How to promote the spread of data-driven business models by involving all relevant stakeholders?

The case of the pay-per-stress model

K. Valerie Carl [1], Constantin Brîncoveanu [2], and Oliver Hinz [3]

Abstract: Sustainable practices change businesses in various domains, leveraging digitalization and the according spread of sensor technology and connectivity. In this context, data-driven business models emerge that foster sustainability. Despite the potential benefits of such emerging business models, adoption has been limited. To foster their spread, every affected stakeholder group must benefit. Hence, this study investigates potential incentives to adopt data-driven business models, particularly pay-per-stress, considering all affected stakeholder groups. We examine pay-per-stress in the context of the manufacturing industry, accordingly considering manufacturers, lessors, and lessees. Through semi-structured interviews with 19 experts stemming from those three stakeholder groups, we identify a potential incentive system for enabling more wide-spread adoption. This research contributes to understanding the incentivization of data-driven business models that foster more sustainability by encouraging a use of leased products that enables longer lifespans.

Keywords: Pay-per-stress, Data-driven Business Models, Business Models for Sustainability, Servitization, Manufacturing, Stakeholder Incentives

1 Introduction

The push towards sustainability is reshaping business models across various industries [SLH16]. Meanwhile, digitalization allows for innovative business practices such as servitization, promising enhanced value creation and competitive differentiation [Ne08], albeit not always satisfying sustainability goals [Ni22]. One illustrative example are emerging, often data-driven, business models such as pay-per-use that ground on classical leasing but capitalize on digitalization's ability to enable precise tracking and billing of product usage [Bo21]. This facilitates a shift from traditional capital-intensive purchases

[1] Goethe University Frankfurt/Main, Chair of Information Systems and Information Management, Theodor-W.-Adorno-Platz 4, 60323 Frankfurt/Main, kcarl@wiwi.uni-frankfurt.de,
https://orcid.org/0000-0003-4655-1046
[2] Goethe University Frankfurt/Main, Chair of Information Systems and Information Management, Theodor-W.-Adorno-Platz 4, 60323 Frankfurt/Main, brincoveanu@wiwi.uni-frankfurt.de,
https://orcid.org/0009-0008-4390-3599
[3] Goethe University Frankfurt/Main, Chair of Information Systems and Information Management, Theodor-W.-Adorno-Platz 4, 60323 Frankfurt/Main, ohinz@wiwi.uni-frankfurt.de,
https://orcid.org/0000-0003-4757-0599

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or fixed leasing rates to flexible, service-oriented solutions that are particularly beneficial for small and medium-sized enterprises facing high product acquisition costs [Bo21]. While models like leasing and pay-per-use are well-established [HTG10], these approaches often fall short in aligning with sustainability objectives, as they lack economic incentives for sustainable usage [Bo21], particularly in settings where conflicts of interest may arise among stakeholders [LÖS09]. Pay-per-stress (PPS), which utilizes data-driven capabilities for precise tracking and billing based on actual wear of the products, therefore emerges as a promising solution, addressing both economic and sustainability concerns [Bo21] besides aligning stakeholder interests. By basing the payment rate on actual wear, the model extends leasing principles and favors more sustainable product use and longer lifespans, thus contributing to the UN's Sustainable Development Goal (SDG) of responsible consumption and production [TH24], and overall ecological sustainability by leveraging the potential positive effects of digitalization. In the insurance industry, it has long been state of the art to monitor customers to some extent, allowing them to pay reduced premiums based on their behavior and risk profiles [We70]. However, research on data-driven business models like PPS is still in its infancy. Particularly, the operationalization of such business models and enabling high market penetration lacks scholarly attention. Recent research aimed at defining the business model and its working [e.g., Bo21; HLM22; St21]. Still, to make these models scalable in practice, a wide adoption is necessary. To enhance the acceptance of PPS, an incentivization among affected stakeholders might be fruitful. We therefore ask the research question:

What are effective incentives to promote the adoption of PPS for all affected stakeholders?

The primary objective of this work is to investigate potential incentives, their relevance, and the strategic importance of PPS across different affected stakeholder groups. Using the manufacturing industry as an example for an industry that digitalization is reshaping [Bu20], we investigate the perspectives of leasing companies (lessors), tooling machine manufacturers (manufacturers), and machine users (lessees). Each of the three stakeholder groups can initiate the deployment of a business model like PPS, however, in most cases, the lessor develops a new offering, promoting it within the further stakeholder groups. Still, to capture each potential case, we assess incentives for all three groups. We evaluate our research question through the lens of a qualitative approach, using semi-structured interviews. Based on our findings, we develop incentive systems, outlining relevant factors that can promote widespread adoption in practice. These findings contribute to the scholarly debate as well as the operationalization in practice by clarifying the conditions under which stakeholders favor an emerging, data-driven business model such as PPS and identifying key areas where further adaptations of the model could increase its attractiveness. The implications extend to theory by bridging gaps in the literature on digital transformation's impact on service-oriented business models, employing the use case of the manufacturing sector, as well as the opportunity of leveraging data for ecological sustainability by employing a new, data-driven business model.

2 Background

2.1 Tooling machines

A tooling machine is a means of production for the manufacturing of so-called workpieces using tools—adapted to the production task at hand [Ba17]. Tooling machines feature high acquisition costs [HH03], long product lifecycles [Go23], and their operation is characterized by wear and tear both on tools and wear parts of the machine according to its use [Hi16; Re12]. Tooling machines generally have an individual load range that allows for optimal usage respectively use with greater wear. Nowadays, tooling machines already have a large number of built-in sensors and are usually connected to a network. This equipment allows, e.g., for the real-time assessment of the machine status, the provision of a digital twin [VHW21], and predictive maintenance [LWW18]. In manufacturing, the implementation of artificial intelligence (AI) models to merge datasets from calculated process features and physical measurements has effectively predicted tool wear and part quality, demonstrating the practicality of this approach during regular machining operations [LWW18]. Regulatory and market pressures are driving the adoption of environmentally friendly practices, emphasizing sustainability in machine usage [SS19]. Traditional purchasing methods incentivize sustainable use to maintain residual value, but the well-established business model classical leasing does not, as the residual value does not directly apply to the lessee [Me20]. New data-driven business models that build on classical leasing besides incorporating additional factors (e.g., sustainable use) can promote more sustainable machine usage. We first introduce leasing before discussing an alternative data-driven business model that may foster sustainability in the future.

2.2 Leasing

In traditional machine leasing, the lessor provides the leased asset—in this case the tooling machine—to the lessee for use for a defined period of time. In return, the lessor receives the regular payment of an agreed, usually monthly, leasing fee, regardless of actual use. Lessee and lessor are not the only parties in a direct relationship (i.e., receiving regular payments for the transfer of use). The supplier of the machine is also part of this construct in the initiating phase of the leasing contract (i.e., advising the lessee and delivering the machine, receiving payments from the lessor), with legal and economic links to the other two stakeholders involved [Bo21]. Classical leasing inherits one central conflict of interest between the objectives of the lessee and the lessor. While the lessee prioritizes maximum machine utilization (e.g., of tooling machines) and thus maximum output without considering machine deterioration, the lessor's focus is on maintaining the machine value, as the lessor bears the residual value and material risk in leasing [Bo21]. This conflict of interest usually results in the lessor adding a risk premium to the lease payment to reduce the own residual value risk due to machine wear [St20]. This conflict between lessor and lessee is an example of the principal-agent problem [St13]. In this context, a data-driven business model emerged building on leasing but incorporating machine usage: PPS.

2.3 Pay-per-stress (PPS)

PPS leverages modern digital technologies [Bo21] and aims to align the interests of lessors and lessees. This model ensures that leasing rates are reflective of the actual wear on products, thereby addressing the inherent inefficiencies caused by information asymmetry in traditional leasing contracts [Bo21, St20]. In this way, this data-driven business model ensures a pairing between wear and the payments of installments. PPS encourages sustainable machine use and penalizes exceptionally heavy wear. Accordingly, the payment model aims to extend the lifespans of machines through more sustainable use. In particular, this aims to delay the necessary scrapping of machines and thus ensures a more sustainable use of resources, thus directly contributing to the UN's SDG goal of responsible consumption and production [TH24]. Relationship dynamics within PPS are characterized by mutual benefit and cooperation. In contrast to classical leasing with mainly two players closely interacting, three stakeholder groups and their interests interact in this business model over the entire lifecycle. Within the manufacturing industry, the manufacturer has to enable access to the tooling machine's sensory system [Bo21], in exchange receiving (potential) access to collected data and the lessee over the entire lifecycle. This potentially involves technologies such as machine learning for predicting wear based on stress levels [HLM22] and a blockchain with smart contracts to ensure secure data processing [Bo21]. Lessees may benefit from more equitable leasing rates and complementary services aimed at minimizing machine stress, while lessors benefit from leasing rates reflecting the residual value of the tooling machine after the contract ends [Bo21]. From an economic perspective, PPS offers a resolution to the principle-agent problem prevalent in traditional leasing scenarios by making wear the basis for financial calculations [St20]. From an ecological perspective, paring wear and according payment can incentivize lessees to use their tooling machines more sustainable, thereby enabling a longer lifespan and contributing to more sustainable manufacturing in general.

3 Methods

In our study, we explore the effectiveness of incentives to support PPS within the German manufacturing industry. We adopted a qualitative research design with semi-structured interviews (following the principles of [MN07] and [My09]) to aggregate comprehensive insights into three stakeholder perspectives: manufacturers, lessors, and lessees. For this sake, we conducted a pilot study with two companies per stakeholder group to discuss and collect potential incentives complemented by assessing relevant literature to finally build three distinct incentive sets. In the main study, the pilot study companies as well as further recruited companies assessed the relevance of the incentives applicable to their respective stakeholder group, besides an assessment of the level of support of the baseline business model (leasing) compared to the emerging data-driven business model (PPS). In this way, we aimed to examine the effectiveness of incentives for each stakeholder group to build a comprehensive and effective incentive system. In total, we collected data from six interviewees in the pilot study and in total 19 interviewees in the main study active in the

German manufacturing industry. More specifically, we conducted interviews with representatives from seven manufacturers (subsequently labeled as interviewee #1 to interviewee #7), seven lessors (interviewee #8 to interviewee #14), and five lessees (interviewee #15 to interviewee #19). For each stakeholder group, we aimed to recruit a heterogeneous sample, capturing different company sizes for all groups, external and internal lessors, as well as lessees operating in various industries. We conducted the interviews using semi-structured guidelines (following the principles of [MN07] and [My09]) that we adjusted after a pretest. For the main study, we employed a rating scale to assess the relevance of various incentives for adopting business models. This rating scale ranges from of 0 ('not relevant at all for my company and no influence on the support of a business model'), to 3 ('very relevant for my company and main influence on the support of a business model'). We employed a second rating scale to assess the level of support by the incentives on a business model (classical leasing vs. PPS), capturing values from 0 ('dissatisfying') to 4 ('ideal'). We recorded and transcribed the interviews, and subsequently analyzed them using MAXQDA to facilitate content analysis. First, we quantitatively analyzed the results using medians for each response to accurately reflect central tendencies, given the ordinal nature of our data. Second, two coders independently performed a qualitative content analysis in several iterations [Kr04], settling deviations in mutual agreement. A third coder assessed the results and agreed with the coding.

4 Results

When assessing the effectiveness of incentives, we rely on (i) the quantitative comparison employing both the relevance of an incentive and the comparative advantage of PPS versus classical leasing as well as (ii) the qualitative analysis of companies' impression of the varying business models and potential incentives. For tooling machine manufacturers (see Tab. 1), all of the incentives that interviewees predominantly regarded as very relevant for their company and as a main influence on support of a business model (relevance=3), namely 'corporate image', 'long-term presence and relevance', 'access to big data – maintenance', and 'warranty claims', notably showed an increase in support for PPS compared to classical leasing. The results particularly highlight a strong preference for PPS in leveraging big data for maintenance purposes as well as for handling warranty claims, which suggests that machine manufacturers expect warranty claims to be solved more easily with the help of PPS. As interviewee #4 mentioned, "The downtimes are of course relevant […] and if I […] know more precisely when I have to replace [it], then I can simply […] increase capacity utilization from 85 to 90 percent." Interviewee #1 regards main advantages of PPS being a more sustainable machine operation and offering good conditions: "I have to build a good machine that achieves a good residual value and breaks down little. That is certainly vital through PPS […] to be able to offer good conditions." This is also reflected by the interviewees' desire to cherish corporate image, going hand in hand with fair contracts. As interviewee #6 put it, "Image is always important, if you do anything dubious […] it's never effective. At the end of the day, the customer must feel that they are in good hands and must not […] feel ripped off."

Similarly, incentives that interviewees predominantly regarded as relevant for their company but no main influence on the support of a business model (relevance=2) all show a preference for PPS, except for 'customer loyalty lessee', remaining constant.

Incentive	Relevance	Classical	PPS
Access to big data – maintenance	**3**	**0**	**4**
Corporate image	**3**	**3**	**4**
Long-term presence and relevance	**3**	**2**	**3**
Warranty claims	**3**	**0**	**3**
Access to big data – AI training	2	0	2
Access to big data – customizing	2	0	3
Access to big data – development	2	0	4
Add-on selling	2	1	4
Corporate philosophy	2	2	3
Customer insights	2	1	3
Customer loyalty lessee	2	3	3
Growth potential	2	2	3
Increased revenues – additional equipment	2	0	3
Increased revenues – additional services	2	0	3
Relationship to the customer	2	2	3
Value-added services	2	1	4
Vertical value added	2	0	3
Attractiveness for potential employees	1	0	1
Customer loyalty lessor	1	3	3
Increase in know-how	1	0	3
Network	1	2	3

Tab. 1: Effectiveness of incentives for manufacturers (values are medians over all interviewees)

Regarding incentives for lessors (see Tab. 2), the data distinctly shows that for all incentives that are very relevant for companies and a main influence on the support of a business model (relevance=3: 'customer insights', 'comparability of the offer', 'add-on-selling', 'long-term presence and relevance', 'increase in know-how', and 'network'), PPS consistently outperformed classical leasing. Interviewee #8 mentioned that "With classic machine leasing, they don't have these usage data […] whereas with the PPS model or pay-per-use model, you see the ongoing usage. And that's why classical […] machine leasing can actually only say that we take an ageing and wear and tear effect up front, rigidly, while the other model can be flexible." This shows that lessors value the insights gained from such a model. The positive stance towards PPS is similarly reflected in incentives that interviewees predominantly regarded as relevant for their company but no main influence (relevance=2), where the incentives generally also show higher support for PPS, underscoring the lessors' perception of PPS as a superior model in enhancing business outcomes. Notably, 'continuity of the cash flow' was the only incentive where classical leasing scored higher than PPS, suggesting that some financial stability aspects

of classical leasing still hold appeal. But lessors may trade-off this benefit in practice or decide on the proportion of the flexible component of the PPS payment rate, since those monthly rates consist of a defined (fixed) base rate and an additional variable share based on the machine wear. As interviewee #8 said, "The higher the variable portion of the leasing rate, the more difficult it is for the leasing company to manage it. And also to secure interest rates." This indicates that there might be a sweet spot in-between that allows both financial predictability and the benefits that come along with PPS. When asked whether there is a fixed rate in any case, interviewee #14 said: "Exactly, some basic rate, yes. And be it that a certain number of hours where you are allowed to use the machine, cutting hours or whatever that is as a relevant variable, that it is then paid accordingly, yes. But you can't really go and say that zero rate equals zero use. So, that means the variability is actually in the utilization." This shows that the continuity of the cash flow is an incentive that further research needs to address carefully for advancing the adoption for PPS. Still, the overall data illustrates potential strategies to foster adoption.

Incentive	Relevance	Classical	PPS
Add-on selling	**3**	**1**	**4**
Comparability of the offer	**3**	**2**	**4**
Customer insights	**3**	**1**	**3**
Increase in know-how	**3**	**3**	**4**
Long-term presence and relevance	**3**	**2**	**4**
Network	**3**	**3**	**4**
Access to big data – machines	2	2	4
Alignment of machine wear with payments	2	2	4
Attractiveness for potential employees	2	2	3
Continuity of the cash flow	2	4	2
Corporate image	2	2	4
Customer loyalty lessee	2	3	4
Growth potential	2	3	4
Increased revenues – additional services	2	1	4
Predictability of the residual value	2	2	4
Return on investment	2	2	4
Sustainable machine utilization	2	2	3
Value-added services	2	1	4
Access to big data – customizing	1	2	4
Access to big data – increased efficiency	1	1	2
Cross-customer machine park management	1	1	1
Vertical value added	0	2	3

Tab. 2: Effectiveness of incentives for lessors (values are medians over all interviewees)

In assessing lessees' preferences between classical leasing and PPS models (see Tab. 3), our analysis highlights a distinct pattern: 'Data security', the only incentive that interviewees predominantly regarded as very relevant for their company and as a main

influence on support of a business model (relevance=3), strongly favors classical leasing. Keeping data safe is vital for lessees, "And of course we don't want competitors to be informed about our data or approaches." as interviewee #19 voiced it. Further research needs to show that PPS can respond to those concerns. Interviewee #16 described those concerns and doubts as follows: "With […] PPS […], I can't imagine today how […] data protection can be realized. If they process the [data], it is still the case that others will get [our know-how] […]. So […] I can't […] imagine that. Unsatisfactory." Conversely, all remaining incentives demonstrate a preference for PPS. Interviewee #17 mentions a positive effect on know-how, "We would certainly use it to […] train our staff accordingly so that they […] can make programming, tool use and everything else involved as stress-free as possible for the machine." This reveals a trend towards adopting PPS for its knowledge benefits, advanced analytical possibilities, and reduced risks, though classical leasing remains preferred for data security. Hence, to ensure widespread acceptance of this business model, it is crucial to demonstrate robust data security measures to lessors.

Incentive	Relevance	Classical	PPS
Data security	**3**	**4**	**1**
Access to big data – maintenance	2	0.5	3
Access to big data – usage recommendations	2	0	2
Additional services received	2	1	2
Increase in know-how	2	0.5	3
Sales opportunities	2	1.5	2
Total cost of ownership	2	0.5	2.5
Wear risk	2	0.5	1.5
Access to big data – optimization	1	0	2.5
Alignment of usage and costs	1	0.5	3
Data as means of payment	1	3	3
Entrepreneurial risk	1	0	2.5
Influencable costs	1	2	3
Network	1	1	3
Standardized analytics	1	0.5	3
Capacity sharing	0	0	3

Tab. 3: Effectiveness of incentives for lessees (values are medians over all interviewees)

5 Discussion and Conclusion

Data-driven business models such as PPS have the inherent ability to incentivize sustainable corporate behavior and to penalize the opposite (i.e., higher payments). While directly sustainability-related incentives such as 'sustainable machine utilization' (see Tab. 2) or 'capacity sharing' (see Tab. 3) are less relevant for companies' decision which business model to employ or to offer, PPS can contribute to sustainable machine use.

Hence, such a data-driven business model can promote ecological sustainability despite not being a central determinant in companies, therefore being a valuable measure to foster sustainable corporate behavior. Drawing from the insurance industry's practice of adapted premiums [We70], our study further underscores the potential benefits of data-driven models in other sectors, including the manufacturing industry. The advancement in PPS models ties closely with the industry's push towards sustainability and efficiency, thereby reducing environmental impact and enhancing economic efficiency [Da21; Go23; SS19].

The preference for PPS, as indicated by our results, suggests that stakeholders recognize its potential benefits including improved maintenance predictions and optimized equipment usage, resulting in an extended product lifecycles. Particularly tooling machine manufactures respond positively to the data-driven business model PPS and, according to our results, can be incentivized to support its operationalization in practice. However, our findings also highlight a notable exception in the preference for classical leasing over PPS in terms of data security (see Tab. 3). This concern suggests that while stakeholders are eager to embrace the advantages of PPS, there remains a critical need to address and mitigate data security risks effectively. Enhancing trust in the security measures of PPS models is essential to their broader adoption and success, at least from the lessees' view. Accordingly, incentivizing further adoption involves proving an adequate level of data security to lessees to successfully operationalize PPS in practice. This also includes introducing measures for making sure that no conclusions about business metrics are possible for the lessor, such as data anonymization and aggregation techniques. Furthermore, while there is an overall positive stance towards PPS, certain aspects of classical leasing such as financial stability and predictability, represented by the incentive 'continuity of the cash flow', still hold significant appeal (see Tab. 2). This suggests that while PPS offers numerous advantages, incorporating elements that preserve the financial predictability and stability valued in classical leasing can increase the attractiveness for lessors. Hence, incentivizing the broad acceptance of PPS from the lessors' view involves emphasizing the advantages of PPS, which can compensate for its poorer predictability compared to classical leasing. A successful operationalization involves showcasing the most effective incentives such as 'add-on selling' and 'customer insights'. Lastly, our results underline the heterogeneity of determinants to participate in a particular business model. In the future, an orchestration of the most effective incentives [MC24] allows for a working incentive system that targets each of the three stakeholder groups.

Our research makes significant theoretical contributions to the field of sustainable business models and incentivization. First, it enhances the understanding of how to effectively incentivize the adoption of data-driven business models within the manufacturing industry. Mostly, lessors drive the promotion of such a business model, however, both other actors can initiate PPS as well. Against this background, we opted to evaluate incentives for each of the relevant stakeholder groups, enabling an initiation from each actor. Second, our study contributes to the discourse on sustainable business practices by demonstrating how the adoption of data-driven models like PPS can lead to environmentally responsible behaviors. Last, we contribute directly to the development of PPS by mapping out its stakeholder implications within the context of the manufacturing

industry. From a practical standpoint, our findings facilitate the adoption of data-driven business models like PPS, emphasizing their role in enhancing sustainability and resource efficiency. Our findings suggest a general acceptance of PPS among stakeholders. Still, we highlight the importance of constructing a tailored incentive system that maximizes stakeholder buy-in by prioritizing and clearly communicating the most compelling incentives. Additionally, addressing key concerns such as data security and financial predictability is crucial for a successful incentivization and ultimately operationalization. It is important to proactively inform stakeholders of these challenges, focusing on the specific barriers each group faces to ensure their commitment and support a smooth transition to these innovative business practices, thereby promoting broader adoption in the manufacturing industry. Yet, PPS is not on the market. To initially spread the business model, lessors might consider offering the business model only rewarding sustainable use instead of penalizing the opposite (i.e., similar to telematics tariffs for car insurance).

Despite best efforts this study has some limitations. First, one limitation is this study's focus on German companies and interview partners. While Germany is an important driver of the manufacturing industry, future research may assess potential (national) differences, e.g., the importance of predictability of payments. Second, we aimed to achieve some heterogeneity in each of the interviewed stakeholder groups. Still, especially for lessees, the importance of several criteria may differ according to industries due to the sensitivity of data, possible fluctuations in demand, and potential big data usage. Third, we conducted our study in the context of tooling machines. However, derived results also apply to robotics and further machine types that are suspect to different wear based on the use, besides, e.g., car leasing. While classical leasing and pay-per-use (like car sharing) are well-established for private respectively corporate customers, the residual value of cars also depends on its usage, being a potential application scenario for PPS. Hence, we aim to encourage future research to assess the relevance and applicability of PPS in further scenarios and to assess incentives for affected stakeholder groups. It is important to consider that while there are significant incentives for each party, there are also inherent tensions and trade-offs (e.g., customer insights vs. privacy). We also encourage future research to consider more complex value-added systems, consisting of more entities (e.g., technology partners). Last, we were not able to evaluate PPS "in the wild". As soon as first companies offer this business model, future research can assess incentives in practice.

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