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Antecedents of Non-Ownership Business Model Offerings in the Mechanical Engineering Industry – A Set Theoretic Approach

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Research Paper

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Abstract. The emergence of Industrial Internet of Things (IIoT) technologies drives the offering of non-ownership business models (NOBMs) in the mechanical engineering industry. In a NOBM mechanical engineering firms as machine providers maintain machine ownership and sell their customers only the machine use and/or performance. While literature has already discussed the influence of multiple individual contextual antecedents on the decision of mechanical engineering firms whether to offer NOBMs, little is known about the interplay of these antecedents. By drawing on 16 interview-based cases and fuzzy-set Qualitative Comparative Analysis (fsQCA), we applied a configurational perspective and identified each two configurations of four key contextual antecedents (high digital service capabilities, high machine standardization, high share of large customers, and high market competition) that lead to presence or absence of NOBM offerings by mechanical engineering firms. Moreover, we used our case insights to discuss the interplay of these antecedents within the identified configurations.

Keywords: Non-ownership business models (NOBMs), Contextual antecedents, Mechanical engineering industry, Manufacturing industry, fuzzy-set Qualitative comparative analysis (fsQCA).

1 Introduction

The emergence of Industrial Internet of Things (IIoT) technologies drives the introduction of new business offerings in the mechanical engineering industry. One of these new offerings are part of so-called non-ownership business models (NOBMs). In NOBMs, mechanical engineering firms as machine providers still design and produce the machines. However, they maintain ownership and do not sell them to their customers anymore. Instead, they sell machine use and/or performance (Adrodegari et al., 2015, 2018; Ehret and Wirtz, 2010, 2017; Selviaridis and Wynstra, 2015). A prominent NOBM example from the mechanical engineering industry is the 'Sigma Air Utility' model from the compressor manufacturer Kaeser. In this model, customers no longer buy the compressors. Instead, they only pay for the compressed air they consume. Kaeser remains the owner of the compressors and builds and operates the compressors on behalf of the customers (Bock et al., 2019). In NOBMs, the machine customer benefits from the machine provider taking over the risks and burdens associated with the acquisition and operation of the machine. Therefore, the machine customer can avoid high investments in expensive machines (capital commitment). Moreover, since the provider takes over burdens related to the operation of increasingly complex machines (especially maintenance), the machine customer can fully focus on its core business. On the other side, taking over these burdens (especially the typically profitable service and maintenance business) allows the machine provider to realize new revenue and profit opportunities (Bock et al. 2023; Hypko et al., 2010a, 2010b; Schnaars et al., 2022).

However, despite these benefits and opportunities for the machine customer and provider, this business model has yet to be widely applied in practice. For example, a recent study shows that only 14 percent of German mechanical engineering firms offer non-ownership services (Relayr, 2022). A key reason that machine providers still hesitate to offer NOBMs are the financial and operational risks associated with this business model for them. For example, since the machine providers are paid during the machine usage time, they risk losing money if the customer is unable or unwilling to pay (Böhm et al., 2016; Hypko et al., 2010a; Wiengarten et al., 2013). Based on literature, we identified four key contextual antecedents (the levels of digital service capabilities, market competition, machine standardization, and type of customer base) that affect the risk level of the machine provider and thus influence whether they opt to offer a NOBM (e.g., Bock et al., 2019; Guajardo et al., 2012). These contextual antecedents can lead in different manifestations (e.g., presence or absence of high machine standardization) to the offering of NOBMs (Schnaars et al., 2022). Moreover, these antecedents interact with each other. For example, a high market competition level may lead to NOBM offering despite a customer base that increases the risk for the machine provider (Hou and Neely, 2018; Selviaridis and Wynstra, 2015). This implies that it is not enough to focus on these contextual antecedents individually, as existing literature does (e.g., Hou and Neely, 2018; Schnaars et al., 2022), but on their combination and the resulting configurations. Therefore, we want to answer the following research question: *What configurations of contextual antecedents lead to presence or absence of NOBM offerings by mechanical engineering firms?* To answer this research question, we first conducted 16 primary interview-based case studies with firms that fulfill certain prerequisites for the offering of NOBMs (e.g., customer's demand for this business model) and decided for or against NOBM offering. Second, we applied configurational theory by using fuzzy-set qualitative comparative analysis (fsQCA) to identify multiple combinations of the four mentioned contextual antecedents, also referred to as conditions, that lead to presence or absence of NOBM offerings. We contribute to a more nuanced understanding of the NOBM offering decision (Ragin, 2009). Moreover, these configurations can support practitioners in their assessment whether to offer a NOBM or not.

This paper is organized as follows. The second section introduces NOBMs and relevant contextual antecedents. In the following two sections, we describe our methodology and the results. In the fifth section, we discuss the contributions and limitations.

2 Research Background

2.1 Non-ownership Business Models

As in many other domains, the transformation to so-called 'service-oriented' business models is also a key phenomenon in mechanical engineering. In this regard, Adrodegari et al. (2015) distinguish between ownership-oriented and service-oriented business models. In ownership-oriented business models, product ownership is still transferred to the customer, and related add-on services are offered. In contrast, in service-oriented business models the provider maintains the ownership of the product and only the function of the product is sold as a service. NOBMs belong to the latter type (Adrodegari et al., 2015; Adrodegari and Saccani, 2017; Neely, 2008; Sjödin et al., 2020).

Generally, a business model can be defined as a "rationale of how an organization creates, delivers, and captures value" (Osterwalder and Pigneur, 2010, p. 14). Al-Debei and Avison (2010) formulated four central dimensions to describe the design of a business model: (1) The value proposition describes the core value offering and the targeted customer segment(s). In a NOBM, as central offering, the customer can use the machine as product for a certain period of time. This usage includes associated services, such as financing, maintenance, installation, dismantling, training, and/or consulting (Adrodegari et al., 2015; Gebauer et al., 2017). After this period, the customer can extend the usage, buy the machine, or return it to the provider. (2) The value architecture describes the configurations of core resources and capabilities needed for the offering. In a NOBM the machine provider (or a finance partner) maintains machine ownership. Moreover, to provide the mentioned associated services, the machine providers need key capabilities, such as IIoT technology for machine supervision or a related service infrastructure (Wittkowski et al., 2013). (3) The value network concerns the position of the company in the value network and the relationships with various stakeholders. These stakeholders include NOBM financial partners (to finance the upfront investment, support the payment scheme design, and provide insurance) and technology partners (to provide the necessary technical infrastructure) (Hypko et al., 2010a; Ng et al., 2013). (4) The value financing pertains to the cost, revenue, and pricing structure. Regarding the pricing scheme, literature distinguishes between three key schemes for NOBMs: pay-on-access (fixed, regular fee; e.g., classic rent or lease), pay-per-output (e.g., pay-per-produced unit or usage time), and pay-per outcome (payment depends on results set in the contract; e.g., cost savings or service level achievements) (Adrodegari et al., 2015).

2.2 Contextual Antecedents for NOBM Offering

Scholars discussed a plethora of contextual antecedents, or conditions, that lead to presence or absence of NOBM offerings by mechanical engineering firms (e.g., Bock et al., 2019; Schnaars et al., 2022). These antecedents can be classified into three main groups. The first group (i.e., market demand, expected financial value added for the provider, a sufficient service network, and sufficient equity or dept for machine pre-financing) comprises necessary antecedents (i.e., they have to be fulfilled) that a firm offers a

NOBM (Hypko et al., 2010a; Schnaars et al., 2022). The second group (i.e., high digital service capabilities, a high share of large customers, high market competition, and high machine standardization) includes four conditions that may not be necessary but sufficient for offering a NOBM (i.e., they can be absent or present). Their necessity or sufficiency depends on the combination with the other factors (Schnaars et al., 2022; Selviaridis and Wynstra, 2015; Wittkowski et al., 2013). The third group (e.g., well-monitorable usage environment of the machine) includes factors that a mechanical engineering company uses to determine whether to offer a NOBM to an individual customer. For this, of course, the mechanical engineering company must generally offer a NOBM (Schnaars et al., 2022). In this study, we focus on the four antecedents of the second group, since we are interested on their combinations and their interplay.

As the first condition, high *market competition* in machine sales and the associated service business can lead to the offer of NOBMs. If the machine provider is not paid by the customer in advance but over the contract period of the machine, not the customer but the machine provider is responsible for the upfront machine financing. This can be an additional sales argument in a competitive environment (Bock et al., 2019; Wittkowski et al., 2013). In addition, customers may purchase the machines from one provider but maintain them themselves or contract another (often cheaper) vendor to do the maintenance. In the case of a NOBM, however, the machine provider takes over the maintenance, often also provides the spare parts, and can secure the corresponding service revenues (Bock et al., 2019). With this antecedent we want to investigate how high competition as one possible important driver for the NOBM offering decision is interacting with the other conditions (Schnaars et al., 2022).

As second condition, a high level of *machine standardization* supports the offer of NOBMs because these machines can be offered to another customer without major additional cost and effort after the NOBM contract ending or in case of customer bankruptcy. In addition, standard machines reduce the transaction costs for the machine provider, as no customer individual services and investments (in training or equipment) need to be offered (Schnaars et al., 2022; Toffel, 2008). In contrast, other literature argues that more customized machines are more suitable for NOBMs because then machine provider's payment can depend at least in part on the fit of the machine to the individual customer needs. This allows the provider to gain another selling point with the customer and thus an advantage in case of high market competition (Guajardo et al., 2012; Hypko et al., 2010a).

A third condition are high *digital service capabilities.* These refer to advanced machine sensing, data transmission, and analytics capabilities by the potential machine provider. These capabilities are relevant for the planning and implementation of NOBM service offerings. For example, remote access can improve fast troubleshooting, or predictive maintenance can prevent machine downtime. This is particularly important for NOBMs, as the provider's payment is often, at least to some extent, based on usage and performance parameters (Glas and Kleemann, 2017; Selviaridis and Norrman, 2014). Moreover, these capabilities are relevant for the protection of fraud by the customer. Since the machine provider carries the risk of machine failures, it is necessary to determine if such failures are the customer's (e.g., through misusage) or the machine provider's (e.g., through insufficient maintenance) fault (Grubic, 2014; Schnaars et al., 2022).

Therefore, in case of other risk increasing contextual antecedents (e.g., a large base of small customers where the provider is unsure about machine usage) high digital service capabilities can reduce the machine providers risk and support the decision to offer a NOBM (Jovanovic et al., 2016; Selviaridis and Wynstra, 2015).

As fourth condition, a high *share of large customers* may lead to the offering of NOBMs since typically large firms are more financially stable and have a lower risk of bankruptcy and therefore reduce the uncertainty for the machine provider (Cathcart et al., 2020). Moreover, literature argues that there is even a higher demand by large firms since small firms are often owner-managed and these owners often do not want to share property (Smith and Wakeman, 1985; Wittkowski et al., 2013). On the other hand, literature argues that non-ownership is a substitute for high investment (Wittkowski et al., 2013). Since smaller firms usually lack capital for high investments, they have a corresponding demand for NOBMs. With a high share of small customers and the corresponding demand, this can lead to the offering of NOBMs by machine providers (Smith and Wakeman, 1985; Wittkowski et al., 2013). Figure 1 shows our research model. A Venn diagram should denote our configurational perspective. The left side shows the interacting antecedents leading to the outcome (right side).

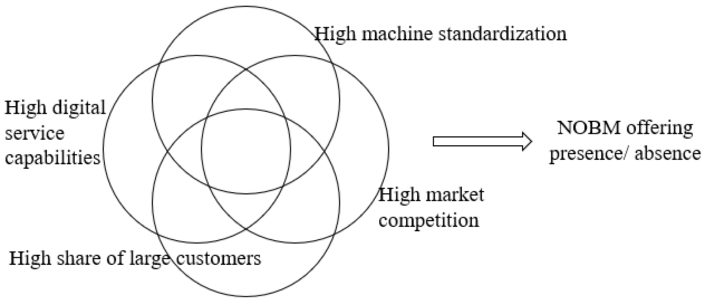

Figure 1. Research Model

3 Research Method

Data collection: For our data collection, we relied primary on semi-structured interviews with mechanical engineering firms. We found the participating companies over a search on the German Mechanical Engineering Federation member list, a podcast series (Klemkow, 2023), and our own network. We tried to include companies with different sizes (ranging from small to large) and from different mechanical engineering sectors. Moreover, before we started the interviews with the case companies, we conducted one more interview with a consultant to gain a deeper practical insight into NOBMs and to improve our interview guideline. The resulting dataset includes 16 cases of European mechanical engineering companies (or company segments) that fulfill according to the interview partners the antecedents of the first group (i.e., sufficient demand, sufficient capital for pre-financing, etc.) and then decided for or against the offering of a NOBM for this company (or company segment). NOBMs are offered in 11 of the 16 cases. The machines in one case are relatively homogeneous. From our 16 cases, 12 cases represent each one company. The other four cases belong to two companies (cases Delta/ Ny and Theta/ Xi belong each to one company). We could identify each two cases for these two companies because these companies offer two different machine types (each representing one company segment). Overall, we included 14 mechanical engineering companies in this study. On the one hand, with 12 of these 14 companies, we conducted one semi-structured interview (duration between 30 and 75 minutes). On the other hand, for the two remaining companies (cases Iota and Kappa), we found extensive interviews with a company representative in a podcast series (Klemkow, 2023). Table 1 presents an overview of the cases and the position of the interview partners.

Fuzzy-Set Qualitative Comparative Analysis: To analyze the combination of contextual conditions leading to the introduction of a NOBM, we used fsQCA. This configurational method supports the analysis "how configurations of conditions lead to outcomes and, thereby, richly explain the dynamics of complex digital phenomena" (Mattke et al., 2022, p. 208). Configurations are defined as "a specific combination of [conditions] that produces a given outcome of interest" (Ragin, 2009, p. xix). In other words, fsQCA investigates the "interplay between multiple conditions that influence an outcome" (Mattke et al., 2022, p. 209). In fsQCA, cases are designated into sets depending on their characteristics. A case can have non-membership (fully out) or full-membership (fully in) in a condition. Partial membership scores are possible, too. Correspondingly, fuzzy-set values (ranging from 0 for non-membership to 1 for full membership on a continuous range) are the basis for the analysis (Fiss, 2011; Pappas and Woodside, 2021). The fsQCA approach investigates how membership in conditions lead to membership in an outcome. Moreover, fsQCA is particularly useful for a small sample size of 12-50 cases with rich data (Park et al., 2020). Literature also suggests collecting at least as many cases as theoretically possible configurations (with 2^n configurations and n = number of conditions) (Schneider and Wagemann, 2012). Based on this background, our fsQCA presents with 16 cases a sufficient number for four conditions.

For our fsQCA approach, we performed four main steps: (1) articulating the research topic and building the research model, (2) calibrating the data, (3) deriving configurations by analyzing the truth table, and (4) discussing the configurations (Brosig et al., 2022; Park et al., 2020). More precisely, we followed the example of similar QCA studies with a qualitative interview-based data collection and a small sample size (less than 20 cases) (Soto Setzke et al., 2021, 2020). In the first step, we defined the outcome and selected the four core conditions which resulted in the proposed research model (see Figure 1). We combined an inductive and deductive approach by relying on the identified literature and the case- and interview-based insights to identify the four conditions. We first conducted an open coding, followed by an axial coding. In the second step, we did the data calibration. In this step, the conditions and the outcome are transformed into fuzzy sets on a scale from zero to one (Pappas and Woodside, 2021). For the final assignment of fuzzy-set values to each condition/ the outcome and case, see Table 1. In order to do so, we needed to create a calibration scheme that quantifies how much (i.e., to what degree) a case belongs to a specific set (Ragin, 2009). Therefore, we first defined the ideal states (fully in = 1/ fully out = 0) as anchor points. Regarding the level of detail, we decided for a four-value scale (in addition to 1/0 for fully in/out; more in than out = 0.66/ more out than in = 0.33). Such a scale has proven practical in similar studies (cf. Soto Setzke et al., 2021). The final scales with the set-scores (see Table 2) were derived either theory-based (e.g., for the condition of high digital service capabilities, we used Schnaars et al. 2022) or, if not available, based on in-depth cross-case and in-case comparisons (Brosig et al., 2022). For the NOBM offering scale, for example, we used the threshold value of 5 %, as this value, according to our findings from the interviews, delimits companies with a NOBM that has just started (NOBM share <5 %) or is already more established (>=5 %).

Table 1. Case study overview and calibration table

Case	ME Sector	PO	SZ	IT	CO	ST	CU	NO
Alpha	Healthcare	BD	S	0.66	0.33	0.33	0.66	0.66
Beta	Materials Handling	BD	S	0	1	0.66	1	0.66
Gamma	Materials Handling	SE	L	1	1	1	0.33	1
Delta[1]	Food Processing	SE	M	0.66	1	1	0	1
Epsilon	Machine Tools	SA	M	1	0.66	1	0.66	1
Zeta	Machine Tools	FI	S	0.33	0.66	0.66	0.33	0.66
Eta	Power Transmission	SA	L	0.33	1	0	1	0.66
Theta[2]	Metallurgy	SA	L	1	1	0.66	1	0.66
Iota*	Metallurgy	SA	S	0.33	1	0.66	0.33	1
Kappa*	Food Processing	SA	S	0.33	1	1	0.66	0.66
Lamba	Machine Tools	FI	M	1	0.66	1	0.66	1
My	Healthcare	SE	L	0.33	1	1	0.33	0.33
Ny[1]	Food Processing	SE	M	0.66	0.66	0.33	0.66	0
Xi[2]	Metallurgy	SA	L	1	0.66	0	1	0
Omikron	(Micro) Electronics	MA	S	0.33	0	0.66	1	0
Pi	(Micro) Electronics	MA	S	0.66	0	0.33	1	0

[1/2] Cases belong to the same company; * Data collection via podcast and not via semi-structured interview; ME: mechanical engineering; PO: department of interview partner; BD: business development; SE: service; SA: sales; FI: finance; MA: firm management; SZ: Company size; S: small firms: < 1,000 employees; M: medium-sized firms: 1,000-10,000 employees; L: large firms: >= 10,000 employees; IT: high digital service capabilities; CO: high market competition; ST: high machine standardization; CU: high share of large customers; NO: NOBM offering

In the third step of our approach, we first analyzed the necessary conditions and then built the configurations with the truth table analysis. To do so, we used the fsQCA software program. In using the fsQCA software, we follow the instructions of Pappas and Woodside (2021).We used a frequency threshold of only one, as this is recommended for such a small sample size (Ragin, 2009). Moreover, we chose a raw consistency threshold of 0.85, which is higher than the generally accepted threshold of 0.75 (Schneider and Wagemann, 2012). The raw consistency "indicates the proportion of configurations that show the outcome" (Mattke et al., 2022, p. 220). PRI consistency represents an alternative consistency measure and "is used to avoid simultaneously subset relations of configurations in both the outcome and the absence of the outcome (i.e., negation)" (Pappas and Woodside, 2021, p. 10). For the PRI consistency, we chose a widely recommended cut-off value of 0.65 (Schneider and Wagemann, 2012). After we reduced the truth table by using the frequency, raw consistency, and PRI consistency thresholds, we received configurations of conditions that lead to the outcomes of interest (Pappas and Woodside, 2021). In the fourth step, we discussed the configurations.

Table 2. Calibration scheme

Condition	0 (Fully out)	0.33 (More out than in)	0.66 (More in than out)	1 (Fully in)
High digital service capabilities	No remote internet connection of provider to machine	Connection of provider to machine and descriptive analysis/ monitoring	Connection of provider to machine and predictive analysis	Connection of provider to machine and prescriptive analysis
High market competition	Low competition in machine sales and services	Low competition in machine sales and high in service	High competition in machine sales and limited in service	High competition in machine sales and service
High machine standardization	Completely customized to individual customer needs	Customer individual machine based on standard components	Standardized machine with small customer adjustments	Fully standardized machine
High share of large customers	Machine customers are mainly small (annual revenue <= 40 Mio. €)	Machine customers are small and large; majority small	Machine customers are small and large; majority large	Machine customers are mainly large firms
NOBM offering	No NOBM offered and not planned	No NOBM offered but planned	NOBM share <5%*	NOBM share >= 5%*

* Indicates how many of the annual machine deliveries are in a NOBM; the rest are sold traditionally

4 Results

Table 3 presents the identified configurations of conditions that lead to the NOBM offering presence or absence. For both outcomes, each two configurations were identified. We followed the established QCA convention and marked the presence of a condition with a black circle and the absence of a condition with a crossed-out circle. If there are blank spaces, the condition can be either present or absent. Moreover, in fsQCA, there are core and peripheral conditions for explaining the outcome. We only identified core conditions. The identified solutions have a consistency of 0.91 and 0.87. That is well above the commonly accepted level of 0.8 (Ragin, 2008). In addition, the coverage values of both solutions (0.74 and 0.64) allow explaining a considerable share of both outcomes. In the analysis of necessary conditions, we received for the condition high market competition with the outcome NOBM offering a consistency value of 0.891. For the condition high share of large customers with the outcome of no NOBM offering, we also received a consistency value of 0.897. Although these two values do not exceed the generally accepted threshold for a necessary condition of 0.9, this value is relatively close to the threshold. These conditions can thus be considered as necessary ones. Two configurations are leading to the offering of NOBMs. In the first configuration (O1) a combination of high market competition, high machine standardization, and high digital service capabilities leads to NOBM offering. This solution is indifferent regarding a high share of large customers. The second configuration (O2) states that the absence of high digital service capabilities, presence of high market competition, and a high share of large customers leads to NOBM offering. High machine standardization can be present or absent. For not offering NOBMs also two configurations exist. In configuration N1, the presence of high digital service capabilities and a high share of large customers, in combination with the absence of high machine standardization leads to not offering a NOBM. This solution is indifferent regarding high market competition. The last configuration (N2) states that in case of the absence of high digital service capabilities and high market competition, in combination with a high share of large customers and a high machine standardization, mechanical engineering firms decide against the NOBM offering. For both outcomes, the respective first configuration (O1/N1) is more relevant due to the higher coverage values.

Table 3. Solution Chart for NOBM Offering

Conditions/ Outcomes	Offering		Not offering	
	O1	O2	N1	N2
High digital service capabilities	●	⊗	●	⊗
High market competition	●	●		⊗
High machine standardization	●		⊗	●
High share of large customers		●	●	●
Raw coverage	0.57	0.36	0.59	0.3
Unique coverage	0.4	0.18	0.35	0.05
Raw consistency	0.94	0.83	0.86	1
Solution coverage	0.74		0.64	
Solution consistency	0.91		0.87	

Black circles: presence of a condition; Crossed-out circles: absence of a condition; Empty cell: condition either present or absent; Identified only core and no peripheral conditions; Frequency cut-off: 1; Raw consistency cut off: 0.85; PRI consistency cut-off: 0.65

5 Discussion

5.1 Observations and Patterns across Configurations

As noted above our results show two distinct configurations of contextual antecedents each for the offering and non-offering of NOBMs. Since we identified multiple configurations that lead to the same outcome, we can demonstrate that the decision of mechanical engineering firms whether to offer a NOBM or not does not depend on the influence of individual factors, but is more complex; that is the combination of different contextual antecedents is relevant for explaining this decision (Ragin, 2009).

Machine providers in the *first configuration* of contextual antecedents (O1; e.g., cases Gamma or Delta) described that "the hardware, i.e., the [machine] itself, is becoming increasingly commoditized. And even in the premium segment, the [machines from different providers] do not differ much from each other" (Gamma). This situation, which refers to high machine standardization, leads to increased market competition, another key characteristic of this first configuration. The interview partners in cases Gamma and Delta further describes that they reacted to this increased competition in two different and connected ways. First, they developed advanced digital services (e.g., predictive maintenance or production and machine usage optimization solutions). By doing so, these machine providers want to provide another quality-based unique selling point beyond the machine hardware. The second way of reacting to this high competition is the offering of a NOBM, whereas the high digital service capabilities act as an important enabler. For example, these capabilities allow them advanced maintenance as part of the service bundle. Driven by high competition and the ability to monitor the machines through digital service capabilities, these machine providers offer these machines to all customer bases (presence or absence of a high share of large customers).

Based on the in-depth analysis of the cases that have the characteristics of the *second configuration* (O2), we split this configuration into two sub-configurations (O2.1 and O2.2). These two sub-configurations have the same characteristics as shown in Table 3 (absence of high digital service capabilities, presence of high market competition and high share of large customers), but for O2.1 the condition of high machine standardization is present. In O2.2 this condition is absent. Examples for the first sub-configuration (O2.1) are the cases Beta or Kappa. They also face the challenge of high market competition resulting from the 'commodity' of their standard machines. These rather smaller firms responded as in the first configuration by offering a NOBM and developing the necessary 'basic' monitoring capabilities. However, they did not reach high digital service capabilities yet (i.e., no predictive or prescriptive services). Moreover, since these machine providers work mostly with large customers with long-term relationships, their risk of customer bankruptcy or fraud is limited. For the second sub-configuration (O2.2), we found only one case (Eta). Eta also reacted to the high competition by adapting the machine components to the individual customer processes to achieve customer targets (e.g., increased overall equipment effectiveness; OEE). This connection was already described in literature (Guajardo et al., 2012). As an additional selling point, Eta offers a NOBM where payment is based (at least partially) on this target achievement (e.g., if the OEE is higher than with the old machine components, Eta earns more). Moreover, this NOBM can be offered because Eta has machine monitoring capabilities and a stable base of large customers they trust (financially and operationally). This is very important because Eta makes significant initial investments in the design of customized machine components.

Two examples for the *third configuration* (N1) are the cases Ny and Xi. Their core NOBM offering inhibitor was the limited standardization of the machines. The interview partners described that even in the case of a trustworthy and financially stable base of large customers, it was too risky for them to offer their machines in a NOBM arrangement because they cannot sell these machines on the used machine market or give them to another customer without significant retrofit effort. Moreover, Ny emphasized that if they wanted to offer this customer individual machines in a pay-per-output or pay-per-outcome arrangement, they lack the necessary experience for the payment scheme calculation since every machine project is new. Since in contrast to N1 in O2.2 customized machine (components) are offered in a NOBM, we compared the corresponding case examples (Ni or Xi for N1 and Eta for O2.2). We identified one main difference. In contrast to the other cases, the machine components in Eta have a lifetime not significantly exceeding the contract duration. Therefore, there is a limited risk for Eta of being unable to sell the machine on the used machine market.

In the cases belonging to the last and *fourth configuration* (N2; e.g., Omikron or Pi) the key NOBM offering inhibitor was the limited market competition, regardless of the other conditions (especially despite high machine standardization as a risk reducing antecedent for the machine provider). The interview partners in these cases described that the reason for this limited competition is typically the development (and patenting) of a specific hardware component, enabling them to differentiate from the competition. Generally, most machine providers preferred traditional sales over a NOBM because the former entails the lowest (financial and operational) risk. Based on our results, we consider the conditions of high market competition and high machine standardization as the two most relevant ones for the decision of the machine providers on whether to offer a NOBM or not. While high market competition is already highlighted in the literature as a key driver for the NOBM offering decision (e.g., Schnaars et al., 2022), the high importance of machine standardization is not emphasized in existing literature (Böhm et al., 2016; Schnaars et al., 2022).

Moreover, in the configurations O1 and O2.1, some of our interviewees (e.g., Gamma or Epsilon) mentioned as another offering driver the '*high profitability'* if the NOBM is in the form of a short-term standard machine rental (duration a few months up to two years), where the customer has an instant need for a machine. This high profitability is based on a comparison with traditional sales and longer-term oriented NOBM offerings. For example, the interview partner at Epsilon described that one of their "customers needed additional machines on short notice because a customer's automotive production line was scheduled to run for two more years." The interview partners explained that since the machine users have specific needs and delivery commitments, they are also willing to pay more for the machine, resulting in higher profitability for the provider. However, in such a business, the machine provider has to keep a pool or fleet of standard machines ready to be offered at short notice, which favors larger providers. Moreover, the machine providers need a high utilization rate of their rental machines. Overall, high profitability as another driver for NOBM offerings was only emphasized to a limited extend in literature (Böhm et al., 2016; Schnaars et al., 2022).

5.2 Contributions, Limitations, and Future Research

In this paper, we investigated which configurations of contextual antecedents or conditions lead to the presence or absence of NOBM offerings by mechanical engineering firms. To reach this research objective, we relied on 16 interview-based cases and fsQCA as a set-theoretic approach.

Theoretical contributions: Our paper contributes to a more nuanced understanding of contextual antecedents' influence on mechanical engineering firms' NOBM offering decisions in two connected ways. First, we identify each two configurations of antecedents that lead to the presence or absence of NOBM offerings. This configurational perspective is new since other literature (e.g., Hypko et al., 2010b; Schnaars et al., 2022) identified multiple antecedents but have yet to investigate their interplay. With our study, we show that this offering decision does not only depend on individual antecedents. Instead, the interaction of these antecedents also plays an important role. Second, we not only identify the four mentioned configurations of antecedents, but also describe the interactions between these antecedents based on our in-depth case insights in detail. For example, for the first configuration (O1), we describe the interplay between the antecedents of high digital service capabilities, high machine standardization, and high market competition. With our study, we respond on recent calls for research on drivers and barriers for the NOBM offering in the mechanical engineering industry (Hypko et al., 2010b; Schnaars et al., 2022).

As the case companies change key elements of their business model by introducing a NOBM, our study also contributes to research on antecedents for business model innovation (Foss and Saebi 2017). In a methodological context, we show that the steps of Soto Setzke et al. (2020, 2021) are well-suited to calibrate interview-based (qualitative) data into fuzzy-sets. We access this approach as appropriate for research cases where it is difficult to acquire large sample sets.

Practical implications: Practitioners (such as business development managers of mechanical engineering firms or consultants) can compare the configurations and case descriptions with their situation and use them as a decision support tool whether to offer a NOBM or not.

Limitations and future research opportunities: As with any research, our study has several limitations. First, our sample with 16 cases is still relatively small. This limits the generalizability of our results. Nonetheless, we intended to explore the contextual antecedents and their interplay using in-depth qualitative interview-based data. Future research can investigate our results by relying on larger data sets (e.g., by conducting a survey). Second, researchers may have concerns of the findings since we calibrated data from interviews into fuzzy-sets. However, we tried to follow established guidelines from the literature and described our calibration scheme in detail (Brosig et al., 2022). Third, although our configurations have relatively high coverage and consistency values, we might have omitted some relevant contextual antecedents as conditions that would allow even more detailed insights. Moreover, future research could investigate how the configurations of contextual antecedents (e.g., level of market competition or machine standardization) influence the actual design of the NOBM (e.g., if the machine providers offer an access-based, a pay-per-output or pay-per-outcome payment scheme or on what partners they rely on). Since most companies have just started to implement NOBMs, research should investigate the success factors of these business models in a few years when companies have long-term experience with this business model.

In *conclusion*, we hope that our configurations and related insights will help mechanical engineering firms in their decision on whether to offer a NOBM or not, as well as foster future research in that field.

References

Adrodegari, F., Alghisi, A., Ardolino, M. & Saccani, N. (2015), From Ownership to Service-oriented Business Models: A Survey in Capital Goods Companies and a PSS Typology, *in:* 'Proceedings of the 7th Industrial Product-Service Systems Conference - PSS, industry transformation for sustainability and business', CIRP, pp. 245–250.

Adrodegari, F., Bacchetti, A., Saccani, N., Arnaiz, A., & Meiren, T. (2018), 'The transition to wards service-oriented business models: A European survey on capital goods manufacturers', *International Journal of Engineering Business Management* **10**, 1-10.

Adrodegari, F. & Saccani, N. (2017), 'Business models for the service transformation of industrial firms', *The Service Industries Journal* **37**(1), 57–83.

Al-Debei, M.M. & Avison, D. (2010), 'Developing a unified framework of the business model concept', *European Journal of Information Systems* **19**, 359–376.

Bock, M., Wiener, M., Gronau, R. & Martin, A., (2019), Industry 4.0 Enabling Smart Air: Digital Transformation at KAESER COMPRESSORS, *in*: 'Digitalization Cases, Management for Professionals', Springer International Publishing, pp. 101–117.

Bock, M., Wiener, M. & Saunders, C. (2023), 'Non-Ownership Business Models in the Manufacturing Industry: Uncertainty-Exploiting versus Uncertainty-Mitigating Designs and the Role of Context Factors', *Electronic Markets*, **33**(1), 1-18.

Böhm, E., Backhaus, C., Eggert, A. & Cummins, T. (2016), 'Understanding outcome-based contracts: benefits and risks from the buyers' and sellers' perspective', *Journal of Strategic Contracting and Negotiation* **2**(1-2), 128–149.

Brosig, C., Bley, K., Strahringer, S. & Westner, M. (2022). The Missing Piece – Calibration of Qualitative Data for Qualitative Comparative Analyses in IS Research, *in*: 'Proceedings of the Thirtieth European Conference on Information Systems', AIS.

Cathcart, L., Dufour, A., Rossi, L. & Varotto, S. (2020), 'The differential impact of leverage on the default risk of small and large firms', *Journal of Corporate Finance* **60**, 101541.

Ehret, M. & Wirtz, J., (2017), 'Unlocking value from machines: business models and the industrial internet of things', *Journal of Marketing Management* **33**(1-2), 111–130.

Ehret, M. & Wirtz, J. (2010), 'Division of Labor between Firms: Business Services, Non-Ownership-Value and the Rise of the Service Economy', *Service Science* **2**(3), 136–145.

Fiss, P.C. (2011), 'Building Better Causal Theories: A Fuzzy Set Approach to Typologies in Organization Research', *Academy of Management Journal* **54**(2) 54, 393–420.

Foss, N.J. & Saebi, T. (2017), 'Fifteen Years of Research on Business Model Innovation: How Far Have We Come, and Where Should We Go?', *Journal of Management* **43**(1), 200-227.

Gebauer, H., Haldimann, M. & Saul, C.J. (2017), 'Competing in business-to-business sectors through pay-per-use services', Journal of Service Management **28**(5), 914–935.

Glas, A.H., Kleemann, F.C. (2017), 'Performance-based contracting: contextual factors and the degree of buyer supplier integration', *Journal of Business & Industrial Marketing* **32**(5), 677–692.

Grubic, T. (2014), 'Servitization and remote monitoring technology: A literature review and research agenda', *Journal of Manufacturing Technology Management* **25**(1), 100–124.

Guajardo, J.A., Cohen, M.A., Kim, S.-H. & Netessine, S. (2012), 'Impact of Performance-Based Contracting on Product Reliability: An Empirical Analysis', *Management Science* **58**(5), 961–979.

Hou, J. & Neely, A. (2018), 'Investigating risks of outcome-based service contracts from a provider's perspective', *International Journal of Production Research* **56**(6), 2103–2115.

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

Hypko, P., Tilebein, M. & Gleich, R. (2010b), 'Benefits and uncertainties of performance-based contracting in manufacturing industries: An agency theory perspective', *Journal of Service Management* **21**(2), 460–489.

Jovanovic, M., Engwall, M. & Jerbrant, A. (2016), 'Matching Service Offerings and Product Operations: A Key to Servitization Success: Existing conditions, such as product characteristics or market attributes, may determine the success of a move toward servitization', *Research-Technology Management* **59**(3), 29–36.

Klemkow, J. (2023), https://subscribedindustry.podigee.io/. Accesses: 02.02.2023

Mattke, J., Maier, C., Weitzel, T., Gerow, J.E., Thatcher & J.B. (2022), 'Qualitative comparative analysis (QCA) in information systems research: status quo, guidelines, and future directions', *Communications of the Association for Information Systems* **50**, 208-240.

Neely, A. (2008), 'Exploring the financial consequences of the servitization of manufacturing', *Operations Management Research* **1**, 103–118.

Ng, I.C.L., Ding, D.X. & Yip, N., (2013), 'Outcome-based contracts as new business model: The role of partnership and value-driven relational assets', *Industrial Marketing Management* **42**(5), 730–743.

Osterwalder, A. & Pigneur, Y. (2010), *Business model generation: A handbook for visionaries, game changers, and challengers*. John Wiley.

Pappas, I.O. & Woodside, A.G. (2021), 'Fuzzy-set Qualitative Comparative Analysis (fsQCA): Guidelines for research practice in Information Systems and marketing', *International Journal of Information Management* **58**, 102310.

Park, Y., Fiss, P.C. & El Sawy, O.A. (2020), 'Theorizing the Multiplicity of Digital Phenomena: The Ecology of Configurations, Causal Recipes, and Guidelines for Applying QCA', *Management Information Systems Quarterly* **44**(4), 1493–1520.

Ragin, C.C. (2009), Qualitative comparative analysis using fuzzy sets (fsQCA), *in* 'Configurational Comparative Methods: Qualitative Comparative Analysis (QCA) and Related Techniques', Sage Publications, Thousand Oaks, pp. 87-122.

Ragin, C.C. (2008), *Redesigning Social Inquiry Fuzzy Sets and Beyond*. University of Chicago Press.

Relayr (2022), https://relayr.io/de/relayr-studie-entscheider-der-deutschen-industrie-setzen-auf-equipment-as-a-service-als-zukunftsmodell-fuer-den-maschinenbau/. Accessed: 03.02.2023.

Schnaars, N., Galipoğlu, E., Haasis, H.-D. & Kotzab, H. (2022), Performance-based Contracting im Maschinen- und Anlagenbau, in: 'Smart Services, Forum Dienstleistungsmanagement', Springer Fachmedien Wiesbaden, pp. 277–304.

Schneider, C.Q. & Wagemann, C. (2012), *Set-Theoretic Methods for the Social Sciences: A Guide to Qualitative Comparative Analysis*. Cambridge University Press.

Selviaridis, K. & Norrman, A. (2014), 'Performance-based contracting in service supply chains: a service provider risk perspective', *Supply Chain Management: An International Journal* **19**(2), 153–172.

Selviaridis, K. & Wynstra, F. (2015), 'Performance-based contracting: a literature review and future research directions', *International Journal of Production Research* **53**(12), 3505–3540.

Sjödin, D., Parida, V., Jovanovic, M. & Visnjic, I. (2020), 'Value Creation and Value Capture Alignment in Business Model Innovation: A Process View on Outcome-Based Business Models', *Journal of Product Innovation Management* **37**(2), 158–183.

Smith, C.W. & Wakeman, L.M. (1985), 'Determinants of Corporate Leasing Policy', *The Journal of Finance* **40**(3), 895–908.

Soto Setzke, D., Opderbeck, L., Böhm, M. & Krcmar, H. (2020). Pathways to Successful Business Model Innovation in the Context of Digital Transformation, *in*: Proceedings of the Twenty-Fourth Pacific Asia Conference on Information Systems', AIS.

Soto Setzke, D., Riasanow, T., Böhm, M. & Krcmar, H. (2021), 'Pathways to Digital Service Innovation: The Role of Digital Transformation Strategies in Established Organizations', *Information Systems Frontiers*, forthcoming.

Toffel, M.W. (2008). Harvard Business School Technology & Operations Mgt. Unit Research Paper No. 08-063, https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1090237. Accessed: 23.12.2022

Wiengarten, F., Pagell, M. & Fynes, B. (2013), 'The importance of contextual factors in the success of outsourcing contracts in the supply chain environment: the role of risk and complementary practices', *Supply Chain Management: An International Journal* **18**(6), 630–643.

Wittkowski, K., Moeller, S. & Wirtz, J. (2013), 'Firms' Intentions to Use Nonownership Services', *Journal of Service Research* **16**(2), 171–185.