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Revenue models for digital services in the railway industry: A framework for choosing the right revenue model

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ABSTRACT

While digital servitization provides manufacturing companies with the potential to earn additional revenues in the transition process from physical to digital offerings, the implementation of adequate value-capturing mechanisms is a major hurdle. The literature discerns little on the factors that influence the choice of revenue models for digital services. To address this knowledge gap, we build on a case study approach involving two global manufacturing companies in the railway industry that have experience in offering diverse digital services. The analysis reveals specific features and characteristics of three major revenue models for digital services – namely, subscription, usage-based, and performance-based revenue models. In addition, we identify overarching factors influencing the choice of revenue models for digital services. They are related to a) *customer digital readiness*, b) *digital service sophistication*, and c*) digital ecosystem partnerships.* Building on these influencing factors, we propose a framework that recommends that companies evaluate revenue models in relation to specific digital services. We furnish several theoretical contributions to the digital servitization literature and provide managerial implications for practitioners to assist in the choice of revenue models for digital services.

1. Introduction

An important element in a competitive business strategy currently pursued by manufacturing companies is the introduction of digital servitization, which involves making the transition from products to services, or a combination of both (Chirumalla, Leoni, & Oghazi, 2023). Although this transition can attract new customers, increase efficiency, and create additional revenues (Classen & Friedli, 2021), companies often struggle to obtain the expected financial returns from their digital offerings (Kamalaldin, Linde, Sjödin, & Parida, 2020; Korkeamäki, Sjödin, Kohtamäki, & Parida, 2022). This phenomenon, referred to as the *digitalization paradox*, occurs when companies are unable to capture profits from investing in R&D or implementing new technologies (Gebauer, Fleisch, et al., 2020; Kohtamäki, Parida, Patel, & Gebauer, 2020).

The way a company captures value from digital services is determined by its *revenue model* (Huikkola & Kohtamäki, 2018); a construct that describes how companies monetize the sales of their products and services (Casadesus-Masanell & Zhu, 2011). Revenue models and business models are not synonymous. While business models determine the structure under which organizations create, deliver, and capture value (Teece, 2010), the revenue model relates to the value-capture dimension of the overall architecture of a company's business model (Zott & Amit, 2010). It exclusively alludes to the financial viability of the company (Sjödin, Parida, & Visnjic, 2022), or "the revenue formula" through which customers are charged (Huikkola & Kohtamäki, 2018). Misaligned revenue models hamper profit generation (Gebauer, Fleisch, et al., 2020). Thus, the inadequate choice of a revenue model becomes an obstacle to the optimal positioning of digital services (Angeren, Vroom, McCann, Podoynitsyna, & Langerak, 2022). It means that the choice of a revenue model requires companies to reshape the traditional strategy of selling standalone products and adopt a logic that permits them to move toward product–service–software offerings (Kohtamäki, Rabetino, Einola, Parida, & Patel, 2021).

Among the business model elements, the value-capture dimension – and, specifically, the revenue model – is the one that has received least attention (Chen, Visnjic, Parida, & Zhang, 2021). Only a limited number of studies have explored revenue models holistically (Classen & Friedli, 2021; Remeňová, Kintler, & Jankelová, 2020), whereas most of the empirics have been built on revenue models for data-driven services

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(Enders, Schüritz, & Frey, 2019; Sá, Carvalho, Silva, & Rezazadeh, 2022; Schüritz, Seebacher, & Dorner, 2017). Indeed, the dominant literature has been based on insights retrieved from consumer markets and information goods (e.g., apps, mobile products, and online platforms) (Angeren et al., 2022; Numminen, Sällberg, & Wang, 2022; Roma & Ragaglia, 2016). Limited research has contributed to an understanding of revenue models for digital services (Linde, Frishammar, & Parida, 2023; Tidhar & Eisenhardt, 2020). In addition, knowledge of the factors that influence that choice remains largely uncharted territory. This gap is even more evident when witnessing the scarcity of research on the revenue models for manufacturing companies undergoing digital servitization transformation (Chen et al., 2021; Linde et al., 2023). Therefore, the overarching purpose of this research is to *advance understanding of the factors that influence the choice of revenue models for digital services in manufacturing companies*.

To address this gap, we built our observations from two global manufacturing companies in the railway industry that are gradually moving toward digital servitization. The railway industry is a suitable sector to explore the challenges that manufacturing companies face in choosing revenue models for their digital services (Jabłoński & Jabłoński, 2020). This is because the railway industry is experiencing slower levels of digitalization compared to the pace of the overall transportation industry (Jabłoński & Jabłoński, 2019). Such concerns have been highlighted as part of the role of the business model in the implementation of digital services (Kans & Ingwald, 2021), particularly in the value-capture dimensions of the business model (Tabares & Parida, 2022).

Our contributions to the literature are threefold. Firstly, we extend our knowledge of digital servitization by providing a rich perspective on revenue models and the value-capture dimension of business models for the digital services offering. Secondly, we provide insights to overcome the *digitalization paradox* by exploring the factors that influence the choice of revenue models. We show that manufacturing companies take into consideration three factors in choosing revenue models for digital services – namely, customer digital readiness, digital service sophistication, and digital ecosystem partnerships. Thirdly, we extend the pricing and revenue model literature by moving beyond traditional approaches focused on an internal view of the company and offering an ecosystem perspective – a perspective that has recently been receiving consideration in the literature.

In this paper, we start by providing a theoretical background on digital servitization in manufacturing companies and revenue models for digital services, including a review of existing research on revenue models for digital services. This is followed by addressing the methodology and describing the data collection and data analysis processes. We continue with the findings, structured according to the revenue models utilized by manufacturing companies and the factors that influence that choice in offering digital services. We conclude with a discussion of the study's limitations and a consideration of avenues for future studies.

2. Theoretical background

2.1. Digital servitization in manufacturing companies

Manufacturing companies are embracing the possibility of capturing value by moving from product-centric models to advanced service-oriented offerings (Kohtamäki et al., 2021). This transition has been referred to as *digital servitization* (Gebauer, Paiola, Saccani, & Rapaccini, 2021), a concept frequently described as the use of digital technologies to shift from pure products to smart product–services–systems (Kohtamäki et al., 2020). We define digital servitization as "*the transition towards smart solutions (product-service-software systems) that enable value creation and capture through monitoring, control, optimization, and autonomous function. Digital servitization emphasizes value creation through the interplay between products, services, and software*" (Kohtamäki, Parida, Oghazi, Gebauer, & Baines, 2019, p. 383). Using enabling technologies, such as the Internet of things (IoT), cloud computing, artificial intelligence (AI), machine learning, and other technologies, digital servitization promotes new market-generation opportunities for companies (Kamalaldin et al., 2020).

By streamlining digital servitization, a better understanding of digital services can be envisioned. Specifically, digital services consist of "*bundles of products and services aimed at solving customer problems by delivering targeted results or outcomes*" (Linde et al., 2023, p. 2). To provide digital services, manufacturing companies need to connect *physical elements* (e.g., hardware, equipment, and devices) with *digital technologies* (e.g., software, sensors, and microprocessors) through *connectivity elements* (e.g., ports, protocols, antennas, and networks) (Porter & Heppelmann, 2015) to retrieve *data* that can be processed and analyzed (Huikkola, Kohtamäki, & Ylimäki, 2022; Wünderlich et al., 2015).

To provide a more comprehensive understanding of digital services, various categorizations have been proposed in the literature. Based on previous categorizations, digital services can be classified into three levels of complexity: basic, intermediate, and advanced (Baines & Lightfoot, 2014; Raddats, Naik, & Ziaee Bigdeli, 2022). *Basic* digital services are centered around outcomes associated with the provision of a product (e.g., product support); *intermediate* digital services are focused on maintaining a product's condition (e.g., help desk, monitoring, product support, lifecycle and maintenance, prototype, and design); while *advanced* digital services revolve around product performance (e.g., optimization, outcome generation, optimization, and performance) (Baines & Lightfoot, 2014; Kohtamäki et al., 2019; Raddats et al., 2022).

The gradual adoption of digital services holds paramount potential for manufacturing companies because it enables them to attract new customers, reinforce customer relationships (Baines & Lightfoot, 2014), increase efficiency (Classen & Friedli, 2021), and enhance their competitive advantage (Vendrell-Herrero, Bustinza, Parry, & Georgantzis, 2017). Through digital services, manufacturing firms complement and enhance the perceived value of physical goods, allowing them to generate additional revenue streams (Kohtamäki et al., 2020).

Although studies have demonstrated that digital servitization can bring positive profit gains to manufacturing companies (Huikkola et al., 2022), firms often struggle to monetize their offerings. Along this journey, companies are often trapped in a *digitalization paradox* (Gebauer, Fleisch, et al., 2020), meaning that companies are incapable of capturing financial returns from their digital services (Gebauer, Arzt, et al., 2020). Digital servitization is, to a large extent, conditioned on the adequate selection of revenue models (Kohtamäki et al., 2020; Teece & Linden, 2017). Previous studies assert that a relational view is especially relevant in the context of digital servitization (Kamalaldin et al., 2020), while the literature on the value-capture dimensions of business models has demonstrated that a customer-centric and iterative approach is key in framing revenue models for digital services (Linde et al., 2023).

2.2. Revenue models for digital services

The study of revenue models for digital servitization is rooted in either the pricing or business model literature. Although the pricing research stream has been dominant (Linde et al., 2023), it primarily focuses on pricing strategies and contractual aspects (Agarwal, Simonsson, Magnusson, Hald, & Johanson, 2022) as well as customers' willingness to pay for digital services (Bencsik, Palmié, Parida, Wincent, & Gassmann, 2023; Sá et al., 2022). However, the selection of a revenue model is a decision that goes beyond creating pricing strategies. Revenue models are related to the value-capture dimension of a company's business model (Huikkola & Kohtamäki, 2018). Revenue models have been described as the "*modes in which a business model enables revenue generation*" (Zott & Amit, 2010, p. 218) because they determine the mechanisms through which a company appropriates value and the approaches it employs to monetize its offerings (Casadesus-Masanell & Zhu, 2011).

To date, most research on revenue models for digital servitization has focused on the empirical setting of digital platforms, mobile, and app products (Ammirato, Felicetti, Linzalone, & Carlucci, 2021; Angeren et al., 2022; Numminen et al., 2022; Stebbins, 2001; Tidhar & Eisenhardt, 2020). However, studies on manufacturing companies have mostly centered on the role of contractual flexibility (Agarwal et al., 2022), the predominance of cultural values (Classen & Friedli, 2021), the design process of revenue models (Linde et al., 2023), the strategies to enhance revenue streams (Gebauer, Arzt, et al., 2020) and avoid the digitalization paradox (Gebauer, Fleisch, et al., 2020), or customers' willingness to pay for a digital service in a smart-city context (Bencsik et al., 2023). As shown in Table 1, there is limited understanding of the value-capture implications for manufacturing companies moving toward higher levels of digital servitization and a lack of exploration of the factors influencing the choice of revenue models.

A central question on the choice of revenue models, and a critical step in digital servitization, concerns the decision on how to charge customers (Enders et al., 2019). In this landscape, revenue models for digital services have been framed as innovative value-capture mechanisms, which differ from traditional sales based on fixed-price product transactions (Bonnemeier, Burianek, & Reichwald, 2010). A different logic has been developed for charging customers for the provision of digital and data-driven services (Kohtamäki et al., 2019). One such logic is *hardware plus*, which involves companies integrating digital features to add value to physical products and expand their characteristics (Gebauer, Arzt, et al., 2020). Another logic is *licensing*, where customers are allowed to make use of a software application for a fixed period (Schüritz et al., 2017).

In the digital servitization literature, three revenue models have been identified (Andreasson & Lambrecht, 2022), which integrate traditional logic into innovative revenue models (Bonnemeier et al., 2010; Gebauer, Arzt, et al., 2020). *Subscription-based revenue models* – also known as *service-fee-based models* (Su & Jin, 2022) – involve customers paying periodic fees to access services for a defined period. Therefore, companies charge customers for a period independently of how much the digital service is used during that time (Enders et al., 2019). Subscription models are based on an input-based logic, focusing on customer process support services and product lifecycle services (Kindström & Kowalkowski, 2014). Although a variety of subscription models are often combined with free trial versions (*freemium*), which are usually enlarged with extended subscription fees (Lambrecht et al., 2014), this strategy is mostly adopted by app developers (e.g., Tidhar & Eisenhardt, 2020). *Usage-based revenue models* are those in which companies charge only when the customer uses the service. It is also known as a "pay-per-use model", which relies on quantifiable parameters measured on service usage metrics – for example, time, distance, intensity, or volume (Bonnemeier et al., 2010). Finally, *performance revenue models* rely on dynamic pricing strategies and focus on the performance of the digital service. These models are also called "output-based" or "pay-for-performance" models, in which the company's compensation depends on the outcomes generated for the customers (Enders et al., 2019). Performance models often use gain-sharing mechanisms (Schüritz et al., 2017) or smart service contracts in which an expected performance is guaranteed (Gebauer, Arzt, et al., 2020).

The capture of economic value for data-based and digital services is problematic (Sá et al., 2022), particularly given the lack of evidence on monetization processes for both service and data-based revenue models (Hartmann, Zaki, Feldmann, & Neely, 2016). As revenue models for digital services vary by industry (Schüritz et al., 2017), studies reveal a lack of understanding of revenue models for businesses moving from a product-based to a product–service–software logic (Gebauer, Arzt, et al., 2020), which is a challenge for the manufacturing industry. Therefore, the primary hurdle for manufacturing companies is to choose revenue models that align with their digital offerings (Gebauer, Arzt, et al., 2020).

For instance, if customers lack proficiency in using advanced digital services, this can hinder the implementation of complex revenue

Table 1
Seminal research on revenue models for digital servitization.

Author	Type of Study	Industry	Contribution
Bencsik et al. (2023)	Qualitative	Smart cities	Describes twelve business model configurations that deploy digital sustainability in the smart city context that depend on four variables: the focus of the value proposition on social improvements; the focus of the value proposition in regard to environmental improvements; whether payments are made by the end-user or not; and the difference between physical and digital service delivery
Sá et al. (2022)	Qualitative	Urban mobility platform	Identifies the relationship between value capture and value proposition in digital platforms for connected cycling urban ecosystems utilizing service-based and data-based business models
Numminen et al. (2022)	Quantitative	App developers	Suggests a combination between free downloads with in-app payments for superior revenue generation in gaming apps, and a choice between upfront payment and in-app payments for productivity apps
Agarwal et al. (2022)	Quantitative	Manufacturing industry	Price-variance contractual flexibility, contract length, and transparency influence customer perception of value in digital offerings enabled by AI
Angeren et al. (2022)	Quantitative	Mobile and app products	Suggests a set of revenue models to achieve optimal performance in paid and free app products
Ammirato et al. (2021)	Quantitative	Mobile and app products	Stresses that cultural tourism apps adopt well-established revenue models, such as three-party advertising and in-app transactions or a combination of them while providing suggestions to exploit mobile app technologies
Classen and Friedli (2021)	Qualitative	Manufacturing industry	Explores how cultural values influence revenue models for smart industrial services in Pacific Asia
Linde et al. (2021)	Qualitative	Manufacturing industry	Concludes that revenue models depend on close collaboration between providers and customers and stresses that it is a customer-centric, iterative, and agile process
Gebauer, Fleisch, et al. (2020)	Qualitative	Manufacturing industry	The study describes three growth paths for revenue enhancement: digital solutions commercialization, product connectivity, and establishing IoT platforms
Gebauer, Arzt, et al. (2020)	Qualitative	Manufacturing industry	The authors suggest modifications to business model elements moving from hardware plus logic, converting services into outcome-based business

(*continued on next page*)

Table 1 (*continued*)

Author	Type of Study	Industry	Contribution
			models, and collaborating with external partners
Tidhar and Eisenhardt (2020)	Quantitative	Mobile and app products	The study provides a three-revenue model activity system configuration linking value capture and value creation for App Store products
Remeňová et al. (2020)	Quantitative	Wine producing industry	The authors design a general concept of the revenue model that identifies the variables with a strong influence on revenue optimization (e.g., revenue stream, pricing, and market segment)

models, such as performance-based models (Enders et al., 2019). Additionally, aspects such as customer interest in paying for digital services (Sá et al., 2022) and their cultural orientation (Classen & Friedli, 2021) can limit the choice of certain revenue models, which in turn restricts the provision of cutting-edge digital services and impedes further digitalization. This setback reveals how little we know about the choice of revenue models (Numminen et al., 2022; Tidhar & Eisenhardt, 2020) and why some companies are still trapped in a *digitalization paradox* (Gebauer, Fleisch, et al., 2020). A central concern in this research is to *advance understanding of the factors that influence manufacturing companies in the choice of revenue models for digital services*.

3. Methods

3.1. Research context

The digitalization of the railway industry is built on two levels: a technical system that encompasses fixed infrastructure and mobile equipment, and a socio-technical system that requires information from manifold data sources and actors (Kans, Galar, & Thaduri, 2015). The digitalization of the railway industry is fueled by a wide range of digital technologies to process a sizeable flow of data (e.g., cloud computing, machine learning, and AI) and to leverage overarching digital services – namely, connected commuters, the Internet of Trains (IoTr), mobility-as-a-service, traffic control systems automation, and predictive maintenance (Pieriegud, 2018). To date, the industry continues to undergo a digital transformation (Gerhátová, Zitrický, & Klapita, 2021), altering companies' organizational and technical aspects, and necessitating modification of their value creation and value offerings (M. Jabłoński & Jabłoński, 2019).

We directed our attention to manufacturing companies in the railway industry because this sector has shown a growing alignment toward service and digital-based business models (Kans & Ingwald, 2021). Relevant insights have been garnered on the role of digitalization for business models in value creation and value delivery (Jabłoński & Jabłoński, 2019). However, the literature has been determinant in showing that insufficient attention to the value-capture dimension is limiting the scope for innovation (Lovell & Nightingale, 2016). Although it has been demonstrated how innovation can generate financial revenues in the entire railway industry (Bruckmann, Bomhauer-Beins, & Weidmann, 2015), value-driven processes in business models (Kans & Ingwald, 2021) and the exploration of value-capture dimensions are specifically missing (Tabares & Parida, 2022). The railway industry provides an intriguing context for interpreting the choice of revenue models. It represents an effort to support the transition to digital servitization that will carry the entire industry.

3.2. Research approach

Having the revenue model choice as the level of analysis, the empirical setting in which the research is conducted is built on an explorative and qualitative case study approach (Yin, 2014). The case study methodology has allowed us to retrieve insights from rich, real-life cases and to analyze complex aspects of the research topic that clearly need further theoretical development (Eisenhardt, 1989). Accordingly, we looked at several revenue model choices in two global railway equipment manufacturers. The cases offered a suitable setting for understanding the topic since both companies implement a different array of revenue models for digital services. Hence, the case study methodology provides complementary insights into the phenomena under study allowing us to contrast and compare data. By following a theoretical sampling strategy (Patton, 2014), we sampled two manufacturing companies that were representative of the dynamics and struggles of the railway industry in providing digital services.

Company Alpha is a large supplier of railway infrastructure and rolling stock equipment (e.g., trains and associated components). The company operates in approximately 30 countries, providing rail fastening and switch systems for railway operators. Revenue models identified in the Alpha case offered a *hardware-plus logic* that provides sensors and physical products (e.g., signaling systems) with software applications. The digital service combines traditional sales with fixed prices under the logic of yearly *subscription models* for software functioning. An extensive range of digital services includes digital consulting, life cycle management software, rail logistic solutions, and remote monitoring, which are combined with *subscription* and *usage-based models*. Usage models are usually presented in the form of a bundled offering (a package integrating the number of times a service can be used), determined by the choice of parameters in the digital service (e.g., the number of times per year the digital service is used).

Company Beta is a large multinational company that operates in over 60 countries and is well-known for the design, supply, and manufacture of railway equipment. Besides the manufacturing of urban transit, high-speed trains, and railway equipment, Beta offers a wide range of digital services aimed at modernizing and maintaining signaling and infrastructure systems. The company implements *subscription models* to provide digital services that support customer processes, asset life cycle management, and condition-based and predictive maintenance. Beta uses subscriptions for visualization-based digital services to identify an asset's condition and functioning. Subscription models are also used for basic services, such as remote technical support, and for e-training and customer portals. Moreover, *usage-based models* are used for specific digital services that require data visualization and interpretation, such as monitoring services. Additionally, the company implements *performance-based models* to provide solutions that aid in decision making, such as predictive maintenance services that correct failures and defects in railway operations.

3.3. Data collection

Interviews were the primary source of data collection (Gioia, Corley, & Hamilton, 2013) and were carried out over three stages between May 2022 and February 2023. In the *first stage*, we conducted open-ended exploratory interviews with academic and industry experts in the railway industry, aiming to gain a comprehensive understanding of the phenomena under investigation (Leech & Onwuegbuzie, 2008). During this stage, we conducted interviews with informants, which lasted between 45 and 60 min. These interviews helped to structure and endorse ideas obtained from the literature. The respondents were chosen based on their expertise and knowledge of the current challenges facing the industry. Concurrently, we reviewed the prior literature to better understand contextual issues and practical problems related to revenue models for digital services in the railway industry.

In the *second stage*, we utilized a case study protocol (Gibbert &

Ruigrok, 2010) to conduct semi-structured and in-depth interviews with key informants from the two participating companies. Informants included respondents from the digitalization, innovation, and service development departments. The diverse range of respondents from various fields of expertise and positions in the digital servitization of the railway industry allowed us to obtain a nuanced dataset. In parallel with this stage, we conducted interviews with the companies' customers and IT players. The interviews lasted between 60 and 90 min, and we utilized an interview guide to increase internal validity. An example of the questionnaire is shown in Appendix 1. Moreover, to maintain a well-informed understanding of the research phenomena, we conducted supplementary literature reviews.

During the *final stage*, we conducted a collaborative workshop session that involved academic, industry, and technical experts. This workshop aimed to address any remaining gaps in understanding and clarify key points on the factors that influence the choice of revenue models for digital services by manufacturing companies in the railway industry. This stage can be defined as confirmatory (Leech & Onwuegbuzie, 2008). An overview of the data collection stages, along with the company description and respondents, is presented in Table 2.

Secondary sources, such as company websites, public and annual reports, firm material, and study cases, were also included. By using and contrasting multiple sources of data collection (e.g., from different respondents and secondary sources), we were able to achieve construct validity (Gibbert & Ruigrok, 2010) in our claim to obtain qualitatively rich and in-depth insights into the real-life phenomena under scrutiny (Eisenhardt, 1989).

3.4. Data analysis

The data analysis process was based on a thematic analysis, which allows for the identification of patterns from an extensive and complex dataset (Braun & Clarke, 2006). The thematic analysis provides a means to effectively identify links between diverse analytical themes. Thus, data analysis consisted of an iterative process of comparisons and iterations to identify themes and overarching dimensions in order to develop an empirically grounded model (Gioia et al., 2013). Our empirically grounded framework consisted of three steps.

As a first step in our data analysis, we carried out an in-depth examination of the collected information (including the interview transcripts and secondary material). The data analysis consisted of reviewing the material several times to reach a deep understanding of the content (Nag, Corley, & Gioia, 2007). We developed an open-coding content analysis by interpreting and classifying common phrases, terms, labels, and words. We used in-vivo labeling to classify the emerging codes into first-order themes, describing the related experiences of informants based on their own words (Corbin & Strauss, 2015).

The second step of the analysis consisted of arranging first-order themes into distinct groups of links and patterns in line with the existing literature. An iterative approach allowed us to identify second-order themes (Nag et al., 2007), which represented a higher level of abstraction than the first-order categories. Following the validity criteria drawn from the literature, the themes were refined using the literature insights and data from primary and secondary sources.

The third step represented the highest level of abstraction of the coding process, involving the generation of aggregate themes that were built on first-order and second-order themes to achieve a grounded categorization based on theory and practice. From the data, two categories of aggregate dimensions were identified, corresponding to revenue models for digital services and the factors influencing the choice of revenue models. On the one hand, revenue models were grouped into three categories – notably, subscription, usage-based, and performance-based revenue models –unveiling different characteristics regarding payment type, risk level, and contractual orientation. On the other hand, three overarching influencing factors concerning the choice of revenue models were identified – namely, customer digital readiness, digital service sophistication, and digital ecosystem partnership. Fig. 1 summarizes the first and second-order themes and aggregated dimensions.

4. Results

This section aims to elaborate on the aggregate dimensions. To begin, we conceptualize the three revenue models identified in our data. Following this, we explain the factors that influence the choice of a particular revenue model to offer digital services. By presenting the revenue models and their corresponding influencing factors, we propose a process model or a framework that assists in the decision-making process of revenue model selection, which is discussed in section 5.

4.1. Revenue models for digital servitization in the railway industry

Different types of revenue models are utilized by railway equipment manufacturers to charge for digital services. A common revenue model is based on a *hardware-plus logic,* which consists of the acquisition of physical products with an annual software subscription for services that complement or improve the use of the physical product. Once the yearly subscription finishes, the digital service derived from the software by the customer is interrupted. Alpha's chief connected asset analyst explained: *"We have the traditional product sales. Somebody buys a component and, after that, owns it. Sometimes including the sensors and sometimes including*

Table 2
Overview of studied cases and respondents.

Company	Revenues	Company description	Examples of digital services	Data collection stages		
				Stage I: Open interviews	Stage II: Semi-structured interviews	Stage III: Collaborative Workshop
Alpha	€930 million	Rail infrastructure and technology company of rail fastening, switching, and signaling systems	Digital consulting, e-training, and education, fastening system app, life cycle management software, rail logistic solutions, remote monitoring and control systems, rail tracking	Expert 1 (3), Expert 2 (1), Expert 3 (2), Expert 4 (2), Expert 5 (1), Expert 6 (1), Expert 7 (1), Expert 8 (1) *12 interviews*	Chief connected asset analyst (1), sales and project director (1), managing director (1), head of digitalization (1), head of innovation (1), 4 customers (1 each), 3 IT service providers (1 each), 3 consulting companies (1 each), head of research center (1) *16 interviews*	6 academic experts, 4 infrastructure managers, 1 maintainer, 1 research institute, 1 consultant, 1 IT service provider *4 hours session* *14 participants*
Beta	€942.8 million	Manufacture of equipment for power plants, streetcars, rolling stock, and locomotives	Predictive maintenance platform, control and monitoring railway operation, traffic and signaling management, train scanner, and digital marketplace		RAM director (reliability–availability–maintainability) (1), methods and tools manager RAM services (1), service director (1), global head of services and sales (3), 4 customers (1 each), 3 IT service provider (1 each), 4 consulting companies (1 each), maintainer (1) *17 interviews*	

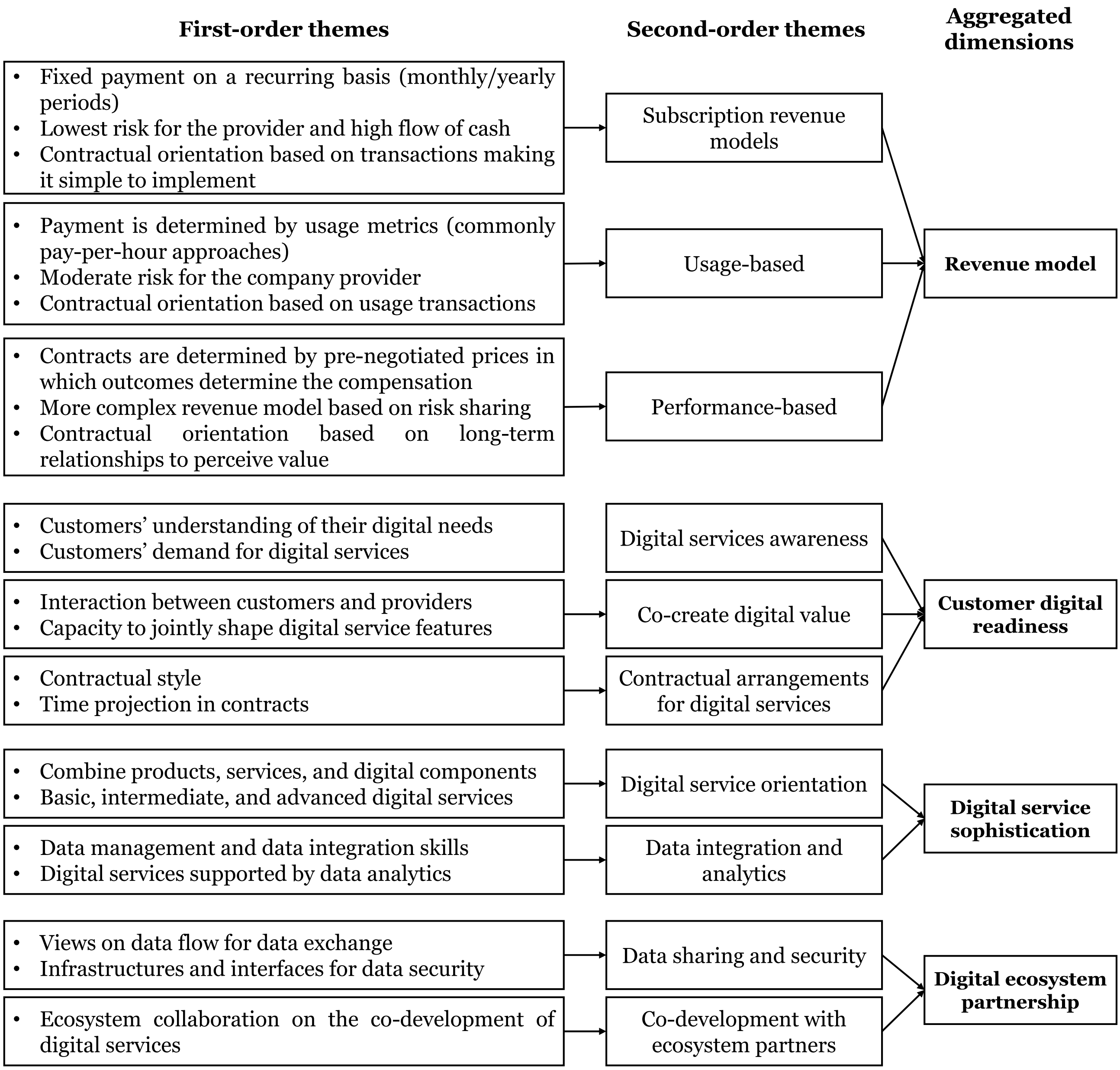

Fig. 1. Data structure and coding process.

some digital support". The hardware-plus logic combines a fixed price logic with *subscription-based revenue* model approaches, which are based on the idea of charging customers recurring fees on a regular basis. Alpha's head of innovation stated:

> *Big companies that own a network and have their maintenance fleet are mostly interested in owning the data and understanding the track condition, so they buy the sensors and the monitoring system. They would then basically consume the data that we receive through the sensors on the track, paying a fee for that. Since the changes happen on the track rather gradually, it's a long-term approach. They pay a small amount of money over a longer period to get the monitoring of the data, and they can then decide, whenever they want, to send out their maintenance crews to repair or maintain the tracks.*

Subscription models are the most basic revenue model and are characterized by their simplicity and low risk in providing a service and making it available. They represent a high cash flow for the company and the simplest payment option for the customer. Although companies may vary in the parameters for the use of subscription models with customers, Beta bases its choice on the number of connected assets involved in the provision of a digital service. Beta's global head of services sales said:

> *For these types of solutions, we move along the lines of subscription models based on the number of connected things. For example, a level-crossing machine. It could be one machine or various machines that have the ability to send data; data that is collected and analyzed. That is one model that can apply, maybe the simpler model. We can do a combination of a number of connected things versus a reduction of traffic disruptions and come up with a new digital business model that we can work with customers based on subscriptions and outcomes.*

A second group of revenue models that we uncovered is *usage-based models*. By agreeing on pre-negotiated fees, customers are charged during the time a digital service is used – the higher the use, the higher the fees. Based on the interviewee's responses, the usage-based model holds a moderate risk for the provider since the revenue streams are dependent on customer usage of digital services. If customers reduce their use of the service, this could represent a revenue gap for the company. Although this model is frequently offered under a pay-per-hour approach, customers can openly agree on using a digital service in different types of units of measure (e.g., intensity, volume, time). A correlated approach to usage-based models is utilized by companies charging customers for a bundled offer of digital services. Thus, the contractual orientation is based on the provider–customer contractual transactions related to service usage. Customers are expected to pay for new functionalities through a set-up fee that activates features of the digital service through an agreed period or through the addition of customized functionalities. Alpha's sales and project director of the signaling department outlined its approach:

> *For this type of digital service, sometimes we provide a bundle price. We assign a maintenance service contract with a customer, and we make sure that their system and software are updated. If customers want to improve the system with new functionalities, for example, we offer a bundle price, for instance, five times a year. If customers want more than five times a year, new functionalities that are added, they pay extra. Customers may also request a hotline which can also be bundled.*

However, depending on the choice for delivery of a digital service, a company can combine both subscription and usage-based revenue models, which are tailored according to the needs of their customers. Beta's head of services summarized its options:

> *In the case where customers ask for support, we have a yearly support fee, or even support by hour, but more likely a yearly support fee. If we host the data, we also rely on yearly data and so on. If we make use of the data by ourselves, it is done to lower our maintenance costs, then you don't short it, you just make the benefit yourself.*

The last type of revenue model we identified is the *performance-based* model. This model is characterized by the pre-negotiated price, in which the company's compensation can vary with the expected outcome of the digital service. To illustrate, Beta offers a digital platform that enables the remote monitoring and predictive maintenance of railway assets (e.g., trains and signaling system). Here, customers are charged for the company maximizing asset performance and reducing downtime – and not necessarily the number of connected tools. At the same time, performance-based revenue models need a long-term contract orientation because the added value is determined only after a long period of utilization.

From the interview responses, we noticed that the performance revenue model entails a risk since variable outcomes can be generated for both companies and customers over the time when the digital service is utilized (e.g., the poor performance of a digital service can result in penalties for the provider). To illustrate, Beta uses a system where customers are expected to pay according to the number of breakdowns or delays that are prevented by digital services. Beta's global head of services sales explained:

> *If in the model we have a set fee for something that has a performance, if that performance is below a certain threshold, then there will be some mechanisms in the fee that will say: this is the minimum that we pay on a monthly basis because the performance is at this minimum.*

4.2. *Influencing factors in the choice of revenue models for digital servitization*

Several insights emerged from studying the factors that influence the choice of revenue models for digital servitization by manufacturing companies in the context of the railway industry. Three aggregate dimensions arose from the analysis that laid the foundations of this study – namely, the *customer's digital readiness, digital service sophistication,* and *digital ecosystem partnerships*.

4.2.1. *Customer's digital readiness*

A common theme that emerged among the informants was related to customer digital readiness, which is interpreted as the capacity to leverage, utilize, and implement digital services. We captured three factors that determined the level of readiness: digital service awareness, co-creation of digital value, and contractual arrangements for digital service. Below, we elaborate on all three.

Our data revealed that customer digital readiness was associated with customers' eagerness to comprehend and demand digital services, engagement in the process of digital service customization, or commitment to perform contracts that allow digital service execution. In concise terms, digital readiness was associated with ***digital services awareness***, referred to as customers' understanding and comprehension of their digital needs. It demonstrates customers' propensity to exploit the full potential of a digital service, which is interpreted as the recognition of their own digital requirements in using digital services for their specific industry needs. The managing director from Alpha stated:

> *Customers have a vision for their assets and how they want to perform in terms of capacity, punctuality, safety, and reliability; therefore, they need to have a certain awareness of which digital services meet the needs of their policies.*

Thus, digital service awareness determines customer demand for digital services, as they recognize the benefits and characteristics as well as the expectations of digital servitization. Simultaneously, customers' digital readiness is associated with the ***co-creation of digital value***, recognized as the collaborative process of interaction and cooperation with providers to meet the needs and goals that digital services can deliver. Beta's global head of services sales illustrated this idea: "*Now, going to the point of which model it is that has the right fit, the model that has the right fit is the one that you identify by having many iterations with the customer.*".

A similar approach was addressed by Alpha's head of innovation:

> *It's essential for us to work together with customers because we want to really build products and services that really cling to them. Our innovation process, for example, is organized into different steps and has different criteria that we look into, that are evaluated. One of them, of these criteria, is, obviously, then customer focus.*

Value co-creation for digital servitization demonstrates a customer's commitment to work closely and iteratively with providers, participating in the generation of ideas and sharing experiences across the use of digital services. Characterized by a process of feedback and communication, value co-creation involves a two-way journey in which the providing company and the customer jointly shape the features of digital services in an iterative approach to service refinement. Customer involvement in the process of digital service provision characterizes the levels of engagement in the co-creation process, and the capacity to tailor a provider's digital offering. It also showcases the customer's capacity to communicate and select the expected outcomes of the digital service. The CEO of an IT player outlined its approach:

> *We do roadmaps with our customers so that we work with them continuously, and we help them with the digitalization process. If we see a problem and we don't have that service, then we recommend somebody else or we develop something together with the customer. Joint with our customers, we do that. It's really not our job to push [Public Customer]. I think they should push us and other companies or involve everybody to make actually that kind of role. I think there are initiatives within [Public Customer], but I think they're not so visible.*

Finally, digital readiness is associated with the type of ***contractual arrangements for digital services*** defined as the level of acceptance and capacity to implement novel forms of contractual arrangements for the provision of digital services. It reveals customers' inclination toward contractual agreements, determining the scope for digital services execution. The innovation procurement strategist from a public customer in the railway industry underscored what is needed:

We cannot implement an innovation like going from manual to digital and so forth. There are larger steps within our current contracts for performing preventive maintenance. We must follow strict regulations to contract services as we must follow a specific procurement process.

Contractual arrangements for digital servitization are also associated with the length of the contract and the type of joint relationship between customer and company. The following extract reflects the contractual conditions to which public customers in the railway industry are bound:

The railway industry needs to work more with digital servitization considering long-term contracts, what we call performance-based.… The industry needs a change. By changing contracting conditions, there would be more incentives for long-term relationships. I know that [public customer] wants to do that, but they just need support to create these kinds of contract forms in a good way.
Industry Expert, Consulting Company (Workshop)

Alpha's sales and project director from the signaling department provided a similar comparison:

The big change, as we have seen for a couple of years, is that very mature customers, which have an organization that is quite developed, try to focus now not only on the purchasing price of the system but on the lifecycle price of the solution. One key aspect of pricing is to provide the full picture to the customer and to try to minimize not only its CapEx but also its OpEx in the future.

4.2.2. Digital service sophistication

The second prominent group of factors that surfaced concerns the sophistication of the digital service, which refers to the diverse group of interdependent factors that are involved in delivering a digital service. Two factors emerged from our data in relation to digital service sophistication. We label them *digital service orientations* and *data integration and analytics.* We elaborate on them below.

Digital service sophistication is associated with the provider's capacity to harness ***digital service orientation***, defined as the ability to create, design, and leverage a combination of products, services, and digital components when providing a digital service. Digital service orientation assesses how the company utilizes smart physical products to deliver digital services ranging from basic to intermediate and advanced offerings. Basic levels of digital service orientation focus on complementary digital services that support physical products, while intermediate to advanced digital services focus on customized offerings based on availability or outcomes. The types of digital service orientation were described by Alpha's head of innovation thus:

Digitalization means that you utilize anything in terms of the IoT domain to collect some data. If you mean sensors installed is one level. We have an approach that is called "sense, see, solve," which means sensing from sensors so we can provide only that and stop there, so then the sensors can be linked to whatever the customer wants to link it to. We can see which is then offering the monitoring, so use the data to visualize it so that it is humanly interpretable. Solve is then the next level, which is then really providing the solution to solve cracks on the track that we see. There are basically three layers I will describe in that context.

Our data showed that digital service sophistication is underpinned by ***data integration and analytics***, which relates to the use of formalized data management and integration processes combined with analytics capabilities. It is defined as the ability to examine, process, and analyze data captured from physical devices and to add digital functions to optimize the use of physical infrastructure. Data interpretation is the result of a comprehensive combining of multiple data sources into a unified analysis, while data analytics use the richness of the data through advanced analytic techniques. Therefore, data integration and data analytics provide insights into the customer's data so that they can be used to benefit their operations. By using data analytics and data integration, companies are able to use computational methods to extract new information derived from identified trends and patterns captured from the data.

Basic levels of digital service sophistication utilize data integration for business intelligence purposes, such as employing data to generate reports and dashboards to support decision making. Moreover, a more proficient use of data integration leads to advanced digital services in which data is used for advanced analytics, such as employing sophisticated techniques to discover insights, make predictions, and generate recommendations for customers. Greater sophistication requires the involvement of advanced technologies, such as AI, machine learning, and automation, where consolidating and encrypting a large amount of data is required. In this regard, Alpha's ales and project director explained:

We are trying to figure out what to do about the data, and to try to transform this data into information, information that will be used to do less maintenance because we'll have a better knowledge of the systems because we'll be able to see that the failure is happening before it will happen, and so on. To do that, we are relying more and more on artificial intelligence, and this is a keyword and the password in the industry. The technologies that are used in terms of data processing and big data, machine learning, and so on, if you want them to be really useful you have to get a lot of data. When I mean a lot of data, it's really a lot of data. The key question still is, do we have enough data in the railway industry or not? This is not clear.

4.2.3. Digital ecosystem partnership

Our data shows that the focal company often needs help from ecosystem actors (e.g., railway operators, track contractors, infrastructure managers, and IT companies) to deliver a digital service. We refer to a *digital ecosystem partnership* as the extent to which ecosystem actors are willing and able to engage in the provision, integration, and delivery of digital services. A digital ecosystem partnership serves as a mechanism for the focal company to position the components of the overarching digital services across the various actors that participate in its delivery and align them with the expectations and needs of customers. We identified two critical factors that enable the focal company to do so: data sharing and security, and co-development with ecosystem partners.

Data sharing and security refers to the views that ecosystem partners have on the circulation of data flow, data sharing, and security. Liberal data sharing permits collaboration among ecosystem actors, allowing those actors to gather precise data from diverse sources that are needed to leverage accurate digital services. Some digital services require a low exchange of data with ecosystem actors. That is the case with life cycle management software, a tool that collects data from sensors and inspection systems. It requires permission for data access but needs only limited collaboration between interfaces. However, for other services, data sharing is critical. For instance, to offer digital services that improve operational efficiency on trains, the focal company must obtain data-sharing rights from the railway operators to access information on the trains and maintenance schedules, which are necessary to optimize train functioning. Alpha's head of services pointed out the obstacles:

The most important thing that we need from our ecosystem to learn is data usage… However, not many players are sharing data, and this is preventing us from designing, possibly, a better asset. It is preventing us from deriving our knowledge of the asset and their knowledge of the way the asset is degrading. Multiple actors of the ecosystem need to cooperate: original equipment manufacturer networks, maintainers, and IT players.… Since the data sets are split across these three players, we need to share information.

Besides data sharing, ecosystem partners must be willing to build adequate infrastructure systems that protect sensitive data from vulnerabilities. This issue was addressed by Beta's methods and tools manager RAM services: "*The big momentum for digitalization comes from the collaboration between actors and more clear interfaces, more mature interfaces between collaborators in the ecosystem.*" Since data is exposed to cyber-attacks, digital services require an architecture where data sharing aligns with standardized interfaces and protocols that are interoperable with other ecosystem actors. Therefore, data sharing requires an infrastructure that ensures data safety through security standards and interoperable protocols that protect data exchange. As data can be compromised, data sharing and security can be influenced by the ecosystem actors' reluctance. One of the company's customers intimated:

> *We are exposed to attacks almost every day. By securing the system even further, we lock the possibilities for digitalization even more. It's not possible to save anything in any cloud solution. Then, okay, are these actors? Are they going to have their servers in our facilities?*

Additionally, digital ecosystem partnerships are underpinned by digital service ***co-development with ecosystem partners***, which consists of the ability to work with different ecosystem actors to provide and develop digital services. The different approaches to ecosystem co-development involve exchanges and collaborations with different actors (e.g., railway operators, maintenance providers, IT players) to leverage resources and skills in order to provide digital services. Lesser digital ecosystem partnerships are prone to have digital services delivered that are disconnected from other actors in the ecosystem. The head of innovation at Alpha identified where action needs to be ongoing:

> *We have internal skills. We have internal people who develop IT but, obviously, we also use external people for that. We are currently in the phase of building up our internal IT skills. We have already had IT skills for a long time but, basically, this needs to be continuously adapted to the available technologies.*

Close cooperation with ecosystem partners to develop advanced digital services demonstrates a higher level of digital ecosystem partnership. To illustrate, Beta led the creation of a cloud-based predictive maintenance solution in partnership with global players in the tech sector including software developers, global and service consulting companies, and business services providers.

5. Framework for choosing revenue models in digital services

Based on the analysis, this study proposes a framework that describes the different steps that manufacturing companies undergo in choosing revenue models for digital services. The framework is based on themes and dimensions that emerged from empirical data analysis and theoretical insights. The sequential steps in which the framework unfolds were made consistent with previous research, which takes a relational view of digital servitization (Kamalaldin et al., 2020). This is illustrated by the framework in Fig. 2. which exhibits the key phases with each phase building on the previous one. The framework illustrates how manufacturing companies can follow four different steps in choosing a revenue model for digital services: (1) *assessing the customer's digital readiness* (e.g., digitally immature vs. knowledgeable customers); (2) *evaluating digital service sophistication* (e.g., basic vs. advanced); (3) *assessing digital ecosystem partnerships* (i.e., the extent of data exchange and ecosystem collaboration); and (4) *choosing the suitable revenue model* (subscription-based, usage-based, or performance-based model). These steps allow a company to generate an understanding of the factors to be considered in choosing revenue models. The logic of the different steps is explained below.

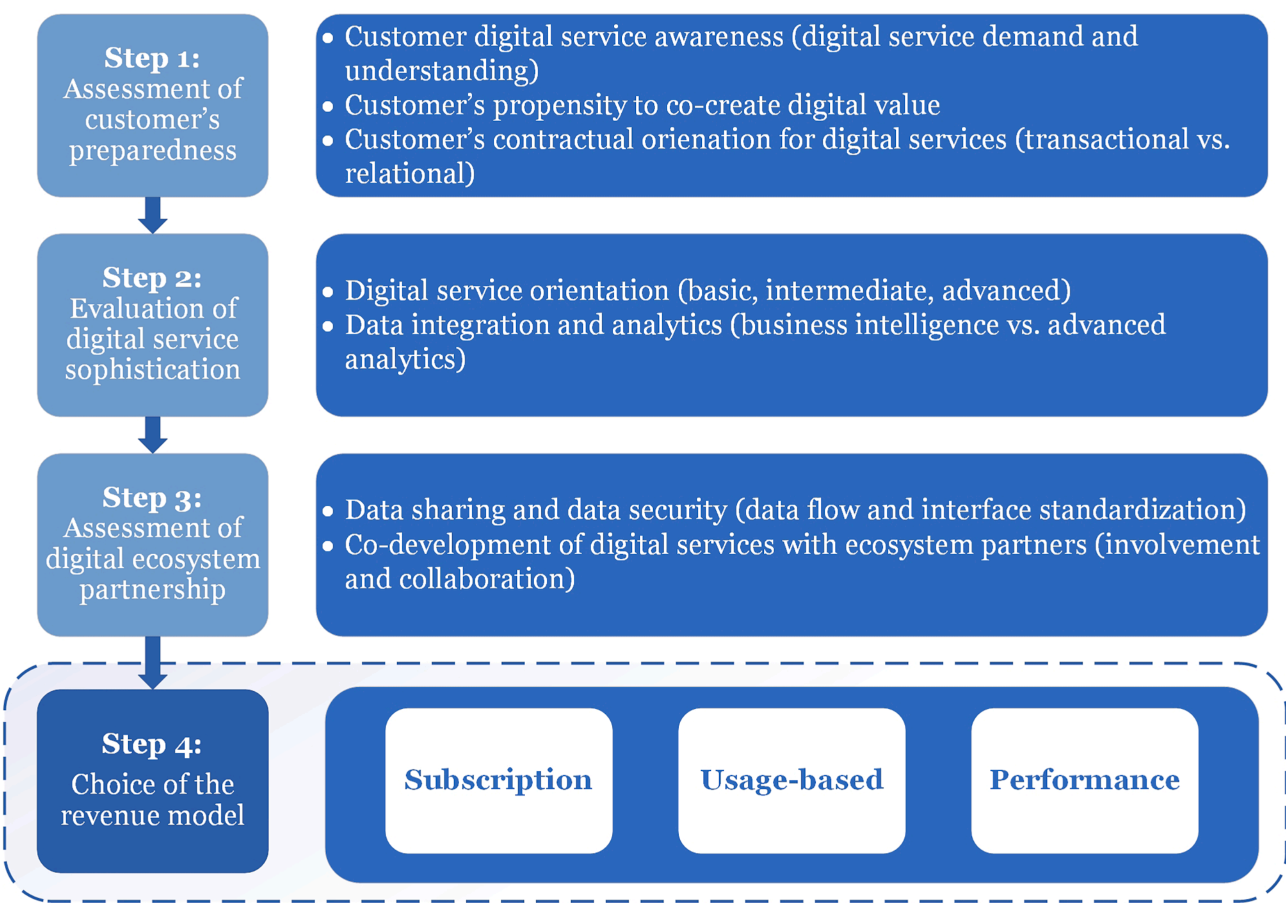

Fig. 2. Framework for the choice of revenue models for digital services.

Step 1: Assessing the customer's digital readiness. As a first step, manufacturing companies start with an overall assessment of the customer's digital readiness by analyzing three aspects: customer's digital service awareness, digital value co-creation, and contractual arrangements for digital services. After conducting the initial assessment, companies can gauge the level of customer preparedness for digital servitization.

From this diagnosis, companies are more inclined to offer digital services through subscription models to customers who have demonstrated limited understanding and scant demand for digitalization, characterized by a narrow focus on basic functions and limited customization. In this case, companies are more inclined to choose subscription models, which provide a more flexible and convenient option for customers based on transactional and short-term contracts. On the other hand, when companies identify customers who are more advanced in their understanding of digital servitization and are open to long-term, flexible contractual agreements, they can choose between usage-based and performance-based revenue models.

By evaluating customers' digital readiness, companies are equipped to determine the type of digital service that meets customers' expectations and demands. For customers who exhibit pronounced digital inexperience, a tendency toward contractual rigidity, and a reluctance to co-create value, subscription models tend to prevail as a suitable option. However, to ensure the best fit for the customer, companies should proceed with step 2, which involves gaining a more thorough understanding of the digital service sophistication required.

Step 2: Evaluating digital service sophistication. The objective of the second step is for companies to assess the digital service that meets the needs of their customer's digital readiness. Thus, digital service sophistication is evaluated according to the digital service orientation (e.g., basic, intermediate, and advanced digital services) and the type of data integration and data analytic capabilities required for its provisioning (e.g., data integration for business intelligence versus data integration for advanced analytics).

Product digital support, help desk, and e-training, which are examples of basic digital services, usually go hand in hand with subscription revenue models. Moreover, subscription models are offered with virtual services that are used to monitor, visualize, and provide real-time diagnostic information on physical assets. Subscription models are akin to services delivered through apps whose main target is to provide modeling, simulation, and planning of asset management. The sophistication of the digital service is associated with data integration to enhance customers' business intelligence.

In the case of customers opting for higher customization levels, usage-based revenue models are more desirable. One of the main differences with the previous model is the implementation of metrics that could alter the sophistication of digital services. Typical digital services are associated with guaranteeing the customer's asset availability or monitoring systems focused on asset conditioning. To give an example, with intermediate digital services, such as smart-lock systems that allow real-time digital access to asset conditions, usage-based is the favored choice of revenue model, encouraging companies to charge flexible fees in relation to the number of locks used and the time for digital service provision.

Performance-based revenue models are more commonly used to provide advanced digital services, and their sophistication is linked to a company's need to incorporate expertise into data integration and analytics. These advanced digital services typically involve performance metrics related to problem resolution and contingency responses, which require higher levels of risk and reward-sharing interactions between the company and its customers. An example of a company's choice of a performance-based revenue model derived from a more sophisticated digital service is the implementation of smart data analytics and predictive or smart maintenance solutions. These digital services incorporate cutting-edge technologies, such as AI and machine learning algorithms, to predict failures in the system or reduce downtime, thereby enhancing the customer's business intelligence performance.

After evaluating the sophistication of the digital service, companies can proceed to determine whether several actors of the ecosystem need to participate in the flow of data exchange or the co-development of digital services.

Step 3: Assessing digital ecosystem partnerships. In the third step, manufacturing companies sketch a broader picture of the choice of revenue models by evaluating the need for data exchange and data security between ecosystem actors and the tendency for them to collaborate in the co-development of digital services. The delivery of digital services may involve data sharing between the company and its customers. However, in other cases, it may require the involvement of ecosystem actors. Basic digital services typically involve data sharing in a one-to-one interaction between a company and its customers. In such cases, subscription and usage-based models are appropriate revenue models, with no requirement for ecosystem actors. The usage-based model is particularly apt when the capture of higher added value is desired by customers. Thus, when ecosystem actors participate in the provision of a digital service, subscription and usage-based models may not be sufficient.

Performance-based revenue models are a more appropriate option when ecosystem actors are engaged in the delivery of a digital service. When customers present a higher demand for sophisticated digital services, a substantial exchange of data among suppliers, partners, and complementors (e.g., infrastructure managers, rolling stock owners, and railway operators) becomes necessary. The joint capture of data between actors in the ecosystem represents a higher risk in operations, which is derived from the need to implement interoperable protocols, security standards, and multi-actor data agreement ownership. Thus, under these ecosystem conditions, performance-based is the most appropriate choice of a revenue model. Broader collaboration and discussion of the benefits of all parties involved are also essential. This requires significant intervention by ecosystem actors – otherwise, the choice of the revenue model can become risky and unprofitable. Furthermore, it should be noted that simply having a highly collaborative digital environment is not enough to justify the adoption of performance-based revenue models. This is particularly true if customers are not yet prepared to understand their digital needs or lack the capacity to integrate higher levels of digital service sophistication. In such cases, subscription and usage-based models may be more appropriate options.

Step 4: Selecting a revenue model. Once the company proceeds with the different diagnoses, the final step consists of verifying and selecting a revenue model that meets the overarching needs concerning customers' digital readiness, digital service sophistication, and digital ecosystem partnerships. As noted, there is no optimal choice of revenue model because the main target of the three assessments is to determine which revenue model is most feasible to address a company's needs and expectations for a digital service. The steps are designed to provide insights into how companies can make a more informed decision on which revenue model is more appropriate for digital services.

Here, a common challenge is to capture those elements that are essential in assessing all three steps because they are frequently interlinked. It is therefore vital that companies make a viable diagnosis of their customers' digital readiness, consider the sophistication of the digital services to be delivered, and evaluate the digital involvement of their ecosystem partners. It is entirely likely that the needs of one customer and its ecosystem will not be identical to any other. Therefore, the choice of revenue model will vary accordingly.

6. Discussion

6.1. Theoretical implications

The present study has sought to advance understanding of the factors that influence manufacturing companies in choosing revenue models for digital services. Due to the transitioning process that manufacturing companies face when moving from selling stand-alone products to advanced product–service–software offerings (Huikkola et al., 2022; Kohtamäki et al., 2021), a deeper understanding of how to make positive profit gains from this transition needs to be developed. Our theoretical contributions relate principally to the emerging literature on digital servitization with a specific focus on revenue models.

As a first theoretical contribution, the present study *extends our knowledge of the digital servitization literature by offering an in-depth perspective on the value-capturing dimension of digital services.* The results of this study demonstrate that manufacturing companies can choose between various options for revenue models. Therefore, we contend that there is not a single or unique choice of revenue model. Centrally, our finding reveals that being able to select an appropriate revenue model for digital services is of critical importance. Thus, we augment the literature on revenue models for digital services by showing that each model contains characteristics that have been overlooked in previous studies (Gebauer, Arzt, et al., 2020; Linde et al., 2023). Revenue model characteristics relate to the payment type (e.g., payment frequency), risk level (e.g., from risk free to risk sharing), and contractual orientation (e.g., transactional vs. long-term approaches). This study reveals that the subscription model is the simplest and less risky option to capture value for digital services, where customers can be charged over a recurring period based on transactional contracts. Usage-based revenue models represent a moderate risk because companies can perceive a potential gap in the flow of revenues in an arrangement where payments are settled through pre-negotiated fees in a unit of measure logic (mostly hourly-based metrics). Performance models are seen as the most complex because they require acute interactions with customers and ecosystem partners, holding more risk and, at the same time, greater value-adding potential in the digital servitization pathway.

Second, *we contribute to the digital servitization literature by identifying and describing influencing factors that mitigate the "digitalization paradox" for manufacturing companies offering a wide range of digital services.* These factors are vital to understand because they influence the choice of revenue model. In this regard, our study identifies and conceptualizes three influencing factors – namely: a) *customer digital readiness,* which refers to the customer's digital service awareness, the customer's willingness to co-create digital value, and the customer's contractual arrangement propensity for digital services; b) *digital service sophistication,* which relates to the orientation of digital services and data integration and analytics; and, c) *digital ecosystem partnerships*, which refer to the processes of data sharing and security, and digital service co-development with ecosystem partners. By proposing a four-step framework that informs the choice of revenue models for digital services (Fig. 2), we extend previous research that contends that a relational view of digital servitization is crucial (Kamalaldin et al., 2020). Specifically, we elucidate how a deeper exploration of the customer–provider relationship is the starting point to strategically address and overcome the digital servitization paradox and remain profitable (Gebauer, Fleisch, et al., 2020).

Third, *we contribute to the pricing and revenue model literature by providing insights that go beyond the internal view of companies offering digital services*. Although the pricing literature has been the core of revenue-model discussion in digital servitization, our research provides a more comprehensive view, taking into account the relevance of involving ecosystem actors – a perspective that is currently being addressed in the literature (Bencsik et al., 2023). This study focuses further attention on the ecosystem dimension of digital servitization (Huikkola, Kohtamäki, & Ylimäki, 2022; Kohtamäki, Parida, Oghazi, Gebauer, & Baines, 2019, 2021, 2022), an analysis traditionally relegated to the relationship between the company and the customer (Linde et al., 2023). This is particularly relevant in the case of performance-based revenue models, where the digital ecosystem partnership is critical in choosing this type of model. As noted in our study, to provide advanced product–service–software offerings, the ecosystem in which a digital service is embedded requires a high flow of data sharing and the construction of data security interfaces. As more actors are engaged in this flowing exchange, ecosystem partners are expected to carry out digital services through co-development practices that adopt a more collective stance and have greater complexity. By deepening the ecosystem dimensions, our findings reveal a much more holistic view of revenue models than previous studies.

6.2. Managerial implications

Although digital services are rapidly developing, our study attests that companies still face challenges in selecting appropriate revenue models that align with their digital servitization goals. Consequently, our research carries significant implications for managers involved in this process. When moving from stand-alone products to combinations of product–service–software offerings, the first implication relates *to the need to broadly understand the nature and characteristics of overarching revenue models utilized for the adequate provision of digital services*. By clarifying the distinctive features of subscription, usage-based, and performance-based revenue models, companies choose revenue models that are in line with the value-capture dimensions of their business models.

The second managerial implication is to *develop a progressive understanding of the factors that influence a company's choice of revenue model.* To facilitate the choice of revenue models for digital services, our framework guides managers through the process that leads to that choice (Fig. 2). By closely looking at the customer's digital readiness, digital service sophistication, and digital ecosystem partnerships, managers can support their value-capture decisions and make adjustments to their offerings, as necessary. Managers should be cognizant that revenue models are subject to constant modification, given that certain underlying factors may change over time. The implication is that the choice of revenue models can always be altered. Our findings seek to aid manufacturing companies in selecting revenue models, enabling them to gradually accelerate the digital servitization transition over the long run.

Finally, we encourage managers to *increase multi-actor participation in digital servitization processes* for revenue model choice. It is important to note that the selection of revenue models for a suitable process on the value-capture dimension depends on the collaboration between ecosystem actors because their engagement facilitates digital servitization for processes, such as co-creation, digital service creation, and risk sharing. We provide managers with a multiple-choice revenue model logic in which companies are encouraged to explore different mechanisms and test them with customers and ecosystem actors. Manufacturing firms must build on their experience and legacy to help other actors in an ecosystem to transition toward pure digital servitization. In other words, a company portfolio should have sufficient flexibility to allow for negotiation with multiple actors and to bring about change when applying a business ecosystem approach.

6.3. Limitations and further research

As with all research, this study has several limitations that need to be considered when interpreting the results. Firstly, our framework explores the choice of revenue models based on insights from two manufacturing companies in the railway industry. Future studies could test the framework's relevance and applicability to manufacturing companies in other industries in order to validate or extend our findings. Secondly, while we focused on three overarching revenue models for digital services – notably, subscription-based, usage-based, and performance-based – future research could devote further attention to other types of revenue model. To illustrate, "freemium" and other variations of "free of charge" services for end-user configurations are revenue models that were not identified in our sampling companies, but they can be explored in other industries. Finally, although we identify a relevant set of factors that influence the choice of revenue models for digital services in manufacturing companies, our research may benefit from refinement and adjustment, thereby warranting attention from future scholars. Developing a weighting system to determine the most critical factors that influence the choice of revenue models could hasten the transition toward digital servitization in the future.

CRediT authorship contribution statement

Sabrina Tabares: Methodology, Investigation, Formal analysis, Conceptualization, Data curation, Writing – original draft, Writing – review & editing. **Vinit Parida:** Supervision, Resources, Methodology, Data curation, Conceptualization, Funding acquisition, Investigation, Project administration, Writing – original draft, Writing – review & editing. **Ivanka Visnjic:** Data curation, Formal analysis, Methodology, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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