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Developing a maturity model for service systems in heavy equipment manufacturing enterprises

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ABSTRACT

Heavy equipment manufacturing firms are increasingly challenged by the integration of service planning and execution in their established product-centred information systems (IS) environment. Despite a few standardisation efforts, there is no common understanding of service systems in industry goods companies and the corresponding requirements for the appropriation of information systems. We address this need by developing a maturity model. The design of the model is grounded in extant literature, focus group and case study research involving eleven organisations over 1.5 years. The evaluation confirms that the maturity model makes a novel and useful contribution to the design of service systems.

1. Introduction

The market environment for heavy equipment manufacturers is changing rapidly and demands players to adapt their business models and to find a beneficial modus operandi for respective IS support.

1.1. Trends

Today, the manufacturing industry is undergoing significant structural economic changes [114,121]. In the German mechanical engineering sector, the total turnover related to industrial services has made significant advancement from 16.8% in 1997 to 22.5% in 2000, while the fraction in the electrical engineering industry has almost doubled during this period [107]. On a European scale, services account for almost half of the profits of industrial goods manufacturers, with an average annual profit growth of five per cent [108]. The constantly rising fraction of industrial services in all Organisation for Economic Co-operation and Development (OECD) countries except Luxembourg [80] faces manufacturing firms with the need to transform their business strategy [63]. By constantly adding new service businesses to their product portfolio, companies trigger a transformation process that requires not only changing strategy and structures but also changing business processes [112]. This trend is particularly incisive with heavy equipment manufacturing companies. The equipment goods that are produced by this industry are characterised as long-living and highly productive. Consequently, services such as maintenance, repair and change operations are particularly important capabilities of the heavy equipment manufacturers for achieving and maintaining high profit margins. Specifically this means they have to complement their primary business focus on engineering and production with the completely different service component. An example of a metal-forming company which had built a large equipment base but did not meet the after-sales needs of its customers illustrates this. Concretely, 80% of the service business on the equipment was captured by competitors. In order to exploit this potential the company had to adopt a new business model including broader geographic coverage, an expanded service product portfolio, a new management team and a more proactive customer management [108].

However, the successive integration of services into business models often drives service operation divisions beyond their physical resource limits; i.e. human resources lack sufficient

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qualified staff to provide the newly offered services. Call centre employees, for example, are often neither trained to deliver technical remote services for the installed base nor do they have access to the necessary information to manage the service request (e.g. information on the installed base, sensor data, etc.). Information technology (IT) artefacts have an enabling effect on this transformation process because they provide technological capabilities to reshape the service processes more efficiently [12]. Mobile computing, remote machine control and data management represent technical means that allow efficiency increase in service processes such as service quality controlling, knowledge management, mobile workforce, call centre processing and predictive analytics. Under limited resources, the development of these technical capabilities is difficult to obtain. For example, customers are physically unable to maintain operational condition on machinery in production facilities at 99.3% availability. Hence, the customer demands an extension in the service offering from call centres' triggered reactions to a prediction-based model. Heavy equipment manufacturers' service divisions need more precise and accurate information about the equipment to establish a professional monitoring and derived prediction process. Precision refers to the provisioning of serialised descriptions on sold assets in combination with deep technical information (e.g. bills of material), while accuracy addresses electronic machine records that give information on the past service activities performed on the machines (e.g. maintenance, repair and overhaul).

1.2. Research gap and research questions

Organisations are challenged by coordinating and managing the broad business-to-IT scope of this transformation. Confronted with the wide array of service business and technology related issues, management needs to obtain a comprehensive view on design and transformation tasks. Since the execution of this holistic transformation processes is a heterogeneous and complex task, it is crucial to prioritise and control the individual measures. Unfortunately, the existing research has not provided deeper insight into business processes [44] and enterprise application systems that are required to integrate manufacturing and service processes in service systems. Service system scholars (e.g. Spohrer et al. [105]) define business processes for service systems but concentrate on service companies, which are not subject to a fundamental transformation process. In particular, heavy equipment manufacturing companies that traditionally have their business focus on product-related business processes struggle with the implementation of service business processes. Oliva and Kallenberg [81] describe the business process challenges of the aforementioned transformation process but lack a description of how IS could support this process. Becker et al. [11,12] mention the transformation process for manufacturing companies and describe the customer-related IS challenges (front stage). In summary, there is a research gap in how back stage IS can support the service transformation process for heavy equipment manufacturing companies and what IS tools could help the management of those companies to master the service challenge. This context of service systems for heavy equipment manufacturing companies hence calls for further research.

Being successfully implemented in the software engineering domain [86], maturity models (MM) represent an established means of supporting effective management for complex and heterogeneous phenomena [2]. Hence, MMs provide valuable instruments to manage this transformation process [27]. To the best of our knowledge, there is no instrument, such as an MM, available in literature that facilitates the transformation process from traditional manufacturing companies to those embracing service systems [11,44]. We apply an information systems research perspective of service science. In view of the foregoing, a concept is needed allowing holistic support for such broad design and transformation tasks.

The objective of this article is to develop an MM that is capable of holistically assessing the IS support of service systems in the heavy equipment manufacturing industry and that is based on highly relevant requirements. Hence, we address the following research questions (RQ):

(1) *What are key requirements for transforming the IS support of service systems to offer service-oriented business in the heavy equipment manufacturing industry?*
(2) *What are characteristics of an MM for service systems targeting key requirements of multinational heavy equipment manufacturing enterprises?*

To address these research questions, we conducted a multiple case study and two focus group workshops with leading heavy equipment manufacturing firms from the heavy equipment goods industry. We contribute to the body of knowledge by identifying requirements that are not covered in existing MMs. Based on the identified requirements, an MM suitable to fulfil these needs is both developed an evaluated. The remainder of this article is divided into four parts: the first part lays the foundation by considering the central terms and the research gap studied in this paper; the second part describes the research methodology; the third part answers RQ.1 by exploring unaddressed requirements and analysing existing MMs and standard specifications; and the fourth part as well as the fifth part are concerned with the development and evaluation of the MM (RQ.2). Finally, we conclude with our major contribution, supplemented with a critical reflection and an outlook on future research.

2. Background

For our work, we apply the IS concept formulated by Agarwal and Lucas [1], who differentiate between the micro domain of IS, namely the IT artefact, and the macro domain, which aims to understand how IS alters organisations, environments and strategy. Since this paper is concerned with managing transformation processes of the integration of service planning and execution in the established product-centred IS environment of manufacturing firms, the concentration on the micro level (the IT artefact), as proposed by Benbasat and Zmud [14], would be inappropriate.

In accordance with the service dominant logic [114], IS scholars define services as the application of competence and knowledge with the aim of creating value between providers and receivers [104]. Lately, the notion of the '*service system*' has been put forward representing '*a value-coproduction configuration of people, technology, other internal and external service systems, and shared information (such as language, processes, metrics, prices, policies, and laws)*' [106]. Service systems aim at the co-production of value [105] through manifold interactions between service providers and service consumers. Interestingly, the theoretical foundation of service systems is rooted in the application of manufacturing system theory to services [68,75]. Similarly to manufacturing systems, service systems are composed of a front stage with direct customer interaction and a back stage with IS support [44], consisting of enterprise applications and the underlying data management systems [54]. The service providers and service consumers can be external (different companies) or internal (e.g. a business unit of the same company) [115].

The traditional focus of value creation in manufacturing firms has long been on developing and producing physical products and not so much on servicing these products [55]. Accordingly, the IS of