Association for Information Systems

AIS Electronic Library (AISeL)

Rising like a Phoenix: Emerging from the Pandemic and Reshaping Human Endeavors with Digital Technologies ICIS 2023

Practitioner-Oriented Research

Dec 11th, 12:00 AM

Design Principles for Creating a Pay-per-Part Value Proposition in Data Ecosystems

Simon Hiller
Ferdinand Steinbeis Institute, simon.hiller@ferdinand-steinbeis-institut.de

Patrick Weber
Ferdinand Steinbeis Institute, patrick.weber@ferdinand-steinbeis-institut.de

Heiner Lasi
Ferdinand Steinbeis Institute, heiner.lasi@ferdinand-steinbeis-institut.de

Follow this and additional works at: https://aisel.aisnet.org/icis2023

Recommended Citation

Hiller, Simon; Weber, Patrick; and Lasi, Heiner, "Design Principles for Creating a Pay-per-Part Value Proposition in Data Ecosystems" (2023). *Rising like a Phoenix: Emerging from the Pandemic and Reshaping Human Endeavors with Digital Technologies ICIS 2023*. 4.
https://aisel.aisnet.org/icis2023/practitioner/practitioner/4

This material is brought to you by the International Conference on Information Systems (ICIS) at AIS Electronic Library (AISeL). It has been accepted for inclusion in Rising like a Phoenix: Emerging from the Pandemic and Reshaping Human Endeavors with Digital Technologies ICIS 2023 by an authorized administrator of AIS Electronic Library (AISeL). For more information, please contact elibrary@aisnet.org.

Design Principles for Creating a Pay-per-Part Value Proposition in Data Ecosystems

Completed Research Paper

Simon Hiller
Ferdinand Steinbeis Institute
Heilbronn, Germany
simon.hiller@ferdinand-steinbeis-institut.de

Patrick Weber
Ferdinand Steinbeis Institute
Heilbronn, Germany
patrick.weber@ferdinand-steinbeis-institut.de

Heiner Lasi
Ferdinand Steinbeis Institute
Heilbronn, Germany
heiner.lasi@ferdinand-steinbeis-institut.de

Abstract

In practice and research, pay-per-part business models are becoming increasingly popular. Amongst others mechanical engineering companies, banks, insurances, and IT companies are working on these new business models. There is increasing evidence that the enabler for pay-per-part approaches is the cooperative use of data across company boundaries, being discussed in literature under the term data ecosystem. Along two case studies, a total of eleven companies were accompanied from the definition of the cooperative pay-per-part value proposition to the implementation of a proof of concept. Based on these case studies, eleven design principles could be derived. These design principles provide companies a guidance when designing a cooperative value proposition within an ecosystem. The identified design principles were mapped to different stakeholder groups that are involved in the design of a cooperative value proposition. The generated design principles were evaluated and implications for practitioners and research given.

Keywords: Pay-per-Part; Design Principles; Data Ecosystem; Action Design Research

Introduction

Recent years have shown a change in consumer behavior from one-time purchases to per-use models (e.g., cars, music, and electronic devices). In the manufacturing domain as-a-service concepts have been widely established (Guo et al., 2019). Software as a Service (SaaS) is a time- and location-independent web-based access to a remote server application which allows simultaneous usage of the same application installation among a wide range of unrelated customers. SaaS offers an attractive logic of payment versus the customer benefits received and provides a continual flow of innovative new software (Sääksjärvi et al., 2005; Sun et al., 2007). Examples of this are hyper scaler platform providers like Amazon Web Services or Microsoft Azure.

Similar developments from the consumer sector and the as-a-service approaches have increasingly been applied in the manufacturing domain. For example, the mechanical engineering company DMG Mori presented their new business model Pay-per-Part (PpP) under the title “Netflix of machine building” (DMG MORI AG, 2021). Through the business model PpP companies offer assets (e.g., machines) not for a onetime purchase fee to their customer, but instead for the output (produced part or the time used to produce it). The ownership of the asset is not sold to the customer but stays with the mechanical engineering company (Endres et al., 2019). Simultaneously to mechanical engineering companies, in particular banks, insurances and IT companies are also working on PpP business models (Siegert et al., 2021; TRUMPF, 2020; DMG MORI AG, 2021; RELAYR, 2018).

Real life PpP applications emphasize the need of an ecosystem with different partners and capabilities to offer such a PpP value proposition e.g., the manufacturing company TRUMPF and insurance company Munich Re (TRUMPF, 2020). Banks are ambitious for financing the assets (Siegert et al., 2021). Insurance companies take on the risk management and, in some cases, technology providers are needed to realize data capturing, data transfer and data analysis e.g., the company relayr (RELAYR, 2020). The mechanical engineering companies position themselves in the currently emerging ecosystems as the central keystone player of the ecosystem (TRUMPF, 2020; Siegert et al., 2021; DMG MORI AG, 2021; Iansiti & Levien, 2004). This collaboration of partners to offer a PpP value proposition is depicted on the left side of figure 1 where through additional partners the keystone player can offer PpP solutions to different customers (represented as a person icon receiving a box in figure 1 left side). The value created for the users of PpP ranges from gaining flexibility and scalability, sharing risk, as well as not having tied capital (Endres et al., 2019; Siegert et al., 2021). However, in practice, PpP approaches with a keystone player are only slowly being established.

A further ecosystem approach that is gaining attention in science as well as in practice is Adner (2017) ecosystem as a structure approach. Here the focus lays on a cooperative value proposition rather than the value proposition of the keystone player (Adner, 2017). Initial implementations indicate that this cooperative approach might be superior to existing ecosystem offerings (Adner, 2017; Baars et al., 2021). It is essential for the realization of cooperative value propositions in the PpP context to gather data and analysis from different sources (e.g., assets) as well as additional services across key partners. In research, these ecosystems are referred to as data ecosystems. Initial findings suggest that PpP approaches alone are not economically viable, but through the cooperative use of data in such ecosystems, additional services (e.g., benchmarking, and preventive maintenance) can be realized by the partners within the ecosystem, shown in figure 1 on the right side (Senyo et al., 2019; Oliveira & Lóscio, 2018; Weber et al., 2020). It is crucial for PpP approaches that data is shared across company boundaries. Literature implies that an important success factor is the creation of trust for the cooperative use of data. Further this trust can be established through a cooperative value proposition (Otto et al., 2022; Baars et al., 2021). In this research paper we focus on ecosystems with a cooperative PpP value proposition which is illustrated on the right side on figure 1, where the ecosystem delivers the PpP solution to its customers (depicted as a person icon receiving a box in figure 1 right side). By this we contribute to the further development of cooperative value proposition ecosystem approaches.

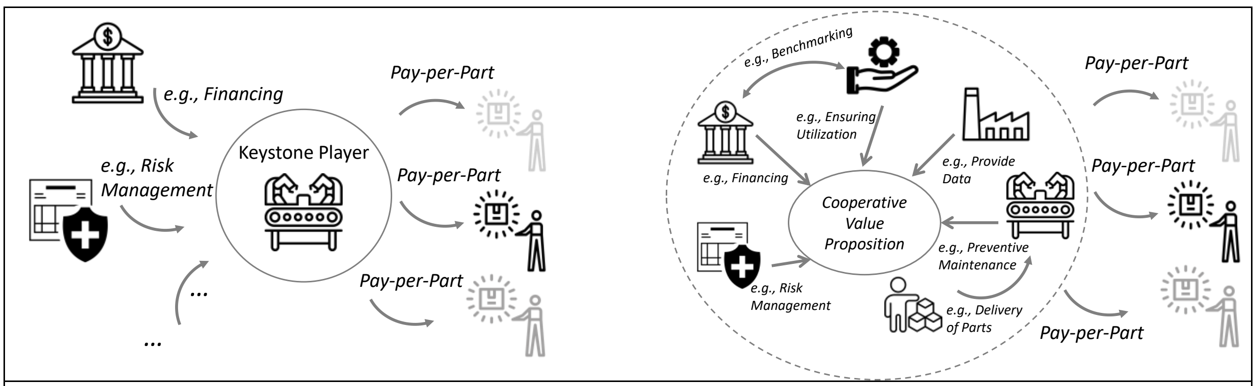

Figure 1. Pay-per-Part – Keystone Player vs. Cooperative Value Proposition

To confirm the research gap and to ascertain the state of the art in research, an upfront structured literature review was conducted. The relevant literature that was identified forms the foundation for the design of the artefact of this paper (see section related work). Building on this foundation, this paper addresses the research question: *Which design principles should be considered when creating a cooperative pay-per-part value proposition within a data ecosystem*? We follow the action design research approach by Sein et al. (2011) and present eleven design principles (DPs) for PpP in data ecosystems based on two case studies. The two case studies were conducted by the authors over a period of more than one year each and contain the participation of seven and respectively four German based companies. The joint itinerary began from the formulation of the cooperative value proposition to the implementation of the proof of concept (PoC) based on workshops and in between meetings. The resulting DPs serve as a support and guidance for decision makers e.g., CEOs and CIOs to overcome the challenges in establishing a PpP value proposition. DPs as an approach for guidance have been used and discussed within information system research for a long time as Gregor et al. (2020) describes. With the DPs we extend the body of knowledge on ecosystems without a keystone player and their establishment of a cooperative value proposition.

The paper underlies the following structure: in the second section the background as well as an upfront literature review is presented. Section three gives an overview about the two case studies based on Yin (2018) and the conducted evaluation. The findings are presented in the fourth section. In section five the DPs are presented. Section six, seven and eight show the implications, the conclusion, the limitation, and outlook on future research.

Related Work

To determine the state of the research, a literature review following the approach of Levy & Ellis (2006) was conducted. The aim of the literature search was to identify relevant publications concerning PpP in ecosystems. The AIS (Association for Information System) eLibrary, IEEE Xplore, and ACM (Digital Library) databases were chosen to provide a broad view on the field of information systems as well as the engineering domain. To cover the different terms used to describe pay-per solutions, the following search terms were defined: (("pay per X" OR "pay per part" OR "asset as a service" OR "equipment as a service" OR "subscription model" OR "pay per use") AND "value network") OR (("pay per X" OR "pay per part" OR "asset as a service" OR "equipment as a service" OR "subscription model" OR "pay per use") AND "ecosystem"). A further restriction to DPs and value propositions was not made because these papers would also be identified in the scope of the literature review. In addition, this brings up publications that deal with these topics using a different wording. Only publications in English or German were considered, work in progress publications were excluded. After screening all three databases, duplicates were removed. A total of 303 articles were then identified. The results revealed that PpP has been a topic for recent discussions in the context of as-a-service and product-service-systems with a strong focus on digital output. When looking at these publications in detail, it is obvious that there is a lacking relation between physical product output in relation to ecosystems within the understanding presented in this paper. After scanning titles and abstracts for relevance to our research, 23 papers remained. The 23 papers classified as relevant were then analyzed in full and a backward search approach was used in order to not disregard possible relevant papers. 21 papers passed the full paper analysis. A brief overview of these 21 papers is given in the following paragraph.

DPs regarding a PpP value proposition within an ecosystem could not be observed within the literature. The distinct differentiation between keystone focused ecosystem and ecosystem without keystone was also not observed in the literature. Whereas most papers had their focus on a digital output (not a physical part) from various perspectives, for example artificial intelligence (Lins et al., 2021), platforms (Giessmann & Stanoevska-Slabeva, 2013; Beimborn et al., 2011), cloud (Repschlaeger et al., 2012; Wu et al., 2015; Wulf et al., 2019; Leimeister et al., 2010; Guo et al., 2019) or software (D'souza et al., 2012; Venkatachalam et al., 2013; Weitzel, 2020). Ângelo & Barata (2022) as well as Weber et al. (2020) described a pay-per-approaches for physical parts in the context of construction assets. Blau et al. (2008) and Woroch & Strobel (2022) promoted approaches for the pricing/monetization of services and data, offering an in-depth analysis into a PpP business model. Gelhaar et al. (2021) focus on the aspect of data sharing within an ecosystem presenting a first hint on possible DPs for PpP. This could also be stated for possible roles which were presented amongst others by Müller & Buliga (2019) and Endres et al. (2019). Müller & Buliga (2019), Kayser et al. (2021), Leski et al. (2021) and Terrenghi et al. (2018) present PpP as a revenue model within a broader view of data driven business models. Endres et al. (2019) on the other hand views PpP as an element of an industrial internet of things service-centered business model.

Data Ecosystem

During the last years, ecosystems have become increasingly relevant in practice and research (Tsujimoto et al., 2018). In business ecosystems, economically independent actors work together to create innovations by combining capabilities. In this process, the companies work cooperatively and competitively to support new products, satisfy customer needs, and finally incorporate the next round of innovations. In this way, business ecosystems are changing established competitive structures and hence create new possibilities for the generation of cooperative value creation through collaboration (Moore, 1993). The alignment of the ecosystem with a cooperative value proposition is based on the approach ecosystem as structure by Adner (2017). In Adner's approach, the shared value proposition is the center of the ecosystem. Based on the value proposition, partners, activities, and their required alignment will be configured accordingly (Adner, 2017).

Data exchange across company boundaries is becoming an integral enabler of ecosystems. These collaborations are referred to as data ecosystems (Senyo et al., 2019; Oliveira & Lóscio, 2018). This data exchange enables the companies to create new data-driven services based on the shared data (Porter & Heppelmann, 2014; Mazhelis et al., 2012). In the following, we understand a data ecosystem as a network of different organizations. The organizations are cooperatively and/or competitively linked via digital technologies. The organizations collectively use digital platform structures to coordinate their value-creation activities (Senyo et al., 2019; Oliveira & Lóscio, 2018). One key enabler for realizing a collaborative value proposition in a data ecosystem is a cooperative data space. A cooperative data space is a shared, trusted space for the exchange of data (Federal Chancellery, 2021). Cooperative data spaces and the underlying software infrastructures must enable trust, interoperability, and interconnectivity of data as well as data sovereignty in the ecosystem (Otto et al., 2022). Initial findings in the context of data ecosystems prove, that sharing condition data (e.g., number of parts or drilled holes) within data ecosystems is a suitable approach as the members of the ecosystem classify this type of data as less valuable for protection (Weber et al., 2020).

The state of the art of research shows that certain basic conditions are necessary in order for a data ecosystem to succeed, regardless from a cooperative value proposition PpP. The following generic basic conditions can be stated: *cross-industry partners* (Endres et al., 2019; Müller & Buliga, 2019), *company representatives at decision maker level, modelling of service interrelations* (Terrenghi et al., 2018; D'souza et al., 2012; Weber et al., 2020), *trust space between partners* (Baars et al., 2021; Gelhaar & Otto, 2020), *open platform/open standards* (Braud et al., 2021), *common understanding of the value-added process* (Al-Debei & Avison, 2010), *the interaction and need of different stakeholders* and *interplay between business and technical task groups* (Lin et al., 2019).

For the design of data-driven solutions in ecosystems, the Industrial Internet Reference Architecture (IIRA) has served as an established framework for research and practice (Weber et al., 2019; Weyrich & Ebert, 2016). The IIRA provides a reference architecture with guidelines and supports the development, documentation, and communication of data-driven solutions, with cross-domain applicability (Lin et al., 2019). In addition to the IIRA the Industrial IoT Consortium provides foundational work e.g., security and connectivity (Joshi et al., 2022). The design of data-driven solutions requires that different stakeholders interact. To achieve this, the IIRA defines four layers, business, usage, functional, and implementation layer (Lin et al., 2019). These layers represent different stakeholder perspectives and are described in the following.

On the business layer, the decision makers of the companies involved in the ecosystem specify the cooperative value proposition as well as the capabilities of the various partners. The engineers and product managers define on the usage layer how the value proposition identified on the business layer can be realized by decomposing it into tasks and activities between different system components (Lin et al., 2019). On the functional layer, system and component architects break down the solution of the data ecosystem into functional components to describe the system structure and the interrelationships, interfaces, and interactions between the functional components as well as external systems (Lin et al., 2019). Developers, integrators, and operators design on the implementation layer the technical representation of the data-driven solutions, and the system components required to implement the activities and functions that are specified by the usage as well as the functional viewpoint (Lin et al., 2019). The distinction is not completely free of overlap, and it should also be noted that the presented stakeholders in an ecosystem belong to different companies. Implying that it is necessary to involve several representatives from each company when designing a data ecosystem.

Pay-per-Part

In literature the term PpP can be found as the financial aspect of a bigger archetype of business model. Müller & Buliga (2019) describe it as part of data-driven business models, Endres et al. (2019) as industrial internet of things service-centered business model. At the core however, the value proposition remains the same. Opposed to the usual the asset (e.g., machine) is not sold but the output (part) is. This is realized by data and analysis from different sources as well as additional services across key partners. PpP can lead to a reduction of downtime with gained flexibility as well as a reduction of fixed costs. (Endres et al., 2019; Müller and Buliga, 2019). Real-world offerings underline the body of knowledge in research. For example, the manufacturing companies TRUMPF and DMG Mori offer PpP solutions based on their machinery. Financing and IT capabilities however are supplied by partners (TRUMPF, 2020; DMG MORI AG, 2021; RELAYR, 2018; Siegert et al., 2021). The developments identified and described in this chapter are summarized in figure 1, the focus of this paper is on the approach shown on the right-hand side.

Research Design

The research question of this paper aims to derive DPs in the context of PpP, in terms of Action Design Research (ADR). In the research process, an organizational-technical solution as an “ensemble artifact" was developed in an iterative process (see figure 2) with the participation of the researchers (Sein et al., 2011). The ADR approach focuses on DPs, which are defined as follows: "A design principle is a statement that prescribes what and how to build an artefact to achieve a predefined design goal" (Chandra et al., 2015). It is important that DPs are formulated in an abstract way, including information about the actions, the material properties, the boundary conditions as well as the corresponding user group to move away from singular settings towards generalizing knowledge (Chandra et al., 2015). The participation of the researchers ensured that the state of the art in the fields of data ecosystems and PpP was considered in both the design and the evaluation. It must be emphasized that the (non-funded) participating companies involved in the design functioned as the final authority for the concrete design of the concrete solution but not on resulting DPs of this research paper. Further the ecosystem was initiated with the intention of initiating and continuously developing this cooperation. We are confident that this specific aim promotes the objectivity of the results, as the measurable economic impact strongly counters statements of favor or aspects of social desirability. The technical PoC developed in the case studies helped to ensure hands-on experience by the participating companies and thus to ensure the validity of the results, the elicitation of further requirements, and thus joint further development. For the implementation of the PoC, we followed established approaches from science and practice. Accordingly, the PoC was structured into the edge, platform and enterprise tier (Mörth et al., 2020). The two case studies show the same structure, starting from the formulation of a cooperative value proposition through the specification of the value proposition to the implementation of the PoC (Weber et al., 2021).

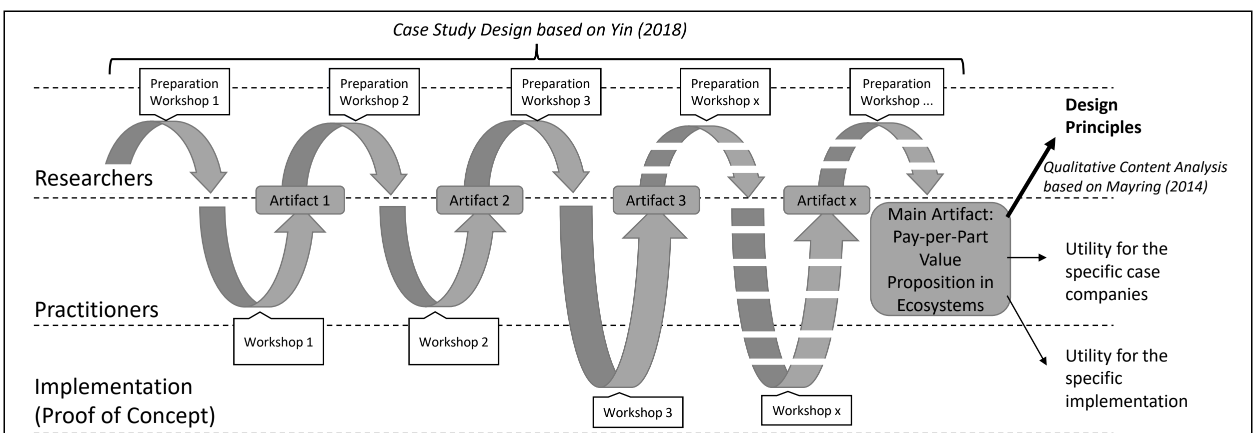

Figure 2. Scheme of the Research Design Based on (Sein et al. 2011)

Alongside the iterative process two case studies based on Yin (2018) with internal preparation workshops of the researchers and main workshops with all case participants were conducted (see figure 2). The participating companies shown in table 1 are all considered large-scale enterprises (lager than 250 employees) and are all German-based enterprises. The preparation workshops were intended to prepare for the main workshops and to set the observation questionnaire. Data was collected alongside every iteration step (see artifact 1,2,3,… in figure 2) in form of written protocols and photo protocols done by the researchers. The data analysis was conducted through qualitative content analysis based on Mayring (2014) (see chapter Data Analysis).

Case Excavator (CS 1)		Case Automotive (CS 2)	
#	Company (Participants)	#	Company (Participants)
E1	Re-insurance (Head of IoT, Head of Finance in IoT)	A1	Original equipment manufacturer (Chief Engineering Officer)
E2	Industrial service provider (Managing Director, CEO, COO)	A2	Bank (Managing Director)
E3	Manufacturer of industrial sensor technology (IoT Strategy Manager)	A3	Industrial service provider (Managing Director, CIO)
E4	Manufacturer of wheel excavators (Managing Director, Division Manager)	A4	Mechanical engineering company (CEO)
E5	Internet and information technology supplier (CAO)		
E6	Mechanical engineering company 1 (CEO)		
E7	Mechanical engineering company 2 (Technical Manager)		
R	Two researchers in both cases (authors of this research work) and a neutral project manager affiliated to the researcher.		

Table 1. Participating Companies in the Two Case Studies

The involved researchers documented the workshops in written protocols and photo protocols of work done on flipcharts. The project manager had the role of managing the cases and following the taken workshop approach proposed by Weber et al. (2021).

Data Analysis

The text material and the research question form the first step for the qualitative content analysis. We followed the iterative steps of inductive category development by Mayring (2014). An inductive approach was chosen due to the lack of existing categories (PpP DPs). The following figure 3 illustrates the steps taken. The second step comprises of a pre-definition of first DPs as categories. In the third step the text material from the excavator case was worked through by one author, the automotive by another. A first set of DPs for each case was formulated as a draft. In a workshop within the fourth step the two sets of DPs from each case were aligned and revised. With this fixed set of DPs, the text material was worked through a final time in a fifth step. Considering the alignment and revision of the categories a second work through of the material was completed with the intra-coder and inter-coder check taken into account. These categories in the form of DPs can be found on table 2 and the following chapters (sixth step).

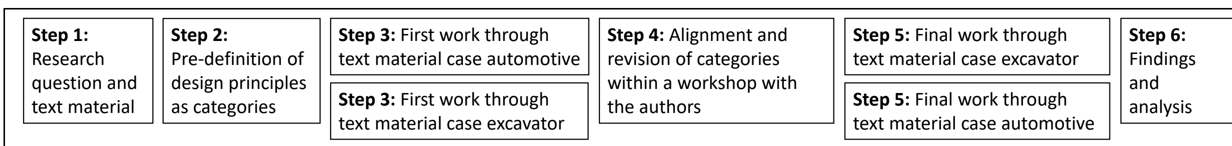

Figure 3. Taken Steps of Inductive Category Development Based on (Mayring 2014)

Case Study Excavator (CS 1)

The seven companies (see table 1 left side) were represented by at least one managerial director or division manager. A total of eight face-to face workshops was conducted with participating companies between February 2018 and April 2019. Six workshops were held at meeting rooms from the researchers, one was held at the production side of the manufacturer of wheel excavators and one meeting at the re-insurance company. Smaller meetings were held between workshops especially for the technical implementation (technical task group). The technical task group implemented the requirements given by the decision makers and gave feedback about their progress to the decision makers. In addition to the workshops, informal one-on-one meetings with company representatives were held on a regular basis. For reasons of confidentiality, these conversations were not recorded but put into written memory protocols afterward.

Initially, there were only bilateral relations between the partners and there was no ecosystem in place. The companies became aware of the opportunity of sharing data across company boundaries and thus be able to realize PpP within an ecosystem. This ecosystem provides the manufacturer of wheeled excavators a payment-per-part for the production of the turntable of wheel excavators. The turntable is the connecting piece of a wheeled excavator between the upper and lower carriage. This turntable passes through several production steps. In the production of the turntable several physical assets are involved, the milling machine, the screwing machine, and the turntable itself. Within the ecosystem, the wheeled excavator manufacturer no longer produces the turntable itself or even owns the machines, but the entire effort is provided by the ecosystem. To realize PpP of the turntable, a prototypical implementation was realized as part of the case study. In the first phase, digital representations of those three assets were implemented. The digital representation of the screwing machine, for example, collected data about the torque and the angle of rotation. In addition, the turntable was tagged with an RFID sensor to be able to identify the turntable in the production flow. A detailed view on the responsibilities and involvement of the companies is later given within table 2.

Case Study Automotive (CS 2)

Initially the participants (see table 1 right side) were only involved in bilateral relations. The original equipment manufacturer (OEM) noticed a business potential in implementing a PpP approach in one of their assembly lines. Within eight workshops (two face-to-face meetings at conference rooms of the researchers and six online meetings) an ecosystem-based PpP approach was developed together with the participants. It was important that all ecosystem participants had an added value by the implementation of the PpP approach. The desired added value of the OEM was to reduce capital expenditure and gain operational expenditure as well as to react to highly fluctuating market dynamics. The desired added value for the bank was to expand their new business model in PpP and to become a strategic partner for industry enterprises. The industrial industry providers' aim was to achieve customer loyalty and expand their digital business unit as well as functioning as the operator of the assembly line. The mechanical engineering company desired added value consisted of new business models based on better know-how of the machinery performance in the field to further improve for the next generation of machines.

The workshop-based approach of implementing a PpP value proposition within a data ecosystem took place between January 2021 and May 2022. Shorter meetings were held in between the workshops for the technical implementation (technical task group). The technical task group implemented the requirements given by the decision makers and gave feedback about their progress to the decision makers. Transparency of the machinery of the assembly line was achieved via digital representation. Different kind of information needs from the perspective of the respective participants was collected and the corresponding data und context for the information defined. In a first step the data (parts per hour) came from the Manufacturing Execution System (MES) of the OEM and was provided in a cooperative data space for all ecosystem participants. In a second step the implementation was shifted to gather data directly from the machinery besides the IT of the OEM. A detailed view on the responsibilities and involvement of the companies is later given within table 2.

Evaluation

ADR focuses on the construction, intervention, and evaluation of an artifact. The goal of the evaluation is the ongoing improvement of the artifact (Sein et al., 2011). This continuous evaluation in the ADR process is called the human risk & effectiveness evaluation strategy in the FEDS framework (Venable et al., 2014). In addition, a quick & simple evaluation strategy was used to evaluate the final DPs with experts which were not part of the case studies (Venable et al., 2014). March & Smith (1995) were used for choosing the evaluation criteria. The evaluation focuses on the following three evaluation criteria: (1) completeness, in terms of the DPs for PpP, (2) usability, regarding the comprehensibility of the DPs for the target group practice and academia, (3) functionality, in terms of the benefits that the DPs provide in establishing pay-per-part models in ecosystems.

As part of the quick and simple evaluation two semi-structured expert interviews (Myers & Newman, 2007) were conducted. Expert 1 represents the field of academia as a postdoctoral researcher with focus on ecosystems, platform economy and industry 4.0. The expert is seen as a good fit in regard to the three evaluation criteria from a research perspective. Expert 1 was not part of the two case studies or research activities connected to it and is not affiliated with the authors. Expert 2 is a practitioner as a product owner PpP at a mechanical engineering company, the expert is seen as a good fit especially considering the completeness and usability of the DPs. The mechanical engineering company offers a PpP business model in collaboration with a financial institute and an IT company. Expert 2 is also not affiliated with the authors and the mechanical engineering company which offers the PpP solutions was not part of the two presented cases. The semi-structured interviews were conducted and recorded via an online video call by the two researchers. Interviews took place in November 2022 and had a length between 60 and 90 minutes. In the first part the ecosystem view (see figure 1) of the research was explained to the experts. Followed by a presentation where the basic conditions as well as the DPs were presented and the response of the experts was visualized. The remarks and adaptions recommended by the two experts were noted by the researchers and visually presented to the experts. The summarizing transcript was analyzed using hermeneutics (Myers 2020).

Findings

In addition to the basic conditions presented in the chapter *related work*, the PpP DPs were derived from the case studies. Table 2 illustrates the key findings from each of the two case studies. It shows in which workshop of the case study the derived DPs were generated. In the assignment of the DP and the workshops, large differences in the case studies can be observed for the following reasons. CS 2 is a smaller ecosystem and was initially built around the PpP scenario whereas CS 1 had a more open approach in finding the scenario PpP. The presented order is based on the appearance of the design principle (DP) in the OEM case study (CS2) and does not represent importance.

#	Findings from the Cases	Work-shop #	DP
CS 1	Ecosystem partners must have complementary capabilities to realize PpP. Examples of key capabilities are: • *Mechanical engineering company*: production know-how • *Re-Insurance*: risk know-how, capital strength • *Industrial services provider*: represented globally and locally, vendor neutrality	W 1, W 2	Capabilities for PpP
CS 2	Examples of key capabilities in CS 2 are: • *OEM*: product know-how, production know-how, operation know-how, access to the market • *Bank*: financing know-how, risk know-how, capital strength • *Industrial service provider*: operation and service know-how, vendor neutrality, connectivity know-how • *Mechanical engineering company*: machinery know-how, production know-how, process know-how	W 1	
CS 1	One of the key enablers for the PpP is that based on the shared data, one or more partners can take over the financing of the assets in the field. To take on the financing, it was important to the ecosystem partners that the very wide range of risks is shared between the partners. Examples of risks in the case study were distributed as follows: • *Mechanical engineering company*: asset risks • *Industrial service provider*: process risk • *Re-Insurance*: part failure in the field	W 5, W 6, W 7	Risk and financing sharing within the ecosystem

CS 2	As the part assembled in the line is critical for the safety of a vehicle, the allocation of the risks of the part, the process, the failure of the line or missing demand was intensively discussed and assigned to the partners as follows: • *OEM*: parts risk stayed with the OEM • *Industrial service provider*: process risk • *Mechanical engineering company*: process risk, asset risk The risk of breakdowns or no demand needs to be distributed to all four partners of the ecosystem.	W 1	
CS 1	The case study showed that PpP only works if the asset is as standardized as possible and can be used in different contexts. The standardization must be the given to be attractive for the partners from the perspective of financing and risk.	W 4, W 5, W 6	Specification of the PpP scenario and selection of relevant assets
CS 2	The automotive case showed that the asset know-how is needed to understand where in the assembly process of cars a PpP scenario is useful. From a financial perspective it is only possible to finance assets which are standardized. This showed some difficulty as the chosen assembly line is highly specified to the OEMs needs.	W 1, W 2	
CS 1	The different roles of the partners in the ecosystem must be distributed and unassigned roles must be allocated to a partner or new partners and/or service providers. The basis for the specification of the roles are the capabilities of the partners. Below are examples of the roles from different partners of the ecosystem: • *Mechanical engineering company*: asset provider, 2nd level support. • *Re-Insurance*: asset owner, risk assumption • *Manufacturer of industrial sensor technology*: connectivity provider	W 6	Role allocation within the ecosystem
CS 2	In the case automotive, the following roles could be identified which are necessary to capture the mentioned added value: • *Bank*: asset owner, risk taker, financier, payment provider • *OEM*: specification of product & processes, risk taker, asset operator, connectivity provider • *Industrial service provider*: risk taker, asset maintenance, connectivity provider • *Mechanical engineering company*: specification of machinery & processes, risk taker, connectivity provider	W 3	
CS 1	All partners must transparently document the benefits that arise for their company. It became clear that the benefits of implementing PpP can be very different. Below we briefly summarize a selection of benefits: • *Industrial service provider*: expansion of the service portfolio, e.g., by assuming a broker role for production capacities or by increasing plant productivity. • *Manufacturer of wheel excavators*: reduction of fixed capital, stable calculation basis, increase of production flexibility. • *Mechanical engineering company*: simplified start of operations, fast payment.	W 2	Transparency about added value
CS 2	In case 2 the participants specified the following added values: • *OEM*: becoming more efficient, reduction of costs, capital expenditures to operating expenditures. • *Bank*: offering new financial services • *Industrial service provider*: becoming more efficient, expanding their existing business model of servicing the machines. • *Mechanical engineering company*: becoming more efficient, expanding their existing business model in the direction of data services.	W 4	
CS 1	Based on the defined value for each partner, different information requirements are derived for each partner. The information requirements of the manufacturing company included the number of produced good parts per hour. For the insurance company, downtimes, setup times and scrap rates. For the industrial service provider, torque, and the utilization of the plant.	W 3, 6, activities of the technical task group	Implementation of the information requirement
CS 2	For each partner of the ecosystem different information requirements are needed to fulfill their roles. Production output per hour and availability of each assembly station were the most important information requirements.	W 5 - W8	

CS 1	From the viewpoint of the companies and their data security officers, the cross-company data exchange cannot be implemented in the existing IT systems of the partners. This was especially due to reservations regarding trustworthiness and technical feasibility. For this reason, additional sensors were attached to the assets. The cooperative data space for PpP was therefore set up outside the partners' existing IT structures. A German cloud solution was used for this purpose. For analyses, the partners can link the cooperative data space to their existing IT systems as an additional data source.	W 5, 6,activities of the technical task group	Cooperative technical implementation / Implementation beside the existing IT
CS 2	The MES system of the OEM was the data source of the information required for the first PoC. The data was provided to the cooperative data space by the industrial service provider, open to all four partners and visualized via a dashboard. In a next step the partners had agreed on the implementation of the data source directly form the asset, creating a digital representation of the asset.	W5, activities of the technical task group	
CS 1	The partners were only ready to further develop the PpP scenario when there was transparency about the process. Otherwise, the risks were not tangible for the partners. The case study demonstrated that creating transparency is a good entry point into PpP approaches for the companies. In this case, digital representations of three assets were implemented, the milling machine, the screwing machine, and the turntable itself. The digital representation of the screwing machine captured data of the torque and the angle of rotation.	W 1, 2	Asset transparency
CS 2	Creating a digital representation of the assets is crucial for a PpP system. In the automotive case we consolidated on a few parameters for the digital representation to achieve asset transparency. These parameters were output per hour, availability of stations of the assembly line as well as the cycle time.	W 5	
CS 1	It is important for the technical specification to focus on condition data of the assets. This focus increases the acceptance of data sharing and increases the speed of implementation. Additional contextual information will be relevant for the realization of the PpP concept and can be integrated into private data spaces in a second step.	W 1, 2, activities of the technical task group	Trustworthiness / Data security
CS 2	An important step in ensuring data security and trustworthiness which was very important to the participating companies is the focus on machine-based condition data and no personal data infringing the GDPR rules. Another level of security is to distinguish between data, context, and information. Data without the context could be easily shared. However, the contexts of the data which makes it an information was only shared with a limited number of stakeholders.	Activities of the technical task group	
CS 1	The shared data enables the partners to implement other value-added scenarios in addition to PpP. In the case study, process optimization, predictive maintenance, risk management and other services could be realized based on the shared data. The case proved that only the PpP scenario is economically not suitable.	W 5, W 7	Additional services based on shared data for the PpP value proposition
CS 2	The transparency of the output per hour of the assembly line to all ecosystem partners has generated ideas of new additional services such as improved maintenance, new production planning and spare parts supply.	W 8	

Table 2. Design Principles for Pay-per-Part Derived from Case Studies

Evaluation of the Design Principles

The above-mentioned DPs were presented in the evaluation interviews. Several suggestions to the clustering and allocation of the DPs were made by the experts. The DP *capabilities within the ecosystem* was confirmed by both experts in the evaluation and is closely linked of the DP roles allocation. Expert 1 further stated that a compilation of both DPs to one DP would increase effectiveness. Expert 2 highlighted the need of two different DPs as the capabilities are an important aspect of the ecosystem design. Expert 2 also stressed that stating their companies' capabilities is not an easy task for decision makers.

One adaption to the DP *risk and financing sharing within the ecosystem* was made. This DP was divided into two DPs for better understanding. Expert 1 stated due to the importance of the DP it should be listed separately. The split DP r*isk sharing within the ecosystem* was viewed as a critical DP from expert 1. To know which partner faces which risks, the ecosystem must cover all existing risks. Expert 1 noticed the risk of accountability of the asset in the field. This risk occurred in both cases. Expert 2 resolved that it is not possible without the sharing of risks within the ecosystem. The DP a*sset financing within the ecosystem* was confirmed by both experts. Expert 2 stated that connected with the financing of the asset the pricing of the single part is a difficult task as standardized pricing concept will not work within a data ecosystem.

An in depth analysis also from the technical experts is an absolute necessity claims expert 2 confirming the DP *specification of the pay-per-part scenario and selection of the relevant assets*. Knowledge about each process must be made available in order to gain knowledge for example of the possible risks. Expert 1 agreed with the statement that the scenarios must be thoroughly thought trough.

The DP *role allocation within the ecosystem* was also agreed on by both experts. In addition, expert 1 mentioned the dynamic change of roles within an ecosystem over time. This could also be a possible scenario within the data ecosystem PpP. Expert 2 sees the allocation of the roles and the partners within the ecosystem as eagerly important to reach the transparency about the added value.

The DP *transparency about the added value* was declared an important DP from both experts. It was considered an absolute necessity to support is an existing business case (stated by expert 2). Expert 1 added that transparency also improves trust within the ecosystem. Occasionally the added value is not always perceived as direct but can also be indirect for example the additional services in the other DP.

The DP *implementation of the information requirement* can be a controversial aspect within the partners of the ecosystem according to expert 2. It must be clarified which partner is sharing, what data, to whom.

The DP *cooperative technical implementation / implementation besides the existing IT* is of importance especially for new and development projects according to expert 2. For out of the box solutions companies are working on standardized containers to implement within the existing IT landscape.

Expert 2 stated the DP *asset transparency* is of relevance for a PpP value proposition and stressed that other than stated above to gain transparency the digital representation is not always needed. Expert 1 stated that this DP could be seen as a basic condition, which must be given for every data ecosystem and further mentioned the *mobility data space*, which designs a data space connector that creates the basis for connecting assets to the *mobility data space* based on open-source software.

Very important and underrepresented is the DP *trustworthiness / data security* stated expert 2. The distinction between data, context, and information to improve data security is seen as crucial by expert 1.

Expert 1 sees approaches of coopetition (cooperation and competition) within the DP *additional services based on shared data*. Expert 2 also identifies the rise of these additional services outside of PpP coming to marked. Such services may also arise over the lifetime of the ecosystem.

Design Principles for Pay-per-Part

The DPs presented in table 2 and subsequent comments within the evaluation indicate that they are relevant for different stakeholders within the scope of the case studies. In the case studies, a breakdown into business and technology task groups was made. The business task group, consisted of the decision makers as well as the product managers, the technology task group attendees were developers of the physical asset and software developers. The evaluated DPs are presented in figure 4 on an abstract level with an allocation to the stakeholder group. The numbering of the DPs from one to eleven does not represent an order or importance of the DPs. It is chosen to help the understanding and the overview about the DPs. It is based on the appearance of the DPs in CS 2 (see table 2) as well as the allocation of the DPs to the stakeholder group. As a basis for structuring, the IIRA was used, with its various viewpoints and corresponding stakeholders (Lin et al., 2019). The eleven DPs are described in detail in the following with the necessary information about action and material properties of the DPs following the understanding of Chandra et al. (2015) were as the boundary conditions are PpP ecosystems with a cooperative value proposition.

DP 1 *capabilities for pay-per-part*: Decision makers must assess which capabilities their companies have and add to the ecosystem. As a base of needed capabilities for PpP, the following were observed: *connectivity know-how, financial know-how, market access, process know-how, production know-how (asset), product know-how (part), represented globally and locally, risk know-how, service know-how, vendor neutrality,* and *operator know-how.*

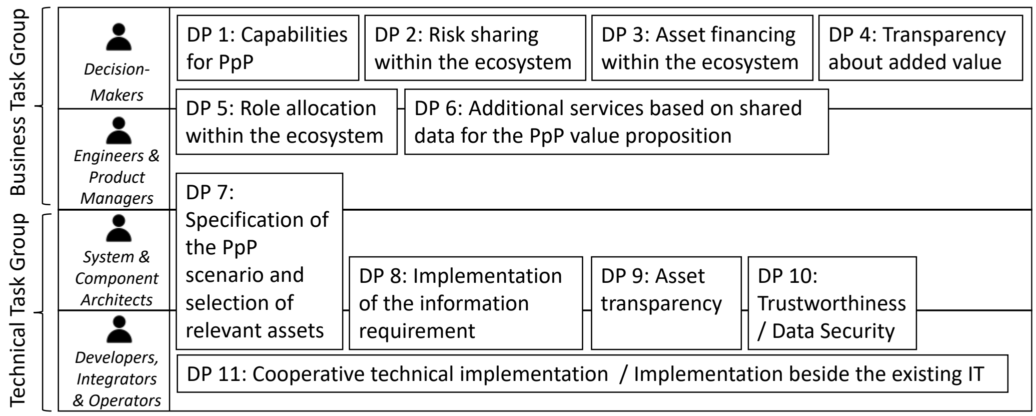

Figure 4. 11 Pay-per-Part Design Principles

DP 2 *risk sharing within the ecosystem*: The different sources of possible risks must be shared across the partners of the ecosystem. The identification as well as the apportionment of the risks are difficult and highly dependent on the chosen asset, domain, and partners setting with the ecosystem. The following risks could be observed: *failure in asset output or asset break down*, *risk of part breakdown in the field*, *process risks*, and *risk of marked fluctuation*.

DP 3 *asset financing within the ecosystem*: The high-level decision makers within the ecosystem must assure the existence of the *financier* role. This is closely linked to the knowledge of existing risks as well as the pricing of the final part which might be difficult to assess. Due to fiscal policies highly customized machinery may cause difficulties in the balancing of companies. Therefore, a focus on standardized assets is advisable when the reduction of capital expenditures to operational expenditures is strived for.

DP 4 *transparency about added value*: Not only the decision makers must recognize the added value achieved by the PpP approach for their company but also the other partners within the ecosystem. Possible added values in the context of PpP are flexibility, scalability, less bound capital, risk sharing and the enablement of new business models but could also occur in an indirect manner for example through additional services. However, the assumed added value must be within the strategic scope of the company. Transparency of the added value for the different partners in ecosystems without a keystone player, further prevents that one partner of the ecosystem might be favored and hence promotes trust.

DP 5 *role allocation within the ecosystem*: Within a PpP business model different roles can be observed. Decision makers und project managers must be aware of which roles are needed and which role is appointed to which partner. Also, partners can hold multiple roles or share roles depending on the domain and case. Role allocation could also evolve during the lifecycle of an ecosystem. The roles are closely linked to the above-mentioned added value. The following roles were central for pay per part value propositions to the two case studies: *asset provider, asset operator, asset owner, connectivity provider, financier, payment provider, risk assessment, risk taker,* and *service provider*.

DP 6 *additional services based on shared data for the pay-per-part value proposition*: Decision makers and product managers must be aware and ready to capture additional services based on the shared data and contexts and add value for the ecosystem partners. E.g., transparency on the machinery condition can help improve service efficiently or allow predictive maintenance.

DP 7 *specification of the pay-per-part scenario and selection of relevant assets*: For the lower-level technical experts, specifying the scenario as well as the asset (machinery) and the part to be produced is highly relevant. They are the stakeholders which can point out added value, technical challenges of advantages of choosing the suitable asset. DP 3 can be of assistance for DP 7.

DP 8 *implementation of the information requirement*: Stated information requirements from the decision makers need to be implemented by the stakeholders of the technical level. Other than in data-lake approaches, the chosen cooperative data space approach is based on the principle to only include data required for the chosen value proposition. Data is provided by the digital representation of an asset (see DP

9). Data which does not add value is not collected in the data space of the ecosystem. Challenges can arise in the discussion which partner provides which data and what kind of contexts to make it an information.

DP 9 *asset transparency*: PpP is based on the transparency of the assets. Information requirements will define the needed condition data. This transparency is established via the digital representation based on the condition data. The implementation is provided by the technical stakeholders.

DP 10 *trustworthiness / data security*: Trustworthiness and data security are key in such an ecosystem. The focus on condition data of the machines and not on personal data as well as the differentiation between data, context and information is important. So, data can be shared with all partners of the ecosystem, but contexts might be restricted. The approval of the respective responsible data security manager of the companies within the ecosystem must be given.

DP 11 *cooperative technical implementation / implementation besides the existing IT*: Linked to the implementation of the information requirements the technical cooperative implementation should be outside existing IT structures of the companies. This improves data security and provides a higher acceptance among the technical stakeholders. A provider of platform services (cooperative data space) is needed to host the digital representations. This could be provided by a partner of the ecosystem or an external service provider dependent on the case requirements.

Implications

Decision makers, e.g. CEOs or CIOs pursuing a PpP approach need to ensure knowing which ecosystem perspective they want to follow. Either the company is part of an ecosystem with a keystone or partner within an ecosystem with a cooperative value proposition. As figure 1 indicates schematically with the arrows, the openness for collaboration between different companies is bigger in the researched setting of an ecosystem with a cooperative value proposition. Accompanying the companies over the years of the case studies showed that there must be an openness to such cooperations on the top-level management of a company. One big factor is trust within the ecosystem which is also mentioned amongst others by Baars et al. (2021) and Gelhaar & Otto, (2020), and stated as a basic condition in the related work chapter.

If companies want to follow the ecosystem approach with a cooperative value proposition, the stated DPs can be a guidance for decision makers in building a PpP value proposition. The different partners within the ecosystem can realize various PpP value scenarios (DP 7) based on the roles and capabilities they contribute to the ecosystem. Which assets and the definition of the part is a crucial factor for the success of the ecosystem. An emphasis should be taken on standardized assets. Decision makers must be aware of which added value will arise for which partner (DP 4) fundamentally helping in building trust within the ecosystem. Only through the combination of roles and capabilities it is possible to realize the shared PpP value proposition (Müller & Buliga, 2019; Endres et al., 2019). Especially the roles financier, payment provider, asset provider, and risk taker are seen as highly relevant and must be taken on by the partners of the ecosystem (DP 1 & 5). Furthermore, the role of the asset manufacturer must be structured differently than traditionally. A high degree of asset standardization is required to implement PpP, which might be very challenging for customized machinery. Only with a high degree of standardization the risk is assessable and tradable for an insurance company, which is important for the role of risk taking (DP 2). To be able to achieve this standardization, it is necessary that the users of an asset do no longer provide a product specification for their own application context, rather it is necessary that the user of a product specifies which result (part) he requires at the end of a production process. This shifts the decision on the design and configuration of an asset back from the user of an asset to the manufacturer of the asset. The service relationships between the partners in a data ecosystem with a cooperative value proposition PpP, is closer than in data ecosystems with other business models (Leski et al., 2021; Leimeister et al., 2010; Terrenghi et al., 2018; Weber et al., 2020). This becomes particularly clear when we consider that the role of risk taker is shared between several partners of the data ecosystem, because risks arise at different points within the ecosystem (DP 2). As well as the asset financing, which must have deep knowledge about the asset to understand its output and market potential (DP 3).

Furthermore, the findings of the two case studies indicate that just the PpP value proposition is not an economically viable business model for the partners in an ecosystem without a focal company. Decision makers and developers must therefore work on the realization of additional services based on the cooperative data space and asset transparency (DP 6 & 11). These additional services e.g., preventive maintenance or process optimization, lead to an economically superior ecosystem with a focus on the shared value proposition PpP.

In contrast to PpP approaches with focal companies (Wulf et al., 2019; Ângelo & Barata, 2022), the two conducted case studies have made first indications that data ecosystems with the cooperative value proposition PpP and additional services would profit from a separate legal entity that empowers the sharing of data (DP 9 & 10). This confirms the findings of other authors and demonstrates that it is very important for the separate entity to create a balance between larger and smaller partners in data ecosystems (Otto et al., 2022; Baars et al., 2021; Weber et al., 2020). Only if this balance is achieved for example through a legal entity a long-term cooperative use of data is possible. This legal entity must also regulate which partners contribute which data and therefore specify which services will be realized based on the shared data (DP 8).

Conclusion and Limitations

Results from our conducted case studies indicate that for the development and implementation of strategies in the context of digital transformation an interplay of several partners in one ecosystem is essential. The interplay of several DPs is required to be able to realize PpP. The results of this paper therefore provide a first structure for decision makers and researchers to identify which DPs are needed to create a cooperative value proposition within a data ecosystem. However, the findings do not show the order in which the DPs have to be structured. PpP approaches are currently becoming increasingly relevant, especially in the context of the Covid-19 pandemic, the energy crisis and other factors that make long-term planning difficult. The reduction of investment costs, flexibility and the reduction of fixed costs are therefore becoming increasingly relevant.

The presented DPs were derived from a limited number of two case studies using ADR. Whether some of the principles also apply to ecosystems with a keystone player should be part of further research which therefore is a limitation towards our research. The two case studies were accompanied by the authors from the initiation of the ecosystem to the PoC. The roll out of the ecosystem (additional cycles within ADR) was not part of the research. How successful the PpP business model is in the context of scaling and in long term cannot yet be assessed. This study is also limited by the qualitative approach of only two case studies in somewhat similar contexts where the participants had no prior knowledge about PpP in data ecosystem. As well as the limited number of two expert interviews for the final evaluation.

Future Research

Further research activities arise from the taken research approach as well as the resulting DPs itself. DPs 1-7 regarding the business representatives opens up a variety of different implications as future research needs which should be addressed. E.g., which category of assets are well suited for PpP approaches or how the appearance of different kinds of risks could be quantified and combined with the financing to a final part price. For the DPs 7-11 blueprints and methods of how a successful implementation is made are a key artifact coming from research serving practitioners. Whether the DPs might change with additional knowledge of companies about PpP in data ecosystem needs to be assessed. Further research is especially needed for a possible standardization of the design of the digital representations. As PpP business models find their way into a broader use by enterprises in the future the DPs must be further evaluated from the business and technology group perspective towards completeness, usability, and functionality in their practical application and formulated into an applicable method. Additionally, the question arises how a legal entity can be structured housing a PpP value proposition in data ecosystems which could be done with additional cycles using ADR surpassing the PoC towards a PpP business model. An in depth analysis when and which ecosystem approach (see figure 1) is more suitable in which situation remains a task to be done for future research, as well as the embedding of PpP as a business model (Müller & Buliga, 2019; Endres et al.,2019) into approaches like product-service-systems. To address these questions and to increase the robustness of the DPs additional ecosystems outside of the presented domains need to be initiated.

References

Adner, R. (2017). Ecosystem as Structure. *Journal of Management*, *43*(1), 39–58. **https://doi.org/10.1177/0149206316678451**

Al-Debei, M. M., & Avison, D. (2010). Developing a unified framework of the business model concept. *European Journal of Information Systems*, *19*(3), 359–376. **https://doi.org/10.1057/ejis.2010.21**

Ângelo, A., & Barata, J. (2022). Pay-Per-Sustainable-Use: A Case of Product Service System Innovation. *PACIS 2022 Proceedings, 58*. **https://aisel.aisnet.org/pacis2022/58/**

Baars, H., Tank, A., Weber, P., Kemper, H.-G., Lasi, H., & Pedell, B. (2021). Cooperative Approaches to Data Sharing and Analysis for Industrial Internet of Things Ecosystems. *Applied Sciences*, *11*(16), 7547. **https://doi.org/10.3390/app11167547**

Beimborn, D., Miletzki, T., & Wenzel, S. (2011). Platform as a Service (PaaS). *Business & Information Systems Engineering*, *3*(6), 381–384. **https://doi.org/10.1007/s12599-011-0183-3**

Blau, B., Michalk, W., Neumann, D., & Weinhardt, C. (2008). Provisioning of Service Mashup Topologies. *ECIS 2008 Proceedings*, *109*. **https://aisel.aisnet.org/ecis2008/109/**

Braud, A., Fromentoux, G., Radier, B., & Le Grand, O. (2021). The Road to European Digital Sovereignty with Gaia-X and IDSA. *IEEE Network*, *35*(2), 4–5. **https://doi.org/10.1109/MNET.2021.9387709**

Chandra, L., Seidel, S., & Gregor, S. (2015). Prescriptive Knowledge in IS Research: Conceptualizing Design Principles in Terms of Materiality, Action, and Boundary Conditions. *48th Hawaii International Conference on System Sciences,* 4039–4048. **https://doi.org/10.1109/HICSS.2015.485**

D'souza, A., Kabbedijk, J., Seo, D., Jansen, S., & Brinkkemper, S. (2012). Software-As-A-Service: Implications For Business And Technology In Product Software Companies. *PACIS 2012 Proceedings*, *140*. **https://aisel.aisnet.org/pacis2012/140/**

DMG MORI. (2021). DMG MORI launches subscription business with PAYZR: With "Sub & all-in instead of Investment & Purchase" to the Netflix of machine building [Press release]. **https://en.dmgmori-ag.com/resource/blob/564672/7138e2982e5897593ce7b68a18f82781/dmg-mori-launches-subscription-business-with-payzr-pdf-data.pdf**

Endres, H., Indulska, M., Ghosh, A., Baiyere, A., & Broser, S. (2019). Industrial Internet of Things (IIoT) Business Model Classification. *ICIS 2019 Proceedings*, *2*. **https://aisel.aisnet.org/icis2019/practice_is_research/practice_is_research/2**

Federal Chancellery. (2021). *Data Strategy of the Federal German Government: An innovation strategy for social progress and sustainable growth*. **https://www.bundesregierung.de/resource/blob/975292/1950610/fb03f669401c3953fef8245c3cc2a5bf/datenstrategie-der-bundesregierung-englisch-download-bpa-data.pdf?download=1**

Gelhaar, J., Gürpinar, T., Henke, M., & Otto, B. (2021). Towards a taxonomy of incentive mechanisms for data sharing in data ecosystems. *PACIS 2021 Proceedings*, *121*. **https://aisel.aisnet.org/pacis2021/121/**

Gelhaar, J., & Otto, B. (2020). Challenges in the Emergence of Data Ecosystems. *PACIS 2020 Proceedings*, *175*. **https://aisel.aisnet.org/pacis2020/175/**

Giessmann, A., & Stanoevska-Slabeva, K. (2013). Business Models of Platform as a Service (PaaS) Providers: Current State and Future Directions. *Journal of Information Technology Theory and Application (JITTA)* (13). **https://aisel.aisnet.org/jitta/vol13/iss4/4/**

Gregor, S., Kruse, L., & Seidel, S. (2020). Research Perspectives: The Anatomy of a Design Principle. *Journal of the Association for Information Systems*, *21*, 1622–1652. **https://doi.org/10.17705/1jais.00649**

Guo, J., Nikolay, M., & Wan, G. (2019). The Partner Ecosystem Evolution from On-premises Software to The Partner Ecosystem Evolution from On-premises Software to Cloud Services: a case study of SAP Cloud Services: a case study of SAP. *PACIS 2019 Proceedings*, *219*. **https://aisel.aisnet.org/pacis2019/219**

Iansiti, M., & Levien, R. (2004). Strategy as ecology. *Harvard Business Review*, *82*(3), 68–78. **https://hbr.org/2004/03/strategy-as-ecology**

Joshi, R., Didier, P., Holmberg, C., Jimenez, J., & Carey, T. (2022). *The Industrial Internet of Things Connectivity Framework: An Industry IoT Consortium Foundational Document*. **https://www.iiconsortium.org/wp-content/uploads/sites/2/2022/06/IIoT-Connectivity-Framework-2022-06-08.pdf**

Kayser, L., Fruhwirth, M., & Mueller, R. M. (2021). Realizing Value with Data and Analytics: A Structured Literature Review on Classification Approaches of Data-Driven Innovations. *Proceedings of the 54th Hawaii International Conference on System Sciences*. **https://aisel.aisnet.org/hicss-54/os/org_issues_in_bi/5/**

Leimeister, S., Böhm, M., Riedl, C., & Krcmar, H. (2010). The Business Perspective of Cloud Computing: Actors, Roles and Value Networks. *ECIS 2010 Proceedings*, *56*. **https://aisel.aisnet.org/ecis2010/56/**

Leski, F., Fruhwirth, M., & Pammer-Schindler, V. (2021). Who Else do You Need for a Data-Driven Business Model? Exploring Roles and Exchanged Values. *BLED 2021 Proceedings*, *38*. **https://aisel.aisnet.org/bled2021/38/**

Levy, Y., & Ellis, T. J. (2006). A systems approach to conduct an effective literature review in support of information systems research. *Informing Science: The International Journal of an Emerging Transdiscipline*, *9*, 181–212. **https://doi.org/10.28945/479**

Lin, S.-W., Miller, B., Durand, J., Bleakley, G., Chigani, A., Martin, R., Murphy, B., & Crawford, M. (2019). *The Industrial Internet of Things Volume G1: Reference Architecture: Version 1.9*. **https://www.iiconsortium.org/pdf/IIRA-v1.9.pdf**

Lins, S., Pandl, K. D., Teigeler, H., Thiebes, S., Bayer, C., & Sunyaev, A. (2021). Artificial Intelligence as a Service. *Business & Information Systems Engineering*, *63*(4), 441–456. **https://doi.org/10.1007/s12599-021-00708-w**

March, S. T., & Smith, G. F. (1995). Design and natural science research on information technology. *Decision Support Systems*, *15*(4), 251–266.

Mayring, P. (2014). Qualitative content analysis: theoretical foundation, basic procedures and software solution. Beltz Verlag.

Mazhelis, O., Luoma, E., & Warma, H. (2012). Defining an Internet-of-Things Ecosystem. In D. Hutchison, T. Kanade, J. Kittler, J. M. Kleinberg, F. Mattern, J. C. Mitchell, M. Naor, O. Nierstrasz, C. Pandu Rangan, B. Steffen, M. Sudan, D. Terzopoulos, D. Tygar, M. Y. Vardi, G. Weikum, S. Andreev, S. Balandin, & Y. Koucheryavy (Eds.), *Lecture Notes in Computer Science. Internet of Things, Smart Spaces, and Next Generation Networking* (Vol. 7469, pp. 1–14). Springer Berlin Heidelberg. **https://doi.org/10.1007/978-3-642-32686-8_1**

Moore, J. F. (1993). Predators and prey: a new ecology of competition. *Harvard Business Review*, *71*(3), 75–86.

Mörth, O., Emmanouilidis, C., Hafner, N., & Schadler, M. (2020). Cyber-physical systems for performance monitoring in production intralogistics. *Computers & Industrial Engineering*, *142*. **https://doi.org/10.1016/j.cie.2020.106333**

Müller, J., & Buliga, O. (2019). Archetypes for data-driven business models for manufacturing companies in Industry 4.0. *International Conference on Information Systems 2019 Special Interest Group on Big Data Proceedings* (2). **https://aisel.aisnet.org/sigbd2019/2/**

Myers, M. D. (2020). Qualitative research in business and management (Third edition). SAGE.

Myers, M. D., & Newman, M. (2007). The qualitative interview in IS research: Examining the craft. *Information and Organization*, *17*(1), 2–26. **https://doi.org/10.1016/j.infoandorg.2006.11.001**

Oliveira, M. I. S., & Lóscio, B. F. (2018). What is a data ecosystem? In M. Janssen, S. A. Chun, V. Weerakkody, A. Zuiderwijk, & C. C. Hinnant (Eds.), *Proceedings of the 19th Annual International Conference on Digital Government Research: Governance in the Data Age* (pp. 1–9). ACM. **https://doi.org/10.1145/3209281.3209335**

Otto, B., Hompel, M. ten, & Wrobel, S. (2022). *Designing Data Spaces*. Springer International Publishing. **https://doi.org/10.1007/978-3-030-93975-5**

Porter, M. E., & Heppelmann, J. E. (2014). How smart, connected products are transforming competition. *Harvard Business Review*, *92*(11), 64–88.

RELAYR. (2018). *Relayr acquired by Munich Re to advance its IoT strategy*. **https://relayr.io/relayr-acquired-by-munich-re-to-advance-its-iot-strategy/**

RELAYR. (2020). *Pay-per-part: TRUMPF and Munich Re plan new business model for the manufacturing industry*. **https://relayr.io/pay-per-part-trumpf-and-munich-re-plan-new-business-model-for-the-manufacturing-industry/**

Repschlaeger, J., Zarnekow, R., Wind, S., & Klaus, T. (2012). "CLOUD REQUIREMENT FRAMEWORK: REQUIREMENTS AND EVALUATION CRITERIA TO ADOPT CLOUD SOLUTIONS. *ECIS 2012 Proceedings*, *42*. **http://aisel.aisnet.org/ecis2012/42**

Sääksjärvi, M., Lassila, A., & Nordström, H. (2005). EVALUATING THE SOFTWARE AS A SERVICE BUSINESS MODEL: FROM CPU TIME-SHARING TO ONLINE INNOVATION SHARING. *IADIS International Conference on E-Society*, 177–186.

Sein, M. K., Henfridsson, O., Purao, S., Rossi, M., & Lindgren, R. (2011). Action Design Research. *MIS Quarterly*, *35*(1), 37. **https://doi.org/10.2307/23043488**

Senyo, P. K., Liu, K., & Effah, J. (2019). Digital business ecosystem: Literature review and a framework for future research. *International Journal of Information Management*, *47*, 52–64. **https://doi.org/10.1016/j.ijinfomgt.2019.01.002**

Siegert, J., Brehm, A.-K., Bölstler, M., Bornschein, C., Becker, L., & Stojkovski, I. (2021). *Asset-as-a-Service: The Transformation from Capex to Opex – a further step towards Industry 4.0*. **https://corporates.db.com/publications/White-papers-guides/asset-as-a-service**

Sun, W., Zhang, K., Chen, S.-K., Zhang, X., & Liang, H. (2007). Software as a Service: An Integration Perspective. In D. Hutchison, T. Kanade, J. Kittler, J. M. Kleinberg, F. Mattern, J. C. Mitchell, M. Naor, O. Nierstrasz, C. Pandu Rangan, B. Steffen, M. Sudan, D. Terzopoulos, D. Tygar, M. Y. Vardi, G. Weikum, B. J. Krämer, K.-J. Lin, & P. Narasimhan (Eds.), *Lecture Notes in Computer Science. Service-Oriented Computing – ICSOC 2007* (Vol. 4749, pp. 558–569). Springer Berlin Heidelberg. **https://doi.org/10.1007/978-3-540-74974-5_52**

Terrenghi, N., Schwarz, J., & Legner, C. (2018). Towards Design Elements to Represent Business Models for Cyber Physical Systems. *ECIS 2018 Proceedings*, *181*. **https://aisel.aisnet.org/ecis2018_rp/181/**

TRUMPF. (2020). *Pay-per-part: TRUMPF and Munich Re plan new business model for the manufacturing industry*. **https://www.trumpf.com/en_INT/newsroom/global-press-releases/press-release-detail-page/release/pay-per-part-trumpf-and-munich-re-plan-new-business-model-for-the-manufacturing-industry/**

Tsujimoto, M., Kajikawa, Y., Tomita, J., & Matsumoto, Y. (2018). A review of the ecosystem concept — Towards coherent ecosystem design. *Technological Forecasting and Social Change*, *136*, 49–58. **https://doi.org/10.1016/j.techfore.2017.06.032**

Venable, J., Pries-Heje, J., & Baskerville, R. (2016). FEDS: a Framework for Evaluation in Design Science Research. *European Journal of Information Systems*, *25*(1), 77–89. **https://doi.org/10.1057/ejis.2014.36**

Venkatachalam, N., Fielt, E., Rosemann, M., & Mathews, S. (2013). Software as a Service (SaaS) for Small and Medium Enterprises (SMEs): The Role of Intermediaries. *ACIS 2013 Proceedings*, *152*. **https://aisel.aisnet.org/acis2013/152/**

Weber, P., Hiller, S., & Lasi, H. (2019). Design and Evaluation of an Approach to Generate Cross-Domain Value Scenarios in the Context of the Industrial Internet of Things: A Capability-Based Approach. *PICMET 2019,* 1-8, **https://doi.org/10.23919/PICMET.2019.8893687**

Weber, P., Hiller, S., & Lasi, H. (2020). Identifying Business Potentials within an IoT Ecosystem – An Explorative Case Study in the Industrial Domain. *AMCIS 2020 Proceedings*, *19*. **https://aisel.aisnet.org/amcis2020/org_transformation_is/org_transformation_is/19**

Weber, P., Hiller, S., & Lasi, H. (2021). Dual Scientific Research Framework – Generating Real World Impact and Scientific Progress in Internet of Things Ecosystems. *PACIS 2021 Proceedings*, *190*. **https://aisel.aisnet.org/pacis2021/190**

Weitzel, D. (2020). The Influence of Psychological Ownership on Software as a Service in the Context of Commercial Customers. *AMCIS 2020 Proceedings*, *14*. **https://aisel.aisnet.org/amcis2020/adv_info_systems_research/adv_info_systems_research/14/**

Weyrich, M., & Ebert, C. (2016). Reference Architectures for the Internet of Things. *IEEE Software*, *33*(1), 112–116. **https://doi.org/10.1109/MS.2016.20**

Woroch, R., & Strobel, G. (2022). Show me the Money: How to monetize data in data-driven business models? *Wirtschaftsinformatik 2022 Proceedings*, *13*. **https://aisel.aisnet.org/wi2022/digital_business_models/digital_business_models/13**

Wu, J., Qing, C., & Gao, S. (2015). How SaaS Application Led To Cloud Enabled Business Innovation: A Case Study from China. *PACIS 2015 Proceedings*, *9*. **https://aisel.aisnet.org/pacis2015/9/**

Wulf, F., Westner, M., Schön, M., Strahringer, S., & Loebbecke, C. (2019). Preparing for a Digital Future: Cloud Strategy at Continental AG. *ICIS 2019 Proceedings*, *1*. **https://aisel.aisnet.org/icis2019/practice_is_research/practice_is_research/1/**

Yin, R. K. (2018). Case study research and applications: Design and methods (Sixth edition). SAGE.