007) stating that Lean should also include "*[...] under-researched sectors, such as low-volume manufacturing and service environments [...]"* in future research. The study takes on a managerial point of view; therefore the pilot search was conducted with EBSCO's Business source complete.

(2) Selection bias: Another threat to validity is selection bias. The judgement of the content of a research item by reading the abstract is a limitation, as the abstract may not fully reflect the content. To mitigate this risk, 20 of the irrelevant categorized papers were selected randomly for full-text reading. None turned out to be relevant. Additionally 50 randomly selected relevant and irrelevant research items were reviewed independently by the second author. In 1 out of 50 cases there was disagreement, due to a misreading of the second author. All remaining 49 out of 50 (98%) items were categorized identically.

(3) Extraction bias: Also extraction bias is a threat to validity. Several thorough discussions and feedback loops between the authors were applied to jointly define the classification scheme a-priori and to critically reflect coding and categorization decisions regarding individual literature items.

In summary, we consider the research approach being robust. However, for a later repetition of the research an inclusion of further databases, searching a longer timeframe or using even broader search terms might provide an incremental increase in quality.

5.2 Research learnings and opportunities

The main learnings from this research can be summarized as following: (1) Research is merely related to theory; (2) Research does not provide a clear and justified answer to what makes the implementation of Lean Management of IT organizations successful; (3) The majority of research still focuses on production/manufacturing functions. More research is necessary in service functions characterised by higher complexity and novelty.

(1) Theory based research was nearly absent and future research should try to build more upon reference theories. As the implementation of Lean Management programs might also be seen as major transformation in the way how employees do their daily work it seems worthwhile to consider Change Management theories for future research. Remarkably but not unexpected: Only half of the investigated items use empirical methods. Especially the application of quantitative and confirmatory methods is lacking. (2) While there is some research on specific situations, we could not identify systematic investigations on how to implement Lean Management of IT organizations in order to increase chances for success. An answer to this question might be especially helpful for management to know where their involvement is necessary/their time spent most valuable. (3). Research currently focus on how IT can support Lean Management in production/manufacturing functions (*what* to work on) but not on how Lean Management can be applied to the daily work (*how* to work). Future research therefore should focus on the "direct" application of Lean Management to IT organizations.

Future research should aim to address above research opportunities. Figure 5-1 proposes a research agenda in which the paper at hand is incorporated as step I. Step II could be the investigation of implementation success factors for Lean Management of IT Organizations based on literature and a Delphi study with experienced practitioners. Step III could validate all previous findings in a broad empir-

ical setting (e.g. multiple case studies). The last step, step IV then should investigate all outcomes critically, visualize connections and contradictions, and set results into context to scientific literature.

Research plan for Lean Management of IT organizations

Step	Activities	Step	Activities
I	Conduct state of the art analysis	III	Investigate empirically
II	Identify implementation success factors ▪ A. Literature-based ▪ B. Delphi-based	IV	Validate outcomes

Figure 5-1: Future research plan for Lean Management of IT organizations.

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