Against the IoT: a multi-method examination of the barriers to the adoption of smart objects

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Abstract:

Despite the Internet of Things (IoT) is expected to open up new business opportunities, consumers' adoption of smart objects is still limited. Extant literature has widely analyzed the barriers to consumers' adoption of innovation in general and IoT services. Conversely, it investigated the barriers to smart object adoption limitedly. Therefore, the aim of this study is to investigate the specific barriers to consumers' adoption of smart objects, and to identify the most relevant barriers across different consumer segments. This paper is based on a multi-method approach. In Study 1 (N = 132) we run a qualitative survey based on the critical incident technique while in Study 2 (N = 468) we present the results of cluster analysis based on an online survey. Our results reveal that despite price and value are perceived as relevant obstacles to adoption, privacy concern (collection) is the most important barrier in profiling consumers across clusters.

Keywords: smart objects, Internet of Things, barriers

Track: Innovation Management & New Product Development

1. Introduction

Smart objects are physical objects connected to the Internet that can interact with other objects and people, and that can collect, store, and process a huge amount of data. These actions are made by smart objects with agency, autonomy, and authority (Hoffman & Novak, 2018). These characteristics entail changes in the way consumers use and interact with this kind of innovation delineating a different context compared to that of innovation in general. The Internet of Things (IoT) is expected to unlock significant market opportunities. The combined markets of the IoT is forecasted to grow to about $520B in 2021 (more than double the $235B spent in 2017 – Columbus, 2018), and the number of devices connected to the Internet has exceeded 31B in 2018 (Morelli et al., 2018).

Despite these favourable predictions, the diffusion of smart objects in the market is still in its infancy. For instance, consumers' intentions to purchase smart objects increased only by 1% in the 2015-2016 period (Björnsjö, Lovati, and Viglino, 2016).

Scholars and practitioners have increasingly ascribed this inconsistency to the occurrence of relevant adoption barriers, that is, actual (functional and psychological) obstacles that may hinder consumers' desire to adopt innovations (Berger-de Leon, Reinbacher, and Wee, 2018; Mani & Chouk, 2017, 2018). However, while extant empirical research has focused on the barriers of adopting innovation in general (Laukkanen, 2016;Laukkanen, Sinkkonen, Kivijärvi, and Laukkanen, et al., 2007) and of adopting IoT services (Johnson, Kiser, Washington, and Torres, 2018; Mani & Chouk, 2018), the investigation of the specific barriers to the adoption of smart objects has been pursued to a more limited extent (Mani & Chouk, 2017; Park & Chen, 2007).

The present study addresses this research gap. Specifically, it aims to investigate the barriers to consumers' adoption of smart objects, and to identify the most relevant barriers across different consumer segments. In this regard, Study 1 shows the results of a qualitative study that combines the barriers identified by previous literature with those ones specific to the adoption of smart objects. Second, Study 2 shows the results of a quantitative study that highlights the most relevant barriers to the adoption of smart objects for different consumer segments.

2. Theoretical Framework

To accomplish the objective of this study, the literature about the barriers to consumers' adoption of innovations in general, smart services, and smart objects is analyzed. To date, most of extant literature concerns with the barriers to consumers' adoption of innovation in general (Laukkanen, 2016; Laukkanen, Sinkkonen, Kivijärvi, and Laukkanen, 2007; Ram & Sheth, 1989). Ram and Sheth (1989) distinguish functional barriers from psychological barriers. Functional barriers occur when "consumers perceive significant changes from adopting the innovation" (Ram & Sheth, 1989, p. 7). Functional barriers are categorized in three typologies: "usage", "value", and "risk" barriers. Psychological barriers occur when the adoption of the innovation is in "conflict with customers' prior beliefs" (Ram & Sheth, 1989, p. 7). Psychological barriers stem from the image of the innovation and from the tradition. Ram and Sheth's model has been widely tested in the service innovation context, such as mobile and Internet banking (Laukkanen, 2016; Laukkanen et al., 2007).

More recently a few studies have proposed extended versions of the Ram and Sheth's model, and empirically tested it in the context of smart services and smart objects (Mani & Chouk, 2017, 2018). In the context of smart services, Mani and Chouk (2018) adapted Ram and Sheth's (1989) theoretical framework by identifying new aspects of existing innovation barriers, such as perceived security risk, self-image incongruence, and need for human interaction. Furthermore, they identified a new category of barriers that is related to individual traits. Similarly, Johnson et al. (2018) identified the ease of use, relative advantage, visibility, perceived security, and privacy risk as barriers to the adoption of m-payment services.

In the context of smart objects, Mani and Chouk (2017) identified two groups of barriers to the adoption of smartwatch: 1) functional barriers based on product characteristics (e.g., perceived usefulness, perceived novelty, perceived price, and intrusiveness); and 2) psychological barriers based on consumer characteristics (e.g., self-efficacy). Perceived ease of use and perceived usefulness are also found to be barriers to the adoption of smartphones in the medical sector (Park & Chen, 2007).

These studies shed light on potential barriers to consumers' smart objects adoption as well as innovation and smart services. In order to further investigate the concepts discussed above, we conducted a first qualitative study to identify specific barriers to the adoption of smart objects.

3. Study 1

3.1 Method, sample and data collection

Given the need to deeper understand the barriers impeding consumers' adoption of smart objects, Study 1 envisaged a qualitative online survey, using an adaptation of the critical incident technique (CIT) (e.g., Bitner, Booms, and Tetreault, 1990). Respondents were asked to recall a recent opportunity in which they could purchase a smart device, but they decided on not buying it. They were asked to describe the incident and the motivations for the smart object non-adoption. 157 respondents participated in the study, and 25 participants were disqualified because of lack of any barrier or incompleteness of the answer. Hence, responses from 132 respondents (48 female and 84 male; average age = 32.46) were analyzed.

3.2 Results

Two independent coders categorized the responses. In some cases, individuals reported more than one motivation as to why smart objects were not adopted. These responses were classified into multiple categories yielding 204 occurrences. Discordances in coding were discussed by the coders in order to reach a solution. The categorization process resulted in nine main categories of adoption barriers. Barriers' definitions, absolute frequencies, and participants' quotes are reported in Table 1.

As evidenced from the results, perceived value and perceived price are the main consumers' barriers. This outcome is not surprising given that Study 1 is based on the memory recall of the incident. However, other relevant reasons were reported by respondents concerning the non-adoption (e.g., risky purchase and privacy concerns). Therefore, to detect and delve into the role of specific barriers for consumer segments characterized by different levels of adoption, a quantitative study is conducted with a new group of participants. To this end, a set of measurement scales were used to identify the barriers to smart objects adoption.

Barrier	**Definition**	**Qualitative comments**	**Absolute frequency**
Perceived value	Consumers perceive the smart object as useless and of low value	Int. #2: "Was debating on whether I should swap my current iPhone 6 to get the new iPhone. I didn't purchase it in the end because my current phone is working fine."	74
Perceived price	Consumers perceive the price as too high and inconsistent with the functionalities of the smart object	Int. #132: "Smartwatch. I did not buy it mainly because I found it too expensive."	54
Novelty	Consumers perceive smart objects as lacking originality and innovativeness	Int. #21: "Smartwatch. Not for the price (that I think it is too high) but for the features that don't represent a breakthrough."	20
Negative externalities	Consumers perceive a mismatch between the devices they already own and the smart objects	Int. #118: "About one month ago I was going to buy a "Samsung smart fitness watch" from Amazon, but I didn't, because it was not compatible with my Samsung tablet."	15

Risky purchase	Consumers perceive the risk of a bad purchasing decision (in terms of product, spending and contractual condition terms)	Int. #58: "Alexa…but I didn't know if I could have used it in Italy"	14
Knowledge	Consumers have not enough information about smart object features at the moment of purchase	Int. #71: "We were looking for a new TV. We had a look at a Smart TV which looked good, but we didn't know much about it. We decided to collect more information about it."	8
Privacy concerns	Consumers are concerned about how smart objects may process their personal information (i.e., collection, storage and diffusion of data, intrusiveness)	Int. #122: "I have been thinking about purchasing a larger TV such as 80". However, almost all the large TVs are Smart TVs. The problem is that I want a TV to be a TV, not a device that can listen to voice commands 24/7 and one that tracks everything you do. I believe the security on TVs is not good and it is not updated. The wifi and camera (if it includes it) can easily be turned on without your knowledge."	7
Self-efficacy	Consumers' self-perception of their ability in using smart objects is low because of their cognitive technology aversion or object complexity	Int. #80: "I had the chance to have a smart device that allowed me to control heating from any room in the house or outside. I felt that this could be too complicated, and things could just go wrong."	7
Miscellaneous	- Consumers are concerned about becoming dependent on the smart objects - Consumers' conservative personality hinders the adoption of smart objects	Int. #57: "Fitbit. I didn't buy it because I thought that it could have influenced significantly my behaviors" Int. #91: "We were going to purchase a Smart TV. However, after talking to the shopping assistant, my husband realized he didn't like the Internet via a TV as he is old fashioned, and he doesn't trust the Internet at all."	5

Table 1. Qualitative excerpts organized by category.

4. Study 2

4.1 Method, measures, sample and data collection

Study 2 envisaged a quantitative online survey. To measure the barriers to smart objects adoption, that emerged from the literature review and Study 1, we used measurement scales validated by previous literature. Some of the scales were adapted to a smart object context. The questionnaire included latent constructs measured on seven-point Likert scales (1 = "strongly disagree" to 7 = "strongly agree"), except for perceived value and price fairness that were measured with bipolar scales (Table 2)[1]. The questionnaire was composed of three sections. The first section introduced the definition of smart objects and provided some examples. In the second section, respondents were asked to recall a recent opportunity in

[1]Structural equation modeling (LISREL 8.80) was used to assess the convergent and discriminant validity of the measures. Indices of fit were all above or below the recommended thresholds. The results are available from the authors upon request.

which they could purchase a smart device, but they decided on not buying it (see Study 1 for the procedure). The third section recorded the model variables, controls, socio-demographic data, and thanked the participants. The respondents took about 12 minutes to complete the questionnaire.

A total of 516 individuals participated in the survey, and 468 fully completed the questionnaire (62% female; 59% aged 18 – 30, 26.6% aged 31 – 45, 12.6% aged 46 – 60 and 2.8% aged over 60).

4.2 Results

To better detect the barriers to the adoption of smart objects, and their relevance across different consumer segments, we conducted a cluster analysis. Respondents were clustered based on their perceptions of the main barriers (i.e., privacy concerns, collection, unauthorized secondary use, improper access, dependence, perceived value, price fairness, risk and ease of use). Individual traits (i.e., optimism, innovativeness, discomfort and insecurity), and the number of smart devices owned were not included in the clustering procedure but were used for descriptive purposes.

A two-step cluster analysis was conducted to categorize sample respondents based on their responses to the clustering variables (Punj & Stewart, 1983): first, we conducted a hierarchical cluster that suggested a 3-cluster solution; second, a non-hierarchical, k-means clustering procedure (MacQueen, 1967) was used to develop a 3-cluster solution. Table 3 summarizes the resulting segments. ANOVA analyses and Bonferroni pairwise comparison tests were conducted to compare the three clusters (Table 3). After respondents were grouped in clusters, we labelled them based on their degrees of purchase intentions and positive word-of-mouth (WOM).

Cluster 2 is composed of the “Innovators”. These consumers show the highest purchase and WOM intentions. Furthermore, this segment shows the lowest means for privacy concerns, data collection, unauthorized secondary use, improper access and dependence. Moreover, this segment shows the lowest means for the traits of insecurity and discomfort.

Cluster 1 is composed of the “Skepticals”. These consumers exhibit the lowest means on both purchase intention and WOM. This segment is significantly more concerned about privacy, data collection, dependence and risk. Skeptical consumers show the lowest means for value perception, price fairness and ease of use. Moreover, as they are compared to the other segments, the Skepticals are significantly higher on insecurity and discomfort traits, and lower on innovativeness and optimism traits.

Cluster 3 is composed of the "Early majority" and it occupies an intermediate position. This cluster shows high values of purchase intentions (not significantly different from cluster 1) and intermediate level of WOM intention. This segment is significantly different from the other two and intermediate on privacy concerns, data collection, dependence, insecurity and discomfort traits. These individuals present some similarities with the Innovators (i.e., levels of perceived value, price fairness, risk and ease of use and innovativeness and optimism traits), and some others with the Skepticals (i.e., unauthorized secondary use and improper access).

The three segments differ in terms of the relative importance they attribute to specific barriers to the adoption of smart objects. In particular, Cluster 2 and 1 differ significantly on all the barriers. Cluster 3 is similar to Cluster 2 across all the functional barriers and it is similar to Cluster 1 for the psychological barriers. Moreover, privacy and data collection concerns represent significant barriers to smart objects adoption for Early majority and Skeptical consumers.

Scale	**Source**	**M**	**SD**	**Reliability**
Privacy concern	adapted from Mani and Chouk (2017)	4.51	1.71	r = 0.81
Collection	adapted from Hsu and Lin (2016)	4.71	1.66	r = 0.83
Unauthorized secondary use	adapted from Hsu and Lin (2016)	6.42	0.92	α = 0.76
Improper access	adapted from Hsu and Lin (2016)	6.08	0.95	α = 0.78
Dependence	adapted from Mani and Chouk (2017)	3.77	1.47	α = 0.83
Ease of use	adapted from Laukkanen et al. (2007) and Lu, Yao, and Yu (2005)	5.58	1.05	α = 0.89
Perceived value	adapted from Kleijnen, Ruyter, and Wetzels (2007) and Voss, Spangenberg, and Grohmann (2003)	5.64	1.19	α = 0.94
Price fairness	adapted from Haws and Bearden (2006)	4.08	1.20	α = 0.93
Risk	adapted from Laroche, Yang, Mcdougall, and Bergeron (2005)	3.27	1.51	r = 0.71
Intentio to buy	adapted from Grewal, Monroe, and Krishnan (1998)	5.36	1.49	α = 0.96
Wom intention	adapted from Arnett, German, and Hunt (2003), Harrison-Walker (2001) and Zeithaml, Berry, and Parasuraman (1996)	4.69	1.46	α = 0.92
Optimism	adapted from Rojas-Mendez, Parasuraman, and Papadopoulos (2017)	5.27	1.10	r = 0.65
Innnovativeness	adapted from Rojas-Mendez, Parasuraman, and Papadopoulos (2017)	4.45	1.46	α = 0.90
Discomfort	adapted from Rojas-Mendez, Parasuraman, and Papadopoulos (2017)	3.89	1.02	α = 0.69
Insecurity	adapted from Rojas-Mendez, Parasuraman, and Papadopoulos (2017)	3.54	1.48	α = 0.85
Intrusiveness	adapted from Mani and Chouk (2017)	3.14	1.34	α = 0.88
Self-efficacy	adapted from Mani and Chouk (2017)	5.90	1.20	r = 0.84
Number of smart devices	adapted from Hsu and Lin (2016)	5.77	1.10	α = 0.81
Perceived critical mass	adapted from Hsu and Lin (2016)	5.78	1.35	α = 0.94
Perceived compatibility	adapted from Hsu and Lin (2016)	5.18	1.41	r = 0.87
Novelty	adapted from Campbell and Goodstein (2001), Cox and Cox (1988), Cox and Cox (2002), Dimofte, Forehand, and Deshpandé (2004)	3.05	1.45	r = 0.57
Knowledge	adapted from Smith and Park (1992)	4.37	1.46	α = 0.86

Table 2. Measures and descriptive statistics.

5. Conclusion

The results of Study 1 and Study 2 provide relevant insights into consumer perceptions about the barriers of smart objects adoption. Price and value have emerged in Study 1 as major obstacles. These findings are partially supported in Study 2. However, Study 2 revealed that privacy concern (collection) is the most important barrier in profiling consumers and assigning them to the three different clusters.

Based on these findings, we are currently developing a set of experiments. The experiments aim to assess the efficacy of intervention strategies that may reduce consumers' concern about privacy (i.e., collection of personal information), and therefore increase their likelihood of purchasing smart objects. The preliminary results of the experiments will be presented if the paper is accepted for the conference.

		Cluster						**Comparison tests**
		Innovators		Early majority		Skepticals		
		Cluster 2		Cluster 3		Cluster 1		
	Cluster size (%)	123 (26.28%)		207 (44.23%)		138 (29.49%)		F value (df); p
Clustering variables	Privacy concerns	2.34 (0.90)	(1; 3)	4.93 (1.07)	(1; 2)	5.81 (1.11)	(2; 3)	393.26 (465); p < 0.001
	Collec-tion	2.49 (0.93)	(1; 3)	5.15 (0.92)	(1; 2)	6.04 (0.90)	(2; 3)	531.80 (465); p < 0.001
	Unautho-rized secondary use	6.06 (1.26)	(1; 3)	6.50 (0.77)	(2)	6.64 (0.61)	(2)	15.43 (465); p < 0.001
	Improper access	5.59 (1.19)	(1; 3)	6.19 (0.81)	(2)	6.34 (0.73)	(2)	24.96 (465); p < 0.001
	Depen-dence	2.82 (1.27)	(1; 3)	3.83 (1.27)	(1; 2)	4.54 (1.44)	(2; 3)	55.68 (465); p < 0.001
	Perceived value	6.04 (0.96)	(1)	5.89 (0.91)	(1)	4.90 (1.39)	(2; 3)	45.81 (465); p < 0.001
	Price fairness	4.29 (1.16)	(1)	4.19 (1.03)	(1)	3.74 (1.38)	(2; 3)	8.57 (465); p < 0.001
	Risk	2.65 (1.39)	(1)	2.66 (1.02)	(1)	4.74 (1.17)	(2; 3)	153.63 (465); p < 0.001
	Ease of use	5.88 (0.86)	(1)	5.78 (0.77)	(1)	5.01 (1.31)	(2; 3)	33.00 (465); p < 0.001

Outcome variables	Int. to buy	5.78 (1.25)	(1)	5.55 (1.30)	(1)	4.69 (1.71)	(2; 3)	22.51 (465); p < 0.001
	Wom int.	5.29 (1.26)	(1; 3)	4.79 (1.25)	(1; 2)	4.01 (1.64)	(2; 3)	28.64 (465); p < 0.001
Individual traits	Optimism	5.61 (0.98)	(1)	5.37 (0.96)	(1)	4.81 (1.24)	(2; 3)	19.94 (465); p < 0.001
	Innovati-veness	4.67 (1.34)	(1)	4.55 (1.40)	(1)	4.09 (1.57)	(2; 3)	6.27 (465); p < 0.01
	Discom-fort	3.52 (1.05)	(1; 3)	3.77 (0.90)	(1; 2)	4.39 (1.00)	(2; 3)	28.84 (465); p < 0.001
	Insecurity	2.80 (1.33)	(1; 3)	3.45 (1.35)	(1; 2)	4.36 (1.39)	(2; 3)	43.89 (465); p < 0.001
Number of devices owned		4.14 (1.40)	(1)	4.05 (1.28)	(1)	3.55 (1.40)	(2; 3)	7.71 (465); p < 0.01
Demographic information	Gender (% of women)	63.41%		63.67%		57.97%		
	Age (% < 46 years)	84.55%		86.47%		81.88%		

Table 3. Consumer characteristics by cluster.

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