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Procedia CIRP 134 (2025) 360–365

www.elsevier.com/locate/procedia

Proceedings of the 58th CIRP Conference on Manufacturing Systems 2025

The Servitization Ecosystem Canvas (SEC): Towards a framework for developing service-oriented and data-driven business models in ecosystems

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Abstract

The mechanical engineering industry is undergoing a significant transformation. Trends such as Industry 4.0, digital technologies, and the shift from product-centric to service-centric business models, including product-service systems (pss), are driving this change. These developments offer companies the opportunity to differentiate from competitors. A structured process to find suitable business models for this transformation is needed. This work proposes a framework for developing service-oriented and data-driven business models within ecosystems. The servitization ecosystem canvas (SEC) is introduced to describe, analyze, and develop these models. The SEC consists of two stages: the ideation stage and the integration stage.
An application model is also presented, guiding the structured development of business models using the SEC. In the integration stage, the influence of ecosystems on business models is explored. Finally, a case study validates the SEC, demonstrating its effectiveness in helping companies in the mechanical engineering industry transition to digital servitization.

Keywords: Servitization, Business Model, Ecosystem, Framework, Service-oriented, Data-driven

1. Motivation

The machinery and plant engineering sector is facing increasing pressures due to global competition, supply chain disruptions, and rising costs [1]. As traditional product-based markets reach saturation, it is becoming harder for companies to differentiate themselves [2]. In response to these challenges, industry is shifting toward digitalization and Industry 4.0 offering new avenues for innovation [3].

Service-oriented and data-driven (s.o. & d.d.) business models have emerged as a promising solution, a phenomenon known as servitization. By integrating services with traditional product offerings, companies can create new revenue streams and maintain competitiveness [4]. However, to fully realize these models' potential, a well-structured and fitting business model is required [5,6].To develop effective service-oriented and data-driven business models, it is crucial to leverage digital technologies such as IoT, Big Data analytics, and AI. These technologies enable the creation of hybrid value bundles that combine traditional product sales with innovative services, facilitating differentiation and competitive advantage in a saturated market [7,8]. To support this transition, a framework for designing and deriving business models for servitization within ecosystems must be developed.

10.1016/j.procir.2025.02.139

Only holistic and well-developed business models can achieve sustainable economic success and be effectively scaled [9]. This framework will guide companies in leveraging digital technologies like IoT, Big Data, and AI, while ensuring that these business models are scalable and sustainable. By fostering collaboration and innovation within ecosystems, such a framework will help transform technological advancements into successful, long-term business strategies.

2. Fundamentals

2.1. Business models and frameworks

A business model describes how organizations create, deliver, and capture value for their customers [9]. It serves as a blueprint bridging the gap between strategy development and execution, detailing how a company operates and generates revenue [10]. Business models are typically divided into four key dimensions: value proposition, value creation, value delivery, and value capture [11]. The value proposition defines the offering and its promised benefit to customers. Value creation refers to the processes, resources, and partnerships that enable the development of the offering. Value delivery encompasses how the offering reaches customers, including distribution channels and partnerships. Finally, value capture outlines the mechanisms by which the company generates profit and ensures long-term sustainability [10]. Together, these dimensions provide a holistic view of how businesses operate, enabling companies to effectively implement strategies and achieve success [5].

Business model frameworks, on the other hand, are scientific models used to describe, analyze, and develop business models. They function as conceptual tools and can be viewed as design canvases composed of various dimensions and elements that need to be completed to form a comprehensive business model. By structuring and mapping these elements, business model frameworks facilitate derivating and developing suitable business models, helping companies systematically design, adapt, and refine their business strategies [12].

2.2. Servitization and the integration of digital technologies

Services are becoming increasingly important for manufacturing companies, offering opportunities to expand portfolios, deliver additional value, and differentiate from competitors [13]. This shift from a product-centric to a service-oriented approach, known as "servitization", focuses on providing integrated solutions combining products, services and expertise [14]. The advantages of servitization include improved customer satisfaction, stronger customer relationships, and enhanced competitiveness [15]. By offering tailored services, companies can increase revenues and profitability while fostering long-term customer loyalty [16].

The transformation from product-based businesses to Product-Service Systems (PSS) is a key aspect of servitization. PSS integrates products and services to better meet customer needs and drive revenue growth. These systems range from product-oriented models, where services like maintenance are added, to more advanced use- or outcome-oriented models [17].

Digital servitization leverages digital technologies to reshape industrial offerings [18]. Data, in particular, allows companies to gain insights into customer needs and behaviors, thus enabling real-time communication and more personalized services [19]. This data-driven approach creates new opportunities for efficiency and innovation, helping businesses remain competitive in the digital era [18].

2.3. Value creation in ecosystems

The transformation in mechanical and plant engineering necessitates significant changes in value creation, especially with the shift towards PSS and integrated solutions [13,20]. Companies must adapt their organizational structures to meet evolving customer demands, moving from traditional value chains to value networks and ecosystems [21]. There are various types of ecosystems, including business, platform, and innovation ecosystems, with business ecosystems being particularly relevant in this context [22]. A key benefit of business ecosystems is their modularity, allowing various companies to contribute components to a comprehensive solution while maintaining flexibility [23]. Business ecosystems also foster better coordination among participants, enhancing innovation and customer value [22]. Although s.o. & d.d. business models can exist outside ecosystems, they often benefit from the collaborative nature and risk-sharing that ecosystems provide [24].

In summary, Industry 4.0 has led to a rise in data-driven PSS, increasingly implemented through value co-creation within ecosystems [25]. BM frameworks assist in developing & detailing these models. However, there is a need for a framework tailored to s.o. & d.d BM within manufacturing ecosystems. This paper aims to address this research gap.

3. Methodology

The results presented in this research paper were created using the Design Science Research (DSR) methodology, as outlined by Hevner et al. [26]. DSR aims to enhance the capabilities of individuals and organizations by developing novel and innovative artifacts. These artifacts, which may include constructs, models, or methods, are scientific outputs designed for evaluation and comparison with pre-existing artifacts [26]. In this context, the developed framework serves as the primary artifact. The framework's development followed several key stages. First, the knowledge base was

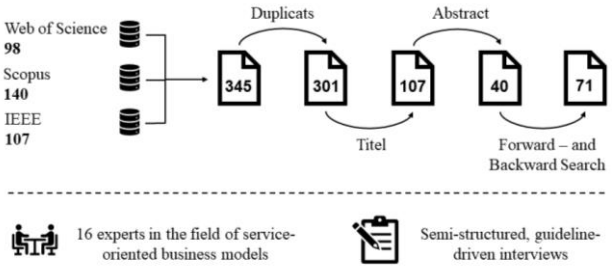

Fig. 1. Methodological Process

expanded through a systematic literature review, adhering to the process described by vom Brocke et al. [27], in line with the rigor cycle.

Subsequently, the relevance cycle was addressed by conducting 16 semi-structured, guideline-driven expert interviews. These interviews, guided by the methodologies of Homburg & Krohmer [28] & Mayring [29], involved sixteen experts in s.o. & d.d. business models from the mechanical & plant engineering industry. The interview data were analyzed using a grounded theory approach, with coding facilitated by MAXQDA, a software used for qualitative research analysis. The methodology of this cycle is presented in Fig. 1. Finally, during the last cycle, the design science research, the artifact - a business model framework - was developed, building upon insights gained from the two preceding cycles. This process is detailed in the following two chapters.

4. Towards a framework for service-oriented and data-driven business models

4.1. Related Work

From the theoretical foundation, a total of eleven frameworks were identified. However, due to the scope of the study, only the four most relevant frameworks will be described in detail in the following.

The business model navigator by Gassmann et al. [5] provides a structured approach for describing and analyzing business models, based on four key components: customer, value proposition, value chain, and revenue model. These components are framed by specific questions, such as "Who?" to identify the target customers, "What?" to define the value offered, "How?" to outline the internal processes and resources required, and "Value?" to describe how revenue is generated. This framework allows for a comprehensive definition of a business model. Its four components together form the "magic triangle".

The Business Model Innovation Canvas by Jin et al. [30] is a structured tool for visualizing, developing, and validating innovative business models. It consists of seven key elements: Value Driven, Value Goal, Value Proposition, Value Creation, Value Transmission, Value Capture, and Value Evaluation. Each element addresses a specific aspect of the business model, from identifying internal and external drivers of innovation, aligning resources, and delivering value to customers, to capturing revenue and evaluating the model's profitability and strategic fit.

The Value Proposition Canvas, by Osterwalder et al. [31] focuses on customer-centricity by identifying customer needs and problems (pains) & corresponding solutions (gains). It consists of two sections: the customer side, detailing pains, customer jobs, & gains, & the offering side, featuring Products & Services, Pain Relievers, & Gain Creators. The essential fit between these sides ensures that solutions align with customer needs. While it has a narrower scope & may not cover the entire BM, it is crucial for developing offerings that effectively meet customer requirements.

The EaaS Canvas by Kett et al. [32] develops a business model for equipment as a service, shifting from traditional machine sales to a service-based model. It includes five elements: core offering and customers, EaaS offering, internal structures, cooperative structures, and incentive mechanisms and pricing models. The canvas identifies customer needs, delivers value, assesses internal resources, emphasizes necessary partnerships, and establishes pricing frameworks. This specialized framework is especially relevant to the s.o. & d.d. focus of this paper.

4.2. Requirements for business model frameworks

In order to construct a business model framework, specific requirements for such models were identified. They can subsequently be employed as design principles [12]. This study gathered these requirements through both theoretical and practical approaches. The theoretical requirements were derived from the analysis and comparison of existing business model frameworks. These were then scrutinized and validated through expert interviews. Furthermore, additional requirements were incorporated based on the practical experiences of companies.

The identified requirements are categorized into content-related and methodological groups based on their codes in MAXQDA. An overview of the complete set of requirements is provided in Fig. 2. They will be further elaborated upon in the following.

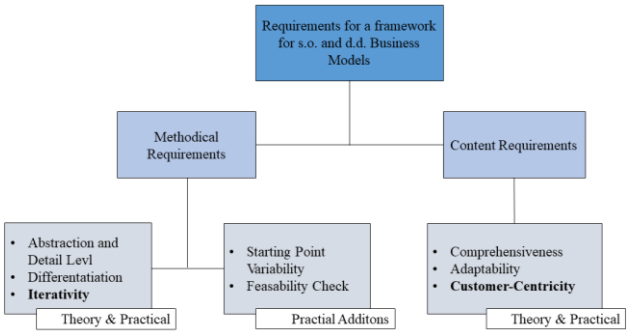

Fig. 2. Set of requirements

Content-related requirements focus on the structure and elements of the business model framework, while methodological requirements pertain to the design and practical implementation of the framework.

Methodical Requirements:

- *Abstraction and Detail Level*: The appropriate level of abstraction balances complexity and usability in business model frameworks [33].
- *Differentiation*: Specific frameworks differ in the details of their elements, allowing deeper abstraction compared to generic models [12].
- *Iterativity*: Business model innovation is a nonlinear, trial-and-error process that requires continuous testing and adjustment [34].
- *Starting Point Variability*: Business model development

does not require a fixed starting point; any dimension can initiate the process [35].
- *Feasibility Check*: Essential prerequisites, such as technical, organizational, and financial factors, must be met for successful model implementation [36,37].

Content Requirements:

- *Comprehensiveness*: A framework should cover the essential components of a business model, including value proposition, creation, capture, and delivery [5,20].
- *Adaptability*: Frameworks must be adaptable to new technologies and market trends, especially in digital and service-oriented models [38].
- *Customer Centricity*: Successful business models should prioritize customer needs, pain points, and future opportunities from the outset [31].

The analysis demonstrates that the practical requirements align closely with those from the theoretical domain, with key additional insights from practice emphasizing the iterative nature of business model development and a strong focus on Customer-Centricity, underscoring a frameworks' dual role as both a strategic guide and a practical approach to innovation.

4.3. Conceptualization of the business model framework

The requirements for business model frameworks outlined in the previous chapter serve as a foundation for conceptualizing the proposed model [12]. To achieve this, the alignment between existing business model frameworks and

○ not ◔ hardly ◑ partly ◕ mostly ● completely	Methodical Requirements		Content Requirements		
	Fit with		*Fit with*		
	Abstraction and Detail Level	Differentiation	Comprehensiveness	Adaptability	Customer-Centricity
Business Model Navigator; Gassmann, et al., 2021	◑	◔	●	◔	◔
Business Model Canvas; Osterwalder & Pigneuer, 2010	◕	◔	●	◔	◑
Value Proposition Canvas; Osterwalder, et al., 2014	○	◑	○	◑	●
Business Model Innovation Canvas; Jin, et al., 2021	◕	◑	●	◑	◑
Industry 4.0 Business Models Framework; Weking, et al., 2020	◑	◑	●	◑	◔
Gree Digital Servitization Framework; Chen et al., 2021	◑	◑	◑	◔	○
sPS2 Risk Framework; Coba et al., 2024	◑	◑	◔	◑	◔
PSS Business Model; Moro, et al., 2022	◕	◕	●	◕	●
Data-Driven Innovation Canvas; Zillner, 2021	◕	◔	◑	◔	◔
Business model analysis framework for Manufacturing Servitization; Hui, et al., 2015	◑	◑	◑	◔	◑
Equipment-as-a-Service Canvas; Kett, et al., 2023	◕	◕	●	◑	◕
Servitization Ecosystem Canvas	●	●	●	●	●

Fig. 3. Evaluation of existing frameworks based on the requirements

these requirements is assessed. However, the requirements of Iterativity, Starting Point Variability, and Feasibility Check are excluded from this evaluation as they are more operational in nature and will be addressed in the application model. Additionally, the elements of the frameworks are clustered according to the four core dimensions of a business model: value delivery, value proposition, value creation, and value capture. The fit of each framework with these requirements is evaluated using Harvey Balls, as shown in Fig. 3.

The evaluation of existing frameworks reveals that none fully meet the requirements for s.o. & d.d. business models. Some models address many criteria, while others are more specialized & only meet a few requirements especially well. The Value Proposition Canvas, for example, strongly highlights the requirement customer centricity, but lacks comprehensiveness & the proper abstraction and detail level [31]. This highlights the need for a tailored framework that fully pertains to all requirements.

Based on this analysis, the dimensions & elements of the servitization ecosystem canvas (SEC) are developed.

The core dimensions of the model are **Customer View**, **Value Proposition**, **Value Creation**, & **Viability**. The Customer View emphasizes *Customer-Centricity* and includes the elements **Job-to-be-done** & **Key Customers**, enabling the identification of customer Pain Points and needs. The Value Proposition comprises **Offering** & **Added Value**, where Offering represents the solution to the Jobs-to-be-done and Added Value describes the concrete benefits provided to customers. These dimensions meet the requirements of *Differentiation* and *Adaptability* for products and services. Value Creation involves **Capabilities** & **Ecosystem Capabilities**, outlining the necessary skills within the offering company or its ecosystem. The viability dimension focuses on economic profitability, consisting of the **Pricing Model** & **Cost Structure**. Together, these dimensions enable a *Comprehensive* description and development of s.o. & d.d. business models. The division into four core dimensions and eight elements also fulfills the requirements for appropriate *Abstraction and Detail Level*.

Accordingly, the Servitization Ecosystem Canvas fully meets the identified requirements, enabling the description, development, and derivation of s.o. & d.d. business models within ecosystem contexts.

5. The Servitization Ecosystem Canvas (SEC)

SEC, the core outcome of this study, provides a framework for describing, developing, and deriving service-oriented and data-driven business models within ecosystem contexts. It serves as a valuable tool for fostering business model innovation, specifically tailored to service-based and data-driven applications. The canvas integrates ecosystems into value creation processes, facilitating companies' transition towards Product-Service Systems (PSS) and supporting the identification and implementation of new business models. The SEC is presented in Fig. 4. The framework is structured into dimensions and elements, introduced in the previous chapter. These elements are connected by interdependencies represented by solid arrows. Rather than following a linear sequence or process, the framework allows users to start from any element or dimension and iteratively work through them. It provides a canvas that identifies the relevant elements and

illustrates how they are interconnected. Dashed arrows represent the derivation of the business model. The application model further elaborates on how to navigate the canvas and apply it to business model development.

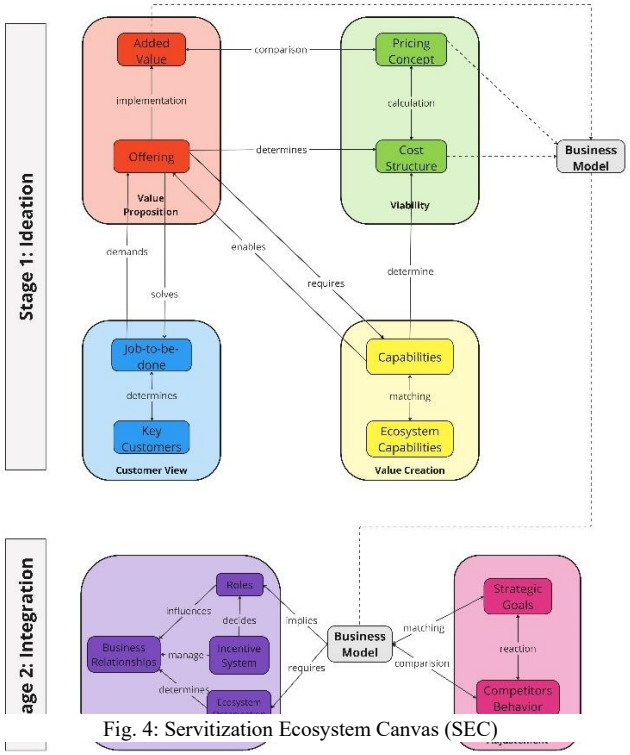

Fig. 4: Servitization Ecosystem Canvas (SEC)

The SEC is a two-stage framework, comprising the ideation and integration phases. In the Ideation stage, the development and derivation of business models are structured through the four dimensions: Customer View, Value Proposition, Viability, and Value Creation, encompassing the eight key elements introduced in the previous chapter.

The integration stage consists of the internal and external stages, addressing the implementation of the business model. The internal stage aligns the business model with the company's strategy through the dimension of business model adjustment, focusing on strategic goals and competitors' behavior. In contrast, the external stage consists of the Ecosystem Orchestration dimension, which emphasizes collaboration within the ecosystem. It includes the elements Roles, Incentive Systems, Ecosystem Organization, and Business Relationships, highlighting how different business models necessitate distinct organizational structures and partnership dynamics for successful ecosystem integration.

6. Application of the Servitization Ecosystem Canvas

6.1. Application Model

To effectively utilize the SEC, a guide is required that outlines how its dimensions and elements should be navigated to design an appropriate BM. The application model of the SEC is structured into six steps, as shown in Fig. 5. This process focuses on the ideation phase because this phase is crucial for the development & refinement of BMs, whereas the integration phase deals with external factors and implementation within an ecosystem.

In the development of the application model, the three remaining requirements Iterativity, Starting Point Variability and Feasibility check which had not been used in the conceptualization of the framework's elements were considered due to their strong focus on application. Iteration is supported through feedback loops between the six steps, allowing users to revisit previous stages as needed. The process is non-linear, enabling users to start from any point and adjust based on feasibility outcomes. This ensures that all dimensions and elements are refined iteratively until a fully aligned business model is achieved [36].

The first step entails identifying customers and their needs by analyzing pain points, potential gains, & market conditions

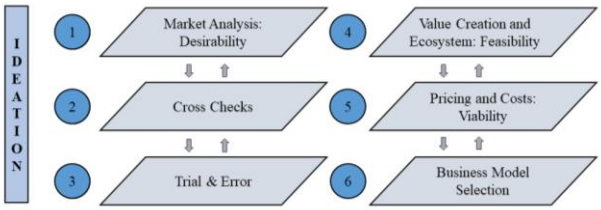

Fig. 5. SEC Application model

to ensure alignment with actual demands.

The second step involves conducting preliminary feasibility checks on the identified customer problem and proposed solution to evaluate the idea's viability and identify potential obstacles before further development.

The third step describes the development of the value proposition in an iterative trial-and-error process.

The fourth step focuses on detailing the implementation of the business model by analyzing the required capabilities, resources, and activities, assessing their availability within the focal company or the ecosystem, and identifying any capability gaps that need to be addressed.

The fifth step involves analyzing the economic viability of the business model by creating a business case that compares costs and potential revenues across various pricing models, focusing on costs associated with the value proposition and alignment with customer needs.

The final step involves selecting a business model based on the complete development of its elements, emphasizing the added value for customers and the pricing model, which are essential for assessing economic viability, alongside qualitative factors such as customer satisfaction & alignment with the company's strategic goals.

6.2. Validation with the Use-Case AOaaS

The SEC & its application model were validated using the industry use case autonomous operation as a service (AOaaS). AOaaS is a pivotal innovation within Industry 4.0, designed to enable smart factories to operate autonomously without the need for on-site personnel. It harnesses advanced technologies, including smart remote monitoring, & AI algorithms, to allow machines to be operated remotely from a control center. Machines such as the TRUMPF TrueLaser 7030 are delivered as a service with customers paying for

usage while the provider retains ownership & responsibility for maintenance and operational management. The project is realized within an ecosystem comprising various partners as part of the Factory-X research initiative.

Based on the SEC application model, a workshop with four experts from the Factory-X consortium was conducted to develop a suitable business model for AOaaS. The experts, representing different companies, provided diverse perspectives. Validation followed a systematic approach, including market analysis, assessment of desirability, feasibility, & viability, solution development, value creation in the ecosystem, financial evaluation, & final assessment. Key findings highlight the growing trend of automation in manufacturing & the demand for autonomous machine operation & remote maintenance. The subscription model emerged as a promising option for continuous revenue. The validation process helps identify market trends & customer needs, refining pricing models accordingly. Overall, the SEC model proved effective in developing s.o. & d.d. BMs.

7. Conclusion

This paper examined s.o. & d.d. business models in the context of ecosystems within the machinery and plant engineering sectors. These models are increasingly important due to advancements in servitization and digital technologies. The study developed the servitization ecosystem canvas, a framework that structures the creation of business models. Theoretically, this work advances the literature on business models in servitization and ecosystems, offering a structured framework that meets key requirements. It contributes to future research by providing criteria for evaluating similar frameworks and filling a gap in the academic discussion. Practically, the SEC provides companies with a tool to develop service-oriented models & adapt to industry changes, ensuring business models are economically viable at any stage of development. Limitations include the subjectivity in expert interviews and the limited number of analyzed theoretical frameworks, which call for a further in-depth analysis. Additionally, operationalizing the SEC beyond its application model could enhance its effectiveness in developing s.o. & d.d. business models within ecosystems.

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