DESIGN FOR CONTINUOUS USE OF PRODUCT-SERVICE SYSTEMS: A CONCEPTUAL FRAMEWORK

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ABSTRACT

Product-service systems (PSSs) have attracted researchers in engineering design for the past decades. Recent advances in digital technologies have expanded the potential functionalities that PSSs could deliver and designers' repertoire of tools and techniques to make new value propositions. The key to the success of new value propositions is to achieve customer acceptance and continuous use. However, little is known about the precise routes by which customers accept and use PSSs over time and its dynamics. This conceptual study aims to provide an enhanced view of customer acceptance and continuous use of PSSs by integrating multiple theories and literature streams. In this paper, we suggest three propositions based on the key concepts found in our literature review—well-being, trust and control—, and illustrate a conceptual framework that represents the dynamics of customer acceptance and continuous use of PSSs. Based on the proposed framework, we outline further research questions that could advance our knowledge about design for continuous use of PSSs.

Keywords: Product-Service Systems (PSS), Uncertainty, Requirements

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1 INTRODUCTION

The past two decades have witnessed a remarkable change in design object from being a single product to becoming a whole system of value creation consisting of products and services. This new design object, so-called Product-Service Systems (PSSs) (Mont, 2002; Tukker and Tischner, 2006), has attracted researchers in engineering design because of its novelty and potentials to further development of the research domain (McAloone, 2011; Cavalieri and Pezzotta, 2012). Moreover, recent advances in digital technologies (e.g., wireless sensor network, machine learning, and augmented/virtual reality) have expanded the potential value propositions that PSSs could deliver. For example, smart healthcare devices can track users' health data; and, analysing the data, combined services give feedback to empower users to take prescriptive actions (Valencia et al., 2015). This trend has sparked a new research topic, Smart PSS (Valencia et al., 2015; Chowdhury et al., 2018; Zheng et al., 2018).

The key to the success of new value propositions is to achieve customer acceptance and continuous use. Obviously, the benefits of a PSS can be delivered only if customers are willing to adopt and continuously use the PSS. However, customer acceptance of PSSs could be stifled due to several reasons: financial costs, risks, and habits of consumption (Borg et al., 2020). Although scholars have investigated barriers to customer acceptance of PSSs (Schmidt et al., 2015; Cherry and Pidgeon, 2018; Borg et al., 2020), little is known about the precise routes by which customers accept and use PSSs over time and its dynamics.

This conceptual study aims to provide an enhanced view of customer acceptance and continuous use of (Smart) PSSs. To this end, we constructed our study taking the theory synthesis approach (Jaakkola, 2020) which integrates multiple theories or literature streams. This study is on the foundation of the theoretical notion by Rexfelt and Hiort Af Ornäs (Rexfelt and Hiort Af Ornäs, 2009) that claims relative benefits and uncertainty reduction are central issues to customer acceptance of PSSs. Starting from this claim, we reviewed and integrated multiple theories and literature streams in psychology, information systems, and human-computer interaction. The key concepts that enhance our understanding on relative benefits and uncertainty were well-being, trust, and control. The result of review was crystallized as a conceptual framework that represents the dynamics of customer acceptance and continuous use of PSSs. This paper contributes to theories and practices in two ways. First, to literature on customer acceptance of PSSs, we provide a conceptual framework that represents the dynamics of customer acceptance and continuous use by integrating multiple theories and research streams in different research areas. Second, based on it, we contribute to PSS design literature by providing a research agenda towards design for continuous use of PSSs.

This paper is structured as follows. In Chapter 2, we first review literature about customer acceptance of (Smart) PSSs and identify research questions which we address in this paper. Then, we go through multiple theories and literature streams strongly related to uncertainty reduction and relative benefits of PSSs. Founded on the findings in the literature, the present study introduces trust and well-being as key factors to achieve customer acceptance and continuous use. Chapter 3 illustrates a conceptual framework based on the literature and states our propositions to underpin the framework. Chapter 4 first outlines a future research agenda towards design for continuous use of PSSs and then discusses contributions and limitations of this study. Finally, Chapter 5 concludes this paper.

2 THEORETICAL FOUNDATION

2.1 Customer acceptance of PSSs

Customer acceptance has been originally conceptualized in research of information systems. One of the most widely referred frameworks is technology acceptance model (TAM) (Davis et al., 1989), which regards customer acceptance as the prospective user's intention to use. Based on the theory of reasoned action, TAM explains that customer acceptance is determined by two beliefs: perceived usefulness and perceived ease of use. This model has generated a new research stream where many authors have proposed subsequent models by synthesizing novel predictors of those two beliefs (Venkatesh and Bala, 2008). Venkatesh et al. (2003) also proposed the Unified Theory of Acceptance and Use of Technology (UTAUT) through the review of eight different theories and models including TAM. The recent theory-testing article highlighted four predictors of UTAUT: performance expectancy, effort expectancy, social influence, and facilitating conditions (Dwivedi et al., 2019). Whilst TAM based models and UTAUT targeted behavioural intention to use a system, Lowry et al.

(2015) proposed the model that explains continuance intention resulting from the gaps between pre- and post-use expectations. This model also characterizes the range of expectations stemming from different motives: hedonic (joy), intrinsic (learning), and extrinsic (usefulness).

The differences in customer acceptance between a single product (e.g., an information system) and a PSS can be considered in two ways. First, customers will only accept a PSS if they accept both the products and the related services (Lu et al., 2019). Second, several types of PSS shift away from ownership-based consumption toward access-based or use-oriented consumption, which can encompass new barriers (Cherry and Pidgeon, 2018). Considering these differences, few authors have been engaged in customer acceptance of PSS. The earliest contribution by Rexfelt and Hiort Af Ornäs (2009) found that the central factors to increase customer acceptance of PSS are relative benefits and uncertainty reduction. Lu et al. (2019) applied TAM to a Smart PSS case and identified significant predictors of perceived usefulness and perceived ease of use: interactivity of the mobile app and particularity of the smart product. Other authors undertook their efforts to identify barriers of access-based/use-oriented PSS such as costs, risks, ownership of products, and complexity (Schmidt et al., 2015; Cherry and Pidgeon, 2018; Tunn et al., 2019; Borg et al., 2020).

Although the aforementioned works have revealed some key factors which may increase customer acceptance of PSS, there is a lack of knowledge about the precise routes by which customers accept and use PSSs over time and its dynamics. To address this issue, we base our current research effort on the statement by Rexfelt and Hiort Af Ornäs (2009) because both relative benefits and uncertainty can be reduced and enhanced over time through interactions between customers and systems. Referred to it, we derived the following detailed research questions:

> *RQ1. What are the key factors to enhance relative benefits of PSSs?*

> *RQ2. What are the key factors to reduce uncertainty of PSSs?*

> *RQ3. How do these factors relate to each other and form continuous use of PSSs over time?*

To answer these questions, we constructed our study taking the theory synthesis approach (Jaakkola, 2020) which integrates multiple theories or literature streams. We conducted a literature review across research domains and found the two key literature streams: trust and control; and well-being.

2.2 Well-being

Relative benefits are about perceived superiority of the value proposition compared to alternatives. If we apply TAM to this, perceived usefulness and perceived ease of use can be regarded as the criteria to evaluate superiority of the value proposition. As Lowry et al. (2015) argued, however, such a pragmatic only view is limited when we take potential benefits of PSSs into account. Recent studies in human-computer interaction and user experience design argued that the aspects of well-being are significant to both short- and long-term acceptance from customers (Hammer et al., 2018; Peters et al., 2018).

The term well-being has been used to represent a good state and functioning life debated in philosophy, economics, and psychology. To explain what a good state or functioning life is, researchers often refer to the classification of hedonic view and eudaimonic view of well-being (Ryan and Deci, 2001; Huta and Ryan, 2010). To state it simply, the hedonic view equates well-being with subjective happiness, pleasure, and the absence of pain, whereas the eudaimonic view emphasizes realizing one's potential and living a meaningful life. These views allow us to list relevant factors for measurement of individual's subjective states of well-being. For example, taking the eudaimonic view, the psychological well-being scale was constructed by eight factors: self-acceptance, positive relationship with others, autonomy, environmental mastery, purpose in life, and personal growth (Ryff, 1989). The two views of well-being can be applied to explain not only subjective states (i.e., how well you feel) but also orientation (i.e., what you seek) (Huta and Waterman, 2014). Therefore, well-being is often associated with intrinsic motivation of their daily activities (Ryan and Deci, 2000; Huta and Ryan, 2010).

If well-being is people's essential motive for their activities, products and service should be designed to support it. As a matter of fact, all design may aim to contribute to the users' well-being (Desmet and Pohlmeyer, 2013). However, especially in the context of digital technology, threats to human well-being are heatedly discussed as serious issues (Burr et al., 2020). This issue can apply to Smart PSSs which are included within our scope. To design and promote well-being supportive products and services more explicitly and intentionally, several design initiatives have emerged for recent years, for

instance, Positive Design (Desmet and Pohlmeyer, 2013), Experience Design (Hassenzahl et al., 2013), and Positive Computing (Peters et al., 2018). This movement indicates that design for relative benefits should not lean on pragmatic performance but embrace hedonic and eudaimonic outcomes.

2.3 Trust and control

Uncertainty has been one of the important topics in PSS research. PSSs may inherently include greater uncertainties than single products because the outcome of services cannot be assessed in advance (Borg et al., 2020). Catulli (2012) found what the essential factor to overcome the uncertainty in PSSs is trust.

The phenomenon of trust and its role has been studied extensively in psychological, organizational, sociological and technological domains, based on a common acceptance of its necessity in personal life, organizational behaviour, and technology use. As such there is no one definition of trust, and we begin with the oft-cited definition of trust by Mayer et al. (1995): "the willingness of a party to be vulnerable to the actions of another party based on the expectation that the other party will perform a particular action important to the trustor, irrespective of the ability to monitor or control that other party." (Mayer et al., 1995, p. 712) The notion of trust in this definition is that of the trustor's decision to make him/herself vulnerable. Castelfranchi and Falcone (2010) have developed a model of trust that caters for its existence as a mental attitude, decision and behaviour. Their model views trust as a relational construct between the trustor, the trustee (which could be a human or a technological agent), the task or action to be performed by the trustee to produce an outcome, the goal that is to be attained, and the context (situation or environment). Cofta (2007) regards trust as a qualitative internal state (exists in the mind of the user and is unpredictable), can only be gradually built over time, and yet, is volatile. According to Cofta, trust, while desirable, may not be practical in all situations, especially those where humans interact with technology.

Hence, trust as a belief and trustworthy behaviour as the outcome are not the same concepts. Whereas trust as a belief reflects the trustor's state of mind, the outcome of the decision and act of trusting is a certain expected trustworthy behaviour. In other words, a person or an agent could exhibit trustworthy behaviour even if the trustor is not inclined to trust this person or agent, and vice-versa. This is highlighted by an examination of trust building mechanisms, both in human and technological contexts (McAllister, 1995; Lee and See, 2004; Lewicki et al., 2006). The process of trusting an agent can sometimes begin as a rational, control-based attempt at testing the reliability of the trustee to exhibit trustworthy behaviour, leading to the formation of trust over time. In other cases, the interaction commences with the trustor initially displaying a high level of belief in the trustee's trustworthiness and subsequently calibrating it as more evidence accumulates. Exactly which of these paths is taken is dependent on many factors ranging from personal disposition and competence (Anthony Hoff and Bashir, 2015) to cultural background of the trustor (Hayashi et al., 1999). In light of this view, instead of trust, Cofta (2007) exhorts designers to consider enhancing confidence as a design goal—defined as the "subjective probability of the expectation that a certain desired event will happen (or that the undesired one will not happen), if the course of action is believed to depend on another agent" (Cofta, 2007, p. 14). In this perspective, the user should be given the choice to trust the interacting agents when trust exists and the situation permits, but, at the same time, be provided with control measures to enforce trustworthy behaviour. Irrespective of the path to trustworthy behaviour, what counts is that the user has the choice, and a heuristic to make this choice.

3 CONCEPTUAL FRAMEWORK

The previous chapter shed light on the importance of confidence (i.e., trust and control) and well-being as the design goals to enhance relative benefits and reduce uncertainty for the purpose of customer acceptance and continuous use of PSSs. Integrating the literature streams in customer acceptance (of PSS), trust and control, and well-being, Figure 1 illustrates the integrative framework that represents the dynamics of customer acceptance and continuous use of a PSS. Note that, in this framework, we replaced the term "customer" with "user" to indicate a person who actually interacts with products and services, while knowing that customers and users are sometimes different in fact. The following three propositions are suggested to underpin the points of the framework.
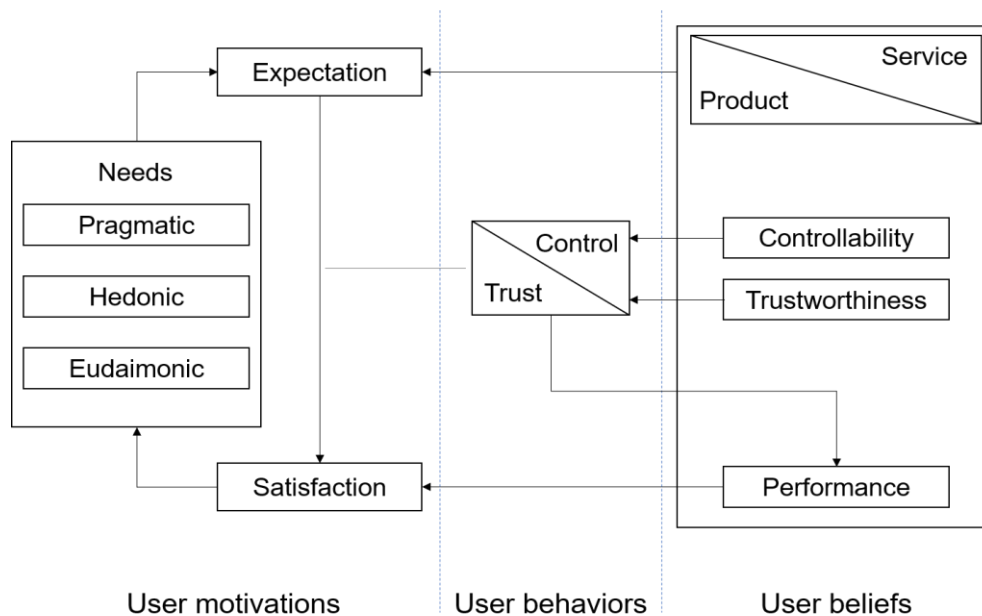
Figure 1. The conceptual framework of continuous use of a PSS

3.1 User motivations

People have different needs related to pragmatic, hedonic, and eudaimonic issues independently of products and services. These needs can be understood as a spectrum ranging from life (e.g., I want to express myself) to task (e.g., I want to finish the task in an hour) levels. Satisfaction of the needs is a motive for their all activities. There are two conceptions of motivation: extrinsic and intrinsic motivation (Ryan and Deci, 2000). The former appears to be related to pragmatic issues, while the latter is mostly related to hedonic and eudaimonic aspects (Mekler and Hornbæk, 2016; Hammer et al., 2018). Given that intrinsic motivation is more influential on intentions for activities (Hagger and Chatzisarantis, 2009), it is reasonable to postulate that hedonic and eudaimonic aspects play an important role to motivate continuous use. Driven by intrinsic and/or extrinsic motivations, people meet PSSs designed to support their activities and form forward looking beliefs regarding the outcomes they expect from PSS use, namely, expectations. Expectations play an important role in not only the decision of acceptance but also the formation of satisfaction. As the expectation-disconfirmation theory (Oliver, 1997) explains, satisfaction is influenced by the gap between expectations and performance which means the user beliefs on how well the PSS could perform. Satisfaction of the needs changes user's states. Some of satisfied needs may disappear from the user's mind or other needs can appear. As long as the spiral of needs, expectation, and satisfaction is going on, the user will intend to continue to use the PSS. Considering above, relative benefits of PSSs can be perceived at two different times: before use (expectation) and after use (satisfaction).
With regard to our research questions, we propose:

> *P1. Relative benefits of a PSS are dependent on the ability of the PSS to meet users' pragmatic, hedonic, and eudaimonic needs; and intrinsic motivations driven by the latter two needs are more influential on continuous use.*

3.2 User beliefs

A set of beliefs about the trustee's (products and services) ability to achieved desired outcomes (and to be protected against undesirable outcomes) held by the trustor (user) is labelled as trustworthiness, that forms the basis of the trusting decision and behaviour. But how does the user form these beliefs in the first place? Mayer (1995) argues that it is the user's propensity to trust without first hand evidence that starts this cycle, in other words, the user begins with an assumption about certain attributes of trustworthiness regarding the trustee's behaviour, decides to act on these assumptions, and calibrates them based on the outcome. Mayer (1995) states three attributes of trustworthiness – competence (the trustee's ability to accomplish the goal), benevolence (the trustee will act in the interest of the trustor and not do harm), and integrity (the trustee will fulfil agreements and promises). Beliefs regarding

trustworthiness of the trustee can change both in a rational, calculated manner based on careful evaluation of evidence (cognitive) or based on experiences (affective) (McAllister, 1995).

In the context of interacting with technology, when viewed in terms of the cognitive effort and time required to develop trust, the need of a PSS to exhibit trustworthy behaviour may be of a greater significance for the trustor than inculcating trustworthiness. Distinguishing between trust and control as alternate means to achieving trustworthy behaviour, Cofta (2007) offers distinct classes of evidence for both. Motivation (trustee benefits from helping the trustor), competence (trustee's capability to influence the future) and continuity (trustee exhibits willingness to continue the relationship beyond the current transaction) are seen as evidences of trustworthiness of the trustee, whereas knowledge (about the trustee's working, past behaviour etc.), influence (presence of instruments and norms to influence the trustee) and assurance (the ability to apply these norms in the future) are seen as factors that influence the trustor's beliefs that the situation can be controlled, namely controllability. A PSS could be designed to provide evidences of both trustworthiness and controllability to reduce uncertainty of the PSS unlike user beliefs on them.

Formally, we propose:

> P2. Perceived uncertainty of a PSS is reduced by cultivating user beliefs on controllability and trustworthiness shaped by gathering evidences.

3.3 User behaviours

Users accept to interact with PSSs facilitated by the expectations and beliefs. It is apparent that as users interact with complex PSSs, they may lack the time and incentives to sufficiently comprehend the PSS in its construction and functioning, and form beliefs about the trustworthiness of these systems. As a result, users may ultimately end up trusting systems not as active, but rather as passive consumers placing their hopes on a positive outcome out of sheer necessity. Here, control is useful for short-term encounters, without the need for complex observations or interactions prior to the transaction (Cofta, 2007).

User behaviors influence performance of the PSSs because users are interwoven in the value co-creation process (Vargo and Lusch, 2008). Control is useful as mentioned above, and more influential on performance for good and bad. However, control requires readiness (Cofta, 2007). If a user lacks the knowledge and skills but takes control over the PSS, performance is obviously deteriorated. On the other hand, in case of trust, performance mostly relies on the functionalities of the PSS. In summary, which routes result in better performance, both in the short and long term, will depend on user beliefs, expectation, PSS functionalities, and use contexts.

Our third proposition builds a bridge between relative benefits and uncertainty reduction as follows:

> P3. Performance of a PSS is influenced by the choice of behavioural routes (trust or control) based on the user beliefs.

4 DISCUSSION

4.1 Towards design for continuous use of PSSs: a research agenda

We depicted the framework consisting of three propositions that enhances our view of customer acceptance and continuous use of PSSs. This is a first step toward development of a new design approach to continuous use of PSSs. In Table 1, we outline research questions related to the three propositions of this paper. The list consists of (a) phenomenological questions about customer acceptance and continuous use of PSSs and (b) methodological questions about design framework, processes, and tools. Both are useful to further enhancement of theories and practices of PSS design.

Regarding (a), there are two main perspectives from which we have derived questions: cultural and product/service differences. As studied in research domains, trust and well-being are constructed based on the socio-cultural context (Doney et al., 1998; Uchida et al., 2004). For instance, in the domain of human technology interaction, Kim (2008) found that 'type II cultures (collectivist, strong uncertainty avoidance, high long-term orientation and high context)' lay more importance on 'transference-based trust determinants (third party seal and positive referral)' compared to 'type I cultures (individualistic, weak uncertainty avoidance, low long-term orientation, low context)'. The present study has not covered such cultural differences, but the integration of these may be crucial for better understanding

the constructions of user motivations, beliefs, and behaviours. In addition, questions about product/service differences will make our framework keener to PSSs. Early researchers attempted to distinguish products and services, and identified four characteristics known as IHIP: intangibility, heterogeneity, inseparability, and perishability (Lovelock and Gummesson, 2004). It is possible that such characteristics affect user beliefs on trustworthiness and controllability and evoke different expectations from a set of needs, which are significant information for designers to create the best mix of products and services.

Design for continuous use of PSSs needs a different direction to overall design process. The methodological questions, numbered as (b), will contribute to the development of a new approach to PSS design. First, design is always built on user needs, so how to grasp user needs is essential to PSS design. This study differentiated three categories of user needs, but the existing methods in PSS design (Song, 2017) may focus on the pragmatic aspect. Thus, the examination and exploration of methods for needs identification becomes a notable area of inquiry. The other questions are about how to design constituents of PSSs based on the propositions of this study. In order to realize continuous use of PSSs, we highlighted some essences for PSS design including cultivating intrinsic motivations, implementing good evidences of trustworthiness and controllability, and guiding users to appropriate behaviours. The questions relevant to these essences are listed in the research agenda.

Table1. Research agenda

Propositions	Research questions
P1. Relative benefits of a PSS are perceived by predicting and appreciating how well the PSS meet users' pragmatic, hedonic, and eudaimonic needs; and intrinsic motivations driven by the latter two needs are more influential on continuous use.	(a-1) How do the socio-cultural differences in user needs influence the PSS- and task-specific expectations? (a-2) Do users form expectations differently depending on whether they interact with products or services? (b-1) How can designers grasp the multi-dimensional nature of and socio-cultural differences in user needs? What method is suitable? (b-2) How can designers make PSSs responsive to changes in user motivations?
P2. Perceived uncertainty of a PSS is reduced by cultivating user beliefs on controllability and trustworthiness shaped by gathering evidences.	(a-3) Do beliefs differ in their salience among product and service elements in PSSs? (a-4) Are beliefs regarding controllability and trustworthiness related to user groups or cultures? (b-3) How can designers effectively implement these evidences in products and services?
P3. Performance of a PSS is influenced by the choice of behavioural routes (trust or control) based on the user beliefs.	(a-5) Do some types of PSS restrict the choice users can take in their own behaviours? (a-6) Does the difference between trusting and controlling behaviours affect what and how user needs are satisfied? (b-4) How can designers guide users to appropriate behaviours without inhibiting their motivations?
Overall	(b-5) All things considered, what kind of design framework can be illustrated?

4.2 Contributions and limitations

This study contributes to theories and practices in two ways. First of all, this paper theoretically contributes to the literature of customer acceptance of PSS by offering a new conceptual framework. To enhance understanding of uncertain reduction and relative benefits (Rexfelt and Hiort Af Ornäs, 2009), we introduced the concepts of trust, control, and well-being. Since these concepts have received relatively little attention in previous studies in the PSS research domain, this point can be regarded as our first contribution. On the other hand, the originality of our framework is not manifested in the conceptual components, but in the whole that they comprise. In this framework, we illustrated customer acceptance and continuous use of PSSs as the dynamic process that changes over time. To be more precise, it explains that the dynamics are stimulated by motivational changes in the spiral of user needs, expectation, and satisfaction, evidences offered and fostered within the interactions, and user's

choices of the behavioural routes. This point is our second contribution that enhances our understating because existing literature has tended to recognise customer acceptance as the consequence of static factors, for instance, usefulness and ease of use (Davis et al., 1989, Liu et al., 2019).

In addition, we also provide implications to PSS design practice and research. First, the framework presented in this study may be suggestive for designers who want to improve their products and services to be more accepted and used. For example, it would be beneficial for designers to think about how to grasp and respond to changing user motivations from well-being perspective and how to implement and provide the evidences to encourage trust and control behaviours. Second, the framework and research agenda will implicate a guide to extend our knowledge of PSS design methodology. For example, in PSS design research, the importance and challenges of analysing dynamic requirement has been argued (Song, 2017). Our framework can provide an evidence of its importance (even though it has not been empirically validated) and the three dimensions of user needs which were not clarified in the research domain.

This paper also includes several limitations need to be considered. First, in this paper, we have not conducted an empirical validation of our framework. Therefore, the contributions mentioned above are limited to the qualitative claims supported by the literature review of multiple research domains. Future studies should include empirical approaches to validating the proposed framework. Second, we employed a selective approach to conduct the literature review. It is possible that our literature base is limited and biased compared to more rigorous methods such as systematic literature review. Thus, the proposed framework may include points to be improved, while it was shaped based on the well-examined theories through careful discussions by authors. Third, in this paper, we do not rule out a conceptual overlap between some of the beliefs involving trust, control, and well-being. For example, studies also show that affect plays an important role in the formation of trust, both as a measure of the process of trust formation and a predictor of it (Williams, 2001). Hence, the present affective state of the individual influences future trust formation, and the act of trusting itself results in positive affective states, indicating a link between hedonic experiences and trusting stance. To sophisticate the framework, further investigations on such conceptual overlaps should be addressed in future work.

5 CONCLUSION

The aim of this study was to provide an enhanced view of customer acceptance and continuous use of (Smart) PSSs. To this end, we made three propositions and proposed an integrative framework. The propositions were induced by integrating literature streams in psychology, information systems, and human-computer interaction. The framework comprised by the propositions visualises the dynamics of which acceptance and continuous use are made within the interactions between the user and PSS. Although the proposed framework contributes to the literature in both customer acceptance of PSSs and PSS design, several limitations were noted. Future works will include an empirical validation of the framework and investigations toward a new and specific design approach for continuous use of PSSs.

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