Journal of Business Models (ISSN: 2246-2465), Vol. 13, No. 2, pp. 31-70

JOURNAL OF BUSINESS MODELS

Designing Outcome-based Contracts for Machine Manufacturers: A Taxonomy of Decision Criteria

Authors

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Abstract

Purpose: Machine manufacturers can enhance their revenues by providing outcome-based contracts (OBCs) that focus on delivering the outcome associated with machine performance. Although OBCs are gaining traction, structured taxonomies of decision criteria to guide their design remain underdeveloped.

Methodology: This study conducts a systematic literature review of academically reported industrial cases to develop a taxonomy of decision criteria for designing OBCs.

Findings: The proposed taxonomy identifies 20 decision criteria that significantly influence lifecycle profits and risk management in OBCs. These criteria mainly relate to ownership responsibilities, and the payment model. The study also outlines its theoretical and practical contributions.

Originality: The paper systematizes existing academically reported industrial cases and clarifies OBC-specific business model decision criteria from the perspective of machine manufacturers. It thus future OBC researchers to describe and analyze OBCs with greater depth and precision.

Practical implications: The taxonomy provides a practical tool for managers of machine manufacturers to design OBCs more effectively.

Keywords Servitization, Outcome-Based Contracts, Manufacturing, Industry 4.0, Business Models, Product-Service Systems

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Please cite this paper as Mittal, S., Menon, K., Khan, M.A., Kärkkäinen, H., Wuest, T., Uuskoski, M (2025). Designing Outcome-based Contracts for Machine Manufacturers: A Taxonomy of Decision Criteria, *Journal of Business Models*, Vol. 13, No. 2, pp. 31-70, DOI 10.54337/jobm.v13i2.7850.

1. Introduction

The notion of service offerings in the business models (BMs) of manufacturing enterprises have radically changed with the advent of Industry 4.0 technologies such as IoT, data analytics and cyber-physical systems (Mittal, Khan, Purohit et al., 2020; Zancul, Takey, Barquet et al., 2016). Traditional investment-based models primarily involve selling machines, whereas outcome-based contracts (OBCs) focus on delivering the outcomes such as availability, output, and economic savings associated with machine performance (Uski, Kukkamalla, Kärkkäinen et al., 2022; Ziaee Bigdeli, Baines, Schroeder et al., 2018; Lazzarotto, Borchardt, Pereira et al., 2014; Baines and Lightfoot, 2013). OBCs offer several advantages for manufacturers, including higher revenues and stronger customer relationships (Eggert, Hogreve, Ulaga et al., 2014; Baines and Lightfoot, 2013; Smith, Plowman, and Duchon et al., 2009). However, there remains a gap in the scientific literature regarding the conceptual models or frameworks that can help both researchers and practitioners in understanding and designing OBC BMs. Specifically, such frameworks are needed to help- a) researchers conducting an in-depth analyses of OBCs within machine manufacturing context characterized by long product lifecycles, the critical role of data analytics, and high product costs; b) machine manufacturers (MMs) operating in B2B markets, address key decision points that determine the feasibility, profitability, and risk profiles of OBCs over extended lifecycles.

Several decision criteria (DCs) and their associated options significantly impact lifecycle profits and risks that MMs must consider while designing or refining their OBCs (Hypko, Tilebein, and Gleich, 2010; Lay, Schroeter, and Biege, 2009). While MMs operate with sophisticated and expensive machines (Rapaccini, 2015), offering OBCs involves a major shift in the ownership of machines and related assets such as data and software, and responsibilities such as installation, maintenance and logistics (Uuskoski, Mittal, Menon et al., 2023; Korkeamäki, Sjödin, Kohtamäki et al., 2022). Although, prior research has discussed approaches to risk management (Dahmani, Boucher, Gourc et al., 2020), these do not directly address OBCs. Thus, offering OBCs can become risky for MMs, compared to offering investment-based models. To mitigate such risks MMs may involve third parties that assume machine ownership, thus reducing capital exposure, but requiring MMs to share a substantial amount of their profits with the third party for a defined period (Uuskoski, Mittal, Menon et al., 2023).

The systematic design and characterization of OBCs from the perspective of MMs remains a relatively novel research domain. Section 2 reviews the relevant literature and positions our work within this context. Notably, only two previous studies (Hypko, Tilebein, and Gleich, 2010; Lay, Schroeter, and Biege, 2009) have proposed conceptual models for the detailed design and configuration of service-based BMs. Both the studies proposed seven critical DCs related to ownership (of machine), responsibility-for maintenance and operational personnel, type of payment model, location of operation, and exclusiveness of use. However, both studies were published almost 15 years ago, before the widespread adoption of Industry 4.0 technologies. At that time the role of data, analytics and sustainability, particularly in relation to long machine lifecycles, was far less prominent. Consequently, those models overlook critical business and earnings dimensions, including data and software ownership, responsibilities for modernization and refurbishment (Paiola and Gebauer 2020; Paiola, Schiavone, Grandinetti et al., 2021; Paiola, Agostini, Grandinetti et al., 2022; Rymaszewska, Helo, and Gunasekaran, 2017).

Given these developments, existing conceptual models for OBCs and their systematic design of OBCs from MM perspective remain incomplete. Existing studies focus on individual criteria rather than a comprehensive set of interrelated DCs that jointly affect lifecycle profits and risks. Moreover, insights from other industries, such as B2C or software contexts, have limited applicability to MMs who face distinct set of challenges in implementing technologies and transitioning from product-based to service-based offerings (Ulaga and Loveland, 2014; Qvist-Sørensen, 2020). For example, MMs assume unique risks associated with machine ownership and operational tasks, such as logistics, manufacturing, maintenance and installation (Adrodegari, Bacchetti, Saccani et al., 2018). Additionally, MMs cannot leverage economies of scale in OBCs to the same scale as software firms. When offering outcomes such as cubic meters of compressed air or energy savings instead of physical machines, scalability depends on the outcomes delivered rather than the units sold (Gebauer, Haldimann, and Saul, 2017). Unlike software providers, for whom marginal costs of additional output are negligible, OBC-based machine builders incur significant costs related to energy, raw materials and maintenance (Gebauer, Haldimann, and Saul, 2017).

Accordingly, this study aims to develop a taxonomy of critical DCs that influence lifecycle profits and risks in OBCs, thereby supporting MMs in systematically designing and refining their OBC offerings. To achieve this research objective, we address the following research question (RQ).

RQ: What are the critical decision criteria (DCs) for designing outcome-based contracts (OBCs) for machine manufacturers (MMs)?

We conducted a systematic literature review and identified eighteen articles published in peer-reviewed journals, containing fifty-four relevant MM case studies. Based on these studies, we systematically extracted, and structured a taxonomy, comprising twenty critical DCs relevant to OBC design. Each DC represents a key decision point that organizations must consider when developing or refining OBCs and related BMs. The identified DCs were considered critical as they significantly influence the lifecycle profits and risks. Additionally, each DC also includes multiple options (e.g., the criterion ownership of machine can have options such as MM, customer, leasing bank/financial institution). Together, these DCs and their options determine an organization’s lifetime profitability and risk exposure. To link the identified DCs with broader BM literature, and to highlight the theoretical contributions and practical relevance of the proposed taxonomy, we developed a relational matrix connecting the identified DCs with the core components of the business model canvas (BMC). This analytical step clarifies how strategic and operational decisions inherent in OBCs align with broader business model configurations. Furthermore, we synonymously use machines to refer to both machines and equipment in this article.

The remainder of this article is structured as follows. Section 2 presents the theoretical background, Section 3 details the research methodology. Section 4 reports the results, and Section 5 discusses the results. Section 6 presents the conclusions, limitations, and future work.

2. Theoretical Background

2.1 Outcome-based Contracts (OBCs)

The servitization journey of MMs can be explained through the concept of product-service systems (PSS), which include product-, use-, and result-oriented BMs, that are offered to make the gradual transition from selling products to offering services (Tukker, 2004). In product-oriented BMs, customer purchase and own machines while paying separately for additional services such as maintenance and repair. Use-oriented BMs include renting and leasing services, where the customer pays to use the machine, while ownership remains with the manufacturer (Tukker, 2004). In contrast, result-oriented BMs link payments to achieve the outcomes, with machine ownership typically retained by the manufacturer. Result-oriented BMs are also referred to as performance-based contracts (Liinamaa, Viljanen, Hurmerinta et al., 2016), performance-based logistics, and OBCs (Grubic and Jennions, 2018; Ng and Nurudupati, 2010).

Furthermore, result-oriented BMs can be categorized as activity management/outsourcing services, pay-per-service units, and functional results (Tukker, 2004). In activity management/outsourcing services, some activities within an organization are outsourced to a third party, e.g., catering services (Tukker, 2004). In pay-per-service units, the customer pays for: i) the number of hours they use the machine referred to as pay-per-use (Uski, Kukkamalla, Kärkkäinen et al., 2022; Gebauer, Haldimann, and Saul, 2017) and availability OBC (Böhm, Backhaus, Eggert et al., 2016; Grubic and Jennions, 2018); and ii) the number of output units produced by the machine referred to as pay-per-output (Uski, Kukkamalla, Kärkkäinen et al., 2022) and output OBC. Finally, the functional results are related to the amount of added value (e.g., energy savings) and economics created by the machine for the customer. Recent studies have used the terms pay-per-outcome (Uski, Kukkamalla, Kärkkäinen et al., 2022) or economic OBC (Böhm, Backhaus, Eggert et al., 2016; Grubic and Jennions, 2018) to denote functional results.

2.2 Business Model Canvas and the Concepts of Value Creation, Value Delivery, and Value Capture in the Context of OBCs

2.2.1 Business Model Canvas

The BMC, developed by Osterwalder and Pigneur (2010), is one of the most widely used conceptual tools for describing, designing, and innovating BMs. The BMC organizes the logic of how an organization creates, delivers, and captures value into nine interrelated components:

1. Key Partners – the external organizations and entities that provide resources, activities, or market access essential to delivering the value proposition.
2. Key Activities – the most important activities an organization must perform to operate successfully and deliver value.
3. Key Resources – the assets, capabilities, and intellectual property required to create and deliver value.

4. Value Propositions – the bundle of products and/or services that create value for a specific customer segment.
5. Customer Relationships – the types and intensity of relationships established with each customer segment.
6. Channels – the means by which a company communicates with and delivers value to its customers.
7. Customer Segments – the distinct groups of people or organizations the business serves.
8. Cost Structure – all costs incurred to operate the BMs.
9. Revenue Streams – the cash inflows generated from each customer segment.

By mapping the recognized DCs to the BMC components, we make explicit how each design decision influences the BMC components and, through them, the mechanisms of value creation, delivery, and capture.

2.2.2 Value Creation, Delivery, and Capture in the BMC

In BM literature, the BMC components can be further grouped under three overarching value dimensions. Value creation refers to how an organization develops and combines resources, activities, and partnerships to produce offerings that meet customer needs. In the BMC, value creation is primarily embedded in Key Partners, Key Activities, Key Resources, and Value Propositions. Value delivery focuses on how the value created is transferred to the customer, ensuring the value effectively reaches and satisfies them. Within the BMC, this dimension is primarily captured through Customer Relationships, Channels, and aspects of Value Propositions. Value capture refers to how the organization realizes financial returns from the value delivered, through monetization and cost management. In the BMC, this is concentrated in Revenue Streams and Cost Structure but also shaped by contractual terms embedded in other components.

In the scientific literature, OBCs are frequently referred to as BMs (Grubic and Jennions, 2018; Ng, Maull and Yip, 2009) and related contracting arrangements, even though they do not encompass all dimensions of a BM. For instance, when analyzed through BMC lens, most OBC-related studies primarily focus on the value proposition, while neglecting dimensions such as Cost Structure, Key Partners, and Customer Segments. In this study, OBCs are conceptualized as contractual mechanisms that enable customers to pay based on delivered outcomes (Ng, Maull and Yip, 2009), rather than machine ownership. Accordingly, this paper, identifies the critical DCs that influence the lifecycle profits and risks associated with OBCs and proposes a taxonomy of DCs that can support MMs in designing their OBCs. The following section reviews prior OBC-related research streams and connects them to the detailed conceptualization and design of OBCs.

2.3 Overall concept design of OBC and related literature

Earlier research on the design and characterization of OBCs for MMs remains limited. However, a number of studies have explored broader aspects of OBC design and configuration. For instance, prior research has examined the readiness of MMs to design and offer OBCs (Adrodegari, Saccani, Kowalkowski et al., 2017; Ziaee Bigdeli, Baines, Schroeder et al., 2018; Glas, Henne, and Essig, 2018) and investigated the capabilities, barriers, and enablers influencing their implementation (Bock and Weiner, 2018; Selviaridis and Wynstra, 2015). Common challenges identified include high machine ownership costs, long payback periods, IP protection, ensure promised outcomes, and the continuous pressure for innovation (Uuskoski, Mittal, Menon et al., 2023).

An earlier study (Adrodegari, Bacchetti, Pinto et al., 2015) examined revenue-related factors relevant to PSSs focusing on MMs in the machinery, automation, and transportation industries. Other studies have demonstrated the use of BMC for designing various servitization BMs, and a few recent previous studies have applied the BMC to PSSs and OBCs (Barquet, de Oliveira, Amigo et al., 2013; Adrodegari, Saccani, and Kowalkowski, 2016; Adrodegari, Saccani, Kowalkowski et al., 2017; de Oliveira, Mendes, Albuquerque et al., 2018). BMC can be considered a design approach for the overall concept-phase design of all diverse types of BMs. However, when moving from conceptual to detailed design of OBCs, the BMC and other generic frameworks fall short. It is because the generic nine BMC components lack the specificity needed to address OBC-related design decisions and their interdependencies.

Therefore, while the BMC is suitable for generic BM conceptualization, detailed OBC design requires additional, academically grounded decision-support mechanisms. Such support could take the form of a taxonomy of critical OBC design questions linked to BMC components, or other structured typologies, patterns, and configuration tools that guide practitioners in making informed, OBC-specific design decisions.

2.4 More detailed design and configuration of OBCs and related literature

Two prior studies proposed (Hypko, Tilebein, and Gleich, 2010; Lay, Schroeter, and Biege, 2009), developed a PSS-related conceptual model consisting of seven critical DCs. These studies were conducted before the emergence of Industry 4.0 technologies and before sustainability concerns became central to manufacturing. The identified criteria they considered were deployed as descriptive parameters to design the umbrella of service-based models (e.g., leasing, full service contracts, performance-based contracting, PSS, and product-life extension services) for all manufacturing industries dealing in B2B (Lay, Schroeter, and Biege, 2009). They were also adopted to present a conceptual model for designing OBCs (Hypko, Tilebein, and Gleich, 2010) for both independent service providers and MMs. The seven OBC DCs proposed by previous studies were *ownership (of machine) during the contract period*, *ownership (of machine) after the contract period*, *responsibility for maintenance personnel*, *responsibility for operational personnel*, *type of payment model*, *location of operation*, and *exclusiveness of usage*.

Overall, these studies (Hypko, Tilebein, and Gleich, 2010; Lay, Schroeter, and Biege, 2009) clarified several novel BM concepts in servitization, especially the OBC- type of outcome-based BMs. They were among the first to systematically organize OBC design-related DCs, typologies and frameworks. Their work specifically targeted manufacturing industries and offered structured approaches for the detailed design of OBC BMs. Based on the frameworks created, the prior studies also empirically demonstrated and analyzed new service-based business concepts, thereby providing a foundation for classifying emerging OBC-related models within manufacturing B2B contexts. Their intention was also to provide decision-makers in manufacturing companies with a concrete approach for structuring and designing new service-based business concepts (Lay, Schroeter, and Biege, 2009), and in the case of Hypko, Tilebein, and Gleich (2010), to specifically guide the design of OBCs. Building on these seminal contributions, the present study extends their findings by identifying and analyzing additional major DCs relevant to the detailed design of OBC for MMs.

2.5 Decision Criteria in Xerox's Outcome-based Contracts

A classic example of OBCs can be found in Xerox's transition from selling copy machines to selling the outcome generated from the copy machine, i.e., the number of copies produced (Baines, Lightfoot, Evans et al., 2007). When they were selling the copy machine, the *ownership of machine* belonged to the customer, and the customer was also responsible for monitoring the machine, taking care of consumables such as copying ink and paper, as well as disposing of the machine in the end of the life cycle. However, when they started delivering the outcome, Xerox owned the machine (DCs-*ownership of machine during and after the contract*), and the payment by customer was based on the number of copies (payment model) delivered from the machine. Similarly, Xerox was *responsible for both the operations and maintenance personnel* required to run the machine. Moreover, the *location of operations* was customer premises and only one customer was using the machine. In addition, Xerox also took responsibility for monitoring the consumables and was penalized when the copier was not working. With the help of Xerox's OBCs we may see how the Xerox considered the DCs suggested by previous studies, (Hypko, Tilebein, and Gleich, 2010; Lay, Schroeter, and Biege, 2009), and we may also observe that this list of DCs is not exhaustive.

2.6 Criticality of Decision Criteria in Designing Outcome-based Contracts

A shift from investment-based to service-based BMs raise a major concern regarding lifecycle profits and risks management from the perspective of MMs (Uuskoski, Mittal, Menon et al., 2023). This is because in investment-based BMs a major source of earnings is derived from the selling of the machine, whereas in service-based BMs like OBCs, delivering service(s) or outcome is central (Bock and Wiener, 2018). OBCs which focus on delivering specific outcomes or results rather than just providing a product or service, inherently shift even considerable part of many risks from the buyer to the supplier (Uuskoski, Mittal, Menon et al., 2023). If the promised outcome is not delivered, the MM will not make earnings. Furthermore, offering services based on BMs through OBC BMs, is more complicated, because the MMs may also take responsibility for many other activities that have not usually been centrally their *responsibility, such as personnel required for operations and maintenance* of machine and sometimes even the delivery and logistics for raw materials (Uuskoski, Mittal, Menon et al., 2023; Galvani et al., 2022; Korkeamäki, Sjödin, Kohtamäki et al., 2022; Hypko, Tilebein, and Gleich, 2010; Lay, Schroeter, and Biege, 2009).Without a taxonomy of critical DCs, inexperienced MMs might miss crucial decision points impacting their lifecycle profits and risks, and jeopardize the success while developing their OBCs. Furthermore, in the absence of knowledge about such DCs, MMs might not be informed of the risk mitigation strategies, such as third-party or a leasing bank owning the machine (Uuskoski, Mittal, Menon et al., 2023). Therefore, in the current article we plan to perform a state-of-the-art review of the critical DCs that will assist MMs in effectively designing their OBCs.

3. Methodology

A systematic literature review was conducted following Fink's (2019) process model, which involves the following steps: selecting research questions, selecting article databases, choosing keywords, applying practical screening criteria, applying methodological screening criteria, conducting the review, and synthesizing the results. The final sample consisted of qualitative case studies on OBCs relevant to the MMs. The underlying research methodology, including the research questions, search strings, databases, and inclusion/exclusion criteria, is summarized in Table 1 and explained in more detail below.

Topic	OBCs for MMs
Research Question	What are the critical criteria for designing outcome-based contracts for machine manufacturers?
Search process and databases	Five search steps - Scopus database - Web of Science database - Literature review articles - Backward and forward search of references - Complementary articles (Google Scholar and/or authors own knowledge)
Keywords and search string	("servitization" OR "pay per use" OR "pay per output" OR "pay per outcome" OR "outcome-based" OR "performance-based" OR "performance-based logistics" OR "performance-based contract" OR "product service systems" OR "product service systems business model" OR "result oriented business model" OR "pay per service" OR "functional result") AND ("manufacturing" OR "manufacture" OR "manufacturer") AND ("case" OR "case study" OR "case studies")
Inclusion criteria	- scope: studies focused on OBCs in a B2B context involving machine manufacturing industries - type of research: qualitative (single or multiple) case study articles - source: journal articles - language: English
Exclusion criteria	- scope: studies where manufacturers sell the machine upfront and have additional services - type of research: quantitative case study articles and theoretical studies - source: conference articles, white papers, and non-academic articles - language: any language other than English

Table 1. Research methodology

After selecting the research topic and defining the research question, we chose Scopus and Web of Science (WOS) as our primary databases, because they are the most comprehensive databases for scientific literature with established quality assurance (Chadegani, Salehi, Yunus et al., 2013). Although most of the articles are available in both databases, there are articles that are present in one of these databases and not in the other. We complemented the search by adding additional articles from Google Scholar because at times, there are articles that are not present in both Scopus and WOS; however, they are present in Google Scholar (Falagas, Pitsouni, Malietzis et al., 2008). Given that Google Scholar does not have rigorous quality screening for Scopus and WoS, we employed a critical assessment before including an article from Google Scholar in the pool of articles. In addition, review of articles from the authors' own knowledge as well as forward and backward reference searches were performed to identify articles relevant to our research. Various academic resources report and support the concept of comprehensive search strategies, including backward and forward searching (e.g., Briscoe, Bethel, and Rogers, 2020; Gough, Oliver and Thomas, 2017). These techniques ensure the comprehensiveness and depth of the literature search, which is a cornerstone of systematic reviews. Fink's process advocates for thorough literature searches, and while not explicitly detailing related methods, the underlying principle of conducting exhaustive searches aligns with the inclusion of backward and forward searching techniques. Incorporating backward and forward searching into a systematic literature review process aligns with our goal of ensuring that the review captures the full extent of the existing evidence on a topic.

In the next step, we developed a search string using relevant keywords. While choosing the keywords, we restricted ourselves to our research question. Therefore, we combined the search terms related to OBCs (e.g., servitization, outcome based contracts, performance based contracts, performance based logistics, pay per use, pay per output, pay per outcome, and product service systems), manufacturing (e.g., manufacturing, manufacture, and manufacturer), and case studies (e.g., case studies, case, and case study).

Next, we applied the practical screening based on the inclusion and exclusion criteria summarized in Table 1. In terms of scope, we included only those articles that focused on OBCs, in B2B context involving machine, equipment, or capital goods manufacturing companies. On the other hand, we excluded the articles that contained case studies of manufacturing companies that sell machines upfront and provide additional services. In terms of research types, we included only the articles that are qualitative in nature and contain single or multiple case studies with sufficient detail and depth. On the other hand, we excluded quantitative case study articles and theoretical studies. To ensure the quality of the final sample, we considered only journal articles and excluded any non-academic, conference, and white papers. Additionally, we included the articles published till the 15th of September 2021 and did not put any time restriction and limited our sample to the articles written in English only. To ensure completeness, the systematic review was updated following the original protocol to include studies published up to December 2022.

Figure 1 shows the process steps and the number of articles we received at every stage. In the first step we received a total of 642 articles after removing duplicates from all the sources (Scopus, Web of Science, literature reviews, backward and forward references). On reviewing the abstracts of these articles and applying the inclusion exclusion criteria as mentioned in Table 1, we removed 510 articles and were left with 132 articles. Three researchers independently went through the reading process of all the 132 articles and applied the inclusion exclusion criteria to end up with recognizing altogether 18 academic articles and related MM cases that were used in the final review. We reviewed qualitative case studies, because case studies are usually in-depth and consider the contextual factors and relevance of why the mentioned criteria was critical for the MMs, which we used as part of the analyses. These cases were then analysed in detail based on the inclusion and exclusion criteria mentioned in Table 2 were identified. This resulted into 54 cases that had OBCs in B2B MMs (see Appendix I).

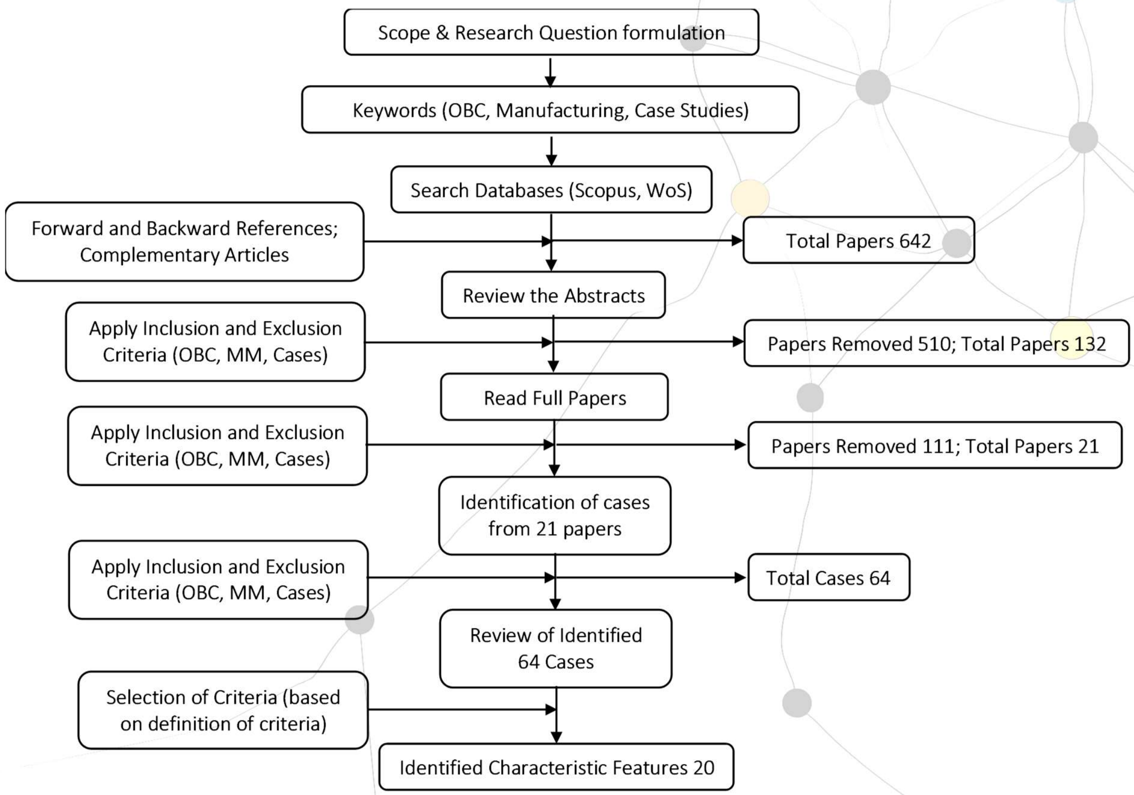

Figure 1. Review Process

Once we had the 54 cases as our final database for the analysis of criteria, we applied the definition of DCs to search the content of all the 18 articles and related 54 cases to determine the critical few criteria relevant for OBCs. We refer to DCs as the major decision points that impact the lifecycle profits and risks, and need to be considered during the design process of OBCs when an organization is switching from offering investment-based model to offering OBCs or re-designing current OBCs. In addition, to identify new critical DCs, we used the seven existing DCs identified in earlier study of Hypko, Tilebein, and Gleich (2010) related to *ownership (of machine) during the contract period*, *ownership (of machine) after the contract period*, *responsibility for maintenance personnel*, *responsibility for operational personnel*, *type of payment model*, *location of operation*, and *exclusiveness of usage*. Since our focus was to design OBCs from MM's perspective only, therefore, we decided, aligned with our RQs and research focus, not to consider the criterion "*Provider's background*" considered by Hypko, Tilebein, and Gleich (2010). In addition, the DC *exclusiveness of operations* used in earlier literature (Hypko, Tilebein, and Gleich, 2010; Lay, Schroeter, and Biege, 2009) was modified in our study to *exclusiveness of usage*, as in OBCs it is the use that matters rather than just the operation. Moreover, these DCs were required to contain potential different decision options, and DCs and their options to impact potentially significantly the lifecycle profits and risks for an organization. For example, when it comes to the DCs "*ownership of machine (during the phase of use)*" the available options can be (or the ownership can belong to) the MM, the customer, the third party or the leasing bank/ financial institute. If the leasing bank/ financial institute, or the third party is considered as an option for the DCs "ownership (of machine) during the contract period", then the lifetime profits and risks for an MM are reduced. Moreover, while we also identified that aspects like sales and customer relationship can be critical from strategy perspective when offering a OBCs, however, they were not considered to have clear decision options and therefore such strategic aspects were not considered as critical DCs.

The identified OBC cases (see Appendix I) had diverse information regarding contextual factors potentially impacting the critical DCs and selecting related options, such as company offerings, standard/customized machines, and movable/immobile machines (Appendix I). At times, a case company offering OBCs specifically mentioned what machine they are manufacturing, for example, manufacturers of trucks and trains (Baines and Lightfoot, 2013), and water treatment MMs (Gebauer, Haldimann, and Saul, 2017). However, at other times a broad level of company specialization was also mentioned, such as mechatronics (Adrodegari, Saccani, Kowalkowski et al., 2017), MMs (Gebauer, Haldimann, and Saul, 2017), and OEM (Raja, Chakkol, Johnson et al., 2018). Similarly, the name of the specific machine that was deployed by a company to offer OBCs was mentioned, such as train, truck, and photocopier (Baines and Lightfoot, 2013); at times, only an overview of the machine offered has been provided, for example, bespoke products (Raja, Chakkol, Johnson et al., 2018). In some cases, the name of the machine was not mentioned (Visnjic, Neely, and Jovanovic, 2018; Korkeamäki, Sjödin, Kohtamäki et al., 2022). Similarly, the value proposition offered in OBCs has been mentioned by some studies, such as, usage hours of the machine (Gebauer, Haldimann, and Saul, 2017), cubic meters of water and compressed air (Gebauer, Haldimann, and Saul, 2017). In some cases, no details regarding the value proposition have been provided (Visnjic, Neely, and Jovanovic, 2018; Adrodegari, Saccani, Kowalkowski et al., 2017). Additionally, it can be observed that there are examples of cases where the machine involved in offering OBCs is moving, e.g., trains, trucks (Baines and Lightfoot, 2013), while in other cases the machine is immobile, e.g., wind power generations and compressors (Gebauer, Haldimann, and Saul, 2017). Moreover, a few cases mention the names of the specific customers, such as Virgin trains (for trains) (Baines and Lightfoot, 2013) and distribution companies, such as Wincanton (for trucks) (Baines and Lightfoot, 2013). Furthermore, based on the data shared in these cases, it was difficult to identify whether the MMs were large enterprises or SMEs.

Finally, to better connect the identified DCs to the overall BM literature and to clarify the theoretical contributions, and to further enhance the practical relevance of the proposed taxonomy, the 20 identified DCs and their relationship to nine BMC components were independently evaluated by the authors. All authors have an expertise in BMC as well as OBC BMs and their design. The evaluation involved identifying whether the proposed decisions related to identified DCs had a direct and substantial association on different BMC components. For example, "*Ownership of software*" was seen to be directly and substantially associated to "*Key Resources*" and "*Value Propositions*" components, while "*Responsibility for logistics*" was similarly associated with both "*Key Activities*" and "*Cost Structure*." Disagreements in the above analysis were resolved through discussion until consensus was achieved.

4. Results

The systematic review methodology resulted in a taxonomy consisting of 20 DCs (Table 2) critical for MMs when designing their OBCs. The identified DCs and the corresponding cases (and articles) are presented in Appendix II. These DCs were organized based on ownership, responsibility, and payment model- consistent with the earlier conceptual models (Hypko, Tilebein, and Gleich, 2010: Lay, Schroeter, and Biege, 2009). Ownership has been considered as a category because it represents a major consideration when it comes to service-based BMs like OBCs. In investment-based models, ownership of the machine (or any asset) typically remains will with the customer. However, in OBCs, customers purchase the outcomes generated by machine (Hypko, Tilebein, and Gleich, 2010), and thus, the ownership of the machine and the costs and risks shift to the supplier. Similarly, in investment-based BMs, customers are responsible for responsible for several operational activities related to the machine, such as logistics, raw material, energy, installation, and maintenance (Uuskoski, Mittal, Menon et al., 2023; Korkeamäki, Sjödin, Kohtamäki et al., 2022; Hypko, Tilebein, and Gleich, 2010; Lay, Schroeter, and Biege, 2009). In contrast, under OBCs, customers focus solely on the outcomes and are not involved in managing these supporting activities. Finally, for suppliers, payment mechanisms in investment-based BMs are relatively straightforward. In OBCs. however, multiple payment models exist, each linked to specific contract terms, performance metrics, penalties, and durations that determine how and what customers pay for. Consequently, these aspects were consolidated under the payment model category of the taxonomy.

The proposed taxonomy (Table 2) is significant as it expands the set of DCs in literature in the three main categories of ownership, responsibility, and payment model. In particular, it enables the users to account for two previously overlooked dimensions: the importance of data and software ownership, and the end-of-lifecycle considerations such as refurbishment, modernization and upgradation (responsibility category), which were not addressed in earlier models (Hypko, Tilebein, and Gleich, 2010). Overall, the discussion of MM OBCs in the scientific literature has just begun. In the reviewed cases, the OBCs were primarily associated with the *ownership (of machines) during the contract period* and *personnel maintenance, software, and production data*, as suggested by 28, 12, and 10 cases, respectively. Regarding responsibilities, only *responsibility for maintenance personnel* was considered as important DCs with 11 cases. For payment models, *penalty schemes* and *duration of contract* have been discussed in 11 and 10 cases, respectively, underscoring their importance OBC design.

Decision Criteria	Description	Total
Ownership during the contract period	Defines who owns the machine during the contract	28
Ownership after the contract period	Defines who owns the machine after the contract	4
Ownership of Software	Defines who owns the software deployed in the machine	11
Ownership of Production Data	Defines who owns the data produced from the machine during the production phase	5
Ownership of Maintenance Data	Defines who owns the data produced from the machine during the maintenance phase	2
Ownership of Raw Materials/ Consumables	Defines who owns the raw materials/ consumables required to keep the machine working	5
Responsibility for Maintenance Personnel	Defines who will be responsible for the personnel involved in machine maintenance	16
Responsibility for Operational Personnel	Defines who will be responsible for the personnel involved in operations of machine	6
Responsibility for Installation and Set-up	Defines who will be responsible for the installation and set-up of the machine	1
Responsibility for Logistics of Machine	Defines who will be responsible for the logistics of the machine	3
Responsibility for Skills and Training	Defines who will be responsible for the skills and training required to work on the machine	7
Responsibility for Refurbishment	Defines who will be responsible for the repair of the machine and its components	1
Responsibility for Upgradation	Defines who will be responsible for further improving the quality of the machine and its components	1
Responsibility for Modernization	Defines who will be responsible for making use of older machines compatible with new tools and technologies	2
Payment Model	Defines the basis of which the machine outcome will be measured	54
Penalty Schemes	Defines the penalty basis when the machine outcome will not be delivered partly or completely	11
Duration of Contract	Defines the period for which the payment model and the penalty scheme will be active	10
Machine Utilization Level	Defines the level of machine utilization that will help in delivering the promised outcome	1
Location of Operation	Defines the premises where the machine will be located	12
Exclusiveness of Usage	Defines how many customers will be served using the machine	9

Table 2. Decision criteria and their corresponding number of cases in reviewed articles

We identified six DCs related to the overarching theme of resource ownership. *Ownership during contract period* emerged as the most critical DC for offering OBCs, as it shapes the financial implications for both MMs and customers. For MMs, owning the machine provides long-term benefits, including greater control over machine modifications needed to achieve the required outcome (Barquet, de Oliveira, Amigo et al. 2013; Adrodegari, Saccani, Kowalkowski et al., 2017). For customers, it eliminates the need to invest in expensive machine, allowing them to focus on their core business activities. *Ownership after contract the period* enables MMs to redeploy the same machine for future OBCs, thereby enhancing sustainability through reuse of machinery and its components (de Olivera et al., 2018; Zhang, Guo, Gu et al., 2018). Software helps MMs to collaborate with their customers using the machine. *Ownership of software* becomes critical as for many MMs software contains the IP, and is offered on a subscription basis (Raja, Chakkol, Johnson et al., 2018; Grubic and Peppard, 2016). If software IP is not adequately protected, MMs risks losing their competitive advantage and may find it difficult to sustain their business operations. Similarly, analysis of production data is critical for making decisions regarding innovations and improvements in machines, whereas analysis of maintenance data helps in predictive maintenance of machine and delivering the overall performance. Thus, *Ownership of maintenance data* (Yang, Smart, Kumar et al., 2018; Zhang, Guo, Gu et al., 2018) and *production data* (Grubic and Peppard; 2016; Raja, Chakkol, Johnson et al., 2018; de Oliveira, Mendes, Albuquerque et al., 2018) becomes important. Finally, *ownership of raw materials and consumables* ensures the machine operates efficiently and delivers the promised outcomes throughout the contract duration (Gebauer, Haldimann, and Saul, 2017; de Oliveira, Mendes, Albuquerque et al., 2018).

We also identified eight DCs related to the responsibilities required for the efficient operation of machines. These include *responsibilities for personnel required for maintenance and operating the machines*. Maintenance personnel was expected to diagnose issues quickly and and perform timely repairs to minimize downtime (Korkeamäki, Sjödin, Kohtamäki et al., 2022; Paiola, Schiavone, Grandinetti et al., 2021). If the machine fails to function as required, the MM may incur penalties for not meeting the agreed outcomes. Similarly, inadequate performance due to *operation personnel* (Yang, Smart, Kumar et al., 2018; Zhang, Guo, Gu et al., 2018), improper *installation and set-up* (Paiola, Agostini, Grandinetti et al., 2022), poor *logistics of machine* (de Oliveira, Mendes, Albuquerque et al., 2018), or substandard *skills and training* (Rabetino, Kohtamäki, and Gebauer, 2017; de Oliveira, Mendes, Albuquerque et al., 2018) can all lead to the failure to deliver the promised outcomes. Finally, the responsibilities related to *refurbishment, upgradation and modernization* can help in increasing the life of machine and its components and make OBCs more sustainable and cost effective (Barquet, de Oliveira, Amigo et al. 2013; Paiola and Gebauer, 2020; Rymaszewska, Helo, and Gunasekaran, 2017).

We also identified DCs related to the payment model. We identified various type of *payment models* such as availability-, output-, and economy- OBCs present in the scientific literature. Similarly, there were *penalty schemes* based on the extent to which outcome has been delivered, and if the required outcome is not delivered then MM might be penalized (Baines and Lightfoot, 2013; Gebauer, Haldimann, and Saul, 2017). Likewise, once the *duration of contract* (Rymaszewska, Helo, and Gunasekaran 2017; Visnjic, Neely, and Jovanovic, 2018) was over then machine could be redeployed in the next OBC. Finally, the required *machine utilization level* was also agreed when designing OBCs (Yang, Smart, Kumar et al., 2018). In OBCs, the customers do not hold the ownership of the machine, and we found situations where MMs or third parties were owning the machine and keeping it in their own or hired premises. As a result, they were able to serve multiple customers using the same machine by varying the utilization level of machines. The utilization level helped in achieving the agreed outcomes.

The *location of operation* could determine whether the MM was ready to assume operation and maintenance responsibilities (Holgao and Macchi, 2021; Zhang, Guo, Gu et al., 2018). Additionally, *exclusiveness of usage* could help to determine whether the machine would serve single or multiple customers at a time, for example, movable equipment such as trucks and excavation equipment (Frishammar and Parida, 2019; Baines and Lightfoot, 2013) can serve parallel customers.

5. Discussion

Prior conceptual studies most closely related to this research (Hypko, Tilebein, and Gleich, 2010; Lay, Schroeter, and Biege, 2009) did not consider DCs such as *ownership of software*, *ownership of production and maintenance data*, and *penalty schemes* (Table 3). This omission likely reflects the period in which these studies were conducted, approximately 15 years ago. During that time, such DCs were not yet central, to BM design and thus rarely discussed in the scientific literature. In addition, Lay, Schroeter, and Biege's (2009) review examined service-based models across all manufacturing industries operating in B2B contexts, whereas Hypko, Tilebein, and Gleich (2010) considered OBCs for all manufacturing industries. We identified that OBC-related MM case studies have appeared more frequently in academic literature during last decade. This trend corresponds with the rise of Industry 4.0 and IIoT technologies, where the large amount of data produced during manufacturing can be stored and analysed (Mittal, Khan, Purohit et al., 2020). Thus, making it critical to add DCs such as *ownership of production data*. Moreover, unlike earlier works (Hypko, Tilebein, and Gleich, 2010; Lay, Schroeter, and Biege, 2009), that relied primarily on conceptual or theoretical papers, our study conducted a systematic literature review focused exclusively on peer-reviewed journal case studies. Based on our analysis, an additional thirteen DCs were identified in our in-depth literature review (Table 3). In addition, we also observed that owing to the high risks involved in the transition of capital-intensive MMs, OBCs were not discussed earlier from the perspective of MMs.

The 20 identified DCs each include multiple design options that influence the configuration of OBCs. For example, when it comes to the *ownership of machine (during the phase of use)*, the design options can be i) the MM, ii) the customer, or iii) a third party (like a financial institute or a leasing bank). To minimize the risk of offering OBCs for an expensive machine, the MM may involve a leasing bank to own the machine. Similarly, if MM's machine has more outcome to offer as compared to what has been agreed in the contract, then the MM may become eligible for performance-based incentives or bonuses. Thus, directly influencing the profitability of OBCs.

In investment-based models, the physical resources like machine and material are important. However, in OBCs it is critical to know who owns these resources. For 'machine', *ownership during and after the contract period* has become vital. On the other hand, 'material' relates to *raw materials and consumables* that are required for the machine's regular operation. Additionally, as OBCs involve collaboration and data analysis and without their presence offering required outcome would be difficult. Therefore, for protection of IP and company core competencies, ownership of resources such as software and data has become critical in OBCs.

Decision Criteria	Lay et al. (2009)	Hypko, Tilebein, and Gleich, 2010	Current Article
Ownership during the contract period	x	x	x
Ownership after the contract period	x	x	x
Ownership of Software			x
Ownership of Production Data			x
Ownership of Maintenance Data			x
Ownership of Raw Materials/ Consumables			x
Responsibility for Maintenance Personnel	x	x	x
Responsibility for Operational Personnel	x	x	x
Responsibility for Installation and Set-up			x
Responsibility for Logistics of Machine			x
Responsibility for Skills and Training			x
Responsibility for Refurbishment			x
Responsibility for Upgradation			x
Responsibility for Modernization			x
Payment Model	x	x	x
Penalty Schemes			x
Duration of Contract			x
Machine Utilization Level			x
Location of Operation	x	x	x
Exclusiveness of Usage	x	x	x

Table 3. Comparison of proposed updated list of decision criteria with the criteria identified earlier (Hypko, Tilebein, and Gleich, 2010; Lay, Schroeter, and Biege, 2009)

Across the identified academic studies and cases, *machine ownership (during the phase of use)* was discussed in 28 cases, and in all of them, ownership remained with the MMs. Although, the case company was not specified in these cases it is reasonable to infer that most were large firms, as they typically possess the financial capacity to retain ownership of expensive machines. Moreover, for some MMs, OBCs may work like 'razor and blade model', when IP resides in the software rather than the physical machine. In such cases, the customers subscribe and pay for licensed software essential to the machine's functionality, and without the software the machine cannot operate. Finally, data ownership also emerge as a critical issue for both manufacturers and customers. In investment-based models data ownership is straightforward because customers own and operate the machines. However, in OBCs, the ownership of data must be agreed, as the customers might not own the machine and might not work on the machine as well. If data were not shared with the MM, they would not be able to deliver the required outcome. As a result, a good deal can be that MM's have data access.

The responsibilities' category includes DCs such as *maintenance personnel*, *operational personnel*, *logistics of machine*, *installation and set-up*, and *training of employees* *working with the machine*, can be invoiced separately by MMs. In investment-based models, however, opportunities for such separate invoices are limited, as customers typically assume most of these responsibilities. Furthermore, the reviewed cases provided limited evidence on how the *location of operations* influences other DCs; for example, when the machines are located at the MM's or a shared facility, they can be used to serve multiple customers, whereas machines installed at a customer's are usually dedicated to a single customer. Similarly, the *location* determines *responsibility for personnel for maintenance and operations*, if the machine is housed at the MM's facility, the MM generally assumes responsibility for both operations and maintenance. OBCs also offer greater sustainability advantages as compared to investment-based models. In OBCs, *ownership of machine (after the phase of use)* typically remains with the MMs, who also oversees the *responsibilities of refurbishment*, *modernization* and *upgradation*. This arrangement enables MMs to recover machines and components directly avoiding complex reverse supply chains. Overall, this example highlights the interdependence among DCs and show how selecting a particular option for one criterion can constraint or influence available options for others, for example, location choices may affect ownership, maintenance responsibility, and the potential for multi customer usage.

Additional examples also illustrate the interrelationships among DCs. For instance, the DC *exclusiveness of usage* determines whether a machine serves a single customer or multiple customers. When multiple customers use the same machine two scenarios are possible: either the machine is mobile and operates for different customers during different shifts, or it produces multiple outcomes (or a high volume of a single outcome) and the *location of machine* is at the customer's or MM's facility. The *location of the machine* further influences utilization expectations. If the machine is installed at the customer's facility, the customer typically expects a high level of utilization rate to maximize value. Conversely, if the *location of the machine* is at the MM's facility, a comparatively lower *machine utilization* level per customer is possible. However, the same machine can serve multiple customers simultaneously.

The frequencies of DCs presented in Table 2 should not be interpreted as indicators of their relative importance. Rather, they reflect the number of reviewed industry cases that mentioned each criterion within the systematic literature review. A higher frequency simply suggests that a particular DC was discussed more often across diverse BMs contexts, indicating perceived relevance rather than definitive significance. In many instances, researchers explicitly referred to DCs identified in earlier studies (e.g., Hypko, Tilebein, and Gleich, 2010; Lay, Schroeter, and Biege, 2009), which helps explain the prominence of certain criteria— such as *ownership during and after the contract period, responsibility for personnel, operation and maintenance, payment model, location of operation,* and *exclusivity of use* appear with higher. These DCs appear more frequently not necessarily because they are more critical, but because they have been more consistently recognized and adopted in prior OBC-related research.

Beyond these, only *penalty schemes* and *contract duration* emerged as frequently discussed DCs. This may be because they were frequently discussed with the payment model in the analysed cases. Given that Industry 4.0 and related technologies have emerged well after the publication of earlier studies, DCs such as *data and software ownership* did not receive substantial in the prior literature. However, with the growing influence of Industry 4.0 and IIoT, sustainability, and the circular economy principles, the previously overlooked DCs such as *refurbishment, upgrading, and modernization responsibilities,* are expected to gain increasing relevance in the design of OBCs.

The DCs outlined in Table 3 provide a practical framework for MMs to address the key challenges associated with implementing OBCs. For example, the challenge of owning an expensive machine can be addressed by considering the DCs related to the machine's ownership during and after the contract period (Uuskoski, Mittal, Menon et al., 2023). In such scenarios, MMs can engage third parties or leasing banks to assume ownership of the machine. Similarly, the challenge of protecting IP can be tackled by considering DCs related to the *ownership of software*, *production data*, and *maintenance data*. MMs can retain ownership of these elements to safeguard IP (Uuskoski, Mittal, Menon et al., 2023). Furthermore, MMs can establish separate revenue streams by assuming responsibility for activities such as maintenance, operations, installation, setup, and logistics. This approach ensures a steady income for MMs (Uuskoski, Mittal, Menon et al., 2023).

Scientific literature advocates the use of a BMC as a tool for designing service-oriented BMs and OBCs. However, the BMC does not provide detailed guidance for designing OBCs. In contrast, the taxonomy proposed in this article offers OBC-specific DCs and design guidance for OBCs. Used together, the BMC and the proposed taxonomy of DCs can serve as complementary tools for a more comprehensive design approach. The BMC outlines generic BM components such as key partners, cost structure and revenue streams. While the taxonomy specifies how these components translate into concrete design decisions. For example, within the BMC's key partners component, the taxonomy helps clarify the partner roles related to the DCs such as operations, maintenance, logistics and installation which may be performed by key partners like third-party collaborators. Similarly, while the BMC identifies the cost and revenue stream categories, the taxonomy extends this by detailing the specific responsibilities and activities that influence both costs and revenues, such as the roles of operational personnel, maintenance personnel, installation-, setup-, and maintenance- services. A mapping of the identified DCs to the BMC components has been depicted in the relational matrix (Table 4).

The identified DCs also present important insights when investigated from the perspective of value creation, value delivery and capture.

Value creation is primarily associated with the BMC components of key resources, key activities, key partners (Davies and Doherty, 2019). Many DCs- especially those related to *ownership (e.g., of software, production data, maintenance data, raw materials)* and *responsibility (e.g., installation, logistics, training)* directly impact how value is created. These DCs determine which resources and capabilities the manufacturer must control or coordinate to ensure consistent outcome delivery. Ownership of both physical and digital assets (software and data) and control over key operational processes such as logistics and installation appears central to the OBC-enabled value creation. Consequently, MMs often need to internalize or tightly orchestrate large portions of value creation chain than in traditional BMs to ensure performance under OBCs.

Decision Criteria/ Components (Business Model Canvas)	Key Partners	Key Activities	Key Resources	Value Propositions	Customer Relationships	Channels	Customer Segments	Cost Structure	Revenue Streams
Ownership of machine (during contract)	0	0	1	1	0	0	0	1	0
Ownership of machine (after contract)	0	0	1	0	0	0	0	1	1
Ownership of software	0	0	1	1	0	0	0	1	1
Ownership of production data	0	0	1	1	0	0	0	0	0
Ownership of maintenance data	0	0	1	1	0	0	0	0	0
Ownership of raw materials / consumables	0	0	1	1	0	0	0	1	1
Responsibility for maintenance personnel	1	1	0	0	0	0	0	1	0
Responsibility for operational personnel	1	1	0	0	0	0	0	1	0
Responsibility for installation and setup	0	1	0	0	1	0	0	1	0
Responsibility for logistics	1	1	0	0	0	1	0	1	0
Responsibility for training / skills	1	1	0	0	1	0	0	1	0
Responsibility for refurbishment	0	1	0	1	0	0	0	1	0
Responsibility for modernization	0	1	0	1	0	0	0	1	0
Responsibility for upgradation	0	1	0	1	0	0	0	1	0
Type of payment model	0	0	0	1	1	0	0	0	1
Penalty schemes	0	0	0	0	1	0	0	1	1
Contract duration	0	0	0	0	1	0	0	1	1
Machine utilization level	0	1	0	1	0	0	1	0	1
Location of operation	1	1	0	0	0	1	0	0	0
Exclusiveness of operation	0	0	0	1	1	0	0	0	0

Table 4. Comparison of proposed updated list of decision criteria with the criteria identified earlier (Hypko, Tilebein, and Gleich, 2010; Lay, Schroeter, and Biege, 2009)

Value delivery corresponds to the BMC components of channels, customer relationships and customer segments (Davies and Doherty, 2019). Fewer DCs such as those of *responsibilities related to operational* and *maintenance personnel*, and especially *location of operation* and *exclusiveness of usage*- affect how and to whom value is delivered. Under OBCs, value delivery is highly context-specific and infrastructure-dependent, and influenced by where the equipment is located, how it is used, and who operates it. Effective delivery therefore requires clear organizational and contractual arrangements, especially in field-level execution where proximity and exclusivity significantly shape customer- perceived value.

The concept of value capture can be related with the BMC components of cost structure and revenue streams (Davies and Doherty, 2019). DCs like *payment model*, *penalty schemes*, *contract duration*, and *utilization level* directly shape how value is monetized and costs managed. Additionally, the DC on *ownership after contract ends* affect end-of-life value extraction and circular revenue opportunities. Therefore, value capture in OBCs is highly sensitive to contractual structuring and incentive alignment, with multiple mechanisms (bonuses, penalties, reuse of assets) coexisting, and thus, it can be considered that the shift to outcomes requires innovative value capture logics that decouple revenue from asset sales and link it to long-term performance.

6. Conclusions

In this study systematically reviewed OBC cases involving MMs published in peer-reviewed journals. The analysed cases represented multiple industries and reflected diverse business logics within manufacturing contexts. As a major contribution, we proposed a taxonomy consisting of 20 DCs, including novel DCs and categorization structure, relevant to digitally enabled OBC models. A more detailed discussion of the academic contributions and managerial implications is presented in the Discussion section.

Supporting both OBC research and practice, the proposed categorization related to ownership, responsibility, payment model and others, enables a more systematic and nuanced characterization of OBCs. The inclusion of 13 additional DCs extends existing frameworks and allows for clearer differentiation among various types of OBCs, as well as other advanced servitization concepts that integrate outcome-based and non-ownership elements. Although, these servitization related BMs may appear similar at first glance, our taxonomy reveals that they differ substantially across critical DCs related to ownership structures, operational responsibilities, payment mechanisms. Such differences can significantly affect lifecycle profits, risk allocation, and ultimately the overall feasibility of OBC models.

Different analytical tools provide distinct but complementary insights for BM configuration. For example, our analysis using the BMC, and the value creation, value delivery, and value capture framework highlights recurring patterns such as the criticality of owning key assets, managing essential responsibilities and decoupling revenue from equipment sales to ensure long-term performance outcomes.

Below we present the academic contributions, managerial implications, limitations and the future work related to our research.

6.1 Theoretical Contributions

The proposed taxonomy consisting of 20 DCs significantly extends prior work (Hypko, Tilebein, and Gleich, 2010; Lay, Schroeter, and Biege, 2009) on OBC design. By systematizing fragmented decision points scattered around the existing literature into a structured taxonomy for understanding and analyzing OBC-related design decisions. The taxonomy not only refines earlier conceptualizations but also offers a lens to examine how digitalization, data ownership, and sustainability reshape the feasibility of OBCs in capital-intensive industries.

Among these 20 DCs, 13 are newly recognized criteria that were absent in previous literature. Their growing importance over the past decade reflects the transformative effects of initiatives such as Industry 4.0 and IIoT (Tsaramirsis, Kantaros, Al-Darraji et al., 2022). Technical advancements, such as the use of affordable sensors, cloud storage, advanced AI and machine learning-based data analytics, and open-source algorithms for data analysis, which were not very mature and popular have also contributed to the identified novels DCs which were not present in the prior studies (Hypko, Tilebein, and Gleich, 2010; Lay, Schroeter, and Biege, 2009).

A further theoretical contribution lies in the logical categorization of these 20 DCs into four broader categories of ownership, responsibility, payment model and others. This structured classification developed through content analysis, has not been presented in prior studies (e.g., Hypko, Tilebein, and Gleich, 2010; Lay, Schroeter, and Biege, 2009) and offers a clearer understanding of how design decisions influence the configuration, profitability and risk profile of OBC BMs. The categorization also facilitates the conceptual application of the framework, helping scholars identify relationships among DCs and their cumulative effects on lifecycle performance.

The taxonomy and its underlying DCs provide researchers with a comprehensive analytical tool for examining underexplored aspects of OBCs. It enables comparative analysis across cases, supports the identification of differences and similarities among OBC BMs, and helps scholars understand how specific DCs affect the earning logic and feasibility of these models. This structured framework can guide future research design, data collection, and theory building by promoting consistent terminology and deeper analytical focus.

Earlier studies (Hypko, Tilebein, and Gleich, 2010; Lay, Schroeter, and Biege, 2009) identified only a limited set of critical DCs that largely reflected traditional servitization models, focusing on basic ownership and responsibility decisions. In contrast, our taxonomy captures the expanded scope of OBC design in the era of Industry 4.0, IIoT, and Smart Manufacturing. While previous studies (Hypko, Tilebein, and Gleich, 2010; Lay, Schroeter, and Biege, 2009) discussed only two ownership-related DCs, *ownership during and after the contract period*, we identify four new ownership-related DCs: *ownership of software, production data, maintenance data, and raw materials/consumables*. These criteria are essential for protecting IP, enabling innovation, and ensuring reliable outcome delivery. Similarly, prior work limited responsibility-related DCs to *maintenance and operational personnel*. Our study introduces three additional responsibility-related DCs, *installation and setup, logistics, and skills and training*, that help MMs establish new revenue streams and improve service quality. Furthermore, newly identified DCs related to *refurbishment, upgrading, and modernization* strengthen sustainability and cost efficiency by minimizing the need for complex reverse supply chains. Previous research also treated the payment model as a single DC. We extend this by identifying three additional payment-related DCs, *penalty schemes, contract duration, and machine utilization level*, that are central to outcome delivery, incentive alignment, and transparent communication between contracting parties.

Overall, by extending prior OBC frameworks (Hypko, Tilebein, and Gleich, 2010; Lay, Schroeter, and Biege, 2009) and following Gregor's (2006) classification of theory types, the proposed taxonomy constitutes a *Type I Theory for Analyzing*. It systematically classifies and structures "what is", the key decision areas MMs must address when designing OBC-based BMs. While it does not seek to predict performance outcomes or prescribe optimal configurations, it serves as a comprehensive framework for analysis, characterization, and comparison of OBCs. This makes it an empirically grounded, conceptually organized foundation for future theory development in a domain where conceptual clarity has so far been limited.

In addition, by developing a relational matrix that links the proposed DCs with the components of the BMC, this study integrates OBC-specific decision-making with the broader literature on BM design. This connection positions our theoretical contribution within the well-established BMC-based tradition and creates a bridge for scholars and practitioners to extend general BM frameworks to the specific context of outcome-based contracting. In doing so, the study answers recent calls for more detailed taxonomies, theoretical models, and design tools that capture the realities of modern servitization and Industry 4.0-enabled BMs (Guarino, Guizzardi, and Mylopoulos et al., 2022; Gregor, 2006).

Finally, the relationship matrix (Table 4) contributes to BM theory by demonstrating the link between decision-level constructs in OBCs and established frameworks such as the BMC. This matrix reinforces our research question by illustrating that DCs are not only relevant to contract design but also foundational to the broader configuration and evolution of BMs in manufacturing contexts.

6.2 Managerial Implications

The proposed taxonomy provides MMs, especially those with limited experience in OBCs, a practical tool to design innovative BMs tailored to their specific business environment. It enables decision-makers to structure OBC design systematically, identify critical DCs, and align choices with organizational goals, risk appetite, and resource capabilities. By working with this conceptual framework, managers of suppliers offering OBC services can better recognize and evaluate how individual decisions influence earnings, profitability and risk across the lifecycle of both the machine and contract.

Our findings reveal OBC BMs vary widely in practice, even though they may appear similar at first glance. When examined through the lens of the proposed decision criteria (DCs), significant differences emerge in how firms generate revenues, manage risks and capture value. For instance, if the *ownership of the machine*, and *responsibility for manufacturing and maintenance personnel*, *remains* with the MMs, the model may resemble traditional servitization models like renting and leasing. However, the OBCs would not be existing. In contrast, genuine OBCs, emphasize DCs such as *ownership of data, software, machine utilization level*, and *performance-based incentive structures* (bonuses and penalties). Therefore, the taxonomy helps managers differentiate OBCs from other service-based BMs and and supports more informed strategic and operational decision-making**.** The comprehensive taxonomy of 20 DCs equips MMs to address key challenges encountered during OBC design. By focusing on these DCs and their categories, managers can evaluate different OBC configurations based on lifecycle profitability and risk exposure. This structured approach enables firms to identify which decisions most strongly influence product lifecycle performance, cost recovery, and long-term financial sustainability.

From a practical perspective, ownership-related DCs assist managers in balancing financial exposure and control. Because MMs typically retain ownership of costly assets under OBCs, they carry a significant portion of the associated risks. The taxonomy highlights strategies to mitigate these risks, such as engaging third-party financiers or leasing partners to hold ownership during the usage phase. Likewise, IP can be protected by maintaining ownership of critical software or data, even when physical assets are externally owned. Responsibility-related DCs provide additional opportunities for revenue generation. Although taking on more operational and maintenance responsibilities increases performance risk, it also allows manufacturers to capture value over the entire equipment lifecycle. MMs can invoice additional responsibilities such as logistics, installation, maintenance, and training, transforming potential risks into recurring income streams. Moreover, assuming responsibilities for refurbishment, upgrading, and modernization helps extend equipment life, enhance sustainability, and secure ongoing earnings across the lifecycle, advantages not available in traditional investment-based models. The payment model-related DCs, including *contract duration, performance penalties, and bonus schemes*, further clarify how revenue and risk are shared between MMs and customers. Performance-based structures allow MMs to be rewarded for exceeding agreed outcomes while also encouraging efficiency and innovation. For instance, when customers share a portion of their cost savings with the manufacturer, new profit mechanisms emerge that were previously unavailable under traditional models.

Finally, mapping the identified DCs onto the BMC) (see Table 4) enhances managerial understanding of how specific OBC-related design choices influence the overall BM architecture. This integrative view supports strategic planning by illustrating how decisions concerning ownership, responsibility, and payments affect value creation, delivery, and capture mechanisms. Managers can therefore use the taxonomy not only as an operational design tool but also as a strategic guide for aligning OBC initiatives with broader BM innovation efforts.

6.3 Limitations and Future Work

The conceptual model proposed in this study— a taxonomy of critical OBC DCs and their mapping to BMC components—serves as a foundational “Theory for Analyzing” (Gregor, 2006) for exploring the design space of OBC-driven BMs in the manufacturing. As such, it provides an essential building block for future theoretical development in this domain. A promising direction for future research is to extend this analytical groundwork toward the development of Type II (Theory for Explaining) and Type IV (Theory for Explaining and Predicting) frameworks. For instance, empirical studies could investigate how specific configurations of DCs influence lifecycle profitability, risk distribution, or customer value realization in different OBC contexts. Such work could generate explanatory models that reveal causal mechanisms linking design choices to performance outcomes, and predictive models that help guide the design of optimal OBC configurations. In this way, the present study lays a conceptual foundation upon which richer, more dynamic theories of OBC-driven BM innovation can be constructed.

Future studies could also evaluate the relative importance of the identified DCs across different organizational and market contexts. For example, for SMEs, the ownership of machine and finding a third-party financing can be more critical than other DCs. However, for large companies working in developing countries, the ownership of software and data can be more critical. Likewise, the relative importance may vary across different industry sectors.

Additionally, future research could identify the challenges and benefits associated with different options for the OBC DCs. For instance, further studies could examine the difficulties that might arise if a third party owns the machine during the contract period, but ownership transfers to the customer after the contract ends. Furthermore, studies could empirically analyse how these challenges can be effectively mitigated.

Finally, another logical next step beyond our taxonomy would be the systematic identification, clustering, and validation of various archetypal BM patterns, making use of the identified DCs, as well as the identification of various decisions options. These could be a starting point for discovering various OBC BM prototypical patterns and archetypes, e.g., systematically analyzing whether certain sets of decision criteria regularly or interestingly co-occur and evaluate their feasibility and limitations in diverse types of industrial companies, markets and contexts. This would be allowed for instance by a morphological analyses of patterns that consist of the DCs and DC-related potential decision options, which have been studied in earlier somewhat similar more generic BM studies, such as Hypko, Tilebein, and Gleich (2010) and Lay, Schroeter, and Biege (2009).

Acknowledgements

The authors would like to sincerely thank the editors and the anonymous reviewers for their constructive comments and valuable suggestions, which have significantly improved the quality and clarity of this manuscript.

Funding

This work was supported by Business Finland funded SNOBI project [grant number 545/31/2020].

Disclosure Statement

The authors report there are no competing interests to declare.

References

Adrodegari, F., Bacchetti, A., Pinto, R., Pirola, F., & Zanardini, M. (2015). Engineer-to-order (ETO) production planning and control: An empirical framework for machinery-building companies. *Production Planning & Control, 26*(11), 910–932. https://doi.org/10.1080/09537287.2014.1001808

Adrodegari, F., Saccani, N., & Kowalkowski, C. (2016). A framework for PSS business models: Formalization and application. *Procedia CIRP, 47*, 519–524. https://doi.org/10.1016/j.procir.2016.03.073

Adrodegari, F., Bacchetti, A., Saccani, N., & Arnaiz, A. (2018). The transition towards service-oriented business models: A European survey on capital goods manufacturers. *International Journal of Engineering Business Management, 10*, 1–11. https://doi.org/10.1177/1847979018754469

Adrodegari, F., Saccani, N., Kowalkowski, C., & Vilo, J. (2017). PSS business model conceptualization and application. *Production Planning & Control, 28*(13), 1251–1263. https://doi.org/10.1080/09537287.2017.1363924

Baines, T., & Lightfoot, H. W. (2013). Servitization of the manufacturing firm: Exploring the operations practices and technologies that deliver advanced services. *International Journal of Operations & Production Management, 34*(1), 2–35. https://doi.org/10.1108/IJOPM-02-2012-0086

Baines, T. S., Lightfoot, H. W., Evans, S., Neely, A., Greenough, R., Peppard, J., ... & Wilson, H. (2007). State-of-the-art in product-service systems. *Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture, 221*(10), 1543–1552. https://doi.org/10.1243/09544054JEM858

Barquet, A. P. B., de Oliveira, M. G., Amigo, C. R., Cunha, V. P., & Rozenfeld, H. (2013). Employing the business model concept to support the adoption of product–service systems (PSS). *Industrial Marketing Management, 42*(5), 693–704. https://doi.org/10.1016/j.indmarman.2013.05.003

Bock, M., & Wiener, M. (2018). Nonownership business models in the manufacturing industry: The role of uncertainty and the industrial Internet of Things. *Proceedings of the Thirty Ninth International Conference on Information Systems (ICIS)*, San Francisco. https://aisel.aisnet.org/icis2018/service/Presentations/6

Böhm, E., Backhaus, C., Eggert, A., & Cummins, T. (2016). Understanding outcome-based contracts: Benefits and risks from the buyers' and sellers' perspective. *Journal of Strategic Contracting and Negotiation, 2*(2), 128–149. https://doi.org/10.1177/2055563616669740

Briscoe, S., Bethel, A., & Rogers, M. (2020). Conduct and reporting of citation searching in Cochrane systematic reviews: A cross-sectional study. *Research Synthesis Methods, 11*(2), 169–180. https://doi.org/10.1002/jrsm.1355

Chadegani, A. A., Salehi, H., Yunus, M. M., Farhadi, H., Fooladi, M., Farhadi, M., & Ebrahim, N. A. (2013). A comparison between two main academic literature collections:

Web of Science and Scopus databases. *Asian Social Science, 9*(5), 18–26. https://doi.org/10.5539/ass.v9n5p18

Dahmani, S., Boucher, X., Gourc, D., Peillon, S., & Marmier, F. (2020). Integrated approach for risk management in servitization decision-making process. *Business Process Management Journal, 26*(7), 1949–1977. https://doi.org/10.1108/BPMJ-07-2019-0279

Davies, I. A., & Doherty, B. (2019). Balancing a hybrid business model: The search for equilibrium at Cafédirect. *Journal of Business Ethics, 157*(4), 1043–1066. https://doi.org/10.1007/s10551-018-3960-9

Eggert, A., Hogreve, J., Ulaga, W., & Muenkhoff, E. (2014). Revenue and profit implications of industrial service strategies. *Journal of Service Research, 17*(1), 23–39. https://doi.org/10.1177/1094670513485823

Falagas, M. E., Pitsouni, E. I., Malietzis, G. A., & Pappas, G. (2008). Comparison of PubMed, Scopus, Web of Science, and Google Scholar: Strengths and weaknesses. *FASEB Journal, 22*(2), 338–342. https://doi.org/10.1096/fj.07-9492LSF

Frishammar, J., & Parida, V. (2019). Circular business model transformation: A roadmap for incumbent firms. *California Management Review, 61*(2), 5–29. https://doi.org/10.1177/0008125618811926

Gebauer, H., Haldimann, M., & Saul, C. J. (2017). Competing in business-to-business sectors through pay-per-use services. *Journal of Service Management, 28*(5), 914–935. https://doi.org/10.1108/JOSM-07-2016-0202

Glas, A. H., Henne, F. U., & Essig, M. (2018). Missing performance management and measurement aspects in performance-based contracting: A systematic process-based literature analysis of an astonishing research gap. *International Journal of Operations & Production Management, 38*(11), 2062–2095. https://doi.org/10.1108/IJOPM-09-2016-0571

Gough, D., Oliver, S., & Thomas, J. (2017). *An introduction to systematic reviews*. SAGE Publications. https://doi.org/10.53841/bpsptr.2017.23.2.95

Gregor, S. (2006). The nature of theory in information systems. *MIS Quarterly, 30*(3), 611–642. https://doi.org/10.2307/25148742

Grubic, T., & Jennions, I. (2018). Do outcome-based contracts exist? The investigation of power-by-the-hour and similar result-oriented cases. *International Journal of Production Economics, 206*, 209–219. https://doi.org/10.1016/j.ijpe.2018.10.004

Grubic, T., & Peppard, J. (2016). Servitized manufacturing firms competing through remote monitoring technology: An exploratory study. *Journal of Manufacturing Technology Management, 27*(2), 154–184. https://doi.org/10.1108/JMTM-05-2014-0061

Guarino, N., Guizzardi, G., & Mylopoulos, J. (2020). On the philosophical foundations of conceptual models. In *Information Modelling and Knowledge Bases XXXI* (pp. 1–15). IOS Press. https://doi.org/10.3233/FAIA200002

Holgado, M., & Macchi, M. (2021). A value-driven method for the design of performance-based services for manufacturing equipment. *Production Planning & Control, 33*(2–3), 161–177. https://doi.org/10.1080/09537287.2021.2008129

Hypko, P., Tilebein, M., & Gleich, R. (2010). Clarifying the concept of performance-based contracting in manufacturing industries: A research synthesis. *Journal of Service Management, 21*(5), 625–655. https://doi.org/10.1108/09564231011079075

Korkeamäki, L., Sjödin, D., Kohtamäki, M., & Parida, V. (2022). Coping with the relational paradoxes of outcome-based services. *Industrial Marketing Management, 104*, 14–27. https://doi.org/10.1016/j.indmarman.2022.04.005

Lay, G., Schroeter, M., & Biege, S. (2009). Service-based business concepts: A typology for business-to-business markets. *European Management Journal, 27*(6), 442–455. https://doi.org/10.1016/j.emj.2009.04.002

Liinamaa, J., Viljanen, M., Hurmerinta, A., Ivanova-Gongne, M., Luotola, H., & Gustafsson, M. (2016). Performance-based and functional contracting in value-based solution selling. *Industrial Marketing Management, 59*, 37–49. https://doi.org/10.1016/j.indmarman.2016.05.032

Mittal, S., Khan, M. A., Purohit, J. K., Menon, K., Romero, D., & Wuest, T. (2020). A smart manufacturing adoption framework for SMEs. *International Journal of Production Research, 58*(5), 1555–1573. https://doi.org/10.1080/00207543.2019.1661540

Ng, I. C., Maull, R., & Yip, N. (2009). Outcome-based contracts as a driver for systems thinking and service-dominant logic in service science: Evidence from the defence industry. *European Management Journal, 27*(6), 377–387. https://doi.org/10.1016/j.emj.2009.05.002

Ng, I. C. L., & Nudurupati, S. S. (2010). Outcome-based service contracts in the defence industry: Mitigating the challenges. *Journal of Service Management, 21*(5), 656–674. https://doi.org/10.1108/09564231011079084

de Oliveira, M. G., Mendes, G. H. S., Albuquerque, A. A., & Rozenfeld, H. (2018). Lessons learned from a successful industrial product-service system business model: Emphasis on financial aspects. *Journal of Business & Industrial Marketing, 33*(3), 365–376. https://doi.org/10.1108/JBIM-07-2016-0147

Lazzarotto, B. O., Borchardt, M., Pereira, G., & Almeida, C. (2014). Analysis of management practices in performance-based outsourcing contracts. *Business Process Management Journal, 20*(2), 178–194. https://doi.org/10.1108/BPMJ-01-2013-0007

Paiola, M., Agostini, L., Grandinetti, R., & Nosella, A. (2022). The process of business model innovation driven by IoT: Exploring the case of incumbent SMEs. *Industrial Marketing Management, 103*, 30–46. https://doi.org/10.1016/j.indmarman.2022.03.006

Paiola, M., & Gebauer, H. (2020). Internet of things technologies, digital servitization and business model innovation in B2B manufacturing firms. *Industrial Marketing Management, 89*, 245–264. https://doi.org/10.1016/j.indmarman.2020.03.009

Paiola, M., Schiavone, F., Grandinetti, R., & Chen, J. (2021). Digital servitization and sustainability through networking: Some evidences from IoT-based business models.

Journal of Business Research, 132, 507–516. https://doi.org/10.1016/j.jbusres.2021.04.047

Qvist-Sørensen, P. (2020). Applying IIoT and AI – Opportunities, requirements and challenges for industrial machine and equipment manufacturers to expand their services. *Central European Business Review, 9*(2), 46–77. https://doi.org/10.18267/j.cebr.234

Rabetino, R., Kohtamäki, M., & Gebauer, H. (2017). Strategy map of servitization. *International Journal of Production Economics, 192*, 144–156. https://doi.org/10.1016/j.ijpe.2016.11.004

Raja, J. Z., Chakkol, M., Johnson, M., & Beltagui, A. (2018). Organizing for servitization: Examining front- and back-end design configurations. *International Journal of Operations & Production Management, 38*(1), 249–271. https://doi.org/10.1108/IJOPM-03-2016-0139

Rapaccini, M. (2015). Pricing strategies of service offerings in manufacturing companies: A literature review and empirical investigation. *Production Planning & Control, 26*(14–15), 1247–1263. https://doi.org/10.1080/09537287.2015.1033495

Rymaszewska, A., Helo, P., & Gunasekaran, A. (2017). IoT-powered servitization of manufacturing: An exploratory case study. *International Journal of Production Economics, 192*, 92–105. https://doi.org/10.1016/j.ijpe.2017.02.016

Selviaridis, K., & Wynstra, F. (2015). Performance-based contracting: A literature review and future research directions. *International Journal of Production Research, 53*(12), 3505–3540. https://doi.org/10.1080/00207543.2014.978031

Smith, A. D., Plowman, D. A., Duchon, D., & Quinn, A. M. (2009). A qualitative study of high-reputation plant managers: Political skill and successful outcomes. *Journal of Operations Management, 27*(5), 428–443. https://doi.org/10.1016/j.jom.2009.01.003

Tsaramirsis, G., Kantaros, A., Al-Darraji, I., Piromalis, D., Apostolopoulos, C., Pavlopoulou, A., ... & Khan, F. Q. (2022). A modern approach towards an industry 4.0 model: From driving technologies to management. *Journal of Sensors, 2022*(1), 5023011. https://doi.org/10.1155/2022/5023011

Tukker, A. (2004). Eight types of product–service system: Eight ways to sustainability? Experiences from SusProNet. *Business Strategy and the Environment, 13*(4), 246–260. https://doi.org/10.1002/bse.414

Ulaga, W., & Loveland, J. M. (2014). Transitioning from product to service-led growth in manufacturing firms: Emergent challenges in selecting and managing the industrial sales force. *Industrial Marketing Management, 43*(1), 113–125. https://doi.org/10.1016/j.indmarman.2013.08.006

Uski, V.-M., Kukkamalla, P. K., & Kärkkäinen, H. (2022). Capability framework implementing pay-per-outcome business model in equipment manufacturing companies. *Journal of Business Models, 10*(1), 30–41. https://doi.org/10.54337/jbm.v10i1.6785

Uuskoski, M., Mittal, S., Menon, K., & Kärkkäinen, H. (2023). Challenges, mitigation and benefits of outcome-based contracts in small and medium-sized machine manufacturers: A qualitative exploratory study. *International Journal of Mathematical, Engineering and Management Sciences, 8*(6), 1149–1170. https://doi.org/10.33889/IJMEMS.2023.8.6.065

Visnjic, I., Neely, A., & Jovanovic, M. (2018). The path to outcome delivery: Interplay of service market strategy and open business models. *Technovation, 72–73*, 46–59. https://doi.org/10.1016/j.technovation.2018.02.003

Yang, M., Smart, P., Kumar, M., Jolly, M., & Evans, S. (2018). Product-service systems business models for circular supply chains. *Production Planning & Control, 29*(6), 498–508. https://doi.org/10.1080/09537287.2018.1449247

Zancul, E. D. S., Takey, S. M., Barquet, A. P. B., Kuwabara, L. H., Cauchick Miguel, P. A., & Rozenfeld, H. (2016). Business process support for IoT-based product-service systems (PSS). *Business Process Management Journal, 22*(2), 305–323. https://doi.org/10.1108/BPMJ-05-2015-0078

Zhang, W., Guo, J., Gu, F., & Gu, X. (2018). Coupling life cycle assessment and life cycle costing as an evaluation tool for developing product-service systems of high energy-consuming equipment. *Journal of Cleaner Production, 183*, 1043–1053. https://doi.org/10.1016/j.jclepro.2018.02.146

Ziaee Bigdeli, A., Baines, T., Schroeder, A., Brown, S., Musson, E., Shi, V. G., & Calabrese, A. (2018). Measuring servitization progress and outcome: The case of advanced services. *Production Planning & Control, 29*(4), 315–332. https://doi.org/10.1080/09537287.2018.1429029

Appendices

Appendix I: Case companies and the corresponding advanced value offered.

Case #	Reference	Case company	Machine/ Product	OBC Offerings	Customer
1	Barquet, de Oliveira, Amigo et al., 2013	Machine tool manufacturer and designer	Pressure (Thermo) forming machines and plastic bags producing machines	Monitoring, training and preventive maintenance	-NA-
2	Baines and Lightfoot 2013	Manufacturer of trains and rolling stock	Trains	Train-life maintenance, renovation, spare parts management, and technical support	Train operating companies, e.g. Virgin trains
3		Manufacturer of trucks and buses	Trucks	Fleet management of trucks inspection, maintenance and worthiness, along with visibility of driver and vehicle performance	Distribution companies such as Wincanton
4		Manufacturer of excavation equipment	Excavation equipment	Customer support agreement Monitoring condition, use and location, preventive maintenance, unscheduled repair	Mine operators such as Rio Tinto, AngloGold Ashanti
5		Manufacturer of office equipment	Photocopier	Manage print services multi-brand print, fleet management, document management, print infrastructure optimisation	Small, medium (local authorities) and large groups (e.g. Fiat Group)
6	Grubic and Peppard 2016	Equipment Co.	Rolling bearings, seals, mechatronics, lubrication systems	Maintenance; Condition monitoring; Bearing refurbishment and alignment	Process and energy industries
7	Adrodegari, Saccani, Kowalkowski et al., 2017	Mechatronics	Robots	-NA-	-NA-

Case #	Reference	Case company	Machine/ Product	OBC Offerings	Customer
8		Battery Manufacturer	Battery	Battery usage	-NA-
9		Water treatment equipment manufacturer	Water treatment equipment	Cubic meters of water	-NA-
10		Solar home system manufacturers	Solar home systems	Kilowatt hours	-NA-
11		Wind power generation	Wind power genrators	Megawatt hours	-NA-
12		Waste water treatment equipment manufacturer	Waste water treatment equipment	Cubic meters of water	-NA-
13		Solar panel manufacturer	Solar panels	Kilowatt hours	-NA-
14		Compressor manufacturer	Compressors	Cubic meters of compressed air	-NA-
15	Gebauer, Haldimann, and Saul, 2017	Cleaning equipment manufacturer	Cleaning equipment	Usage hours of cleaning equipment	-NA-
16		Aircraft engines manufacturer	Aircraft engines	Usage hours of the aircraft engines	-NA-
17		Heavy construction equipment manufacturer	Heavy construction equipment	Usage hours of the construction equipment	-NA-
18		Pump manufacturer	Pumps	Cubic meters of the pumped water	-NA-
19		Medical euipment manufacturer	Medical imager	Medical images	-NA-
20		Construction equipment manufacturer	Construction euqipments	Usage hours of the construction equipment	-NA-
21		Copying and printing machines manufacturer	Copiers and printing machines	Contracted services, equipment maintenance, Consumable supplies	-NA-
22		Drilling machines manufacturer	Drill machines	Fleet management systems	-NA-

Case #	Reference	Case company	Machine/ Product	OBC Offerings	Customer
23		Tire manufacturer	Tyres	Kilometers run by the tyre	-NA-
24		Forklift trucks manufacturer	Forklift trucks	Fleet management systems; Turck usage per hour/ ton transported/ kilometer driven	-NA-
25	Rabetino, Kohtamäki, and Gebauer, 2017	Manufacturer of Marine Propulsion Systems	Marine propulsion systems and power plants	Spare parts and operations and maintenance services for lifecycle	-NA-
26	Rabetino, Kohtamäki, and Gebauer, 2017	Manufacturer of Pulp, Paper and Powder	Product lines/ technologies for pulp, paper, and powder industries	Expert and maintenance services	-NA-
27	Rabetino, Kohtamäki, and Gebauer, 2017	Metal and Mineral Processing Industries	Technologies for metal and mineral processing industries	Spare parts, maintenance, and technical services	-NA-
28	Rymaszewska, Helo, and Gunasekaran 2017	Manufacturer of Sheet Metal Machinery Equipment	Sheet metal machine	Fleet maintenance services	-NA-
29	Rymaszewska, Helo, and Gunasekaran 2017	Manufacturer of Power Generators for Power plants	Power generators/ Gas operated power plants	Guaranteed amount of electricity in short time	-NA-
30	de Oliveira, Mendes, Albuquerque et al., 2018	Manufacturer of High-Value Capital Equipment for Food Processing	Equipment for food processing (especially orange juice)	Extractors that can produce orange juice with 99.5% availability	Large citrus processing companies
31	Raja, Chakkol, Johnson et al., 2018	Original equipment manufacturer (OEM)- Division A	End-products are customized versions of core product	Use-based contracting of the equipment	-NA-
32	Raja, Chakkol, Johnson et al., 2018	Original equipment manufacturer (OEM)- Division B	Bespoke products to suit customer requirements	Availability based contracting (Result oriented)	Government agencies
33	Visnjic, Neely, and Jovanovic, 2018	Manufacturer of Construction equipment, services, and consulting	-NA-	-NA-	-NA-
34	Visnjic, Neely, and Jovanovic, 2018	Manufacturer of Utility Equipment and Services (Water)	-NA-	-NA-	-NA-

Case #	Reference	Case company	Machine/ Product	OBC Offerings	Customer
35		Manufacturer of Utility Equipment and Services (Energy)	-NA-	-NA-	-NA-
36	Yang, Smart, Kumar et al., 2018	Manufacturer of Air Separation Units (ASU)	Leasing of ASU, entire engineering system	Use-based contract	-NA-
37		Manufacturer of Air Separation Units (ASU)	Providing industrial gas	Result oriented	-NA-
38	Zhang, Guo, Gu et al., 2018	Manufacturer of High Energy-Consuming Equipment (HECE)	Air seperation equipment	Supplying oxygen to the client	Industries that use oxygen as raw material in their process
39	Frishammar and Parida 2019	Manufacturer of Metso for Processing Industry	Pressure filter systems in processing industries	Performance based contract	-NA-
40		Volvo Construction Equipment	Construction equipment	Performance based contract	-NA-
41	Paiola, and Gebauer 2020	Retail Equipment Manufacturing Company	-NA-	Will offer performance-based contract in near future	-NA-
42		Retail Equipment Manufacturing Company	-NA-	Currently offering performance-based contract	-NA-
43		Packaging Machines Manufacturing Company	-NA-	Currently offering performance-based contract	-NA-
44		Packaging Machines Manufacturing Company	-NA-	Will offer performance-based contract in near future	-NA-
45	Holgao and Macchi 2021	Manufacturer of instrumentation devices	-NA-	-NA-	-NA-
46	Korkeamäki, Sjödin, Kohtamäki et al., 2022	Mining and energy technology provider	-NA-	Performance-based contracts to achieve targets	-NA-
47		Pulp and paper and energy technology provider	-NA-	Performance-based contracts to improve asset productivity and profitability	-NA-
48		Energy and marine technology provider	-NA-	Performance-based contracts based on asset's productive lifetime, ROI, operational efficiency	-NA-

Case #	Reference	Case company	Machine/ Product	OBC Offerings	Customer
				improvement and reliability services	
49	Paiola, Schiavone, Grandinetti et al., 2021	Packaging Machines Manufacturing Company	-NA-	Remote monitoring solutions	-NA-
50		Packaging Machines Manufacturing Company	-NA-	Remote monitoring solutions	-NA-
51		Retail Equipment Manufacturing Company	-NA-	Remote monitoring solutions	-NA-
52		Retail Equipment Manufacturing Company	-NA-	Remote monitoring solutions	-NA-
53	Paiola, Agostini, Grandinetti et al., 2022	Packaging Machines Manufacturing Company	-NA-	Remote monitoring solutions	-NA-
54		Packaging Machines Manufacturing Company	-NA-	Remote monitoring solutions	-NA-

Appendix II: Cases corresponding to the criteria identified for designing OBCs

Case #	Reference Article	Ownership during the contract period	Ownership after the contract period	Ownership of Software	Ownership of Production Data	Ownership of Maintenance Data	Ownership of Raw Materials/ Consumables	Responsibility for Maintenance Personnel	Responsibility for Operational Personnel	Responsibility for Installation and Set-up	Responsibility for Logistics of Machine	Responsibility for Skills and Training	Responsibility for Refurbishment	Responsibility for Upgradation	Responsibility for Modernization	Type of Payment Model	Penalty Schemes	Duration of Contract	Machine Utilization Level	Location of Operations	Exclusiveness of Usage
1.	Barquet, de Oliveira, Amigo et al., 2013	x						x	x			x		x	x	x					x
2.	Baines and Lightfoot 2013							x								x	x	x		x	x
3.								x								x	x	x		x	x
4.								x								x	x	x		x	x
5.								x								x		x		x	x
6.	Grubic and Peppard 2016	x			x											x					
7.	Adrodegari, Saccani, Kowalkowski et al., 2017	x		x												x				x	

Case #	Reference Article	Ownership during the contract period	Ownership after the contract period	Ownership of Software	Ownership of Production Data	Ownership of Maintenance Data	Ownership of Raw Materials/ Consumables	Responsibility for Maintenance Personnel	Responsibility for Operational Personnel	Responsibility for Installation and Set-up	Responsibility for Logistics of Machine	Responsibility for Skills and Training	Responsibility for Refurbishment	Responsibility for Upgradation	Responsibility for Modernization	Type of Payment Model	Penalty Schemes	Duration of Contract	Machine Utilization Level	Location of Operations	Exclusiveness of Usage
8.		x					x									x					
9.		x														x	x				
10.		x														x					
11.		x														x					
12.		x														x					
13.	Gebauer, Haldimann, and Saul, 2017	x														x					
14.		x														x					
15.		x														x					
16.		x														x					
17.		x														x					
18.		x														x					

Case #	Reference Article	Ownership during the contract period	Ownership after the contract period	Ownership of Software	Ownership of Production Data	Ownership of Maintenance Data	Ownership of Raw Materials/ Consumables	Responsibility for Maintenance Personnel	Responsibility for Operational Personnel	Responsibility for Installation and Set-up	Responsibility for Logistics of Machine	Responsibility for Skills and Training	Responsibility for Refurbishment	Responsibility for Upgradation	Responsibility for Modernization	Type of Payment Model	Penalty Schemes	Duration of Contract	Machine Utilization Level	Location of Operations	Exclusiveness of Usage
19.		x					x									x					
20.		x														x	x				
21.		x														x					
22.		x														x	x				
23.		x														x					
24.		x														x					
25.	Rabetino, Kohtamäki, and Gebauer, 2017	x										x				x					
26.																x	x				
27.												x				x					
28.	Rymaszewska, Helo, and	x		x	x											x		x		x	
29.		x		x	x			x						x	x	x	x	x			

Case #	Reference Article	Ownership during the contract period	Ownership after the contract period	Ownership of Software	Ownership of Production Data	Ownership of Maintenance Data	Ownership of Raw Materials/ Consumables	Responsibility for Maintenance Personnel	Responsibility for Operational Personnel	Responsibility for Installation and Set-up	Responsibility for Logistics of Machine	Responsibility for Skills and Training	Responsibility for Refurbishment	Responsibility for Upgradation	Responsibility for Modernization	Type of Payment Model	Penalty Schemes	Duration of Contract	Machine Utilization Level	Location of Operations	Exclusiveness of Usage
	Gunasekaran 2017																				
30.	de Oliveira, Mendes, Albuquerque et al., 2018	x	x	x			x	x	x		x	x				x	x	x		x	
31.	Raja, Chakkol, Johnson et al., 2018	x		x												x				x	
32.								x	x							x				x	x
33.	Visnjic, Neely, and Jovanovic, 2018															x		x			
34.																x		x			
35.																x		x			
36.	Yang, Smart, Kumar et al., 2018	x	x													x			x		x
37.		x	x	x	x	x	x	x	x		x	x				x				x	x

Case #	Reference Article	Ownership during the contract period	Ownership after the contract period	Ownership of Software	Ownership of Production Data	Ownership of Maintenance Data	Ownership of Raw Materials/ Consumables	Responsibility for Maintenance Personnel	Responsibility for Operational Personnel	Responsibility for Installation and Set-up	Responsibility for Logistics of Machine	Responsibility for Skills and Training	Responsibility for Refurbishment	Responsibility for Upgradation	Responsibility for Modernization	Type of Payment Model	Penalty Schemes	Duration of Contract	Machine Utilization Level	Location of Operations	Exclusiveness of Usage
38.	Zhang, Guo, Gu et al., 2018	x	x	x	x	x	x	x	x		x	x				x				x	
39.	Frishammar and Parida 2019															x					
40.																x					x
41.	Paiola, and Gebauer 2020															x					
42.													x			x					
43.																x					
44.																x					
45.	Holgao and Macchi 2021			x				x								x				x	
46.	Korkeamäki, Sjödin,							x								x	x				
47.								x								x					
48.								x								x					

Case #	Reference Article	Ownership during the contract period	Ownership after the contract period	Ownership of Software	Ownership of Production Data	Ownership of Maintenance Data	Ownership of Raw Materials/ Consumables	Responsibility for Maintenance Personnel	Responsibility for Operational Personnel	Responsibility for Installation and Set-up	Responsibility for Logistics of Machine	Responsibility for Skills and Training	Responsibility for Refurbishment	Responsibility for Upgradation	Responsibility for Modernization	Type of Payment Model	Penalty Schemes	Duration of Contract	Machine Utilization Level	Location of Operations	Exclusiveness of Usage
	Kohtamäki et al., 2022																				
49.	Paiola, Schiavone, Grandinetti et al., 2021							x								x					
50.								x								x					
51.																x					
52.																x					
53.	Paiola, Agostini, Grandinetti et al., 2022									x						x	x				
54.				x												x					