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EXPLORING THE DETERMINANTS OF CONSUMER PREFERENCE FOR PRODUCT-AS-A-SERVICE (PAAS) MODELS: A CASE STUDY ON HEATING SYSTEMS

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ABSTRACT: The study aimed to identify factors influencing the choice of Product-as-a-Service (PaaS) over ownership in customer decisions, using heating systems as a case study as an example of a less saturated PaaS market. The analysis is based on a nationwide quantitative survey of the population of users of single-family houses. An econometric model was created, describing customer choice of PaaS model by two describing decision factors and two of a financial nature. Results showed that quality, service, operating, and maintenance costs were key factors, while demographics had little impact. The text highlights research gaps in PaaS and circular economy, such as understanding consumer preferences, financial models in the built environment, factors affecting PaaS adoption for heating equipment, circular economy finance, and necessary changes in the financial sector. This research enhances consumer preference understanding and underscores PaaS potential for heating appliances.

KEYWORDS: product-as-a-service, customer choice, product service systems, heating systems

Introduction

"Product as a Service" (PaaS) is a business model where a product is offered to customers as a service rather than being sold as a one-time purchase. In this model, the product remains the property of the provider, and customers pay for its use on a subscription or usage-based basis. This approach often includes additional services like maintenance, updates, and customer support (Baines et al., 2009; Hidalgo-Crespo et al., 2024; Thakur & Jena, 2024; Tukker, 2004). PaaS is closely aligned with the principles of the circular economy, promoting sustainability by extending the product's life cycle and reducing waste.

In recent years, the concept of Product-as-a-Service (PaaS) has gained significant attention as a business model that offers access to products and additional services rather than traditional ownership. PaaS represents a shift from the linear for-sale model to a service-oriented approach, wherein the service provider assumes the responsibility for product operation and maintenance (Angelopoulos & Mourtzis, 2022; Boehmer et al., 2020; Calabrese et al., 2019). This paradigm shift has been driven by factors such as digitalisation, the growing importance of sustainability, and a shift in consumer attitudes from ownership to usage.

The development of Product Service Systems (PSS) and the related PaaS concept has been a topic of interest for both supply chain management and customer relations (Abbey et al., 2015; Boehmer et al., 2020; Maiwald et al., 2014; Thakur & Jena, 2024). While research on PSS and PaaS initially focused on business-oriented models (Besch, 2005; Stahel, 1998; Tukker, 2004; Williams, 2006, 2007), the significance of consumer-oriented PSS has been steadily increasing (Koide et al., 2022; Yang et al., 2009). Studies have highlighted the potential benefits of PaaS in reducing resource consumption, emissions, and waste while also fostering innovation and contributing to the circular economy.

Understanding the factors that influence consumer preference for PaaS models is crucial for the successful implementation and adoption of these models. Demographic factors such as age, occupation, and education level can play a role in shaping consumers' attitudes towards PaaS. Furthermore, decision-making factors such as cost (Reim et al., 2015), value proposition (Kriston et al., 2010), customer needs, product life-cycle (Gräßler & Pottebaum, 2021), maintenance (Angelopoulos & Mourtzis, 2022; Boehmer et al., 2020; Reim et al., 2015), sustainability (Reim et al., 2015), technology infrastructure (Boehmer et al., 2020), and brand reputation are key considerations in choosing PaaS over ownership.

While existing literature (Baines et al., 2009; Beuren et al., 2013; Calabrese et al., 2019; Purchase et al., 2021; Thakur & Jena, 2024) has examined consumer preferences in various industries, research specific to heating systems and their adoption of PaaS models is limited. During the literature review, we have identified several research gaps in the field of PaaS and circular economy. These include the limited understanding of consumer preferences for PaaS, the lack of focus on financial models in the built environment, the need for research on factors influencing PaaS adoption for heating equipment, the emerging concept of circular economy finance, and the required changes in the financial sector to support circular economy initiatives. These research gaps highlight the need for further studies on consumer acceptance, financial models, decision-making factors, and the role of the financial sector, providing valuable insights for businesses, policymakers, and researchers in these areas.

This research aims to fill some of these gaps by providing empirical evidence regarding the use of PaaS in single-house heating systems. By exploring the economic choices and behaviours behind circularity in the finance and construction sectors, this study seeks to shed light on the determinants that influence consumers' assessment of PaaS solutions for heating devices. This research sets forth several hypotheses based on previous studies and market research. Hypothesis 1 suggests that demographic factors determine the assessment of PaaS solutions for heating devices. Hypothesis 2 posits that key decision-making factors influence the choice of heating equipment in the PaaS model. Hypothesis 3 proposes that the operating cost and maintenance cost of heating equipment influence decision factors related to PaaS adoption. Finally, Hypothesis 4 states that financial factors, including cost structures and financing schemes, play a critical role in the adoption of the PaaS model, particularly influencing decision-making in the selection of heating appliances.

By gaining insights into consumer preferences and the factors influencing their decisions, this study aims to contribute to the understanding of PaaS models in the context of circular economy

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principles. Furthermore, it aims to provide valuable implications for policymakers, industry practitioners, and financial institutions seeking to align their strategies with the growing demand for sustainable and service-oriented business models.

The paper is organised as follows: in section 2, we present a literature review of the research concerning the development of PaaS, which allowed us to identify gaps and formulate research hypotheses. In section 3 we describe the research logic and applied method. The results of our research are presented in section 4. Sections 5 and 6 are dedicated to the discussion and conclusions.

Literature overview

PaaS refers to the business models in which a product manufacturer offers a service in addition to the product or takes over the operation of the product instead of selling it (Baines et al., 2009; Golinska-Dawson et al., 2024; Hidalgo-Crespo et al., 2024; Krummeck et al., 2022; Matsumoto, 2019; Sarasini et al., 2024; Velamuri et al., 2013). Unlike the linear for-sale business model, in PaaS, the retail and sales role is replaced by a service provider, therefore, instead of paying for the ownership, the customer pays for access to the product and additional services (Circle Economy, 2019). The main drivers of PaaS models are digitalisation, the mega-trend of sustainability, and a change of general attitude from owning to using. The development of product-service systems and the related product-as-a-service concept are important issues for the supply chain functioning as well as for customer relations (Abbey et al., 2015; Boehmer et al., 2020; Maiwald et al., 2014; Thakur & Jena, 2024). Research on them dates back to the 1990s, when research on product-service systems began to gain popularity (Stahel, 1998). Initially, research focused on business-oriented PaaS, where the purchase of products was increasingly replaced by the use of these products as part of a bundle of related services. Already at the beginning of research on PaaS, researchers were interested in the potential benefits for the environment in the form of reducing the consumption of natural resources, reduction of emissions and volume of waste, increasing innovation or the development of a circular economy (Besch, 2005; Brissaud et al., 2022; Liu & Li, 2024; Sarasini et al., 2024; Tukker, 2004; Williams, 2006, 2007). Even more popular strand of research concerning PaaS focuses on the benefits of using business-oriented PaaS, development of industrial product service systems and modularisation of resource planning or development of service engineering (Beuren et al., 2013; Cavalieri & Pezzotta, 2012; Meier et al., 2010, 2011).

Research on the importance of PaaS for consumers developed a bit later, but their importance has been steadily growing in recent years. Yang et al. (2009) in their study proposed extending the use of PaaS to consumers. They pointed out that existing methods and tools related to PaaS are mainly concerned with general PaaS and service design, which cannot easily help consumer product manufacturers to implement and deliver PaaS solutions. For this reason, they proposed the PaaS methodology for consumer products. Lăzăroiu et al. (2020) considered consumers' decision-making processes on social commerce platforms by investigating how their perceptual attitudes, behavioural intentions, and immediate gratifications affect the purchase of products and services online. Their findings point to psychological determinants of consumer engagement in social media, decision mechanisms lying behind the evaluation of prices, the types of perceived risk incurred, and online repurchasing behaviour and intention on social commerce platforms. Research on consumer oriented PaaS also indicates potential for climate change mitigation. In their recent research Koide et al. (2022) investigated 10 types of circular economy strategies – including, among others: reusing, sharing, renting or leasing combined with remanufacturing – and their synergies with climate change mitigation.

With circularity becoming one of the leading trends in modern economy and business, the principles of PaaS are gaining popularity as a financial model embracing those rules. Despite the fact that circularity has been widely defined (Ellen MacArthur Foundation, 2020) and analyses led to the establishing list of fundamental circularity principles, the case built environment is mainly focused on the issue of energy refurbishment and building materials used in the process, leaving behind the financial models. The following paper, based on the heating systems case, will fill in this gap by introducing empirical evidence regarding the use of PaaS in single house heating systems, therefore contributing to understanding the economic choices and behaviours behind circularity both in finance and construction.

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Research on the Product-as-a-Service (PaaS) model increasingly focuses on the role of consumer preferences, particularly how demographic factors influence attitudes towards PaaS. Demographic factors, particularly age, significantly influence attitudes towards the Product-as-a-Service (PaaS) model. Younger consumers, especially millennials and Generation Z, are more favourable to PaaS and subscription models than older generations. For instance, the Deloitte 2020 Millennial Survey (Deloitte, 2020) shows that 64% of millennials and Gen Z prefer access over ownership, emphasising experiences rather than material possessions. This aligns with the PaaS model, which focuses on providing flexible, on-demand services. Similarly, McKinsey's 2018 report on e-commerce subscription trends (McKinsey & Company, 2018) reveals that 15% of online shoppers subscribed to at least one e-commerce service, with 60% of these subscribers being women aged 25 to 44, living in urban areas, and having an annual income between $50,000 and $100,000. Furthermore, the State of Subscription Commerce Report 2022 (Recharge, 2022) indicates that subscribers to recurring services, such as those in the beauty, food, and wellness sectors, saw an average 31% year-over-year growth in their customer base. Younger consumers, who accounted for a significant portion of this growth, displayed higher lifetime value (LTV), showing stronger brand loyalty and preference for subscription models. This numerical evidence underscores the growing inclination among younger demographics towards PaaS models, driven by their values of convenience, sustainability, and a desire for flexibility. Expanding on the importance of sustainable business models, Gräßler and Pottebaum (2021) introduce the Generic Product Lifecycle (gPLC) model, which integrates sustainability and technological insights within Circular Economy (CE) frameworks. The gPLC emphasises the importance of considering material and information flows in multi-disciplinary product–service systems, which align with the goals of PaaS models. By expanding the stakeholder perspective beyond manufacturers and consumers to include recyclers and society, the gPLC model supports the development of sustainable design practices and digital CE business models. This research further underscores the relevance of demographic and technological factors in shaping consumer preferences for PaaS, particularly in the context of sustainability. Moreover, consumer interest in subscription-based models extends beyond technology. A 2024 Deloitte survey found that 67% of consumers in India, 29% in Germany and 28% in the US aged 19-34 is interest in giving up vehicle ownership in favour of a vehicle subscription (Deloitte, 2024). Similarly, Lieder et al. (2018) study confirmed that there is a general interest in paying for access rather than for ownership on the home appliances market.

Based on these studies, we hypothesize that demographic factors significantly influence consumer attitudes towards PaaS solutions, particularly in the context of heating devices. Therefore, Hypothesis 1 (H1) states that: demographic factors determine the assessment of the PaaS solution in relation to heating devices. This hypothesis is supported by evidence that younger, digitally-savvy individuals are more likely to favor PaaS models, while older individuals may be more cautious due to lower familiarity with necessary technologies. Additionally, the integration of sustainable business models, such as those proposed by Gräßler and Pottebaum (2021) may further influence consumer preferences, particularly among those concerned with environmental impact and circular economy principles.

Another identified area of research focuses on understanding the factors driving adoption of PaaS. Consequently, the following section of the literature review synthesizes existing studies in this area to explore the motivations and challenges associated with PaaS. The Deloitte 2020 Millennial Survey (Deloitte, 2020) found that millennials and Gen Z consumers are highly cost-conscious, with 62% of respondents citing financial concerns as a significant factor in their purchasing decisions. These consumers are more likely to choose PaaS models because they allow for spreading out costs over time, avoiding large upfront investments. According to the McKinsey 2018 report (McKinsey & Company, 2018) on subscription e-commerce, 55% of subscribers to replenishment services (a category within PaaS) value the lower cost and convenience of automated purchasing. The study highlights that financial incentives, such as discounts and lower recurring payments, are major drivers for consumers, with 65% of those who use replenishment subscriptions doing so primarily to save money on essential products. The Alves et al. (2023) study on promoting the transition to a circular economy through PaaS models highlights that for 75% of consumers, the ability to avoid high upfront costs was a decisive factor in choosing PaaS over outright purchase. Also Polish research showed that economic factors such as subscription price remain the most important for Polish consumers (Ziobrowska-Sztucka & Markiewicz, 2024). Study by Kesavapanikkar et al. (2022) found that consumers

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are increasingly favoring PaaS models for traditional products because they perceive a better value proposition, especially when factoring in maintenance, repairs, and upgrades. The study revealed that 58% of respondents preferred PaaS models due to the lower long-term costs compared to purchasing and maintaining their own equipment or products. Convenience is also among top reasons consumers remain loyal to subscription services. The ability to have products automatically delivered or services consistently provided without needing to repurchase or renew manually is a strong selling point. Moreover, the report indicates that 62% of consumers value the regular updates and access to the latest versions of products, which is a core benefit of PaaS and subscription models (Recharge, 2022). The study shows that flexibility and access to the latest features are critical for consumers choosing subscription models. The report indicates that 75% of respondents value the ability to upgrade or change their products regularly without the long-term commitment of ownership. This flexibility is particularly important in sectors like technology and automotive, where staying updated with the latest features and innovations is a significant consumer demand (Recharge, 2022). Also maintenance and support are major considerations when choosing PaaS. A study by Antikainen et al. (2018) highlights that consumers are more likely to adopt PaaS models when they perceive that the service includes comprehensive support, reducing the risks and responsibilities traditionally associated with ownership. Consumers appreciate ease and comfort in their everyday life. In the case of house appliances, consumers valued the option for condition-based maintenance. This differentiates PaaS from traditional ownership models, where customers bear full responsibility for maintenance and associated costs. D'Agostin et al. (2020) and Dekhili and Achabou (2013) emphasise sustainability as an increasingly important factor in customer decision-making. Their studies indicate that environmental concern is a key motivation for the adoption of PaaS models, as these models can promote the efficient use of resources and reduce waste, making sustainability a significant consideration for consumers when evaluating PaaS options. Stena Circular Consulting & Cradlenet (2022) highlight the importance of brand reputation and trust in the choice of PaaS. Their report suggests that customers are more inclined to choose services from companies they perceive as reliable and trustworthy. A strong brand reputation, combined with consistent service quality, significantly influences customer decisions in favor of PaaS offerings, especially in markets where trust and reliability are key differentiators. And, last but not least Catulli et al. (2017), along with Raihanian Mashhadi et al. (2019) and Stena Circular Consulting & Cradlenet (2022), discuss the challenges of consumer acceptance of PaaS, despite its potential benefits. They note that PaaS adoption is relatively low, particularly in markets with a strong preference for ownership. These studies suggest that adoption is more likely when consumers perceive both functional and symbolic value in PaaS models. However, barriers such as a preference for ownership and underestimation of the total cost of ownership continue to impede wider adoption, highlighting ongoing challenges related to consumer acceptance.

Based on the above literature review, two additional hypotheses are proposed. Hypothesis 2 stating that there are specific decision-making factors that influence the choice of heating equipment under the Product as a Service model, and Hypothesis 3, indicating that the decision factors for choosing heating equipment in a PaaS model are significantly influenced by the operating cost and maintenance cost associated with the equipment. Hypothesis 2 stems from the general analysis of factors influencing the adoption of the PaaS model. The literature review discusses various customer motivations, such as cost savings, flexibility, and convenience. Since these factors are crucial for PaaS adoption in general, it is logical to assume that they would also influence decisions regarding the choice of heating equipment under the PaaS model. While Hypothesis 3 is supported by multiple references to the importance of operating and maintenance costs as key factors in the decision to adopt the PaaS model. The literature review highlights that customers value PaaS for its ability to help avoid maintenance costs. Therefore, it can be inferred that these considerations would also be significant when selecting heating equipment.

The circular economy presents significant opportunities for the financial sector, offering the potential for higher returns on investment and the development of new financial products. As investments in circular economy initiatives have shown strong performance relative to benchmarks, there is a growing interest in understanding the financial mechanisms that support this transition. The evolving financial landscape necessitates a deeper examination of the factors influencing the adoption of circular economy models, particularly in relation to financing schemes like Platform as a

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Service (PaaS). However, the transition from a linear to a circular economy presents challenges for the financial sector, requiring changes in financial flow structures and cost assessment schemes. For instance, the pay-per-use model characteristic of circular economy practices differs significantly from the traditional pay-for-ownership model, impacting company cost structures and, consequently, financial evaluations (Lundberg Larsen, 2018). This shift necessitates new approaches to product assessment and financing in the circular economy. Previous studies have explored the relationship between servitisation, manufacturing firm performance, and the financial factors involved in transitioning from product-centric to service-centric models. Raddats and Easingwood (2010) and Visnjic and Van Looy (2013) examine the role of risk evaluation and firm performance as factors influencing these shifts, while (Mont, 2002) bridging sustainability and financial determinants in adopting the PaaS model. However, these studies primarily focus on business sector decisions, leaving a gap in understanding the factors influencing individual household decisions in adopting PaaS models.

Given the opportunities the circular economy creates for the financial sector and the importance of financial considerations in adopting PaaS models, we propose Hypothesis 4 (H4): Financial factors, including cost structures and financing schemes, play a critical role in the adoption of the PaaS model, particularly influencing decision-making in the selection of heating appliances. This hypothesis directly connects the financial factors (such as cost structures and financing schemes) discussed in the literature with the specific application to heating appliances within the PaaS framework. It emphasises the critical role of these financial factors, which aligns with the discussion of how changes in financial models (e.g., pay-per-use) impact the adoption of PaaS.

Research logic, method and data

The research questions and hypotheses set above are being tested in our study using statistical and econometric methods, with hypotheses related to particular methods in a manner described in Table 1.

Table 1. List of hypotheses, variables and methods used in the analysis

HYPOTHESIS	DEPENDENT VARIABLE	INDEPENDENT VARIABLES	METHOD
H1: Demographic factors determine the assessment of the PaaS solution in relation to heating devices	PaaS assesment (interval)	Gender (dichotomous) Education (nominal) Size of locality (ordinal) Region (nominal) Age (quantitative)	Test U-Mann-Whitney Test Kruskal-Wallis Test Kruskal-Wallis Test Kruskal-Wallis rho- Spearmann
H2: There are key factors in the decision-making process for heating equipment in the PaaS model	none	A set of specific questions on a 5-point Likert scale	Kaiser-Mayer-Olkin and Bartlett's tests
			Exploratory Factor Analysis
			Alpha Cronbach
H3: Decision factors are influenced by the operating cost and maintenance cost of heating equipment	Factor 1, Factor 2 (ratio)	Costs (ratio)	Pearson and Spearmannn correlation
H4: Financial factors, including cost structures and financing schemes, play a critical role in the adoption of the PaaS model, particularly influencing decision-making in the selection of heating appliances	Evaluation of PaaS (interval)	Device selection (binomial)	U-Mann-Whitney test
		Factor 1, Factor 2 (ratio)	Regression, Spearmann

Sources: authors' work based on Dickinson Gibbons and Chakraborti (2003), Fabrigar and Wegener (2012), Cohen et al. (2002).

In order to solve the research problem defined in this paper, a nationwide quantitative survey was carried out on the population of users of single-family houses (detached, semi-detached and terraced houses). The study population was limited to single-family houses in which no coal or wood, i.e. solid fuels, are used for heating purposes.

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For the purposes of the study, a sample of n = 600 was drawn from the study population. The sample was drawn using a random operator in the form of a nationwide database of households from the defined population. A probabilistic sampling method – stratified random sampling – was applied. The use of a probabilistic sampling scheme will allow the results obtained to be generalised to the entire population. The procedures described above fully guarantee the representativeness of the sample taken. Respondents made a multidimensional assessment of key decision-making elements and heating equipment expectations (Table 2). Questions covered a broad spectrum of qualities of use, operation, ecology and cost. The survey questions determined how important a particular aspect of heating technology is to a given user. Respondents made a rating on a five-point Likert scale by answering 25 survey questions. It can be concluded that respondents do not treat all specific evaluations equally but give them priority. The survey is based on previous research (including pilot studies), where the validity of the Likert scale used, the reliability of respondents' answers (tested with control questions) and the number of survey questions were verified (Kuźmiński et al., 2023; Nadolny et al., 2024). The survey on which this study is based was preceded by a pilot study. It was intended to limit the number of questions. We also found that the 5-point Likert scale was appropriate for describing the decision-making aspects assessed by respondents. The final set of questions includes those in which respondents expressed a strong opinion, questions oscillating (statistically) around the value of 3-(I have no opinion) were excluded (see Table 2).

Table 2. List of hypotheses, variables and methods used in the analysis

Assessed factor		mean	median
everyday purchasing decisions (without reference to heating devices)	price for goods or services	4.29	4
	the quality of the goods purchased or services provided	4.34	5
	the goods or service is environmentally friendly	3.99	4
	the goods have certificates confirming their environmental performance	3.90	4
	reliability	4.57	5
	opinions of loved ones	3.54	4
	recommendation on Internet forums	3.38	4
	recommendation from an advisor in the store	3.41	4
	easy operation	4.29	4
	warranty period	4.34	5
	warranty service	4.40	5
	after-sales service related to technical support	4.11	4
	appropriate appearance or design	3.44	4
	prestige of the brand or manufacturer	3.44	4
	possibility of configuration and personalization	3.80	4
	possibility of remote control (e.g. mobile application)	3.36	4
	low operating costs	4.41	5
requirements for heating devices	heating devices should be environmentally friendly	4.15	4
	heating equipment should generate low heating costs	4.54	5
	low operating costs (including maintenance and upkeep) of the heating system	4.48	5
	brand or manufacturer of the device	3.61	4
	technical characteristics of the heating device	4.27	4
	the ability to control with a mobile application or remote control	3.43	4
	low price of the device	4.02	4
	energy efficiency of the heating device	4.50	5

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It is difficult to find hidden factors (constructs) in the literature describing expectations regarding the use of heating devices. Therefore, this study is exploratory in nature. The lack of research clearly describing the perception of the utility value of heating devices in the PaaS model does not rule out that the isolated factors may be, to some extent, dependent and related. Unlike CFA (Confirmatory Factor Analysis), we do not start by verifying the Cronbach's alpha value for constructs (which we do not actually know). Instead we examine whether reducing the dimensionality of the survey using EFA makes sense. This is evidenced by the result of applying the Kaiser-Mayer-Olkin tests and Bartlett's sphericity test (Table 3). The significance of Bartlett's test reports that there are mutually correlated constructs (groups) of survey questions. The KMO measure details that some of the observable variables can be removed from the set, without significantly reducing the variability of the newly created model based on the extracted constructs. The results of these tests allow for a stepwise EFA (Exploratory Factor Analysis), starting with the entire set of survey questions. It is a multi-step procedure that leads to the identification of a dependency model composed of significantly related survey questions.

Table 3. Kaiser-Mayer-Olkin measure and Bartlett test

KMO measure of sampling adequacy		0.896
Bartlett's sphericity test	chi-square	3496.249
	df	45
	Significance	p=0.000

Items with lower than 0.7 values of factor loadings were eliminated, as well as items loading more than one factor in the model. The multi-step EFA procedure allows for the extraction of a model with two hidden factors (Table 4). The two extracted factors form the decision space for heating system users. EFA excluded from the analysis 15 evaluation aspects such as purchase price valence, reliability aspects, appliance reviews, brand design and prestige, technical properties and configurability. All such factors describe about 32% of the total variation in the collection, while the model describes almost 68% of the variance.

Table 4. Extracted decision-making factors for the selection of heating equipment

FACTOR	Rating the aspect (Likert scale)	Factor loadings
Factor 1 (F_1) Product quality	Quality of goods purchased/services provided	0.779
	The good/service is environmentally friendly	0.789
	The product is certified to be environmentally friendly	0.764
	Easy to use	0.763
	Warranty period	0.817
	Warranty service	0.788
	After-sales service, technical support	0.757
Factor 2 (F_2) Economy of use	Heating devices should generate low heating costs	0.887
	Low operating costs (including maintenance and upkeep) of the heating system	0.910
	Energy efficiency of the heating device	0.862

In addition, it is determined by statistical methods construct meets the assumptions of reliability. It should be noted that the factors presented above are clearly positively correlated with each other, this means that users of heating systems, when making their decisions are primarily guided by the quality factor, however, an additional advantage of the device is its economy.

At this stage of the study, the Crobnach alpha reliability coefficient can be estimated for each factor separately (Table 5). Additionally, factor analysis was performed separately for each construct.

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It showed that further reduction is not justified and the constructs are not divided into smaller subsets. The results allow us to conclude that the constructs designated in this way can be the basis for measuring consumer preferences towards heating devices.

Table 5. Specification of the model

	Alfa-Cronbach	Factor influence in decisions	Percentage of variance explained	Mutually correlated components
Factor F1	0.891	79%	53.7%	0.46 (Spearmann)
Factor F2	0.881	21%	14.2%	
Total explained variance			67.9%	

To summarize the results so far: the multi-stage procedure of EFA allowed to reduce the number of observable variables has identified two key factors for evaluating heating systems (Table 4):

- Factor 1: **Product quality.** Respondents basically expect a bundled product: along with post-purchase service, additionally, they want products to be environmentally friendly and easy to use.
- Factor 2: **Economy of use**. A separate but correlated factor is the aspect of operating and service costs of the heating device.

These factors, as key decision-making aspects, will be used to verify the research hypotheses (Figure 1).

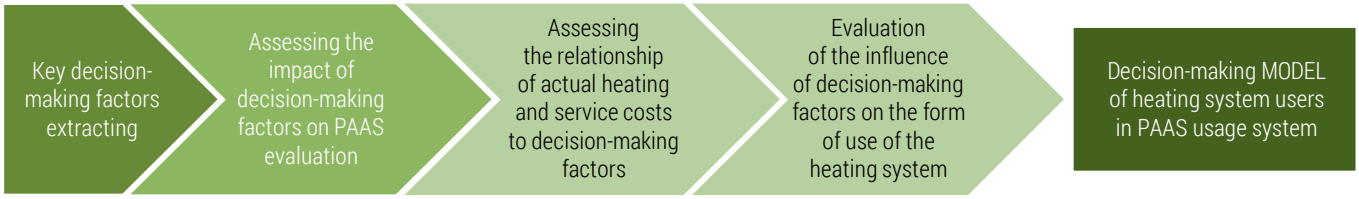

Figure 1. Research procedure

Results of the research

Table 5 shows the results of applying statistical tests of PaaS measurement to respondents' demographic factors. The p-values show that the only differentiating factor is the size of the locality ($p=0.016<0.05$, see Table 6). Using post hoc tests, for the Kruskal-Wallis method, it is possible to conclude that rural residents differ in their assessments only from those living in cities of 200-500,000 residents. With that said, rural residents rate the PaaS model slightly lower than residents of medium-sized cities. Still, the assessment is positive, although the share of undecideds is significantly higher than in the other subgroups of respondents. Other demographic determinants such as gender, education, age or inhabited region do not affect how PaaS is rated. In every case, this usage model is rated positively (median rating is 4).

Table 6. The impact of individual respondents' characteristics on the assessment of the PaaS model

The demographic factor	p-value	Decision
Gender	0.51	Gender has no effect on PaaS rating
Educational level	0.96	Education level does not affect the assessment
Size of locality	0.016	Place of residence has an impact on PaaS assessment
Region (province)	0.67	Opinions show no regional variation
Age	0.53	Age does not affect the assessment

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The extraction of decision-making factors made it possible to positively verify research hypothesis H2. Thus, there are implicit decision-making structures, which consist of selected observable variables (Table 7). The dimension of the decisions of users of heating equipment was reduced to two synthetic measures: Factor 1 and Factor 2. If we analyse the observable variables included in the decision model, two aspects are of great importance here: the cost of operation (see F2) and aspects of warranty or post-warranty service (F1). Therefore, it can be assumed that the decision factors can be directly influenced by the cost of operation (let's denote this variable by P1) and the cost of technical maintenance of equipment (P2) (these variables express nominal amounts, in order to ensure comparability with Fi variables, they have been scaled to 0-10). If this is indeed the case, then perhaps the direct measurement of operation and maintenance costs, rather than indirect determination of decision factors, would be advisable. Such a hypothetical possibility of substitution of variables F_1 and P_1 and F_2 and P_2 was addressed in this study in the form of the hypothesis „H3: Decision factors are influenced by the operating cost and maintenance cost of heating equipment". In addition to some qualitative factors, respondents reported numerically what the approximate annual cost of operating and maintaining the heating system is. The results of the correlation analysis of the variables F_i and P_i (see Figure 2). As it turns out, the financial cost of using heating systems does not influence decision-making factors in any way, despite the fact that the aspect of use and economy is one of the key ones for respondents. The correlations are statistically insignificant. This certainly indicates that respondents separate the actual characteristics of equipment (expressed in terms of cost) from those expected and preferred. One can venture to say that the financial aspect diverges from the expectations of heating system users.

Table 7. Correlation analysis of users' decision-making factors and maintenance/operating costs of heating equipment

		P_1 How much does it cost you per year to heat your home? (On average)	P_2 How much does it cost you per year to maintain a working heating system? (On average)
F_1 Quality and service	r-Pearson	-0.055	-0.095
	p-value r	0.253	0.069
	rho-Spearmann	0.006	0.051
	p-value rho	0.904	0.328
F_2 Economy of use	r-Pearson	-0.002	-0.199
	p-value r	0.959	0.000
	rho-Spearmann	0.028	-0.112
	p-value rho	0.556	0.033

Weak dependence of decision-making factors F_1, F_2 and their independence from costs P_1 and P_2 means falsification of hypothesis H3. Nevertheless, such a conclusion from the study may be crucial in the context of evaluating the use system in a leasing model. This is because it means that there may actually be four decision factors: two arising from user expectations and two related to the cost-of-use aspect. Respondents, based on their own experience and knowledge, gave their opinions in the survey along two additional dimensions: direct evaluation of the heating system leasing system in the PaaS model (Likert scale) and stated explicitly whether they prefer to use their own appliance or a leased one (dichotomous variable). The usage model is a hypothetical service that is not yet widespread in the market. The quantitative evaluation aspect of PaaS is, therefore, a measure of openness, the enthusiasm of potential consumers for the heating equipment leasing system. This openness, however, needs to be confronted with a realistic feeling about the ownership aspect. After all, openness to a new form of use may only be an anecdotal statement when respondents advocate private ownership against leasing goods. Thus, the survey includes a dichotomous variable: choice of ownership v. choice of leasing. It is a control variable, allowing to further estimate the initial size of the market and the receptivity of users to the PaaS model.

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Across the entire group of respondents, the evaluation of the use system in the PaaS model is high. Positive evaluations overwhelmingly prevail (Figure 2). However, in the sample surveyed, despite the relatively high evaluation of PaaS, more than 80% of respondents prefer to own their own device.

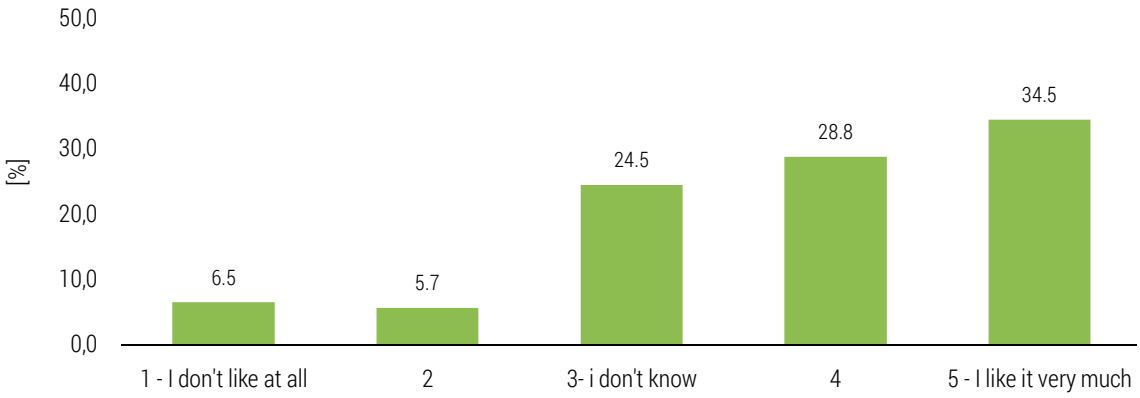

Figure 2. Evaluation of the PaaS usage model

Those who are willing to choose a leased device rate the PaaS usage model significantly higher (median rating 5, mean 4.8) than those who prefer their own devices (median 4, mean 3.4). The rating of those choosing leasing is even enthusiastic, the ratings of those preferring their own devices should be interpreted as moderately favorable. This differentiation is confirmed by tests U-Manna-Whitney (p-value<0,001) and the Kolmogorov Smirnov test of the similarity of distributions (p-value<0,001). It can be concluded that the market is open to a new form of use of heating equipment, with an initial market share of a high 20% and a promising development. The PaaS assessment is also followed by a preference for ownership of heating systems. It is, therefore, legitimate to ask the key question of the study: what actually determines a positive evaluation of PaaS. The study identified four key factors that can influence the evaluation of PaaS (Table 7). Linear correlation of decision-making factors (Table 8) suggests that the evaluation of leasing is a form of linear combination of the decision factors developed above. There is also reason to believe that the evaluation of the leasing model of heating equipment can be linked to the cost of operation and maintenance of the efficiency of the heating system. Thus, each respondent gives four evaluations of aspects of system use: two describing decision factors and two of a financial nature. Preliminary analysis of the data allows us to conclude that a linear dependence of the PaaS variable on the other factors is to be expected, with the assumption that they may interact on a synergistic basis. Therefore, the estimated model will be of the form:

$$PaaS = \alpha_0 + \alpha_1 F_1 + \alpha_2 F_2 + \alpha_3 F_3 + \alpha_4 F_4 + \varepsilon \quad (1)$$

Testing the significance of the parameters of this model will make it possible to determine directly what factors (otherwise crucial to the respondent) have an actual, measurable impact on the evaluation of the heating leasing system. This will allow verification of the hypothesis. In accordance with social research methodology, the Likert scale rating was treated as a quantitative variable, so the verification tool is a linear regression model.

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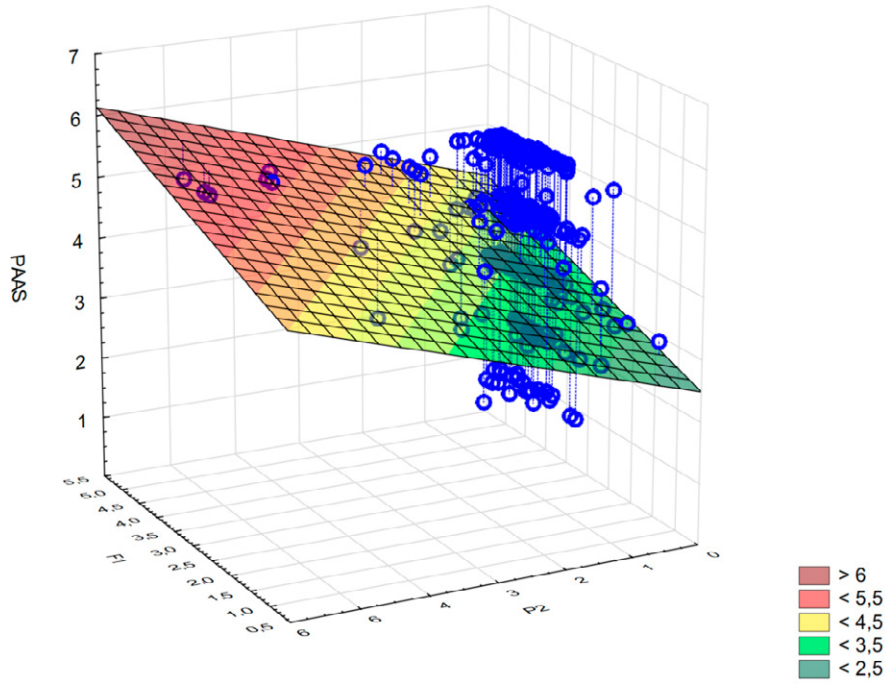
Table 8. Summary of the regression model for PaaS

N=332	R= .25069347 R^2= .06284721 F(2,362)=12.138 p<.00001 Standard error of est.: 1.1772					
	α_i	std. error	a_i	std. error a_i	t(329)	p-value
			2.326	0.407	5.704	0.000
F1 Quality and service	0.177	0.050	0.326	0.093	3.479	0.000
P2 Cost of technical maintenance of equipment	0.188	0.050	0.335	0.091	3.701	0.000

The estimated model for the evaluation of PaaS (see Figure 3) first of all shows a significant relationship between two basic factors: Quality of service (F1) and the cost of maintaining the heating system (P2). This proves the veracity of hypothesis H4, which assumes that certain decision-making and cost factors actually affect respondents' evaluations of the heating equipment leasing system. The model fit is not high and indicates that there are influential observations in the analysis of the phenomenon. Analysing the correlation scatter plot, one can distinguish a clear cluster of points for low P2 values. However, there is a group of observations that are significant outliers (large P2 values), affecting the final form of the model. This result can be interpreted as follows: the maintenance costs of P2 installations become crucial. These costs are the influence points for the estimated model: the higher the costs, the higher the rating of the PaaS (this is indicated by the positive, relatively high statistically significant parameter of the P2 variable). Among those with low maintenance costs (the cluster of points discussed above, see Figure 2), the quality and service factor becomes more important, which translates into a relationship between the rating of the leasing system and the quality of the product and service of the heating equipment. Respondents giving higher ratings to the quality and service of the device also rate the heating system leasing system higher (positive, statistically significant parameter of the F2 variable). Those for whom the aspect of quality and cost is very low rate the PaaS system neutrally (the model's free expression is 2.5).



$PaaS = 2.52 + 0.096F_1 + 0.283P_2$

Figure 3. Graphic presentation of the estimated model

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Discussion

Key results of our study are shown on Figure 4. Their analysis indicates that there are two key decision factors influencing the choice of PaaS as a model for the use of heating devices. At the same time, our study showed little importance of other decision-making factors, including demographic ones (gender, age, place of residence etc.). We show that among key decision making factors are quality and service on the one hand and economy of use on the other. This finding is partially consistent with the results of previous studies presented by various authors and institutions (Alves et al., 2023; Deloitte, 2020; Kesavapanikkar et al., 2022; McKinsey & Company, 2018; Recharge, 2022; Ziobrowska-Sztucka & Markiewicz, 2024) indicating cost savings and convenience as key factors influencing the choice of PaaS. In our study apart from the importance of cost factors, we indicate the role of quality and service.

Moreover, a novelty in our study is not only the indication of the quality of the service, but also testing the relationship between the importance of operating costs and quality. In this context, we found out that quality and service together with costs of maintenance make up the architecture of factors influencing the assessment of PaaS as a form of using heating devices. Our study shows that if maintenance costs are low, the importance of product quality and service of heating devices increases as a factor increasing the attractiveness of PaaS.

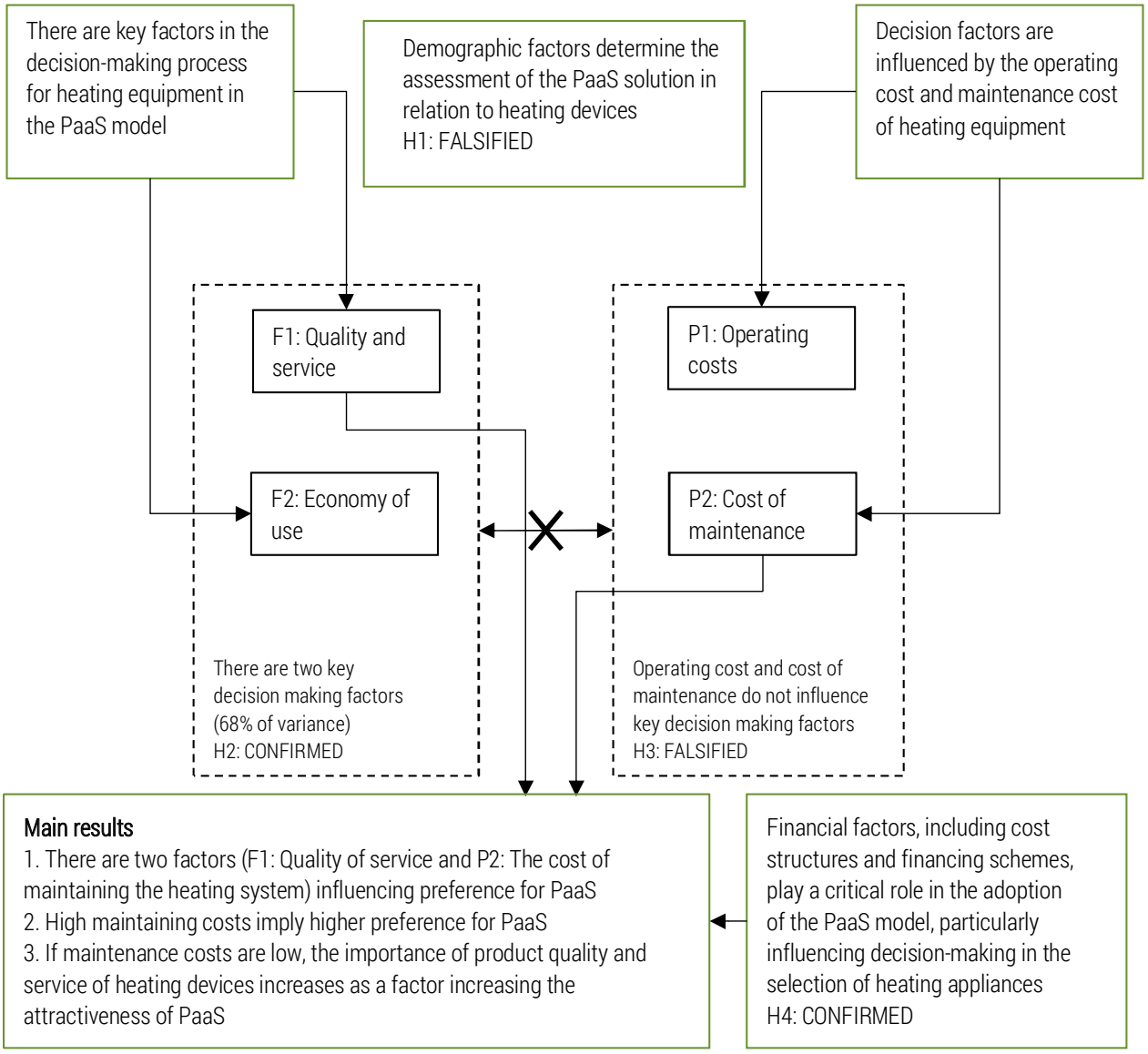

Figure 4. Key results of the study

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Our research also adds value to research on consumer choice regarding PaaS, including in particular in relation to heating appliances, which has not been the subject of similar analyses so far. On the one hand, our study confirmed the greater skepticism of consumers towards PaaS solutions as compared to entrepreneurs, indicated in the literature (Alves et al., 2023; Deloitte, 2020; Kesavapanikkar et al., 2022; McKinsey & Company, 2018; Raihanian Mashhadi et al., 2019; Recharge, 2022; Stena Circular Consulting & Cradlenet, 2022; Ziobrowska-Sztucka & Markiewicz, 2024). On the other hand, we indicate that many customers approach such a solution with great interest, which, after meeting the conditions regarding costs and quality of service, may turn into decisions regarding the choice of this type of solution.

Interestingly, the study found that demographic factors, such as gender, age, and location, have a minimal impact on PaaS adoption. This finding contradicts some earlier studies (McKinsey & Company, 2018; Statista, 2023), which suggested that younger, tech-savvy individuals are more likely to adopt PaaS models. This discrepancy might indicate that the importance of demographic factors is diminishing as PaaS models become more mainstream.

The study contributes to the theoretical framework of PaaS adoption by introducing the relationship between service quality and maintenance costs as a new determinant of consumer preference. This expands the existing models of consumer behaviour in the context of PaaS and circular economy principles, suggesting that future research should explore these relationships further.

For practitioners, these findings suggest that enhancing service quality and minimising maintenance costs should be prioritised in PaaS offerings, particularly in the heating systems industry. Marketing strategies should focus on these aspects to attract a broader consumer base, including those initially skeptical of PaaS models.

While our study provides valuable insights, it is limited by its focus on a specific demographic and product category. Future research should explore whether these findings can be generalised to other sectors and examine the long-term impacts of PaaS adoption on consumer satisfaction and environmental outcomes. Additionally, future studies could investigate how external factors, such as technological advancements and regulatory changes, influence PaaS adoption dynamics.

These additions will strengthen the discussion by connecting your findings to existing literature, suggesting practical applications, and identifying areas for further research.

Conclusions

This study contributes to the understanding of consumer preferences for the Product-as-a-Service model, particularly in the context of heating systems. By exploring the decision-making factors that influence the adoption of PaaS, the research provides valuable insights into how quality, service, and economic considerations impact consumer choices.

The findings of this study highlight the importance of quality and service, along with economic factors, in shaping consumer preferences for PaaS models. This aligns with existing literature that emphasises the significance of cost savings and convenience but also extends the discussion by introducing the critical role of product and service quality. The study adds to the body of knowledge on PaaS by addressing the gap in research focused on consumer adoption in the context of heating systems, a less explored market segment.

For industry practitioners, the results suggest that offering high-quality products and reliable service can significantly enhance the attractiveness of PaaS models. Companies should prioritise these aspects when designing and marketing PaaS offerings, particularly in the heating systems sector. Additionally, the study highlights the potential for PaaS to appeal to a broader consumer base, provided that the cost of maintenance and operation is kept low, and the quality of service is maintained at a high standard.

Despite its contributions, the study has certain limitations. The research was conducted within a specific demographic (users of single-family houses) and focused on a particular product category (heating systems), which may limit the generalizability of the findings. Future research could expand on this study by exploring PaaS adoption across different demographics and product categories. Additionally, further research could investigate the long-term impacts of PaaS adoption on consumer behaviour and satisfaction, as well as the potential environmental benefits of widespread PaaS implementation in various sectors.

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The contribution of the authors

Conceptualization, E.S.-P. and M.-J.R.; literature review, E.S.-P. and M.-J.R.; methodology, M.N. and Ł.K.; formal analysis, M.N. and Ł.K.; writing, E.S.-P. and M.-J.R.; conclusions and discussion, E.S.-P., M.-J.R., M.N. and Ł.K.

The authors have read and agreed to the published version of the manuscript.

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DETERMINANTY PREFERENCJI KONSUMENTÓW DLA MODELI PRODUKT JAKO USŁUGA (PAAS): STUDIUM PRZYPADKU SYSTEMÓW OGRZEWANIA

STRESZCZENIE: Badanie miało na celu identyfikację czynników wpływających na wybór produktu jako usługi (PaaS) zamiast własności w decyzjach klientów, wykorzystując systemy grzewcze jako studium przypadku jako przykład mniej nasyconego rynku PaaS. Analiza opiera się na ogólnopolskim badaniu ilościowym populacji użytkowników domów jednorodzinnych. W badaniu stworzono model ekonometryczny, opisujący wybór modelu PaaS przez klienta za pomocą dwóch czynników opisujących decyzję oraz dwóch o charakterze finansowym. Wyniki pokazały, że jakość, koszty usług, eksploatacji i konserwacji były kluczowymi czynnikami, podczas gdy demografia miała niewielki wpływ na decyzję. W tekście zwrócono uwagę na luki badawcze w PaaS i gospodarce o obiegu zamkniętym, takie jak zrozumienie preferencji konsumentów, modele finansowe w środowisku zabudowanym, czynniki wpływające na przyjęcie PaaS w urządzeniach grzewczych, finansowanie gospodarki o obiegu zamkniętym oraz niezbędne zmiany w sektorze finansowym. Badanie to zwiększa zrozumienie preferencji konsumentów i podkreśla potencjał PaaS w segmencie konsumentów indywidualnych i produktów konsumpcji trwałej.

SŁOWA KLUCZOWE: produkt jako usługa, wybór konsumenta, systemy ogrzewania

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