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Procedia CIRP 130 (2024) 1124–1129

www.elsevier.com/locate/procedia

57th CIRP Conference on Manufacturing Systems 2024 (CMS 2024)

# Framework for the Introduction of Data-driven and Service-oriented Business Models in Mechanical and Plant Engineering Companies

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**Abstract**

The current literature on the topic of data-driven and service-oriented business models (BM) is rich on frameworks describing strategic and organizational impediments, challenges, and solutions. Nevertheless, there is a lack on frameworks that provide a structured guidance for mechanical and plant engineering companies to implement those BM into their organization. This paper aims to close this gap in developing a comprehensive framework. Using the design science research (DSR) approach we conducted a systematic literature review and semi-structured expert interviews to gather strategic and organizational challenges and pertinent frameworks. These findings were converted into requirements to evaluate existing frameworks. From the evaluation, an action delta was derived as a starting point for the development of an artefact. The result of this artefact is the framework TriProGenix, which is designed to assist mechanical and plant engineering companies in developing and implementing data-driven and service-oriented BM. TriProGenix consists of four development levels, in which changes must be undertaken for an effective and efficient adoption: Strategy, Resources, Structure & Ecosystem, and Culture. With the use of a procedural model, the company is guided through the development levels. For further support throughout the process certain methods are provided, including strategy analysis, organizational analysis, etc. The framework is designed to be a valuable tool for decision-makers, to guide them through the process of BM implementation, offering structured problem-solving to improve decision-making, organizational alignment, knowledge sharing, and adaptability.



*Keywords:* Business Model; Organizational Transformation; Service-oriented; Data-driven

## 1. Motivation

Companies operating in mechanical and plant engineering are currently facing different challenges, such as increasing global competition, which causes a slowdown of their growth [1]. New data-driven and service-oriented BM, such as Equipment-as-a-Service (EaaS) or Pay-Per-X, help those companies to differentiate themselves and promise to generate new sources of revenue, while providing simple scalability, financial flexibility, and general cost savings [2,3]. These new BM are a manifestation of digital servitization (DS), which describes the transformation of conventional product-oriented BM towards data-driven and service-oriented approaches [1,2]. By adopting DS, companies must not only innovate their


10.1016/j.procir.2024.10.216

BM and expand their product range but also transform their organization, which poses different challenges [4].

This paper aims to address these challenges by creating a comprehensive framework, building on a procedural model that enables mechanical and plant engineering companies to adopt data-driven and service-oriented BM confidently. The focus lies on strategic organizational challenges, which include generating service-oriented strategies and suitable BM, forming strategies to acquire the required resources, and transforming the companies' structure, ecosystem, and culture.

## 2. **Fundamentals**

### *2.1. Strategy, Business Models and Resources*

Strategy and BM are two terms related to each other but at different levels of information [5]. The strategy describes with a low level of detail how an organization intends to assert itself against its rivals in the existing and future environment using its available resources [6,7]. With a higher degree of detail, the BM describes the basic principle by which an organization creates, delivers, and captures value [8]. The BM of an organization, therefore, is a direct derivation of this organization's strategy.

Companies use business model innovation (BMI) to adapt to changing market conditions and prepare for the future [8]. BMI represents a company's process of exploring new opportunities in value creation, value delivery, and value capture for customers, suppliers, and partners, thus improving or changing the underlying BM or developing a new BM [9,10]. An innovative BM can lead to a sustainable competitive advantage for the company [11]. To generate this competitive advantage, according to resource-based view (RBV) the reconfiguration of existing resources is necessary and represents a strategic decision [12,13]. This includes changes in internal or external processes, partner relationships, or the reconfiguration of capabilities [14].

### *2.2. Servitization and Digital Servitization*

Services play an important role for companies in the manufacturing industry, as they offer a higher margin than product sales [15]. For this reason, more companies are focusing on the provision of services. VANDERMERWE AND RADA [16] first described this phenomenon as servitization, which demonstrates a companies' tendency to add more complex, customer-oriented service bundles consisting of products and services to their portfolio. This includes a strategic reorganization of the entire company and specific organizational changes, like the relocation of skills, human and financial resources, and processes within the organization [3,16]. The goal is to offer integrated end-to-end services using innovative technologies that create added value for the products [3,17]. Hybrid service bundles, also known as product-service systems (PSS), are the offer of this strategy [18,19]. PSS represent a combination of goods, (self-) services, support and knowledge and consists of tangible and intangible services [16,19]. Ownership and use of the product are decoupled from each other and the focus is on selling the solution to address the customer's needs accurately [19].

The digitalization process represents the transition from monitoring to the autonomy of systems and is an important enabler for servitization [20,21]. Through this rapid adoption, the term digital servitization has evolved in the literature [2]. DS can be considered as the use of digital technologies (e.g., machine learning, artificial intelligence, automation, robotics, and sensors) by a company to facilitate the transition from a product-centric to a service-centric logic [4,22]. Value creation is made possible by the interaction of products, services, and software, called smart product service systems (SPSS) [2,23].

The phenomenon of servitization and DS alter how products and services are built and delivered, how companies design their BM, and, based on this, how they structure their organization and design their processes [4,24].

## 3. Related Research

The literature offers various frameworks describing strategic and organizational impediments, challenges, and solutions. Nevertheless, there is a lack on frameworks that provide a structured guidance for mechanical and plant engineering companies solving these challenges in a structured manner. The majority of these approaches concentrate on BM development and the corresponding (S)PSS. However, in the following, some frameworks that integrate strategic and organizational considerations will be explored.

ADRODEGARI et al. [25] have developed a multi-phase method-supported methodology that supports industrial companies in their service transformation. The model ranges from the selection of the appropriate PSS BM to successful implementation in the company's organization. The methodology strongly focuses on BM development but partly neglects organizational effects.

COREYNEN et al. [26] have designed a methodology for scaling PSS. It consists of a diagnostic tool and subsequent workshops. The diagnostic tool differentiates three types of barriers for scaling PSS, namely design, rollout, and logic barriers. This diagnostic tool then shows the tensions inside those barriers and resolves those tensions with interdisciplinary workshops. Even though the methodology helps give orientation, it does not lead the user through the process of implementing servitization in his organization.

ECHTERHOFF [27] elaborated a model for introducing innovative BM in established companies. The model comprises four main phases: BM concept development, BM concept validation, organizational anchoring of the BM, and implementation planning. The organizational anchoring of the BM is the most interesting phase for the subsequent evaluation. The phases deal with the strategic-organizational effects that occur during implementation and the derivation of measures to ensure successful implementation. Even though his approach is holistic and demonstrates the entire process from BM concept to development, to implementation, he neglects the importance of developing the required competencies.

The Aachen Smart Service Engineering Methodology according to JUSSEN et al. [28], consists of three interconnected loops that map the three phases of smart service development: strategy development, prototype development, and market entry. Due to their iterative nature, these three loops offer the user the advantage of going through each phase several times before advancing to the next phase of smart service engineering. The approach mostly focuses on user-centric development and on how to build up the necessary resources but does not analyze the effects on the organization.

LINDE et al. [29] describe a model for designing revenue models for digital services in their work. The model consists of two key components: the three scaling levels for digital services, and three phases for designing the revenue model, which are similar to a process model. Even though the required culture is considered, the focus is mostly on BM development and scaling of the respective BM. There is no consideration of the required structure.

The ABILITY enablement system, according to ARNOLD et al. [30], is a holistic system that supports SMEs in hybrid value creation. It enables SMEs to identify, evaluate, implement, and develop hybrid value creation in their operating environment further. The system is based on the interaction of several elements to guide interested companies through the development and implementation process. Even though the ABILITY enablement system meets nearly all requirements, it ignores the development of the required resources throughout the framework.

| | Formal requirements | | | | Content requirements | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Analysis | | | | Development | | | |
| | Procedural model | Method supported | Agility (Customer -centric, iterative) | Interdisciplinary | Analysis of current strategy and portfolio | Analysis of resources and competences | Analysis of structure and ecosystem | Analysis of culture | Development of strategy and portfolio | Development of resources and competences | Development of structure and ecosystem | Development of culture |
| ADRODEGARI et. al. | + | + | o | - | + | + | + | - | + | + | + | - |
| COREYNEN et al. | - | - | o | + | - | - | o | + | - | - | + | + |
| ECHTERHOFF | o | o | o | + | + | o | + | + | o | - | o | - |
| JUSSEN et al. | + | - | + | - | o | + | o | - | + | + | - | - |
| LINDE et al. | + | - | + | - | + | - | + | - | + | o | + | - |
| ARNOLD et al. | + | + | + | + | + | + | + | o | + | - | + | o |

+ Completely fulfilled o Partially fulfilled - Not fulfilled

Fig. 1. Evaluation of existing frameworks using elaborated requirements

Fig. 1 presents an evaluation of existing frameworks based on identified requirements. These requirements were derived from a systematic literature review and semi-structured interviews.

It is evident from the evaluation that while most frameworks use procedural models to guide users, only two offer a comprehensive toolbox to support the process. All frameworks fully or partially meet the agility requirements and are designed to be customer-centric and iterative. This is a positive aspect. However, only half of the analyzed frameworks require interdisciplinary teams to work with the framework, which may result in neglected perspectives.

It is notable that the majority of frameworks prioritize the development of BM and the analysis and development of existing strategies and portfolios. However, many frameworks fail to conduct a comprehensive analysis and development of the necessary resources for newly developed BM. While most frameworks acknowledge the significance of analyzing their current structure and ecosystem to provide service-oriented BM successfully, they often overlook the importance of organizational culture as a crucial factor. Evaluating the frameworks based on formal requirements reveals a lack of an agile procedural model that considers the needs of all stakeholders involved in the introduction process. The evaluation of the frameworks based on content requirements highlights the need for a comprehensive framework that analyzes and develops an organization's strategy, portfolio, required resources, structure, ecosystem, and culture.

This paper aims to close this research gap and develops such a comprehensive framework, which should effectively assist mechanical and plant engineering companies in implementing service-oriented BM.

## 4. Research Methodology

The framework was developed using the design science research (DSR) approach, as described by HEVNER et al. [31]. The DSR approach seeks to improve the current capabilities of individuals and organizations by creating new and innovative artifacts. Artifacts are the result of scientific work, such as constructs, models, or methods that enable comparison and evaluation with existing artifacts [31,32]. Within the scope of this paper, the developed framework represents the artefact. The following steps were taken to develop the framework:

As a foundation, the knowledge base is expanded in the rigor cycle through a systematic literature review, according to VOM BROCKE et al. [33]. Strategic-organizational challenges in the introduction of service-oriented BM were identified, and pertinent methodologies were evaluated that address the obstacles in question.

The environment is considered in the relevance cycle through semi-structured guideline-based expert interviews, according to HOMBURG and KROHMER [34] and MAYRING [35]. The interviews were performed with thirteen relevant stakeholders that presented their perspective on the challenges and practical solutions. The interview participants consisted of representatives from OEMs, service providers, and academics. The perspectives included product and service development, portfolio management, sales, ecosystem, and holistic views in the interrelations between those perspectives through managing directors.

Identified challenges were coded using the grounded theory approach according to GLASER AND STRAUSS [36]. These codes were developed further, according to specific requirements. The pertinent methodologies were evaluated against these requirements (see Fig. 1) to derive an action delta. This served as the starting point for the iterative development of the artifact, which was validated by applying it to a case.

## 5. Framework for the Introduction of Data-driven and Service-oriented Business Models

The identified requirements and the action delta were utilized to design a comprehensive framework supporting mechanical and plant engineering companies implementing service-oriented BM into their organizations. The framework consists of a procedural model that guides the user through four development levels: Strategy, Resources, Structure & Ecosystem, and Culture. Developments on those four levels are essential for successfully introducing a service-oriented BM. Various methods, organized in method categories, support each step of the process model to generate the required output for the next phase or another development level.

### *5.1. Procedural Model*

Many analyzed frameworks utilize a procedural model guiding through the process in a structured manner. This helps the user solve the challenge in a targeted manner [37]. To support the implementation process, we build on the basic logic of the SPALTEN problem solving process (PSP) according to ALBERS et al. [37]. Originally emerged as a procedural model for product development, it can be applied universally for other problem-solving areas [37].

It consists of seven procedural modules "Situation Analysis" (S), "Problem Containment" (P), "Alternative Solutions" (A), "Selection of Solution" (L), "Consequence Analysis" (T), "Make Decision and Realization" (E) and "Recapitulate and Learn" (N) [37]. Interdisciplinary problem-solving teams (PSTs) are initially formed and equipped with all required information and skills to tackle the challenges. After each module, team capabilities are assessed and adjustments in team compositions are made for the next module. Regular information checks (IC) allow for revisiting previous modules if required information has not been developed yet.

Summarized, the SPALTEN-PSP consists of seven procedural modules that must be regularly checked with PST and allow for jumping back to previous modules through IC. The aforementioned properties of the SPALTEN-PLP align with the formal requirements, procedural model, agility, and interdisciplinarity that were previously defined. Consequently, they serve as a suitable foundation for the procedural model.

### *5.2. Development Levels*

The coding of the challenges and the derivation of the requirements led to the design of four different development levels, essential for the successful implementation of service-oriented BM: 1) Formulating a service-oriented strategy and deriving a suitable BM (*Strategy*), 2) Analyzing the required resources for this new BM (*Resources*), 3) Analyzing and developing the organizations' structure and corresponding ecosystem (*Structure and Ecosystem*) and 4) Analyzing and developing the required culture (*Culture*). All these development levels depend on each other, as information and results from other levels are required for the development of a particular level (see Fig. 2).

As shown in the fundamentals, an organization's BM represents the derivation of its current strategy. Therefore, we decided to combine the process of strategy and BM development in the development level *Strategy*. During the process of developing a suitable BM, relevant information on the required resources is generated, which is essential for the next development level.

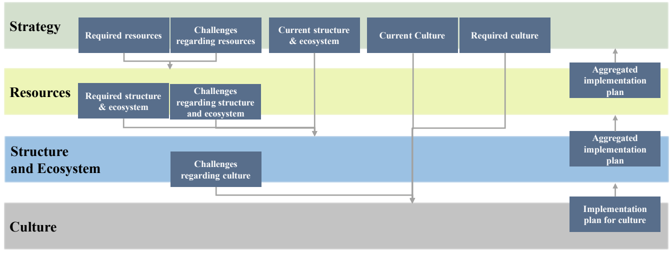


Fig.2. The development levels generate information for other levels

The strategic recombination of a company's resources can result in a sustainable competitive advantage [12]. Therefore, the development level *Resources* formulates strategies for building the required resources to offer the new BM. These strategies generate relevant information on how to structure the organization and the corresponding ecosystem.

Introducing DS has effects on different aspects of an organization's structure and its corresponding ecosystem [4]. The developmental level *Structure and Ecosystem* aims to improve the current value creation and value delivery of the organization and its corresponding ecosystem.

Actions regarding organizational design and processes, and ecosystem's design and processes are formulated.

Literature shows that developing a service-oriented culture is considered a major challenge and crucial for a successful creation and delivery of the new BM [2,4]. With the development level *Culture*, the current culture is developed further toward a service-oriented culture.

### *5.3. Method Categories*

Based on the defined requirements, different methods were collected to support the user through the process on all development levels. The methods, method categories, and respective allocations were developed on the basis of an analysis of existing approaches and the derivation of the relevant scopes, considering the framework conditions and requirements (e.g. ANDLER [38], OSTERWALDER AND PIGNEUR [8], KETT et al. [39]). The methods should be used in each procedural step of each development level to generate the required information using the available information.

To generate a better overview, those methods were clustered into method categories. The categories are diagnosis, *Strategy analysis*, *Organizational analysis*, *Cultural analysis*, *Target-setting*, *Decision-making*, *Creativity*, and *Project management*.

### *5.4. Result - TriProGenix*

The combination of these three dimensions creates a three-dimensional space representing the developed framework *TriProGenix* (see Fig. 3). The procedural model enables users to navigate through the development levels and utilize methods to generate the required information in the procedural model's modules. The information generated is essential for completing the development level or relevant to another development level.

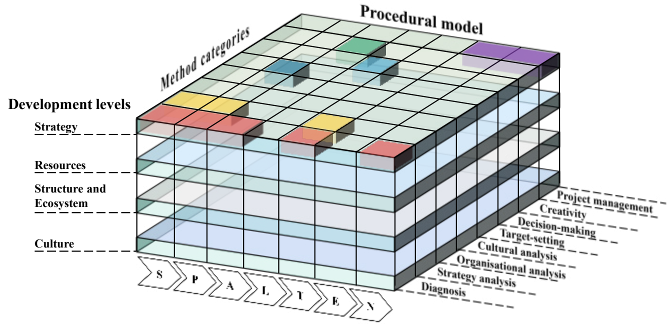


Fig. 3. TriProGenix - Three-dimensional framework with procedural model, various development levels, and individual method categories

## 6. Application of the Framework

The framework was validated by applying it to a strategy developed by an OEM. The scenario describes the developments of the market in which the OEM operates until the year 2040. From this scenario, a strategic direction was developed. The OEM wants to focus entirely on data-driven solutions and tries to act as a system supplier. The generation of added value for customers and monetization as part of the BM is based on the provision of software and services. The purpose of using this framework is to create an implementation plan based on the defined strategy.

In the development level *Strategy*, additional information is gathered through the first module of SPALTEN, *S,* using diagnostic tools such as interviews and surveys, and then consolidated with strategic tools such as SWOT analysis. This provides insights into the current strategic position, structure/ecosystem, and culture. Despite knowing the targeted strategy, information about the necessary culture for its implementation is gathered in the context of the second module *P*. BM are developed in the third module *A*, evaluated, and the most promising one is selected using decision-making tools in module *L*. Opportunities and risks of the selected BM are analyzed in *T* and then transferred together with the new BM in the last module *E*.

In the development level *Resource*, the required resources and current partners for the new strategy are analyzed. Solutions to close resource gaps are developed, considering the required structure and ecosystem. Selected solutions are compared using decision-making tools, analyzed for opportunities, risks, and challenges in transformation, and transferred to module *E* for project planning using project management tools.

In the development level *Structure and Ecosystem*, identified challenges and the current structure/ecosystem are analyzed in *S* using diagnostic and organizational analysis tools, alongside assessing the current culture for development level Culture. Module *P* involves comparing the current structure/ecosystem with the required one for the new BM, formulating necessary changes. Actions for structure/ecosystem transformation are devised in *A*, compared, and prioritized in *L* and evaluated for opportunities, risks, and their impact on culture in *T*. Transformation steps are transferred to *E*, generating a project plan using project management methods.

For the culture aspect, identified challenges and current culture are analyzed in *S*. *P* then consists of comparing current culture with the required one for the new BM, formulating necessary changes. Actions for culture transformation are devised in *A*, compared, and prioritized in *L*, and evaluated for opportunities and risks, and their impact on culture in *T*. Transformation steps, challenges, and risks are transferred to *E* to create a project plan for culture transformation.

Together with the project plans from the other development levels, a comprehensive project plan is generated, which needs to be implemented. The results of the implementation are then reflected in module *N*, where project management tools are used to enable continuous improvement.

## 7. Conclusion

In conclusion, this paper has presented a comprehensive framework, TriProGenix, designed to assist mechanical and plant engineering companies in successfully implementing data-driven and service-oriented BM. The framework addresses the strategic and organizational challenges inherent in adopting such models, focusing on four key development levels: *Strategy*, *Resources*, *Structure & Ecosystem*, and *Culture*. Through a procedural model based on the SPALTEN-PSP and method categories, TriProGenix guides users through various phases, ensuring thorough analysis and development of each aspect necessary for BM implementation.

### *7.1. Theoretical Implications*

Consolidating strategic and organizational challenges into a framework has provided valuable insights into the interdependencies among the described development levels. However, extending this framework to include specific technical aspects by introducing a development level focused on technology could further enhance its utility. Theoretical implications emerge regarding the integration of technological considerations into strategic and organizational frameworks. This expansion allows for a comprehensive analysis of how technological advancements influence strategy formulation, resource reconfiguration, organizational structure, and cultural transformation within a business context.

### *7.2. Practical Implications*

The framework provides practitioners with a valuable tool for organizing the introduction process of strategic decisions within their organization. Practitioners can systematically assess the effects of strategic decisions on various aspects of their organization, including structure, ecosystem, culture, and resource allocation. However, the effectiveness and applicability of the framework can only be fully validated through practical implementation and iterative refinement. Therefore, it is essential to test and refine the framework further in workshops, collaborative sessions, and real-world scenarios. In summary, the practical implications of using this framework include improved decision-making, organizational alignment, iterative improvement, knowledge sharing, and adaptability.

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