Review of PPX business models: Adaptability and feasibility of PPX models in the equipment manufacturing industry

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Abstract. The overall purpose of this study is to understand how manufacturing companies have so far made use of and can make use of pay-per-X (PPX) business models (BMs) largely in capital product markets, and which mechanisms have helped them in the implementation. Through systematic literature approach this study analysed 14 research publications which exclusively focused on PPX business models. The differences between PPX business model patterns were studied from three perspective, namely criticality of product, need of process knowledge and complexity of the process and its output. We find out that the pay-per-outcome business model, is more prevalent for products which are critical, needs extensive process knowledge and are rather complex. In contrarily, pay-per-output business model is more prevalent when these conditions are not met. However, none of these three factors prevents implementing other type of PPX business model but rather specific business model is more feasible when specific conditions are met. This paper contributes a much more in-depth qualitative view on the patterns and related qualitative arguments for the useful application of PPX models in equipment manufacturing industries and helps to understand the differences between PPX business model types.

Keywords: Business model, NOBM, Pay-Per-X, Pay-Per-Output, Pay-Per-Outcome.

1 Introduction

During the last decade, pay-per-x (PPX) services and related business models (BM) have established importance in many fields, e.g. in equipment and capital-intensive product manufacturing industries, where they were earlier found to be difficult to implement, due to inherent significant risks for their suppliers, as well as technological challenges [1]. Additionally, their scalability has been considered as a significant hindrance to their implementation, compared e.g. to the use of similar BMs and services in software business (i.e. SaaS models) or consumer product industry [2].

Due to the above type of challenges, many companies have struggled heavily with the design and implementation of novel pay-per-x services and related BMs for

equipment. For instance, some of the pioneers, the large car tire manufacturer, Michelin, designed to sell pay-per-kilometer services for its tires, but struggled for many years to become commercially successful. [3]. Furthermore, also one pioneering company in equipment manufacturing field, Kaiser, producing compressors, also struggled in the development and implementation of a feasible model. [4]

The actual benefits and particularly the feasibility (and its preconditions) of pay-per-x and especially pay-per-output/outcome type BMs in equipment manufacturing companies have been very little studied and reported in academic literature. It is not yet properly understood in which types of products and more specific industries PPX BMs have been recently used, and thus, in which specific conditions they are feasible and profitable, and how they have been applied to provide feasibility in those cases [5]. In this respect, the equipment and capital product industries have been some of the most challenging ones to apply the above BMs [6], and only very recently, they have been applied and studied [7]. For example, [8] found that the PPX BMs are typical in the context of a capital-intensive, complex engineering product, with a long life cycle, where a product requires a considerable effort to maintain. In addition, Böhm et al. [9] have found that product innovativeness and technological turbulence has an impact on feasibility of different PPX BMs.

When applied usefully in proper setups, PPX services have been found to enable various strategic benefits, such as profitability and sales growth in equipment manufacturing companies [10], [11]. Furthermore, a recent study by [12] found that in a larger empirical survey, PPX offerings were found to be a profitable servitization strategy for manufacturers of equipment and machinery of not only large size but of many company sizes, as well as that many companies (often larger ones) struggled with e.g. scaling issues of the related BMs. The most commonly known and reported equipment manufacturing PPX cases are clearly large or huge companies like Kaiser or Rolls Royce. However, it is not yet properly understood in academic research which types of more detailed mechanisms related to the BM implementation help to create such feasible strategic benefits (here, especially sales growth and related profitability).

The overall aim of this study is to create a picture of more generic patterns on and thus to understand how manufacturing companies have so far made use of and can make use of PPX BMs largely in capital product markets, and which mechanisms have helped them in the implementation. Thus, we aim to study, making use of existing equipment industry studies and reported relevant case studies:

***RQ**: What kind of products and more detailed industries' have made use of PPX business models, and how they have been able to do this feasibly (responding to e.g. the above-mentioned important challenges of the EM industry).*

We followed a systematic literature review approach to identify the relevant articles and cases from the current research. We make use of existing identified 44 case studies to distinguish some overall patterns related to the above aims and the RQ both quantitatively and qualitatively. We then use these to formulate propositions.

Earlier studies that we have been able to find that focused on equipment manufacturing (EMI) context did not make use of a large group of identified relevant case studies from various EMI fields, or a recent systematic review of existing cases. Thus, we

will add to existing research by providing a recent review of the existing EMI cases from various EMI industries, and thus being able to create a good picture of existing patterns from the cases. Through the same approach, we contribute a much more in-depth qualitative view on the patterns and related qualitative arguments for the useful application of PPX models in the wide EMI industries.

2 Theoretical background

The value proposition in the manufacturing industries has changed dramatically in recent years [13]. Designing and selling a combination of service and product is now seen as a prominent value proposition [14]. Companies are integrating services into their core business which have resulted in the evolution of Product-Service systems (PSS). In recent years, the business model literature has produced extensive knowledge on these PSS model [2], [10], [15]–[19]. The non-ownership BMs (NOBM) are one type of PSS BM where the ownership of the product is not transferred to the customer, but customer has only right to use the product. These NOBMs can be divided based on earning logic to three types of pay-per-x (PPX) business models: Pay-per-use, Pay-per-output and Pay-per-outcome BMs. [20]

In pay-per-use BM the customer is paying based on usage (used time) of product instead of buying the product (e.g. pay-per-wash) [3], [16]. For commercial success, pay-per-use services depend on modularizing products and services and effective enforcement resources [3]. Although there are a lot of opportunities on this BM, there are also some risks, like the reduction of revenues due to a low level of product usage which does not cover the fixed equipment maintenance costs [21]. To reduce the risk, companies could enhance operational capabilities by deploying product usage data processing knowledge and optimize service delivery cost [22]. Sousa-Zomer et al. [23] has showed that companies which implemented a pay-per-use BM, has developed new capabilities related to financial activities (such as the financial impact of Pay-per-use services, monitoring the costs along the lifecycle) and legal activities. Other capabilities such as inter-organizational cooperation with different companies to acquire or develop required skills are needed [24].

Though the literature explicitly not provided a comprehensive definition for the pay-per-output BM, Wolfgang [17] defined it as “customers pay a fee that depends on usage and is measured according to clearly specified consumption, output, or other indicators”. According to Menon *et al*. (2019), the pay-per-output is monetized based on a quantified output of the machine rather than the usage of the machine. Only a few studies have explored the Pay-per-output BMs. For example, Uuskoski et al. [25] studied benefits and difficulties during the implementation process of the Pay-per-output BM in SME.

The third PPX BM type, pay-per-outcome BM (selling outcome-based services), has gained a lot of attention from equipment manufacturing companies in recent years [11], [26]. Like the pay-per-output BM, this as well is focusing on the output but not alone in a quantified sense but also from a quality perspective [20]. In this BM, the provider

is responsible for the equipment's or service's output's performance and accepts penalties for shortcomings relate to that as well [8], [11], [18], [19].

Although the Pay-per-outcome BM seems more promising from the service provider perspective, it requires additional capabilities from the organization such as IT [8], performance measurement capability [27], efficient repair and logistics capabilities [28] and necessary information to manage cost and risk [11]. Böhm et al. [9] argued that when technological turbulence is high, buyers perceive significantly more benefits. He also found that pay-per-outcome models demand not only extensive product knowledge and product's performance in the customer's processes.

3 Research Methodology

We followed a systematic review approach [29] to identify the relevant articles, cases pertaining to the current research. Since we were looking for cases published in high impact articles, we considered only the journal articles in English, and which were published in the database of Scopus and Web of Science. As, our research objective was in the context of PPX BMs for equipment manufacturing companies and we wanted to have published cases studies, therefore we used the following keywords and the 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") AND ("manufacturing" OR "manufacture" OR "manufacturer") AND ("case" OR "case study" OR "case studies")

Additionally, we complemented the above pool of articles by deploying articles from authors' own knowledge, and that from forward and backward search of references. Also, since we required an in-depth analysis of data to achieve our research objectives, therefore, we considered only the qualitative single or multiple-case studies. Besides, to adhere to our research objective we selected the advanced business models (i.e. pay-per-use, pay-per-output, and pay-per-outcome) cases studies in B2B context. The review was conducted during July 2020. Totally, we find 528 articles, and after following all the steps we accepted 14 articles with 44 cases.

The concepts were identified by using coding technique [30]. Coding was done in two phases. First the concepts were identified based on few case studies. Second the coding was done for all the cases based on these identified concepts. The three identified concepts were "*criticality of product*", "*process knowledge*" and "*complexity of customer's process and its output*". In addition, we classified each case company based on Global Industry Classification Standard (GICS®) [31] to get more information about industry patterns.

4 Findings and analysis

We have found that, out of 44 cases, 13 companies (30%) have implemented pay-per-outcome BM, 20 companies (45%) have implemented pay-per-output BM and 11 companies (25%) the pay-per-use BM [10], [32]–[44].

With GICS classification, 11 (3 pay-per-use, 6 pay-per-output, 2 pay-per-outcome) cases were from *Moving Capital Goods*, nine (4, 5, 0) cases from *Standalone Capital Goods*, nine (2, 0, 7) cases from *Material*, eight (1, 5, 2) cases from *utility* and seven (1, 4, 2) cases from *Commercial & Professional Services* industries.

In the following sections, we discuss more in-depth these cases using the three identified concepts: *Criticality of product, Process knowledge, and Complexity of customer's process and its output.*

4.1 Equipment Criticality

The criticality of equipment was defined, in such that critical equipment is a central part of the customer's process and without that anything cannot be done. Semi-critical equipment is part of that process but does not have that big impact on the customer's end-product while not-critical equipment are add-ons which can be replaced rather easily, or the process can work even without them.

The case analysis has showed that all companies which have adopted pay-per-outcome model, are providing equipment which are either critical or semi-critical for the customer's process. Whereas pay-per-output BM is dominant in semi-critical equipment and all the not-critical equipment are provided through this BM. However, there is no clear correlation between the criticality and PPX BM type, albeit the distribution of PPX BM differs depending on the criticality (See Figure 1).

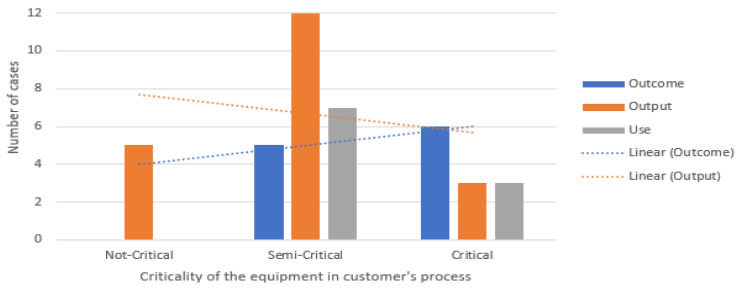

Fig. 1. Distribution of pay-per-x business model types by the equipment criticality.

From the case companies which provide critical equipment majority (8 out of 12) were from material industries. In addition, there were two cases from utility industry and one from moving capital good and one from standalone capital good industry. In contrarily, majority (3 out of 5) not-critical equipment were from office equipment industry. Other two case companies were from utility and standalone capital good industries.

For example, one case company [36] had struggles to utilize outcome-based BM in Cruise & Ferry ship segment. Their equipment, vessel propulsion system, was not critical in that segment and thus the failure of that system would not be major problem. Therefore, the customer was not interested in to invest additional money on that system. However, in Oil & Gas segment it is critical system, and the failure can cause huge

losses in production. Thus, the implementation of the pay-per-outcome BM was possible for that segment. [36] This implies that the equipment's criticality has an impact on customer's willingness to invest on it.

Another case company [40] (Original equipment manufacturer) has implemented two PPX BMs in their offerings. The pay-per-use BM was implemented in division A and pay-per-outcome in division B. The product of division B was more complex and more critical part of the customer's process than division's A product. The division B stated that due to being central part of customer's system they need more closer relationship with the customer. The findings of this study show that the Pay-per-outcome BM is implement in the companies, who provides more critical product in sense of customer's process.

In addition, one sheet metal processing and one power generator manufacturer [41] have been able to implement pay-per-outcome BM as they have moved from selling just individual equipment toward larger entities for the customers. These cases highlight that the implementation pay-per-outcome BMs became easier as the provider's responsible of customer's process increased. In other words, the criticality of the company's solution within customer's process increased as the proportion it covers of the customer's process increased.

Our analysis shows that pay-per-outcome BM is adopted in industries where equipment criticality is high. Based on these finding we present the following proposition:

Proposition 1: *High criticality of an equipment in customer's process in EMI context can enhance the overall ability to implement pay-per-outcome BMs (compared to other PPX models).*

4.2 Process knowledge

The companies' knowledge, resources and their systematic management have become a critical success factor in the manufacturing industry [45]. We have analysed cases from the level of process knowledge perspective. Defining the need of process knowledge can be a hard and thus the case companies are divided only for three categories: low, medium and high (see figure 2). High need of process knowledge means that the supplier must understand how the customer's end-product is made and how their equipment effect on it. For example, one equipment of paper machine cannot be sold if the supplier does not understand how it integrates to whole process line. The low need of process knowledge stands for products in which the supplier does not need to know what the customer is producing; such product would be solar panel which is just providing energy but does not have big impact on the end-product of customer's processes.

The figure 2 indicates that the pay-per-outcome BMs are more common in equipment where needed level of process knowledge is higher while the pay-per-output BM is contrarily more common in equipment which do not need such high level of process knowledge. For the prevalence of the pay-per-use BM the need for the process knowledge does not seem to have an effect. Majority of the cases (9 out of 11) which have high level of process knowledge have implemented pay-per-outcome BMs.

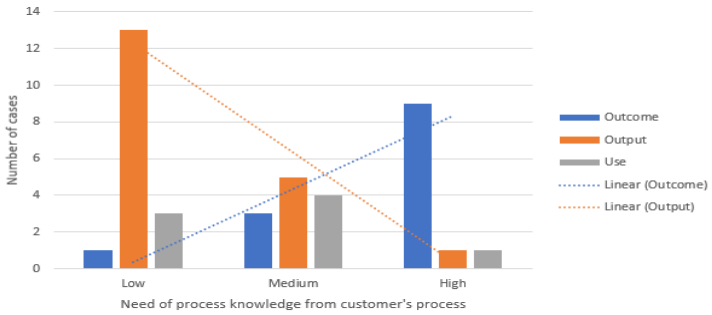

Fig. 2. Distribution of pay-per-x business model types by the need of process knowledge.

Out of the 11 case companies which had high level of process knowledge, six were from material industry. In addition, two from both commercial & professional services and moving capital good industries and one from standalone capital good industry. What comes to companies with low need of process knowledge, the distribution was rather even between moving capital goods (5), utility (5), Commercial & Professional Services (4) and standalone capital goods (3) industries.

The process knowledge such technical skills, experience and product knowledge plays a vital role in implementation of pay-per-outcome BM [36], [38], [42]. As Grubic and Peppard [36] summarize the equipment status cannot always be defined alone from the data, but the process knowledge is needed in order to interpret it, especially when the equipment is complex. With effective analyse of the equipment as part of the customer's process the company can increase its chances to improving the customer's processes and thus allow the company to create additional revenue [36]. Grubic and Peppard [36] has showed that the success of outcome-based BM depends on experts' skills, experience and knowledge rather than the technology. With technology alone, anybody can provide the value, but the process knowledge is the thing which distinguish the company from the competitors [36].

The risk is high in pay-per-outcome BM, where the company's revenue is dependable on the result of its equipment which is used by customer [42]. In some cases, introduced by Visnjic *et al*. (2018) the companies implementing pay-per-outcome BM, have faced huge losses due to failure of meeting promised availability for the equipment. This highlights the vitality of understanding the environment and customer's processes for the companies to avoid promising too much. Paiola and Gebauer [38] showed that especially on the outcome-based BMs the importance of learning from the customers increased. The companies must have in-depth understanding about the customer's activities in order to provide pay-per-outcome BM. [38]

In summary there is evidence that the understanding customer's processes plays important role in pay-per-outcome BMs. This leads us to following propositions:

Proposition 2a: *Equipment manufacturer's high level of customer's process knowledge can enhance the overall ability to implement pay-per-outcome BMs (compared to other PPX models).*

As noticed, based on qualitative analysis (figure 2), there is negative correlation between pay-per-output BM and need of process knowledge albeit there was no qualitative evidence to support this indication. The reason for lack of discussion about the lower need of process knowledge in pay-per-output BMs might be it has not been the focus of these studies. In addition, when the PPX BMs have been studied as a one, there have not been identified the differences between the PPX BMs. Based on this we can lead another proposition:

Proposition 2b: *Equipment manufacturer's low level of customer's process knowledge can enhance the overall ability to implement pay-per-output BMs (compared to other PPX models).*

4.3 Complexity of customer's process and its output

Equipment complexity is a key element to understand the interdependencies of production activities [46]. Even though defining the complexity of customer's process and its output is not unambiguous [47] we can make broad distinction between non-complex products and complex entities. Process complexity informally measures the "difficulty" of describing and executing a process.

The case analysis has showed that the adoption level of pay-per-outcome BM is higher among companies which make equipment for more complex processes. In contrarily, the adoption level of pay-per-output BM is higher among companies which make equipment for less complex processes (See Figure 3).

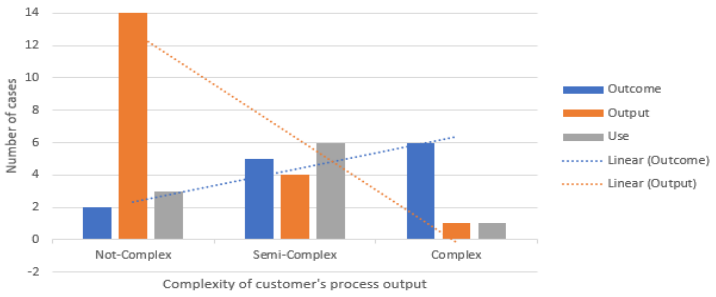

Fig. 3. Distribution of pay-per-x business model types by complexity of customer's process and its output.

The majority (7 out of 8) of companies providing equipment for complex processes were from material industry and only one were from utility industry. The distribution for equipment to not complex processes were following: moving capital goods (7), Commercial & Professional Services (5), utility (4) and standalone capital goods (3) industries.

Yang et al. [43] has showed that a company with right capabilities and resources was actually able to implement both pay-per-use and pay-per-outcome BM. In the pay-per-outcome BM the co-products of the product were monetized, and it was used especially in industrial parks where distribution of co-products was profitable. In similar manner,

one case company [40] was able implement both pay-per-use and -outcome BM and actually the product itself and its role for the customer was the factor which was guiding the selection of the BM. The simpler and more standardized product was sold using pay-per-output BM while critical, more complex tailormade products were sold using pay-per-outcome BM. [40] Paiola and Gebauer [38] argues that the same requirements of the use-oriented BM stay as the company expands toward outcome-based BMs. A couple cases [41] support this idea by showing how the companies were able to provide pay-per-outcome BM as they expanded their offering from equipment to more complex bigger entities. Based on these results we can lead proposition:

Proposition 3a: *High process complexity in EMI context can enhance the overall ability to implement pay-per-outcome BMs (compared to other PPX models).*

From the quantitative analysis (figure 3) we can as well see that the prevalence of pay-per-output have negative correlation with the complexity of customer's process and its output. However, none of the case studies discussed about the low complexity of customer's process and its output in pay-per-outcome BMs and thus there is not qualitative support for this evidence. Yet, it is possible that the focus of these cases studies has been the complexity of PPX BMs in general and thus it has not been discussed that there are differences between the complexity within PPX BMs. Based on this we make another proposition:

Proposition 3b: *Low process complexity can enhance the overall ability to implement pay-per-output BMs (compared to other PPX models).*

5 Discussion

This study aims to address the research question: *What kind of products and more detailed industries' have made use of PPX business models, and how they have been able to do this feasibly?* As an outcome to this, we were expecting to learn more about PPX BM implementation pattern and what conditions favours PPX BMs. We identify three areas where our research contributes, namely "*Equipment criticality*", "*Process knowledge*" and, "P*rocess and its output complexity*" can have an impact on the ability to implement different PPX business models.

5.1 Equipment criticality impact the ability to implement different PPX business models

The study finds out that equipment criticality has an impact on whether implementation of a pay-per-outcome BM is feasible. If failure of equipment can cause huge losses in production, the service provider can utilise this opportunity to implement a pay-per-outcome BM. In contrarily, if the failure of equipment does not have major influence on customer's processes, it might be difficult to implement a pay-per-outcome model. We can argue that the customer would not see the additional benefit of this model in guaranteeing the availability of the critical process. This was supported by the findings in cases [36], [40], [41].

The pay-per-outcome BM were most common in material industry (7/9) in which the process criticality as well is most common (8/12). In contrarily, in commercial & professional services industry where pay-per-output BM is more common the criticality of product for customer's process was lower as well.

5.2 Equipment manufacturer's knowledge of customer's processes impact on the overall ability to implement different PPX business models

The equipment manufacturer's process knowledge of the customer's processes found to be an important factor impacting the selection of PPX BMs. With in-depth knowledge of the customer's processes, the supplier is more probable to be able to improve the customer process, which again support the implementation of pay-per-outcome BM. However, great risk is involved in outcome-based BMs, because, if the supplier failed to meet the promised results, they may face huge losses [42]. Thus, it is vital that the supplier understand how the customer process is working before offering pay-per-outcome BM.

If the company want to implement pay-per-outcome BM, it needs to have in-depth understanding about the environment the equipment is running, be able to learn from customer and gaining the knowledge from the customer's activities [38]. The findings suggest that if these conditions are not met, it is more likely that pay-per-output BM is a better option for the company. Even though, sufficient qualitative data was not found to support this statement, it unfolds a future research avenue.

From an industry pattern perspective, we find out that majority of the case companies in the material industry had a high process knowledge of the customer's processes. As the pay-per-outcome BMs are most common in material industry, this support the above statement pay-per-outcome BMs are more feasible for companies which have high level of process knowledge. On the contrary, in the Utility sector, none of the case companies needed a high level of process knowledge. Similar manner, pay-per-output is dominant business model in utility sector.

5.3 Process and its output complexity impact ability to implement PPX business models

Process complexity informally measures the "difficulty" of describing and executing a process. Our study has shown that the adoption level of pay-per-outcome BM is higher among companies which make equipment for more complex processes. In contrarily, from the quantitative analysis (figure 3) we can see that the adoption level of pay-per-output BM has a negative correlation with the complexity of the customer's process and its output. However, there was no qualitative data support for this evidence which might be due to several reasons, but at least this unfolds an interesting avenue for future research.

We can argue that if the process is more complex (more difficult to operate), the optimization of the result is as well more difficult. Thus, the customer has a higher incentive to pay based on the result if they can't improve the process itself anymore. This

indicates that the customer willingness to use the pay-per-outcome BM increase while the complexity of the process increases.

However, it is studied that lack of standardization hamper the implementation of PPX BM. The possible problems can be the limited amount of data, quality of data and lack of contextual information. [36] For example Grubic and Peppard [36] showed an example how based on sole vibration data there could not be seen any problems in the machine even though the problems were evident for the user of the machine how could hear and see the machine. Thus, we can say that even though pay-per-outcome BMs are more common in complex products, complexity alone is not making them feasible for pay-per-outcome BM.

From the industry perspective, the complex processes and outputs were most common again in the material industry where pay-per-outcome BM is most common. The least complex processes and outputs were in moving capital goods industry, were pay-per-use and -output BMs are more common compared to pay-per-outcome BM.

6 Conclusions and Future Research

By analysing existing 44 EMI-related PPX BM cases, we were first able to identify three important concepts that showed interesting distinctive both qualitative and quantitative patterns in the EMI companies' exploitation of different types of PPX BMs: *1) criticality of product for customer's process, 2) suppliers' customer process knowledge and 3) complexity of the process and its output.* Based on these concepts and identified patterns, we devised propositions concerning different PPX business model types in EMI context.

Through these propositions and their analyses, we were able to create fully new academic understanding that contributes to the existing PPX literature by partially providing new understanding about PPX BM suitability in EMI context and related individual more detailed industries, but also by providing more depth to existing EMI-related PPX studies through detailed case examples regarding especially the three above concepts, and partially also by confirming earlier more preliminary findings about PPX use and overall PPX feasibility in the challenging EMI context.

We have not been able to find any other PPX studies in EMI context with similar findings. Regarding the existing PPX research, some earlier studies [8], [9] have reported e.g. some overall patterns regarding PPX use and overall feasibility in broader manufacturing context and some even more particularly in EMI context, but they do not report exactly same type of findings, and none of the have made use of systematic literature review of the broad pool of PPX cases studies. Thus, there is novelty also in respect to the exact context as well as the methodology and related analysis of existing EMI PPX cases.

Previous studies [8] have identified that the PPX BMs are typical in the context of a capital-intensive, complex engineering product, with a long life cycle, where a product requires a considerable effort to maintain but have not made distinction between different PPX business model types. In addition, it is studied [9] that two environmental factors affects the feasibility of different PPX BM, namely product innovativeness and

technological turbulence. However, the study suggested that other affecting characteristics should be studied as well.

These findings have both academic and managerial value. This study helps to extend our knowledge about some fundamental differences between different types of PPX business models and why some EMI industries are more prone to make use of specific PPX business model types. The study also highlights the need for studying different PPX models independently, as separate type of BMs, albeit many current studies tend to study PPX models as a larger category of similar BMs. From managerial perspective this study helps to understand which PPX business model would be the best fit for specific type of products. The study showed that if the equipment and its output are rather simple, not critical or the company does possess in-depth understanding of customers processes and have expertise how to improve it, then more feasible PPX business model would be pay-per-use or pay-per-output. Our findings will be helpful to especially EMI companies of different types of industries, as well as their responsible business managers, which have been relatively little studied so far regarding PPX model design and implementation.

Some limitations of this paper are related to the collected data and the used literature review and its analysis method. Inherently, the identified existing case studies from the literature do not yet fully represent the EMI context and potential EMI PPX business models necessarily, and they do not focus on the case companies' products in such a depth that would have been needed in order to understand the characteristic features of the case companies or their industries. Thus, as for the future research, the results should be validated with an empirical study with larger set of companies, or companies from specific EMI industries, which would focus solely on the found patterns of PPX business models in EMI context. In this study, the underlying reasons why some companies are more prone to specific types of PPX business models could be studied as well. Furthermore, in our study, so far only three concepts which impact the selection of PPX business model could be identified from these cases in sufficient depth. Therefore, future studies should focus on other factors like standardization level of EMI products and more detailed types of EMI products' output. Third, interesting topic of the future study could be whether it's always feasible to advance from a pay-per-use business model toward result-oriented business models.

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