Pay-Per-X Business Models for Equipment Manufacturing Companies: A Maturity Model

Joonas Schroderus[1], Sameer Mittal[1,2], Karan Menon[1(✉)], Lester Allan Lasrado[3], and Hannu Kärkkäinen[1]

[1] Tampere University, Tampere, Finland
{sameer.mittal,karan.menon,hannu.karkkainen}@tuni.fi
[2] JK Lakshmipath University, Jaipur, India
sameer.mittal@jklu.edu.in
[3] Kristiania University College, Oslo, Norway
lesterallan.lasrado@kristiania.no

Abstract. Pay-per-X (PPX) business models are models where the ownership of the product is not transferred to the customer, but the customer has a right to use the product. The implementation of PPX business models can be time-taking, and complex because many company functions need to interact with each other, especially for equipment manufacturing industries (EMIs). The aim of this paper is to design a PPX maturity model for EMIs using a systematic maturity model development process. We present a PPX maturity model for EMIs with 7 dimensions, 19 sub-dimensions, 5 maturity levels, and relevant boundary conditions. This PPX maturity model is developed empirically with academic and industry experts from the maturity model and PPX perspective. The developed PPX maturity model will allow the EMIs to assess their current as-is situation in the most critical areas of PPX implementation and formulate a roadmap toward the implementation.

Keywords: Pay-per-X · Pay-per-use · Pay-per-outcome · Pay-per-output · Business models · Maturity model

1 Introduction

Pay-per-X (PPX) business models are models where the ownership of the product is not transferred to the customer, but the customer has a right to use the product. These PPX business models can be divided into pay-per-use, pay-per-output and pay-per-outcome business models [1, 2]. In pay-per-use business models, the customer pays for the time units of the machine used by the customer (e.g. per hour, per day) [2], whereas in pay-per-output business models the customer pays for the number of units the machine makes (e.g. per 100 units) [2]. In pay-per outcome business models, the focus is on achieving a specified outcomes or added value such as energy savings, rather than on a set of prescribed specifications [2].

The implementation of PPX business models can be time-taking, complex because many company functions need to interact with each other (for e.g. operations, analytics

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and sales need to work with each other to achieve PPX). As maturity models have been widely and quite successfully applied in implementations of different, complex systems, and strive for representing an evolution path towards the desired stages of maturity [3], they can also help with the implementation of business models [4]; see also [5]. Consequently, maturity models can help with the implementation of PPX business models, which are advanced and complex from both the technical and business-related implementation perspectives. However, despite the vast amount of maturity models in existence [3], maturity models in the implementation of PPX business models, and specifically in the context of business to business (B2B) equipment manufacturing industries (EMIs), present a research gap addressed in this paper. As PPX business models relate closely to concepts such as Industry 4.0, servitization, digitalization and product-service systems, the literature review of this research was consequently conducted by reviewing and analyzing maturity models in these relevant fields. Therefore, the aim of this paper is to design a PPX maturity model in the context of B2B EMIs.

The remainder of the paper is structured so, that first we introduce the main concepts, and explain what maturity and PPX models are. Second, we present the methodological background and choices. Then, through analysis making use of PPX-related literature and maturity models in relevant areas such as Industry 4.0 and digitalization, we present the preliminary maturity model and associated conditions. Lastly, we present our main conclusions and future work.

2 Theoretical Background

2.1 Pay-Per-X Business Models

PPX are the advanced servitization BMs that focus towards offering the use, output and outcome of the equipment offered by the EMIs to the customer [6].Therefore, ownership of equipment in case of PPX does not belong to the customer. PPX BMs are further divided into pay-per-use, pay-per-output, and pay-per-outcome BMs [6]. If the customer pays for a certain number of hours for which it has deployed the EMI's equipment, then it is referred to as pay-per-use BMs [2, 6]. Whereas, if the customer pays for the output units manufactured by deploying the equipment, we refer to it as pay-per-output BMs [6]. If the equipment is deployed to reach a desired outcome such as saving on costs and energy, then we refer to it as a pay-per-outcome BM [6]. EMIs can associate themselves with two major advantages while offering PPX BMs. Firstly, they can create more market segments and thus generate higher revenues [6–8], and secondly, lower the risks of offering expensive equipment by sharing risks with other players like a third party or a financial institute [9–11].

2.2 Maturity Models

Maturity can be defined as "the state of being complete, perfect or ready" [12]. Maturity models are understood as normative theories that should guide the audience towards some desired outcomes [13]. Maturity models are often represented as stage fixed level models, stage continuous level models or a matrix structure in form of focus area models

[14]. According to [15], researchers have used maturity models to facilitate (i) self-assessment or third-party assessment (also known as descriptive), (ii) benchmarking or comparison (comparative), and (iii) provide a roadmap for continuous improvement (prescriptive) [16, 17] with one main purpose being providing a common language to facilitate discussion among stakeholders and thus provide a structure for prioritizing actions [14, 17], which is also the aim of pay-per-X maturity models (PPX-MM). The five core components namely (i) maturity level, (ii) dimensions, (iii) boundary conditions, (iv) path to maturity and (v) assessment that constitutes a maturity model as used in our paper are the same as described in prior studies [17, 18].

2.3 Pay-Per-X Maturity Models

The advanced PPX business models can provide equipment manufacturing industries (EMIs) with new ways of earning in the globally saturated product-centric industries [19]. However, implementing PPX business models can be difficult. As EMIs can provide complex and highly customized solutions to their customers, finding new ways of earning can be challenging due to e.g. changing technologies, routines and business processes in general [20]. If companies lack understanding, these changes can have a negative effect on the performance of the equipment manufacturer [21], and potentially lead to e.g. difficulties in achieving expected returns from the new, service-oriented PPX business models [22]. Overall, the process of implementing business models is consequently still relatively underdeveloped [4, 23] and many business models fail during implementation [24]. Despite this fact, only little research has been done on standardized methods to assess and compare the maturity of business models [25].

Consequently, successful PPX business model implementation requires a systematic approach, that helps the equipment manufacturers to define the operational capabilities needed in the change process [26, 27]. For this, maturity models that have already been widely accepted and used for example in IT management [16], are also being recognized as prospective tools in other areas such as manufacturing and services [28] as well as more complex areas such as product-service systems [29]. Therefore, the argument in this research is that a maturity model can be developed to assess the PPX implementation readiness of EMIs, serving them as a starting point for assessing the companies' current as-is situation in the most critical areas needed in PPX business models. [30] Moreover, the maturity model provides a starting point for the development of a future roadmap towards the PPX business model implementation as well as overall helps the equipment manufacturers to define and reach the desired outcomes as efficiently as possible by providing them a common language within the company [3, 16, 29].

3 Methodology

The methodology deployed in the current research is based on action design research (ADR), developed by [31] (see Fig. 1). ADR combines the different action and design research approaches to emphasize the importance of both iteratively creating an artifact i.e., in this case the maturity model, as well as putting the artifact under development in the organizational context as well as theory. The process can be divided into 4 phases,

which are the problem formulation phase where the problem and theory-based artifact are formulated; building, intervention, and evaluation (BIE) phase where the theory-based artifact is concurrently and iteratively developed in cooperation with the organizations; reflection and learning phase where the problem and artifact relevance are evaluated and finally the formalization of learning phase, where the outcome of the full process is generalized [31].

In the problem formulation phase of the ADR and development of the PPX-MM, the research focused on identifying and conceptualizing the research opportunity, formulating the research questions and more concretely, defining the scope of the PPX-MM. Once the scope was clear, the research included a literature review of both maturity model and PPX-related literature, to ensure there is relevance in the research and we can proceed with the development of a new PPX-MM. In terms of designing the maturity model, the research also utilized the overall maturity model development process created by [3, 12] maturity model design decision criteria helping to define the scope of the PPX-MM. Since scientific literature already consisted of a study [17] that followed ADR approach and focused on developing the dimensions and maturity levels of the PPX-MM. Therefore, we considered the seven dimensions and five maturity levels from an existing study [17].

The building, intervention, and evaluation phase of the development of the PPX-MM is where most of the actual design of the model occurred. However, as [31] state, this does not mean that the other stages are not overlapping or concurrent. The BIE cycle also started to move towards organizations: to assess the theory-based dimensions or the initial "artifact", the PPX-MM went through three series of expert interviews. The PPXBM was first taken to three academic experts in maturity models, and to follow that it was discussed with two academic PPX business model experts. Finally, the relevance of proposed PPX-MM was discussed into the organizational context, i.e., the partner companies and two end users of the PPX-MM. After the three rounds of expert and company workshops, the PPX-MM was again refined and developed within the research team according to findings from the expert and end user feedback, allowing a fully developed PPX-MM with dimensions, sub-dimensions, and unique level descriptions. With the help of the well-defined and validated dimensions, sub-dimensions, and maturity levels, we identified the boundary conditions with the help of a discussion between our research team.

However, even with the full PPX-MM, ADR emphasizes concurrent reflection and learning in the development of the artifact. Consequently, in addition to ensuring we reflected on the design of the PPX-MM against our formulated problem and research questions, we turned the maturity model into a web-based maturity assessment tool to test the validity of the fully developed PPX-MM. This tool was then used to once more test the whole maturity model in the organizational context through three partner companies in Finnish equipment manufacturing pilot company, ensuring we test the validity of the derived maturity model. However, the scope of the current paper is limited to the development of PPX-MM. Therefore, results of assessment, and the reflection and learning that happened with the assessment has not been shared in the current research. Similarly, the formalization of learning has not been done as it was out of the scope of the current paper. The ADR approach has limitation as the dimensions,

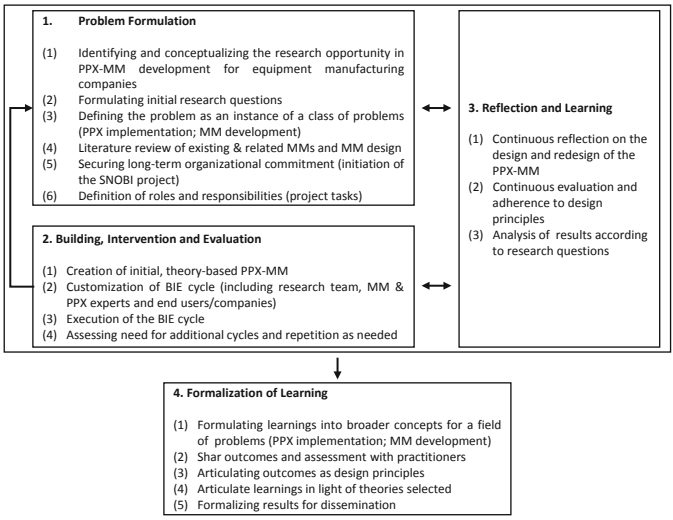

Fig. 1. Action design research followed in current research (adapted from [31])

and maturity levels can be defined in different ways from the perspective of different academic experts. However, since during the formalization and learning process the fully developed PPX-MM went through experts from Finnish equipment manufacturing pilot company, therefore, we were able to overcome this limitation.

4 Results

4.1 Pay-Per-X Maturity Model for Equipment Manufacturing Industries

In the current paper we develop and validate a full PPX-MM consisting of five maturity levels (initial, repeatable, defined, advanced, and optimized) and seven dimensions (organizational governance, strategy, risk management, competences & culture, product lifecycle processes, product & production technology, and data analytics). These maturity levels and dimensions were proposed in an existing study [17]. In the current research, our experts helped in validation of the maturity levels and the dimensions. Furthermore, with the help of several rounds of iteration of PPX-MM and validation of maturity levels and dimensions we were able to identify the boundary conditions. Additionally, we also assessed the entire PPX-MM with three Finnish equipment manufacturing industries. Below are the results of our study.

Organizational governance considers how the standards, rules and regulations are followed towards implementing PPX BMs, and who takes the responsibilities towards implementing the PPX BMs [17]. In the earlier study [17], organizational governance was suggested to have system, people, and data & information as its sub-dimensions. However, with the help of expert interviews we modified system governance to operational governance, as this sub-dimension deals with the operations performed in the organization. The boundary conditions corresponding to the organizational governance

sub-dimensions show how standards and regulations are absent at initial level whereas at optimized level they are fully implemented across the organization (see Fig. 2).

Strategy deals with how the PPX related activities can be planned to align them towards vision of the company, and consists of business strategy, strategic alignment, and resource allocation as its sub-dimensions [17]. With the help of expert interviews, we added more clarifications to sub-dimensions. Business strategy is about how the overall business logic and plan is focused towards offering PPX. Whereas, resource allocation is how resources are efficiently allotted to offer PPX, and finally, strategic alignment is about how overall company strategy is focused towards offering PPX. The boundary conditions corresponding to the strategy sub-dimensions show any kind of strategic initiative is absent at initial level and finally, at optimized level the strategies are fully implemented and unified across the organization (see Fig. 2).

Risk management considers the activities and competences required to mitigate the risks related to offering PPX, its sub-dimensions are business risks, operational risks, and IT risks [17]. With the help of our expert suggestions, we identified that IT risks consists of broad category that can overlap with business and operational risks, therefore we changed IT risks to cybersecurity risks. The boundary conditions corresponding to the risk management sub-dimensions show how risk mitigation is absent at the initial level and finally, at optimized level the risks are being identified and mitigated (see Fig. 2).

Competences and culture dimension deals with the critical competences required for offering PPX BMs, e.g., co-creation (with customers), design of- process, product, and service engineering [17]. Whereas the culture part deals with the collaboration, sharing knowledge and attitude towards accepting PPX BMs in the organization [17]. With the help of our experts, we identified overlaps between leadership commitment (part of this dimension) and strategy dimensions. As a result, we excluded the leadership commitment that was earlier a part of this dimension. The boundary conditions corresponding to the competence sub-dimension suggests absence of PPX competences and no cooperation among the different units of a company at the initial level, whereas all PPX competences are present with support and cooperation at the optimized level (see Fig. 2).

Product lifecycle processes dimension deals with the process required at the beginning, middle, and end of the product lifecycle from the perspective of offering PPX BMs, e.g., product engineering, service design, sales, and logistics [17].

With the help of expert suggestions, we were able to redefine this dimension in terms of the processes involved in the three phases of a product lifecycle. Similarly, earlier we used tasks to define this dimension, however, after discussion with experts' tasks were changed to processes to make this dimension clearer. The boundary conditions corresponding to this dimension are related with absence of any PPX related beginning, middle-, and end- of product lifecycle processes at the initial level, whereas all the PPX related processes are present and continuously improved at the optimized level (see Fig. 2).

Product & production technology dimension consists of three sub-dimensions related to the technologies that help in optimizing the risks and benefits while offering PPX BMs, smart product & factory focus on the hardware and software technologies; connectivity deals with M2M and internet communication, and cloud deals with information access

Dimension	Subdimension	Maturity Level				
		1. Initial	2. Experimenting	3. Defined	4. Advanced	5. Optimized
Organizational Governance	Operational Governance	No PPX-specific operational governance.	Operational PPX architecture requirements identified with ad hoc implementation and development.	Necessary operational PPX architecture requirements are documented and related governance measures are standardized.	Operational PPX architecture requirements are defined and compliance is systematically monitored through related key performance indicators.	Operational PPX governance is integrated across company with best practices in place.
	People Governance	No PPX-specific roles or responsibilities related to PPX business model(s) defined.	Responsibilities related to PPX are identified with ad hoc implementation and development.	Necessary roles and responsibilities for PPX business model(s) are documented, defined and systematically governed.	PPX-related roles and responsibilities are defined with systematic performance monitoring through defined standards and key performance indicators.	Roles and responsibilities related to PPX are optimized and defined with respect to all company activities.
	Data & Information Governance	No set rules for PPX data & information governance.	PPX data & information governance requirements are identified with ad hoc implementation and development.	Necessary data governance requirements are documented and standardized, with data storage infrastructure defined in production.	Data & information governance requirements are defined, with compliance systematically monitored and developed through defined key performance indicators.	Data & information governance measures are optimized and integrated across company.
Strategy	Business Strategy	No defined business strategy for PPX business model(s).	Strategy for PPX business model(s) is experimental with ad hoc implementation and development.	Strategy for PPX business model(s) is defined and documented.	PPX is strategy is defined and continuously developed through defined key performance indicators.	PPX business strategy is fully developed and integral part of the corporate strategy.
	Resource Allocation	No plan for allocating resources towards PPX business model(s).	Basic PPX resource requirements are identified with ad hoc assignment.	Procedures for allocating resources towards PPX business model(s) are standardized, allowing systematic resource allocation for specific PPX activities.	PPX resource requirements are identified and documented across company, allowing systematic resource management and prioritization at an organizational level.	PPX resource allocation follows best practices and is optimized across company.
	Strategic Alignment	No strategic alignment between PPX and other strategic objectives.	Limited understanding of PPX and its relationship to other strategic objectives with ad hoc alignment practices.	Strategic understanding and objectives are shared between relevant business.	Strategic objectives are shared across company with compliance and performance monitored through common key performance indicators.	Full strategic alignment allowing optimization and development of common strategic goals across company.
Risk Management	Business Risks	No PPX-related business risk management.	PPX-related business risks are acknowledged with ad hoc management practices.	PPX-related business risk are documented, with systematic and defined risk management practices in place.	PPX-related business risk management is systematic and monitored, allowing predictive risk management.	PPX-related business risk management is proactive, with continuous improvement and optimization of risk management practices.
	Operational Risks	No PPX-related operational risk management.	PPX-related operational risks are acknowledged with ad hoc management practices.	PPX-related operational risk are documented, with systematic and defined risk management practices in place.	PPX-related operational risk management is systematic and monitored, allowing predictive risk management.	PPX-related operational risk management is proactive, with continuous improvement and optimization of risk management practices.
	Cybersecurity Risks	No PPX-related cybersecurity risk management.	PPX-related cybersecurity risks are acknowledged, with ad hoc management practices.	PPX-related cybersecurity risk are documented, with systematic and defined risk management practices in place.	PPX-related cybersecurity risk management is systematic and monitored, allowing predictive risk management.	PPX-related cybersecurity risk management is proactive, with continuous improvement and optimization of risk management practices.
Competences & Culture	Competences	No identified any PPX-related competences.	PPX-related competences are acknowledged with ad hoc acquisition.	Basic PPX-related competence requirements are defined and documented, allowing systematic competence acquisition.	PPX-related competences are acquired as well as developed systematically.	All PPX-related competences can be acquired and managed proactively.
	Culture	Culture is product-oriented, with no cooperation between different business units.	Organizational culture supports experimentation with limited & ad hoc cooperation between some business units.	Organizational culture supports innovation and is open towards PPX, with frequent collaboration between some business units.	Organizational culture is committed to PPX business model(s) with common incentives, with frequent collaboration across all related business units.	Organizational culture fully supports PPX, with complete trust and open communication at all organizational levels and relevant business units.
Product Lifecycle Processes	Beginning of Life Processes	No identified beginning of life processes for PPX business model(s).	PPX-related beginning of life processes are identified with ad hoc implementation.	PPX-related beginning of life processes are defined and systematically implemented for specific project(s).	PPX-related beginning of life processes are defined and implemented across company with systematic management through defined metrics.	PPX-related beginning of life processes are optimized and continuously improved across company.
	Middle of Life Processes	No identified middle of life processes for PPX business model(s).	PPX-related middle of life processes are identified with ad hoc implementation.	PPX-related middle of life processes are defined and systematically implemented for specific project(s).	PPX-related middle of life processes are defined and implemented across company with systematic management through defined metrics.	PPX-related middle of life processes are optimized and continuously improved across company.
	End of Life Processes	No identified end of life processes for PPX business model(s).	PPX-related end of life processes are identified with ad hoc implementation.	PPX-related end of life processes are defined and systematically implemented for specific project(s).	PPX-related end of life processes are defined and implemented across company, with systematic management through defined metrics.	PPX-related end of life processes are optimized and continuously improved across company.
Product & Production Technology	Smart Product & Factory	No machine data collection capabilities for PPX business model(s).	PPX data collection capabilities are tested in machine(s), allowing contract-specific, ad hoc data collection from customer(s).	PPX data collection technologies are standardized, with systematic data collection from customer machine.	PPX data collection capabilities is integrated in all machines, with performance monitored through defined key performance indicators.	Production technology fully supports data-based products for PPX, with performance optimized through cost minimization and efficiency.
	Connectivity	No connectivity between machines or production processes for PPX business model(s).	PPX product- and production-related connectivity technologies are experimental and non-standardized.	PPX product- and production-related connectivity technologies are standardized and we have access to customer(s)' machine.	PPX product- and production-related connectivity technologies are standardized and monitored through defined quality control measurements for development needs.	PPX product- and production-related connectivity technologies are optimized and continuously improved, allowing 2-way/remote connection and control of machines.
Data Analytics	Data Access	No access to PPX data.	PPX data is identified, but siloed and accessed manually & ad hoc.	PPX data is defined, enabling continous data flow and basic automation with online access.	PPX data is systematically accessed, with related key performance indicators defined and utilized in quality control.	All PPX data can be accessed, with cost efficient, high-performing and optimized best practices in place.
	Data Analysis	No PPX data analysis.	PPX data analysis is unstructured, allowing descriptive analysis and basic monitoring.	PPX data analysis capabilities are defined, enabling diagnostic analysis & recommendations and manual machine tuning.	PPX data analysis is systematic and predictive, with performance monitored through defined key performance indicators.	PPX data analysis is prescriptive/self-learning, with automation and self-adjusting capabilities.
	Data Utilization	PPX data not utilized in decision-making.	PPX data utilized for awareness purposes in basic reporting with ad hoc utilization in decision-making.	PPX data established as an asset and utilized to support decision-making.	PPX data utilzied broadly in the development of overall company strategy, with performance monitored through defined key performance indicators.	PPX data is considered as central to company strategy and operations development.

Fig. 2. Pay-per-X maturity model

applications, platforms, and databases [17]. With the help of expert suggestions, we identified overlaps between the cloud sub-dimension and data access (present in data analytics), therefore, the cloud sub-dimension was removed from this dimension. The boundary conditions corresponding to this dimension are related to absence of hardware, software, and connectivity from PPX perspective at the initial level, and fully supported hardware, software, and connectivity to offer PPX BMs at the optimized level (see Fig. 2).

Based on the functionality of the methods and tools the data analytics dimensions consist of three sub-dimensions, i.e., data collection, transformation & processing, visualization, and decision making [17]. With the help of expert interviews, we identified that data access, data analysis and data utilization are better terms to describe the sub-dimensions of data analytics. As a result, we renamed our sub-dimensions. The boundary conditions corresponding to this dimension are related with the absence of data access, analysis and utilization at the initial level, and full access, analysis, and utilization at the optimized level.

4.2 Pre-evaluation

We followed the recommendations suggested by previous studies [3], by pre-evaluation of our developed PPX-MM with the 3 criteria, i.e., i) comprehensiveness, ii) consistency, and iii) problem adequacy. During the evaluation of our PPX-MM 3 different academic experts were present from the area of MM and PPX, and additionally, three industry experts were from PPX were also present.

1. Comprehensiveness: Overall, experts found our PPX-MM to be very comprehensive, as it was able to cover various aspects that are required while offering PPX BMs. However, with the help of expert suggestions we divided product lifecycle processes into beginning-, middle-, and end of life processes. Similarly, leadership sub-dimension was removed as it overlapped with culture, and sub-dimension cloud was removed as it overlapped with data access.
2. Consistency: Overall, experts found our PPX-MM to be consistent. However, with the help of their suggestions we renamed various sub-dimensions, e.g., data collection became data access, and IT security became cybersecurity. Similarly, the sub-dimension system governance became operational governance.
3. Problem adequacy: Furthermore, we also iterated our PPX-MM several times leading to an improved version from understanding and application context, e.g., our description of boundary conditions was shortened, and reference levels were described with the help of quantitative brackets.

5 Discussion and Conclusions

The current research caters towards the need of guiding EMIs that plan to offer PPX BMs by developing a MM. We conducted focus group interviews with both academic (MM and PPX) and industry experts to check the evaluation criteria (i.e., comprehensiveness, consistency, and problem adequacy) and followed the meticulous ADR approach proposed in literature [3] to establish the comprehensive dimensions (and their sub-dimensions), and maturity levels available in literature [17]. The boundary conditions were identified with the help of scientific literature and were also validated and improved with the help of focus group interviews [3]. Thus, we were able to propose relevant and relatable boundary conditions in MM. Overall, we developed a PPX MM from the perspective of EMIs.

PPX BMs can help EMIs in generating more revenues by increasing their customer segments [6–8] and lowers the risks of offering PPX BMs [9–11]. However, the existing

studies in scientific literature [32] do not cater towards this need. In the current research, we add to the descriptive and prescriptive knowledge on PPX for EMIs from the MM perspective, and contributed to the existing knowledge [25–27]. Overall, we offer the corresponding requirements (boundary conditions) for different dimensions and maturity models that an EMI should fulfil to offer PPX BMs. Additionally, we identified that offering PPX BMs, needs enablers from both technology and management perspective.

Furthermore, the process of developing PPX MM we were also able to develop an online PPX readiness assessment tool that manager of an EMI can deploy for assessing their readiness towards offering PPX BMs. We followed systematic ADR suggested by existing studies [3], and during the process of validating the MM we also used our tool for assessment; however, the results of the assessment are beyond the scope this article. Future research can also focus towards identifying the required technologies and management strategies that will help EMIs in meeting the requirements corresponding to various dimensions and maturity levels proposed in our PPX MM.

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