A framework for technology selection to support sales and operations planning in German medical technology organisations

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Abstract

Original Equipment Manufacturers (OEMs) of the German medical technology sector are being challenged with competition from low-wage countries. Considering the importance of Sales and Operations Planning (S&OP) in these organisations, the current trend of Smart Manufacturing (Industry 4.0), and the dearth of empirical research on both medical technology supply chains and technology-selection processes, this paper presents the outcomes of an action research (AR) study to develop and practically test a technology-selection framework to support S&OP from both intra-organisational and inter-organisational perspectives. The cooperation with the case organisation provided insights into the operational issues faced by the organisation during its implementation.

Keywords: Enterprise Information Management, Industry 4.0. Medical technology sector

Introduction

The rapid economic, technological, and environmental developments are bringing about several changes in people's way of living. With declining fertility rates, the share of elderly population is expected to increase naturally (Cavanaugh and Blanchard-Fields 2018). With a larger share of the population growing older, the growing of chronic diseases and rapidly increasing costs of healthcare are becoming a burden worldwide (American Diabetes Association 2018). While people in developed countries are getting older, economies of developing regions such as the People's Republic of China, India, Latin America, and the Middle East are growing at a steady pace, thus expanding a middle class that is able to afford medical services and medical technology (Maresova, et al. 2015).

In light of these developments, the demand for medical technology is likely to grow in correlation with the increasing demands for better care from developing countries and the longer life span of Baby Boomers who will require more healthcare services and products as they age. The medical technology industry, with its well-known clusters in the USA and in Western Europe, is becoming a front-runner of the complete healthcare sector. The global medical technology industry encompasses thousands of organisations, primarily small enterprises with up to 50 employees, being start-ups the main drivers of innovation in this sector (Meidata 2012).

Medical technology is any technology applied to save the lives of people affected by a wide range of conditions and ranges from mass production items such as sticking plasters, syringes or latex gloves, to specific equipment such as wheelchairs and hearing aids, to high-tech devices such as pacemakers, replacement joints for knees and hips, to intelligent contact lenses (Eucomed 2015).

According to the German Federal Association of Medical Technology (in German Bundesverband Medizintechnologie), the German market is, behind the United States of America and Japan, the third biggest medical technology market of the world and Europe's largest (BVMed 2015). With over 1,200 manufacturers operating in Germany (from which 95 per cent are Small and Medium Enterprises (SMEs) employing less than 250 people) and two thirds of revenues produced outside its domestic market, Germany is home to a very international oriented and successful industry (BVMed 2015). However, this industry has been suffering a number of setbacks in recent years, such as funding difficulties of Germany's statutory health insurance fund (gesetzliche Krankenversicherung), cost-cutting measures on research programs to increase budgetary savings (EY 2013), and an increased competition from Chinese manufacturers (Marucheck, et al. 2011). Furthermore, due to its strong focus on innovation, product lifecycles in this industry are shorter than two years (BVMed 2017) and, as a consequence, inventories of obsolete products and components may generate in its supply chain, thus increasing operational costs for manufacturers (AT Kearney 2017, J & M 2010).

Balancing supply and demand and aligning plans across functional departments and among organisations are of strategic importance for manufacturers in this industry. For this reason, German medical technology organisations consider S&OP a factor critical for success (Garcia-Villarreal et al, 2018). Sales and Operations Planning (S&OP) is a both a cross-departmental and cross-organisational process, as it ranges over all operational areas of an organisation and requires inputs of both key supplier and customers (Sheldon 2006). S&OP is a key process working twofold: it first creates a good overview of future demand trends on the basis of a demand forecast and using input from sales and key customers; then it develops a plan in order to match the forecast against the organisation's existing production and distribution capacities. Previous research has linked S&OP to increased operational performance, such as enhanced forecast accuracy, service levels, inventory levels, and capacity utilisation (Bower 2006, Wagner et al, 2014). This process is a stepwise approach involving a wide array of departments and organisations, with many scholars and practitioners reporting on how the S&OP process should be structured and which steps it should consist of (Grimson and Pyke 2007, Kapp 2000, Thomé, et al. 2012)

This study identified a dearth of research by highly-ranked academic studies concerned with developing and using methods or approaches for the selection of technologies to support S&OP in medical technology organisations or otherwise, with most research offering contributions on the broader subject of Enterprise Resource Planning Systems (ERP). Although there are a number of different studies proposing models for ERP selection (Bernroider and Koch 2001, Verville and Halingten 2003, Everdingen et al, 2000), these models are concerned with selecting technologies that fulfil only the objectives of the focal companies.

This paper regards the technology to support S&OP as an important element of a medical technology organisation's operational strategy, and considering both intra and inter-organisational perspectives, proposes a methodology for selecting technology to support S&OP in the context of medical technology organisations. In the absence of frameworks for S&OP software selection, main recipients of this research are SMEs in search of a structured approach that considers qualitative and quantitative factors.

This paper is organised as follows: first, the research aim and focus are presented. Then, the findings of the literature review are discussed, followed by a presentation of the rationale for the selection of the research methodology. Furthermore, this paper presents and discusses the research findings, including a through description of the framework for technology selection developed during this study. Finally, conclusions, contributions, and avenues for further research are presented and summarised.

Research aim and focus

This paper is concerned with the development of a decision model for technology selection to support S&OP. The field of technology selection is wide-ranging and can be investigated from different perspectives, such as product technology, production technology, and information technology. Subsequently, although there is a quite extensive academic work on technology selection frameworks, there is no clear picture on how the body of literature contributes to the knowledge of how these frameworks help to select appropriate S&OP technologies or how have practitioners addressed this issue in the past. To remedy this gap, two research objectives were formulated and studied:

- To develop a process-oriented framework for S&OP technology selection which incorporates intra and inter-organisational aspects
- To practically test and refine the S&OP technology selection framework during the interactions with a case organisation of the German medical technology sector

Literature review

The literature reports that decision-making supported by appropriate and robust information systems can be of competitive advantage for firms, especially when the latter are aligned with the firm's corporate strategy (Baki and Cakar 2005, Chung and Chik 2001). In order to take full advantage of the opportunities offered by technology, the selection strategy should take into account corporate goals and business needs of delivery, quality, and cost control (Baki and Cakar 2005).

As ERP packages cost hundreds of thousands, purchasing an ERP solution consumes an important share of a firm's budget. Additionally, the selection process of appropriate technologies is a time-consuming endeavour, with firms reporting taking up to 14 months to select appropriate solutions (Hecht 1997). In light of the number of different solutions in the ERP market, selecting the right technology requires a structured approach, with firms using some criteria for determining the right ERP solution. For instance, Vervill and Hallingten (2003) report on firms developing a matrix and assigning weights and scores for each criterion.

Selecting the appropriate software involves decisions related to budgets, timeframes, goals, and deliverables, which shape entire projects (Somers and Nelson 2001). Selecting an appropriate ERP solution to fit the organisational information needs is of importance in order to ensure minimal modification and successful implementation and use. Conducting a requirement analysis at an early stage of the software selection process and reviewing available software solutions might result in the selection of a system that fits to the users' requirements (Petroni 2002).

In the absence of academic research focusing of the selection of S&OP support technology, this literature review provides an overview of available ERP selection frameworks, processes, and tools. The literature review identified that the field of operations management has published the bulk of papers on ERP, followed by the information systems discipline, suggesting that ERP is researched on several fields. Studies on the implementation of ERP are the most researched topic, followed by studies focusing on the management and the optimisation of ERP. Most research in this field has been conducted using case study methods but, recently, this area has been investigated with the use of surveys involving larger samples. This suggests that this research field has reached a certain level of maturity and that research has been driven by an interest in an empirical phenomenon rather than as a new discipline that needs to be explored.

Several articles describing the management of the ERP package selection process were identified by the literature research (Baki and Cakar 2005, Buonanno, et al. 2005, Verville and Halingten 2003). Some of these were more concerned with identifying selection criteria, while others were more focused in developing specific ranking techniques. Selection criteria for ERP packages were reported by studies such as Bernroider and Koch (2001), Everdingen et al. (2000), and Verville and Halingten (2003). Bernroider and Koch (2001) discussed the results of an empirical study concerned with the differences of selection approaches taken by SMEs and Large Enterprises (LEs). Verville and Halingten (2003) conducted a case study to investigate the decision process for selecting an ERP system and reported on major criteria of ERP system evaluation. Another approach for selecting appropriate ERP systems was provided by Wei et al. (Wei, Chien and Wang 2005). The main findings of the literature review were:

- Limited attention given to SMEs, with an exception on work dealing with multi-sector analysis in the context of case studies.
- SMEs are still very dependent on LEs and are compelled to use ERP packages imposed to them in order to stay compatible within their supply chains.
- Although a number of ERP system vendors have focused on SMEs more recently, approaches for small enterprises are still limited.

Methodology

In order to achieve the research objectives, this study employed a flexible, qualitative design with action research (AR) as its research strategy. Both research objectives called for the exploration of particular concerns of an organisation and the implementation of action in order to bring about change, to make improvements, and to influence practice. AR is a methodology focused on change and is concerned with research about action (Coughlan and Coghlan 2002). AR not only helped to address the research objectives, but also provided an example that can be used to engage academics and industrial managers in further research in this field.

The choice of action research as the methodology to address the research objectives requires meeting standards of appropriate rigour without compromising relevance. Näslund et al. (2010) strongly encourage researchers to make proper arrangements for triangulation. Triangulation enhances the robustness of a research investigation, as attacking the same problem with a variety of methods, data sources, and different perspectives from different investigators is not only useful for the study itself, but also for the validity of the analysis (Näslund et al, 2010; Yin, 2009). In the context of this study, triangulation was achieved with the use of multiple sources of data – including company reports, interview transcripts, and testimonials (data triangulation), multiple research methods – semi-structured interviews, workshops, observations, documentary analysis (methodological triangulation), and a team-based approach, consisting of an employee of the case organisation and the researchers (researcher triangulation).

The case organisation

The case organisation is a SME specialised in the design and manufacturing of devices for hip and knee arthroplasty and spinal surgery. The company was established in Germany at the beginning of the 1980s and has 180 employees worldwide. Its main capabilities lie in the development, production, and sales of implants for primary and revision endoprostheses, including all surgical instruments required for hip, knee, and spine arthroplasty.

The case organisation's manufacturing strategy is both make-to-order (for custom-made prosthesis) and make-to-stock (for standard sized prosthesis and instruments). Principles of Lean manufacturing have been implemented in its headquarters since 2013. All facilities have been working on implementing Kanban pull systems with suppliers, visual management, setup reduction, and due-date driven production planning systems in order to synchronise production to customer demand as much as possible. Primary performance measures are product safety, quality, cost, on-time delivery, inventory, and cycle times. These measures are reported by the plants daily, and reviewed with the vice president of operations once a week.

Research findings and discussion

This section describes the framework for technology selection to support S&OP developed in the context of the AR project and presents its different stages. The framework was developed during the interactions with the case company in the context of the AR project and was firmly based on literature on technology selection, supply chain strategy, risk assessment, and S&OP implementation.

In order to develop an understanding of the issues surrounding the research subject, regular visits were made to the case company. By analysing appropriate literature and by gathering feedback generated from the interactions with the case company, its main customers, and suppliers, this research developed a process-oriented approach for S&OP technology selection, combining inter- and intra-organisational factors.

The developed framework consists of six stages (see Figure 1), which were conducted in a cyclical form according to the AR approach during its implementation (Coughlan and Coghlan 2002).

The first stage, 'system analysis', entailed evaluating the case company's current supply chain with the use of a process modelling tool developed for this study, titled SIPOC 2.0. This tool not only displayed the information flow between departments within the case company, but also the exchange of information between the case company and its suppliers and customers. Additionally, each process step was defined using the SIPOC approach, describing the supplier, the inputs, the process, the outputs, and the customer(s) for each process step. The analysis involved a mapping of all relevant processes, the identification of all information flows, and the identification of relevant issues, KPIs, and improvement potentials. Process owners were involved in the mapping exercise in the context of participative workshops and interviews. The outcomes of this stage were a validated as-is process description and a list of improvement potentials, which were then used to describe the to-be process during the 'system design' stage.

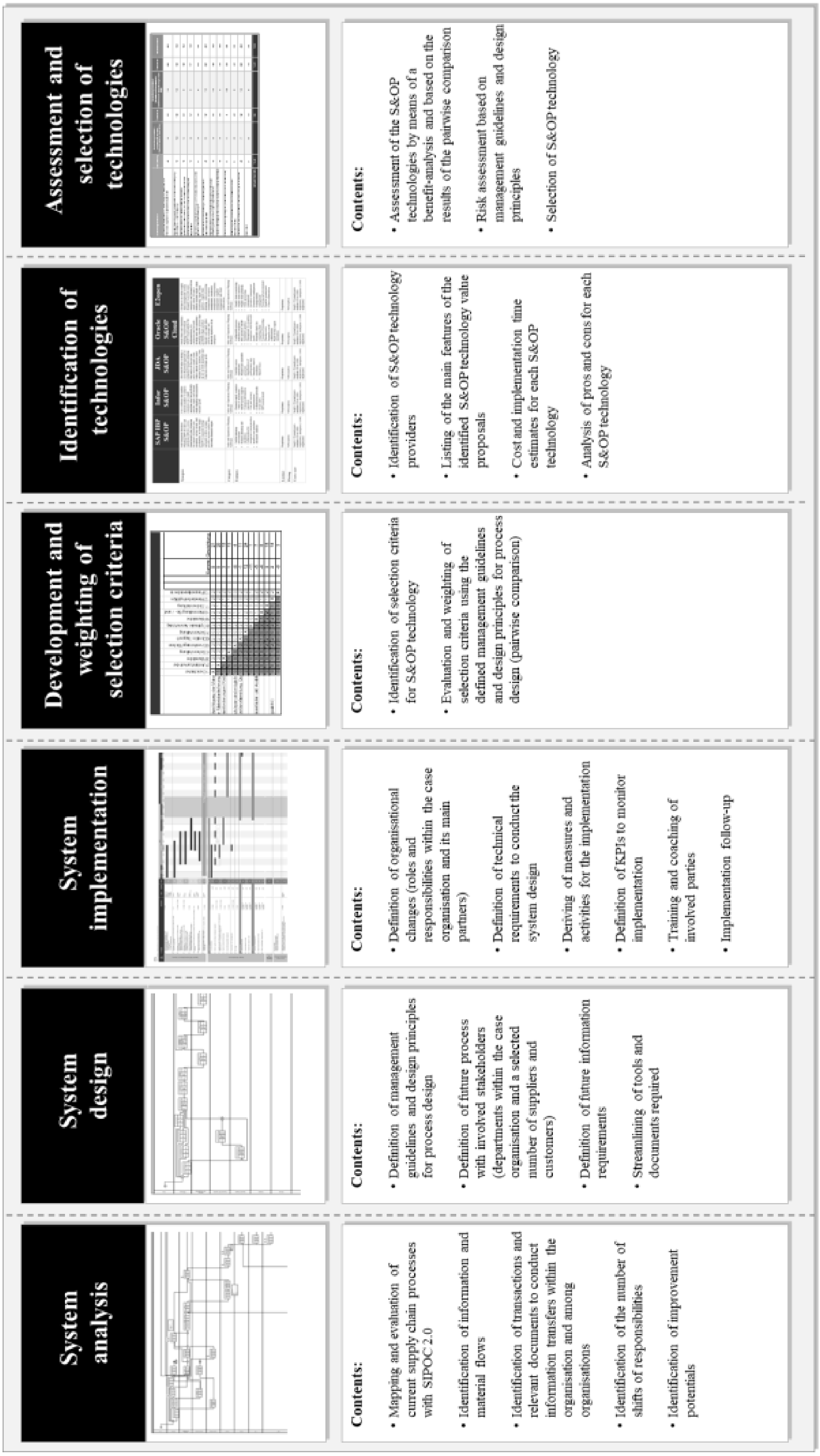

Figure 1. Framework for technology selection to support S&OP developed for this study

The second stage, ‘system design’, involved the same stakeholders as in the first stage. Here, the process owners defined guidelines and design principles for the future process, designed a streamlined process, and defined future information requirements in the context of participative workshops. An interesting find during the conduction of this stage, was that stakeholders were more concerned with defining an organisation or a software solution before defining a future process. Participants were also critical about the necessity of defining a to-be process, as the as-is process was already mapped and analysed. For this reason, the researchers were required to use their moderation skills to ensure that the expected outcomes were produced during these sessions. The outcome of this stage was a concrete definition of the to-be process, including responsibilities, timeframes, deliverables, and milestones. The to-be process was agreed with the management of the case company and with key suppliers and customers.

The third stage, ‘system implementation’, consisted of developing an implementation roadmap, and introducing the necessary changes to establish the agreed S&OP process, which was supported by ad hoc Excel tools to produce forecasts, demand and supply plans, and ‘what if’ scenarios. In this stage, the project participants were required to install the defined process using a concrete product family in order to identify if the to-be process needed corrections or adaptations. The product family used to pilot the new process were hip implants and their instruments, as they represented the highest volumes in terms of sales. S&OP sessions were at first uncoordinated, as participants were not adequately prepared. However, once participants understood their roles and responsibilities, the process was conducted without major disruptions, with participants bringing inputs in order to streamline the process and increase its efficiency.

The fourth stage, ‘development and weighting of selection criteria’, was based on the management guidelines and design principles developed in the second stage and the experiences gained after the implementation of the S&OP process during the third stage. Based on these, a set of criteria for S&OP technology selection was defined in the context of a workshop with process owners. These criteria included ‘functionality’, ‘technical aspects’, ‘cost’, ‘technical support’, ‘compatibility with extant systems’, ‘ease of customisation’, and ‘implementation time’, among others. This criteria was weighted in order to determine priorities.

The fifth stage was the ‘identification of technologies’. This stage required the expertise of process owners, who identified five different technologies that could support the process. These were software package solutions available in the market. In order to identify the key features of each technology, preliminary talks with system providers were conducted. The outcome of this stage was a complete overview of appropriate technologies to run the S&OP process including a list of features for each technology, as well as a first cost estimation.

Finally, the sixth stage, ‘assessment and selection of technologies’, required detailed assessments of the identified technologies based on a benefit-analysis and featured a thorough risk assessment based on the defined criteria during the former steps. The outcome of this stage was a management report including a recommendation for action and a presentation of results to the management of the case organisation.

Based on this framework, the case company was able to decide on an appropriate tool to support the management of its S&OP process using both qualitative and quantitative criteria.

Conclusion and contributions

This study identified a lack of technology selection methodologies for S&OP support. The objectives of this study and its strong focus on implementation led the researchers

to select AR as an appropriate research strategy in order to develop and implement a process-oriented technology selection framework to support S&OP in a case organisation, while considering organisational and inter-organisational perspectives.
In spite of its long implementation process – as it required the inputs from functional departments, IT officials, customers, and suppliers, the framework delivered a robust decision-making tool for industrial managers to select a S&OP tool that supported their supply chain objectives and requirements.

The industrial contribution of this framework is the delivery of a management tool for decision support which includes both quantitative and qualitative criteria, features a holistic and process-oriented approach, and increases supply chain awareness for all stakeholders. The academic contribution of this paper is the framework itself, which is based on exploratory work and is established as a basis for further research. The framework is especially designed for application in the medical technology industry and considers this industry's characteristics. Researchers can use this model as a base to conduct further research work in other contexts other than the German medical technology sector.

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