IoT and Smart solutions for the accommodation industry: A fuzzy logic approach

Abstract

The current competitive scenario is fast-moving toward an integration of sophisticated technological innovations, i.e. smart solutions, for hospitality, in particular the accommodation industry. Internet of Things (IoT) technologies are able to connect and let communicate different devices to craft a personalized customer experience. Given the undeniable impact for the hospitality sector, the decisions about adopting smart solutions is not always linear: benefits and limitations co-exist and need to be weighed against each other. By adopting a fuzzy-set Qualitative Comparative Analysis, this paper compares several decision-making factors that may influence the willingness to adopt IoT, surveying owners/managers in the Greek accommodation industry. Results show four sufficient solutions and the relative configurations: (i) a weighted evaluation of risks and opportunities; (ii) benefits to gain a competitive advantage; (iii) risks and barriers to innovate; and (iv) future technological necessities related to the increasing digitalization. An accurate discussion of theoretical and managerial implications is built upon these solutions.

Keywords: IoT; smart solutions; hospitality; accommodation; tourism; decision-making; fuzzy-set QCA.

1. Introduction

Given the digitalization trends, the tourism sector has been heavily affected by the digital transformation and diffusion of new digital technologies (Dickinson et al., 2014; Law et al., 2014; Pizam, 2017; Mariani, 2020). Specifically, the smart tourism paradigm creates opportunities to increase the touristic offer in terms of efficiency, visibility, traceability, and co-creation (Koo et al., 2017). Companies adopting such paradigm rely on the creation of environments in which human-machine interactions are facilitated and create large bulks of data that are then transmitted and spread autonomously among a network of objects, devices, and virtual and internet-based environments, like apps, platforms, and websites (Caputo et al., 2016; Fakahr-Manesh et al., 2020; Guinard et al., 2010; Trequattrini et al. 2016). At the base of most smart solutions is the Internet of Things (IoT), which allows for all objects and devices in a given environment to autonomously communicate with each other.

The smart solution of IoT can be used to improve the customer experience (Almobaideen et al., 2018; Femenia-Serra et al., 2019), by aligning customers' preferences to a customized experience in a way that meet customers' expectations (Centobelli and Ndou, 2019; Law et al., 2014; Lin, 2011; Pizam, 2017). Smart solutions can provide several benefits: enjoyment of the experience, like offering integrative product and services (Gretzel et al., 2015); familiarity with the travel and destination, such easiness to access ex-ante information about destination or integrated services for inter-modular transportation (Buhalis and Amaranggana, 2015; Buhalis et al., 2019); or even molding the physical environment around customers (Nolich et al., 2019).

In the accommodation industry, however, the decision to adopt such smart solutions is not free from limitations and risks in their implementation. Customers may feel not competent in dealing with the technological systems (Bogicevic et al., 2017), uncomfortable in using the technology and losing control over their data (Ho et al., 2017; Buhalis and Amaranggana, 2015). The general approach to research these topic has mostly been based on normative and theoretical contributions (Gretzel et al., 2015), qualitative case studies (Nolich et al., 2019), or rather linear statistical approach (Bogicevic et al., 2017).

Tourism in Greece is a key element of the country's economic activity, contributing more than a fifth of its overall Gross Domestic Product (GDP) (World Data Atlas, 2020). The country hosts more than 30 million tourists per year (World Bank, 2020), making Greece as one of the most popular destination worldwide, whilst creating a substantial demand for accommodation establishments. In order to accommodate this amount of visitors, in 2018 Greece had about 38,000 accommodation establishments, most of them for holidays and other short stay accommodation types (Statista, 2020). Therefore, due to the ever changing market dynamics the Greek accommodation industry needs to much further embrace the new technologies in order to sustain and further strengthen its competitiveness (Kozak and Buhalis, n.d.; Pappas, 2015; 2018). However, as previously mentioned, the literature is predominantly silent in terms of non-linear statistical approach, whilst the examination of technological adaptation (let alone IoT) in the accommodation industry is nonexistent.

Nevertheless, the understanding of a complex mechanism of balancing benefits and challenges of smart technology adoption in the accommodation industry requires a more complex, non-linear investigation. Hence, the present study aims at improving our knowledge of decision-making about IoT and smart solutions adoption in the accommodation industry by adopting complexity theory and fuzzy logic to develop a comprehensive explanatory framework. The analysis is performed on a dataset of 528 managers/owners of Greek accommodations, through a *fuzzy-set Qualitative Comparative Analysis* (fsQCA). The results confirm the better accuracy of fuzzy analyses over linear models (Pappas, 2019a).

The aim of this research is to examine the willingness of the Greek accommodation providers to adopt IoT. For doing so, it evaluates the aspects of perceived benefits, risks, barriers, competition, innovation and the technology competence of the examined companies. This paper contributes theoretically by validating the assumption that adoption process of smart tourism and IoT is a complex matter that needs to be approached in terms of configurational approach where different factors are weighed against each other. Methodologically, the study further confirms the suitability of nonlinear (asymmetric) research in tourism, which for the discipline is a fairly innovative approach (Pappas 2018, 2019b). Finally, at a practical level, the generated solutions offer hints to hotel owner/manager about most relevant combinations of factors that should receive a careful attention when the decision of adopting IoT and smart solutions is evaluated.

2 Literature review and tenant postulation

2.1. Smart solutions, IoT and smart tourist accomodation

Smart tourism is global phenomenon that is shaping the whole competitive arena (Law et al., 2014; Wang et al., 2016). Nevertheless, smart tourism refers to a rather blurred concept that encompassed a broad array of interventions related to technological innovations (Buhalis and Amaranggana, 2015; Gretzel et al., 2015). Examples of smart solutions range from the trivial creation of a Wi-Fi network accessible at the location site to complex architectural environments in which consumers' preferences are used to mold the touristic experience (Almobaideen et al., 2018; Balandina et al., 2015; Bogicevic et al., 2017; Femenia-Serra et al., 2019). This concept also includes IoT technologies related to a network of objects that use internet to communicate (Guinard et al., 2010). IoT occurs when objects are able to produce data from their functioning and surrounding environments and to share them with other devices, also autonomously (Caputo et al., 2016). Specific protocols allow the interface of different devices and objects and thus the sharing of specific located information across the connected network (Guinard et al., 2010).

As already presented, the implementation of IoT technologies and smart solutions in hospitality can generate a positive impact on the overall touristic sector (Balandina et al., 2015; Dickinson et al., 2014; Pizam, 2017; Mariani, 2020). From a business point of view, the impact can be even more considerable for the accommodation industry in terms of customers' perceptions and operative efficiency (Gretzel et al., 2015).

The use of smart technologies can help tourists to reduce the challenges experienced in dealing with unfamiliar environments outside the safety and familiarity of one's surroundings (Buhalis et al. 2019; Nolich et al., 2019). In conjunction with the whole tourism ecosystem, customers' devices can communicate offers and events for a specific location or being used to register preferences from which infer behaviors that can be anticipated (Centobelli and Ndou, 2019). However, customers unfamiliar with smart technologies can feel at unease in accessing an already foreign environment that is technologically advanced and automated (Střelák et al., 2016). Furthermore, concerns are raising about the need of control over personal data and privacy violations (Ho et al., 2017; Ozturk et al., 2017). Millennials too, despite their technological savviness, expressed serious concerns about data protection and sharing (Femenia-Serra et al., 2019). Thus, tourists put in front of a smart environments may withdraw from engaging with the whole experience (Buhalis and Amaranggana, 2015). For these reasons, the appeal to invest in smart technologies can be limited if these elements are not valued from customers and if the integrative front-office services do not create new significant value (Chen et al., 2017).

There are also several operational benefits in adopting smart technologies for the back-office management of a tourist accommodation. Similarly to other industries, IoT can increase operative efficiencies leading, for example, to waste reduction (Zhang et al., 2017), quick response in case of emergencies (Balandina et al., 2015), optimization of the parking spaces (Mishra et al., 2019). The operative side of a tourist accommodation can also benefit from the data produced by a series of IoT appliances such as smart lights, smart water meters, and smart heating systems. In combination with Big Data and Artificial Intelligence programs, these data can help to gain information and intelligence regarding customers' preferences even without their intervention and, at the same time, to optimize the operations costs by reducing inefficiencies (Inanc–Demir and Kozak, 2019; Trequattrini et al. 2016). Therefore, the emergence of smart environments and IoT technologies seem able to redefine business models to develop and sustain competitive advantage (Wang et al., 2016; Centobelli and Ndou, 2019; Trequattrini et al. 2016).

Implementing smart technologies requires balancing the benefits and challenges against the needed economic investment (Gretzel et al., 2015). Sophisticated solutions require a strong interaction between virtual and physical environments with the instalment of smart appliances and sensors, condition that can naturally increase implementation expenses (Almobaideen et al., 2018; Caputo et al., 2019; Lin, 2011; Nolich et al., 2018). This investment will be even larger if the organizational and technological bases of the company are not solid nor ready for sophisticated innovations (Ho et al., 2017; Saarikko et al., 2017; Sarath-Divisekera and Nguyen, 2018).

2.2. The chaordic perspective

In brief, the theory of chaos was first introduced in 1963 (Lawrence, Feng & Huang, 2003). It indicates that organisational action and structure are capable to influence both the environment and the company (Levy, 1994), whilst it examines the way that chaos and order occur and ultimately lead to changes (Farazmand, 2003) even if it is almost impossible to provide standardised answers due to the variation of organizational and human capacities (Silvestre et al., 2018). The theory of complexity theory has evolved from the theory of chaos (Pappas, 2019a) and suggests that we cannot explain via cause and effect relationships several aspects around us, since specific effects may appear from random interactions, lacking any kind of deterministic cause (Kretzschmar 2015). The concept of a 'chaordic system' derives from the strong relationship between chaos and complexity (Fitzgerald and Van-Eijnatten, 2002), taking its name from the term 'chaord', which is an amalgamation of the words chaos and order (Van Eijnatten et al., 2007). Such systems include a dynamic and complex connection set between elements that form a unified whole, with unpredictable (chaotic) behaviour, whilst simultaneously including specific patterns (order) (Olmedo, 2011).

2.3. Complexity in a smart tourism context and study of the tenants

There is still a scares attention to the main elements that may drive the decision of investing consistent financial and organizational resources to include smart solutions in the tourist reception offer and back-office operations (Bogicevic et al., 2017).

Think of a hotel targeting the elderly tourist segment and the nexus of factors affecting the decision-making around the adoption of IoT and smart solutions. Due to the possible difficulties in dealing with technological innovations of the generalized elderly population, such customers may perceive little, if any, value in smart accommodation solutions. Furthermore, the investment to fill the gap between the current traditional offer and the minimum requirements for adopting smart solutions can be large.

The operational mode of the accommodation, annual or seasonal, is also another important factor. Seasonal accommodations may find the level of investment to adopt IoT too high, risking to capitalize most of future additional earnings. This may further discourage innovations. However, an accommodation that overcomes the technological resistances of its customers could significantly improve their experience and thus their satisfaction and loyalty. IoT allows for more control over the physical surroundings, improving the serviscape and the co-created personalized experiences (Buhalis and Amaranggana, 2015; Roy et al., 2019). A smart serviscape through smart wearable devices allows for the possibility of a continuous monitoring activity, opening up avenues in the health and lifestyle tourism (Pizam, 2017; Almobaideen et al., 2018). Considering the aging of the population in developed economies, this customer segment will grow and smart solutions may help first-movers to gain a sensible competitive advantage (Balandina et al., 2015).

From this example, we may infer that benefits of IoT can offset costs and barriers in implementation. However, a linear logic may fail to fully address the complexity of the problem. The willingness of company to adopt IoT, either positive or negative, can result from the evaluation of the several factors weighed against each other rather than a simple causal logic. The same factor may lead to different outcomes due to the occurrence or intensity of other conditions. Thus, despite the importance of identifying a set of influencing factors, the analysis of their configuration is the key strategy to understand the proper response to a complex touristic decision (Pappas, 2019a). Such condition forces to replace the traditional statistical hypotheses development to a configurational analysis, with the creation of 'tenets' or testable precepts (Wu et al., 2014). The set of tenets should be large enough to grasp the order of conditions related to the complexity at hand (Pappas, 2018).

This specific study examines the presence or absence (binary state) of the willingness to adopt IoT technologies in a touristic accommodation by the key decision-maker, i.e. the owner or manager. Along with the operational mode of the accommodation busienss (annual or seasonal), it is possible to summarize six relevant influencing factors: perceived benefits, perceived risks, perceived barriers, competition, innovation, technology competence.

Hence, this study formulates six tenets (Ti) and their related confirmation criteria (Ci) (Pappas, 2019a).

T1: The same attribute (factor) can determine a different decision depending on its configurational structure/interaction with the others.
C1. All six simple attributes should appear at least in one sufficient configurational solution, i.e. generated solution.
T2: Recipe principle: if two or more simple attributes create a complex configuration, higher scores will be consistently assigned to this generated solution.
C2. At least two out of the six simple attributes should appear in each generated solution.
T3: Complex interactions/configurations may affect the willingness of adopting IoT technologies.
C3. Each sufficient generated solution should provide a different interaction among simple attributes.
T4: Within different combinations, the simple attributes can either positively or negatively influence the willingness to adopt IoT.
C4. None of the simple attribute should appear in all generated solutions.
T5: Equifinality principle: A sufficient configurational solution, thus the presence of a willingness to adopt IoT, is not necessary the result of higher outcome scores for the simple conditions.
C5. fsQCA should provide a minimum of two generated solutions for describing the patterns of the willingness to adopt IoT.
T6: Although the outcomes scores are high, such a given recipe is not relevant for all cases, thus it cannot stimulate the willingness to adopt IoT in all cases.
C6. There should be no generated solutions that have a coverage in all cases.

3. Methods

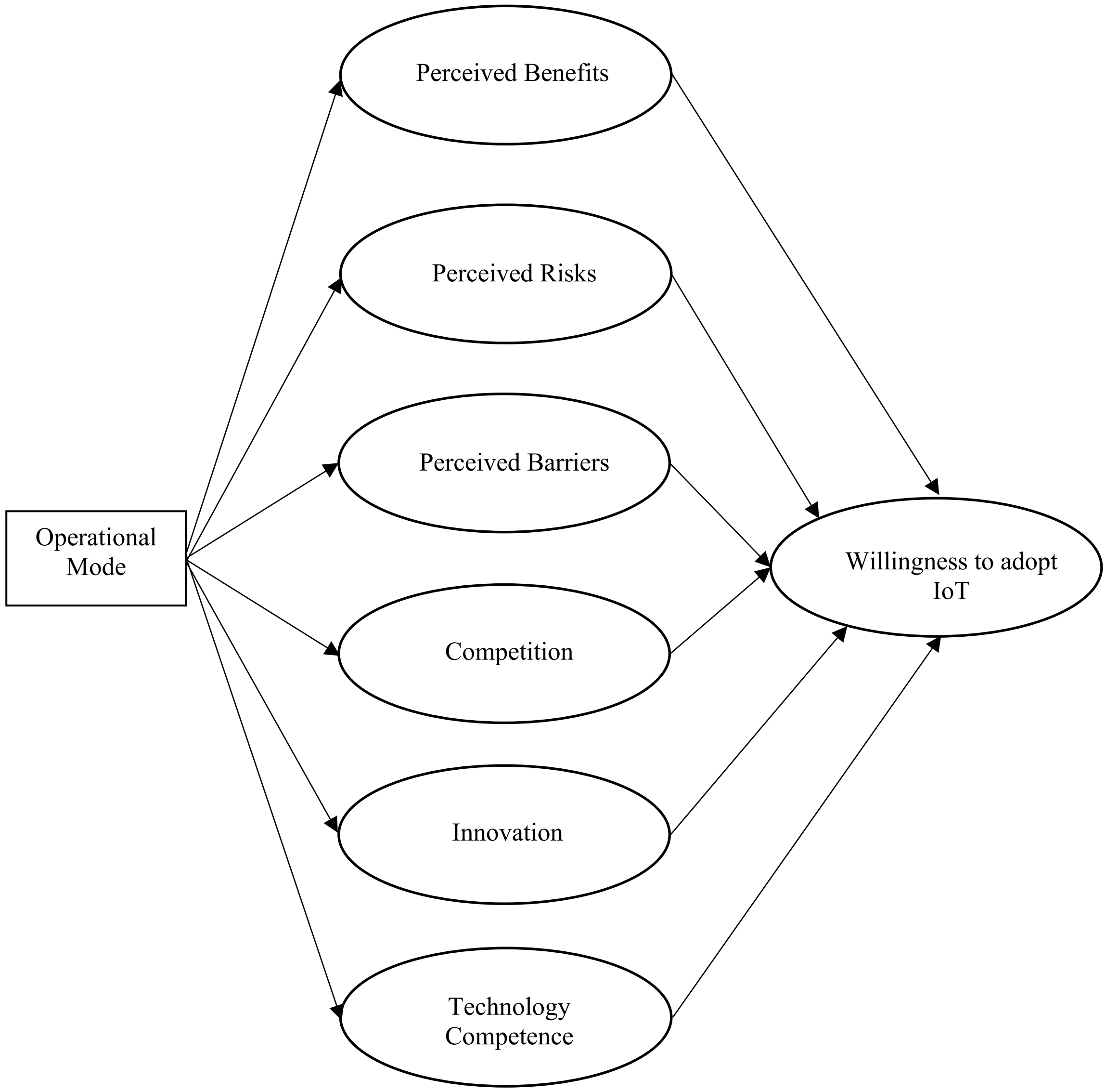
3.1. Sample and measures

The research is based on a nationwide survey. Questionnaires were sent via email to Greek accommodation managers/owners during summertime 2019. Due to this data collection method, the response rate was expected to be low. Thus, approximately 5000 emails were sent. Greek Travel Pages (www.gtp.gr) was used as a source of the email addresses. In total 528 usable questionnaires were collected (Statistical error: 4.26 percent; Level of confidence: 95.74 percent). For missing data handling listwise deletion was adopted (exclusion of the entire record from the analysis), since this is considered as the least problematic method (Allison, 2001).

The questionnaire consists of 42 Likert scale statements (1 strongly disagree / 5 strongly agree). These statements are included in seven different constructs, and all of them have been adopted from previous research. More specifically, the statements concerning perceived benefits (nine statements) and perceived barriers (eight statements) have been adapted from the study of Tan et al. (2009). The five items examining perceived risks have been taken from the studies of Cocosila and Trabelsi (2016), and Ho et al. (2017). The four statements included in competition construct and the six items in technology competence have been adopted from Wang et al. (2016). The five innovation items have been taken from Divisekera and Nguyen (2018). Finally, the willingness to adopt IoT (five statements) has taken under consideration the studies of Gao and Bai (2014), Ozturk et al. (2017), and Park et al. (2017). Moreover, one question was examining the operational mode (annual; seasonal) of the accommodation establishments, and one more question (as an exclusion factor) was included in the questionnaire in order to ensure that the respondents were owners/managers of the respective firms. A linear presentation of the proposed model is illustrated in Figure 1.

The research has analyzed the collected data by using fuzzy-set Qualitative Comparative Analysis (fsQCA), in an attempt to encapsulate the complexity essence. fsQCA evaluates the relationships that can formulate the interesting outcome of any combination of binary sets created from its predictors (Longest and Vaisey, 2008). It is considered as a mixed-method technique since it embeds quantitative empirical testing (Longest and Vaisey, 2008) and inductive qualitative reasoning generated by case analysis (Ragin, 2000). It handles logical complexity by taking under consideration that alternate combinations of characteristics can generate different results when they are combined with different conditions and/or events in an appropriate manner (Kent & Argouslidis, 2005). Negates sets (absence or presence of a given condition) are also examined. Following the study of Skarmeas, Leonidou and Saridakis (2014), the calculation of the membership score in a negated set is made by taking from the original fuzzy set one minus the membership score of the examined case.

Figure 1: The proposed model.



According to Ordanini, Parasuraman and Rubera (2014), in the set theory, a sub-relation's consistency with fuzzy measures is generated when the scores of membership in a causal set of attributes are equal or systematically less than the scores of membership in the outcome set. As a result, the calculation of consistency is:

$$Consistency(X_i \leq Y_i) = \sum_i [\min(X_i; Y_i)] / \sum_i (X_i)$$

where, for owners/managers *i*, X_i is the score of membership in the *X*. Following the same study, Y_i and configuration are the scores of membership in the outcome condition, whilst coverage embeds the assessment of the empirical importance of the generated solutions. Thus, the calculation of coverage is:

$$Coverage(X_i \leq Y_i) = \sum_i [\min(X_i; Y_i)] / \sum_i (Y_i)$$

The metric of asymmetric consistency is analogous to the metric of symmetric correlation, and the metric of asymmetric coverage is analogous to the determination of the symmetric coefficient. Woodside, 2014). When a generated solution is between .27 and .75, and has a consistency above .74 it is considered informative and acceptable (Skarmeas et al., 2014). Furthermore, the score of membership of a causal recipe (complex antecedent condition) is defined as the minimum of the scores of membership of the intersecting simple fuzzy-set causal conditions they include the examined recipe (Woodside and Zhang, 2013). In the correlation matrix, when all coefficients are less than .6, a general asymmetry exists among variables in the respective relationships (Skarmeas et al., 2014), and the causal conditions generated by alternative combinations are likely to lead to the same condition of outcome (Woodside, 2013). As it is showcased in Table 1, all coefficients are less than .6, showcasing the study's general asymmetry. Through the use of fsQCA, this study evaluates the way Greek accommodation providers perceive the potential of the Internet of Things (seventh construct) in their business by focusing on causal recipes that lead to high scores of membership in the other six constructs. The study is based on a non-linear analysis in order to describe the combined relationships and to identify asymmetric relationships.

Table 1: Correlation matrix

		1	2	3	4	5	6	7
1	Perceived Benefits	1						
2	Perceived Risks	.051	1					
3	Perceived Barriers	.007	.011	1				
4	Competition	.046	.102*	.016	1			
5	Innovation	-.065	.015	.028	.013	1		
6	Technology Competence	.117**	.073	.092*	.097*	.079	1	
7	Willingness to Adopt IoT	-.029	-.008	-.007	-.019	.041	.135**	1

*Correlation is significant at the 0.05 level.
**Correlation is significant at the 0.01 level.

Table 2 instead presents the results of the descriptive statistics.

Table 2: Descriptive statistics

	Statements	**Means**	**SD**	**Operational Mode**		**Kurtosis**	**Skewness**
				Annual	*Seasonal*		
	Perceived Benefits						
PB1	IoT can reduce my business costs	3.98	.633	4.07	3.92	.900	-.438
PB2	PB2: IoT can speed up my business communications	3.78	.827	3.85	3.74	.782	-.743
PB3	IoT can provide higher reliability upon my business communications	3.64	.939	3.64	3.64	-.039	-.725
PB4	IoT is an efficient means for coordination among firms	3.70	.875	3.85	3.61	-.280	-.597
PB5	IoT can provide closer relationship among trading partners	3.58	.918	3.70	3.50	-.706	-.380
PB6	IoT can provide better customer communications	4.07	.671	4.17	4.01	.392	-.425
PB7	IoT can generate new business opportunities	4.05	.663	4.14	3.98	.581	-.444
PB8	Through IoT I can access further market information and knowledge	3.91	.648	3.99	3.86	.133	-.211
PB9	Through IoT I can improve my business management and organisation facilitation	3.67	.866	3.78	3.59	-.417	-.443
	Perceived Risks						
PR1	By using IoT there is a risk that my corporate data stored on, and managed by, cloud storage services providers will not be secure.	3.67	.938	3.81	3.58	.591	-.845

PR2	By using IoT there is a risk that my corporate data stored on, and managed by, cloud storage services providers will not be well protected.	3.83	.956	3.99	3.73	.462	-.820
PR3	By using IoT there is a risk that service providers of cloud storage solution will not perform due diligence and will not secure our corporate data.	3.51	1.012	3.58	3.46	-.502	-.522
PR4	By using IoT I should consider the risk that fraudulent behaviour may exit through hacking by stealing and leaking sensitive information.	3.96	.958	4.08	3.87	.635	-.926
PR5	By using IoT I feel that there will be an increasing overdependence of technology.	3.56	.847	3.64	3.50	.281	-.316
	Perceived Barriers						
PBA1	IoT in unsuitable for my business.	2.84	.906	2.84	2.83	-.336	.193
PBA2	It is difficult to find personnel with appropriate knowledge in IoT.	3.08	.940	3.09	3.08	-.726	-.259
PBA3	I don't have sufficient network infrastructure for supporting IoT.	3.07	.840	3.10	3.06	-.409	-.159
PBA4	Employing IoT has a high cost.	3.41	1.084	3.38	3.43	-.888	-.141
PBA5	IoT has an expensive software.	3.31	1.068	3.29	3.32	-1.034	-.060
PBA6	IoT has unbalanced investment costs and returned benefits.	2.71	.939	2.71	2.71	-.393	.262
PBA7	The laws concerning IoT are not clear.	3.06	1.027	2.99	3.11	-.645	.229
PBA8	I don't trust the provided security of IoT.	3.12	1.115	3.11	3.13	-.793	.254
	Competition						
C1	My hotel will experience competitive pressure to introduce IoT.	4.27	.627	4.41	4.18	.964	-.608
C2	My hotel will gain a competitive disadvantage if IoT is adopted.	3.98	.885	4.14	3.86	-.010	-.744
C3	We may lose customers to our competitors if we do not adopt IoT.	3.85	.903	4.00	3.76	-.561	-.438
C4	We feel that it is a strategic necessity to introduce IoT in order to be competitive in the current market.	4.22	.851	4.56	3.99	.214	-.932
	Innovation						
I1	IoT will be innovative for our hotel's services.	4.10	.831	4.29	3.96	.543	-.899
I2	IoT will be innovative for our hotel's marketing.	4.09	.619	4.17	4.04	1.261	-.494
I3	IoT will be innovative for our hotel's human capital.	3.76	.953	3.86	3.69	.140	-.844
I4	IoT will be innovative for our hotel's Information Technology.	4.28	.649	4.37	4.21	.285	-.556
I5	IoT will be innovative for our hotel's collaboration activities.	3.50	1.076	3.58	3.45	-1.011	-.418
	Technology Competence						
TC1	The information technology infrastructure of my hotel is able	3.48	.803	3.71	3.32	-.066	-.396

	to support IoT-related applications.						
TC2	My hotel is dedicated to ensuring that employees will be familiar with IoT-related technology.	3.65	.842	3.94	3.46	.015	-.436
TC3	The employees of my hotel should contain a high level of IoT-related knowledge complexity.	3.29	.909	3.49	3.15	-.446	-.307
TC4	We believe that an IoT is complex to implement.	3.74	.910	3.84	3.67	-.558	-.296
TC5	We believe that developing an IoT is a complex process.	3.88	.918	3.96	3.83	-.474	-.464
TC6	Integrating an IoT into our work practice is very difficult.	3.41	1.120	3.56	3.31	-.790	-.299
	Willingness to Adopt IoT						
WA1	Given the chance I intend to use IoT.	3.65	.945	3.93	3.46	-.067	-.525
WA2	I am willing to use IoT in the near future.	3.11	1.211	3.25	3.02	-1.047	-.164
WA3	I plan to use IoT.	3.80	.970	4.10	3.60	-.051	-.632
WA4	I will recommend IoT to others.	3.98	.957	4.28	3.78	-.290	-.683
WA5	I predict that I should use IoT.	4.07	.940	4.36	3.87	-.183	-.778

4. Results

As the present research includes 528 Greek accommodation institutions, Table 3 shows the sample divided by operational mode.

Table 3: Profile of enterprises

Operational Mode	**N**	**%**
Annual	214	40,5
Seasonal	314	59,5
Total	*528*	*100*

Table 4 describes the grouping variables named “f_” for the various construct used in the fuzzy set model. The symbol “*” has been used for separating the constructs and an indication of their inclusion in model evaluation. The symbol “~” has been used to indicate the excluded construct.

Table 4: Complex solutions for the Internet of Things

Complex Solution	**Raw Coverage**	**Unique Coverage**	**Consistency**
Model: f_wa=f(f_om,f_pb,f_pr,f_pba,f_c,f_i,f_tc)			
S1: f_om*f_pb*f_pr*f_pba*~f_c*~f_i*~f_tc	0.43059	0.12847	0.86837
S2: f_om*~f_pb*~f_pr*~f_pba*f_c*f_i*~f_tc	0.45947	0.14625	0.84273
S3: ~f_om*~f_pb*f_pr*f_pba*f_c*~f_i*f_tc	0.39893	0.13840	0.81028
S4: f_om*f_pb*~f_pr*~f_pba*~f_c*f_i*~f_tc	0.41482	0.11834	0.80581
Solution Coverage: 0.42635	*Solution Consistency*: 0.82894		

f_om: Operational mode	f_pb: Perceived benefits
f_pr: Perceived risks	f_pba: Perceived barriers
f_c: Competition	f_i: Innovation
F_tc: Technology competence	f_wa: Willingness to adopt Internet of Things

The results coming from fsQCA comprise four complex solutions, as highlighted in Table 4. Based on the emergent findings, S1, the first sufficient configuration (f_om*f_pb*f_pr*f_pba*~f_c*~f_i*~f_tc), suggests that the inclusion of the grouping variable operational mode (f_om) together with the perception variables related to benefits (f_pb), risks (f_pr), and barriers (f_pba) is able to produce a risk-evaluation approach for IoT potential adopters. The first solution appears to have the highest consistency (0.868) of all four solutions, with 0.430 coverage. S2, the second solution (f_om*~f_pb*~f_pr*~f_pba*f_c*f_i*~f_tc), shows that the grouping variable (f_om) together with the competition-related variables (competition, f_c; innovation, f_i) is able to produce a competition-based approach with a high consistency (0.842) and the highest cover among the four solutions (0.459). S3, the third solution (~f_om*~f_pb*f_pr*f_pba*f_c*~f_i*f_tc), which excludes the grouping variable, comprise the possible drawbacks associated with IoT adoption with specific attention to risks (f_pr), barriers (f_pba), competitive issues (f_c), and the required technological competence (f_c). S3, the third solution shows good consistency (0.810) and a satisfactory level of coverage (0.398). Finally, S4, the fourth solution (f_om*f_pb*~f_pr*~f_pba*~f_c*f_i*~f_tc), introduces the grouping variable (f_om) again together with perceived benefits (f_pb) and innovation (f_i) showing a process aimed to encompass the future necessities of the business in association with IoT. This final solution has an acceptable consistency (0.805) and a good level of coverage (0.414). Overall, the coverage is good (0.426) and the solution consistency high (0.829). According to methodological references (Skarmeas et al., 2014), this result indicates a satisfactory and informative solution that permits to provide a series of practical and methodological implication.

5. Discussion and Implications

The findings coming from the present study can generate an interesting discussion and contribution around the decision-making around IoT adoption in the tourism sector, particularly the accommodation industry.

As shown in the introduction part, the attention paid to the adoption of IoT by the tourism sector is still scarce and with possible contrasting evidence. The results of this study offer a more precise picture of decision-making in the accommodation industry, identifying several influencing drivers when it comes to service innovation via smart solutions. These drivers are interconnected together in a nexus of decisions; one of these is the perception of the environment by the managers who have to decide about the integration of smart technology in their touristic offers. Such perception and the adoption decision revolve around three levels of elements respectively benefits, risks, and barriers associated with the integration of IoT in the current offering and its serviscape (Carcary et al., 2018; Roy et al., 2019). Secondly, the interconnected nexus of elements intervening into the decision of adoption are summarized into other the decision-maker(s)' perceptions specifically: the sector competition, the extent to which IoT is considered as a viable innovation, and the level of technological competence possessed by the company (Inanc–Demir and Kozak, 2019). Likewise, the operational mode of the company, annual vs seasonal, emerged as another aspect to be considered regarding the willingness to adopt IoT technology in the tourism industry (Pappas, 2018).

The first resulting solution (S1) deals with the evaluation of risks and opportunities associated with adopting smart solutions. Within this solution, the accommodation managers try to examine the perceived risk evaluation and balance the beneficial and the adverse effects of adopting IoT, weighing them against each other. While several studies remarked the benefits arising from integrating IoT solutions into business processes in terms of cost reduction and better service offered to final users (Haddud et al., 2017; Pizam, 2017; Uden and He, 2017), the decision to adopt IoT requires high initial investments in term of financial resources, personnel training, and organizational redesign that could be unsustainable for small businesses (Saarikko et al., 2017). As a result, managers need to evaluate the potential barriers that could reduce the appeal of adopting IoT for specific industries (Carcary et al., 2018; Kamble et al., 2019). The evaluation to adopt or not IoT should be included in a larger picture where additional digitalization paradigms that can enhance the touristic experience are considered in connection with IoT, such as Big Data and Artificial Intelligence (Inanc–Demir and

Kozak, 2019). In this vein, the first solution (S1) propose a holistic view of the IoT potential benefits and risks in term of the resources needed to integrate an IoT infrastructure into the business model of an accommodation. The operational mode (f_om) is included in this solution showing that different types of accommodation consider IoT benefits and risks according to the type of tourists they target.

The second solution (S2) comprises the competitive benefits related to the possible adoption of IoT. As previously noted, IoT shortly will be able to extensively reshape competitive advantage and the dynamics for entire industries similar to what happened into the manufacturing and logistics sector (Saarikko et al., 2017; Trequattrini et al., 2016). Following the market reshaping inducted by IoT, fast movers can gain a defendable and strong competitive position in comparison to latecomers (Westergren et al., 2017; Pizam, 2017; Buhalis et al., 2019). S2 shows that IoT could be used to gain a robust and sustainable competitive advantage. IoT allows strengthening the strategic positioning by offering breakthrough innovations into the business model of a hotel or another type of accommodation. However, IoT could generate a robust competitive advantage only if the customers of the accommodation perceive this element as beneficial during their stay (Pizam, 2017; Buhalis et al., 2019; Roy et al., 2019). Therefore, evaluating the customers' needs and expectations is essential also to leverage the co-created experience via smart solutions that in turn will affect loyalty and word of mouth marketing (Roy et al., 2019).

The third solution (S3) stimulates a reflection around the potential drawbacks and challenges associated with the amount of resources needed to effectively implement IoT (Balandina et al., 2015; Buhalis et al., 2019). The necessary competencies needed for the inclusion of IoT elements into the business model could be relevant and costly to be acquired and developed (Haddud et al., 2017; Carcary et al., 2018). Moreover, customer worries about privacy and their unfamiliarity with smart technologies may hinder the benefits of IoT adoption (Střelák et al., 2016). Therefore, during and after the implementation of IoT solutions, several issues could emerge, mainly related to the extreme novelty of the IoT technology.

Finally, the fourth solution (S4) pertains to a reflection about future technological necessities related to the increasing digitalization of the overall accommodation industry (Bogicevic et al., 2017; Pizam, 2017; Buhalis et al., 2019). A report from McKinsey (Bhattacharjee et al., 2017) showed that several hospitality companies started to equip rooms and lobbies with virtual assistants producing a new type of smart serviscape. In solution four (S4), the willingness to adopt IoT is considered as a way to anticipate future trends and consequentially to preserve competitive positions in the industry. The trend identified by Buhalis et al. (2019), and McKinsey (Bhattacharjee et al., 2017) showed that the hospitality and tourism sectors are moving toward a more pervasive offering based on extra-sensory, hyper-personalized, and beyond-automation integration. In this changing environment, IoT is an enabling technology that can create smart environments aiming to redefine how customers navigate their experiences. Examples of a near-future are related to the reengineering of operational steps such as check-in and check-out possibly replaced with automatic processes, room keys and access or room-service immediately available via smartphone. Similar considerations can be made about the ability to optimize pricing through more accurate analyses and predictions based on customers' or market big data (Bhattacharjee et al., 2017).

Accommodation businesses cannot ignore this trend. Therefore, S4 remarks the evaluation made by managers to catch future necessities of their own business concerning the changing market trends. Operational mode plays a role in shaping how the introduction of IoT and other smart technologies could be useful or not for their type of customers. For example, automatic check-in could be more useful for annual accommodations as they mainly rely on business travelers who may require a 24/7 services.

5.1 Confirmation of Tenets

As shown in Table 4, the coverage of the four generated solutions by the fsQCA is acceptable (0.426). Also, all seven constructs appear in at least one sufficient configuration. This evidence confirms that every sufficient configuration includes a different combination of the examined simple conditions, even if all solutions finally lead to the same outcome (Pappas, 2018). Consequently, every attribute contributes differently to the willingness to adopt IoT. This evidence leads to the confirmation of the first tenet (T1). The four sufficient configurations include at least three attributes out of seven. It confirms that the emerged recipe includes at least two simple conditions leading to the desired outcome. This finding is in line with previous studies (Pappas, 2018; Olya and Altinay, 2016) that leads to the confirmation of the second tenant (T2). Since fsQCA is based on cases instead of variables, the solution proposed generates a combination of variables and association with such configurations (Ordanini et al., 2014). As we discussed above, emerged solutions result from a nexus of complex configurations that have an impact on the outcome, namely, the willingness to adopt IoT. Therefore, a complex configuration may affect the willingness to adopt IoT (T3). Also, since the present study used contrarian case analysis (inclusion/exclusion of attributes), the extent to which a simple condition is present or absent determines its positive or negative influence on the willingness to adopt IoT, confirming the T4. Next, according to the equifinality principle (Woodside, 2014), multiple paths could lead to the same outcome. Considering that the results in Table 4 are not particularly high, data showed that a different approach could be used to reach the same and desired outcome. T5 is, therefore confirmed. Finally, as highlighted in Table 4, the coverage of the configurations identified varies from 0.398 to 0.459. This result suggests that none of the four solutions applies in all cases and covers the entire population (Olya & Altinay, 2016). This evidence confirms the T6, which highlights that a given recipe for the willingness to adopt IoT is not relevant for all cases.

5.2 Fit and predictive validity

Most studies evaluate the extent of the inclusion of factors among the observed variables and their generated relationships by employing model fit (Pappas, 2019a). As a result, very few studies employ predictive validity (Wu et al. 2014) and suggest that a good model does not have to be dependent on a relevant good fit to observations (Gigerenzer and Brighton, 2009). The current research progresses from fit to predictive validity for the models under evaluation, following the process designated by Wu et al. (2014). More specifically, the sample is divided into equally sized holdout and modelling sub-samples, in such way that the patterns of the perceptions of accommodation providers concerning IoT are a consistent indicator for the generation of a high score. The configurational models of the holdout sample are examined with the use of the modelling sub-sample, whilst the combination of the algorithm of the holdout sample is similar to that found from fsQCA for the whole sample. Then, the holdout sample is examined by the modelling sub-sample. The model was consistent by .824 (C1>.74) having a coverage of .416 (.75>C2>.25). The findings indicate a good predictive validity

5.3 fsQCA versus correlational analysis

In the service sector, most studies use correlational analysis (Pappas, 2019a). Hence, the analysis of this study is based on the comparison of fsQCA with the dominant correlational analysis in service-oriented research (regression), aiming to examine the methodological value of fsQCA. Nevertheless, it needs to be highlighted that any comparison of fsQCA with other modes of analysis must be implemented with caution due to the fact that the former employs alternative assumptions (such as complex causality) by setting different objectives, it does not use variables but focused on cases, and it progresses to the identification of the generated solutions through the provision of necessary and adequate conditions in terms of the result it examines (Ordanini et al, 2014).

The evaluation of linear relationships between the examined model's constructs was made through Structural Equation Modelling (SEM). Since all the examined items were adopted from previous research, Confirmatory Factor Analysis (CFA) was employed, whilst SEM has identified and determined the causal relationships amongst constructs. Following Martens (2005) χ^2 ratio is the most common measure, and when it is non-significant it showcases a good fit. When large samples (as in this case) are examined, χ^2 should be divided with the degrees of freedom (χ^2/df) (Chen and Chai, 2007). Kline (2010) suggests that there are numerous fit indices that can be used, but the most important are four of them (χ^2; Comparative Fit Index [CFI]; Standardised Root-Mean-Square Residual [SRMR]; Root-Mean-Square Error of Approximation [RMSEA]). The findings have generated the following results: χ^2=512.367, df=278, χ^2/df=1.843 (acceptable value is $0 \leq \chi^2/df \leq 2$ [Schermelleh-Engel, Moosbrugger, and Müller, 2003]), CFI=.911 (acceptable value is close to 1.0 [Weston and Gore, 2006]), SRMR=.729 (acceptable value is when SRMR<.8 [Hu and Bentler, 1999]), and RMSEA=.435 (acceptable value is when RMSEA<.5 [Browne and Cudeck, 1993]).

Factor analysis has identified the study's important components. All values less than .4 have been suppressed (minimum acceptable value is .4 [Norman and Streiner, 2008]). The evaluation of internal consistency was measured through Crombach's A, whilst in all constructs, the values have exceeded .7 (minimum value .7 [Nunnally, 1978]). Convergent validity was measured by Average Variance Explained (AVE), and in all cases, it has exceeded .5 (minimum acceptable value .5 [Kim, 2014]), whilst in all constructs, Composite Reliability (CR) has exceeded AVE's scores. The loadings of factor analysis are presented in Table 5.

Table 5: Factor analysis

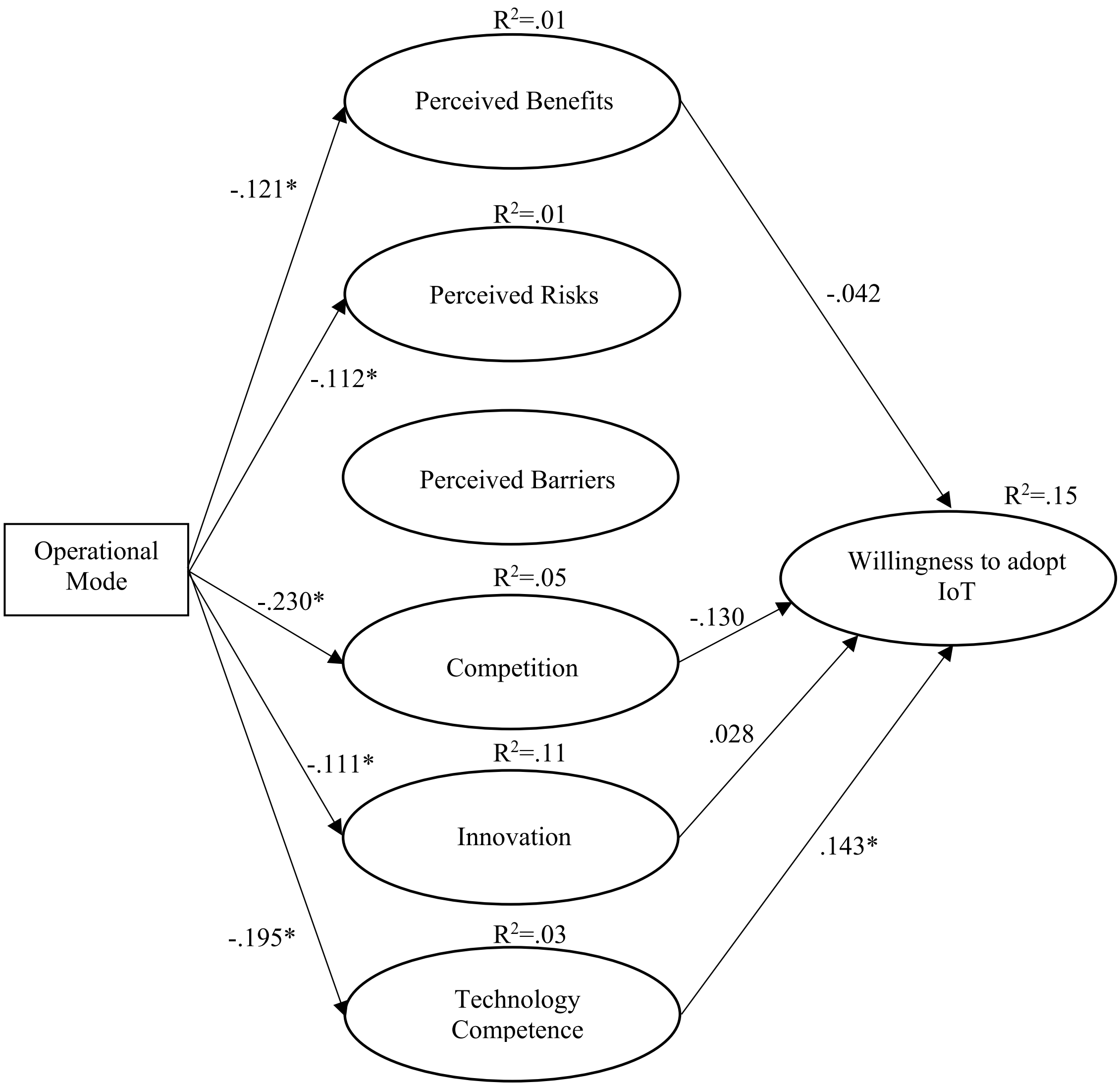
Statement	**Loading**	**A**	**AVE**	**CR**
Perceived Benefits		.913	.629	.937
PB1	.930			
PB2	.729			
PB3	.546			
PB4	.788			
PB5	.722			
PB6	.854			
PB7	.882			
PB8	.854			
PB9	.766			
Perceived Risks		.927	.771	.944
PR1	.945			
PR2	.911			
PR3	.848			
PR4	.842			
PR5	.840			
Perceived Barriers		.917	.650	.936
PBA1	.902			
PBA2	.908			
PBA3	.851			
PBA4	.778			
PBA5	.692			
PBA6	.825			
PBA7	.740			
PBA8	.724			
Competition		.866	.683	.896
C1	.798			
C2	.859			
C3	.845			
C4	.801			
Innovation		.769	.607	.860
I1	LC			
I2	.824			
I3	.829			
I4	.713			

I5	.744			
Technology Competence		.889	.651	.917
TC1	.892			
TC2	.799			
TC3	.746			
TC4	.896			
TC5	.812			
TC6	.674			
Willingness to Adopt IoT		.891	.725	.928
WA1	.885			
WA2	.604			
WA3	.930			
WA4	.922			
WA5	.872			

LC: Eliminated due to low commonality

Figure 2 illustrates the study's endogenous variables. The overall R^2 of the linear model was .15. The categorical variable of operational mode appears to impact most examined constructs (except 'perceived barriers'), mostly influencing 'competition' and 'technology competence'.

Figure 2: IoT adoption in Greek accommodation businesses.



The study has further focused on the comparison of asymmetric (fsQCA) with correlational (regression) analysis. Despite the fact that each analysis has used different algorithms, the research has followed the comparison mode of other previous studies (Ordanini et al., 2014; Pappas, 2019b) and examined their findings. It has evaluated the ability of the respective methods to better highlight the produced complex patterns. The study compared the ability of each method to express the different influences and potentially identify alternative routes that are able to lead to the same outcome, and the coverage extent of the sample under examination.

The results showcase that regression is limited to the provision of a single pathway (i.e.: the linear influence of operational mode of the examined constructs: perceived benefits, risks, and barriers; competition; innovation; technology competence) and the effect of the latter on the intention to use IoT. As it is apparent, parametric analysis cannot adequately encapsulate the full range of alternative combinations and effects that can lead to the same outcome, while this is considered as an inseparable and permanent element of complexity (Pappas, 2019a). For example, SEM analysis appears to suggest that 'perceived risks' and 'perceived barriers' do not influence the 'intention to use IoT'. Conversely, both simple conditions are included in two generated solutions (S1; S3), able to influence IoT usage intention. One more aspect is that all four generated sufficient configurations produce a much higher row coverage (between .399 and .459) and consistency (over .8), compared with the parametric results that offered a low R^2 (.15).

6. Conclusion

In the present research, we focused our attention on the willingness to adopt IoT innovations among the Greek accommodation businesses (annual and seasonal). The present paper stems from the idea that in order to remain competitive, the accommodation industry should embrace the benefits coming from smart technologies that could permit and extension of the services offered (Pizam, 2017; Buhalis et al., 2019). From a practical viewpoint, we identified that four possible combinations of solutions have emerged. Each solution covers a different aspect of the adoption of IoT and deals with specific issues emerging in the decision to adopt IoT. In brief, solution one (S1) mainly deals with the risk evaluation in adopting IoT. Conversely, solution two (S2) deals with the possible competitive benefits coming for IoT, while solution three (S3), mainly focused on potential drawbacks resulting from the introduction of this emerging technology. Finally, solution four (S4) encompasses the future necessities of the hotel industries concerning IoT adoption in consideration of changing market trends within the tourism industry.

Managers should consider IoT as a viable source of competitive advantage that could act at two different levels. The first level is the front-office or customers' point of view, by offering extra-sensory and hyper-personalized experiences that could attract particular categories of tourist. Considering the operational side, IoT adoption could help reducing inefficiencies in routine operations thanks to a constant monitoring of appliances and resource usages. This contributes to the reduction of waste and increases the overall sustainability footprint of the business.

This paper also offers methodological contributions as it further refines the use of the fsQCA method and fuzzy logics in management studies, particularly to the thematic areas of tourism and services sector studies, innovation and business model research. The study supported the claim that non-linear methods are suitable to explore the complexity of the environment for the tourism sector.

Alongside its contributions, the study has also some limitations. The use of a cross-sectional survey from a single country is a limitation, which opens up avenues for future research to test and extend the study results in different countries and by adopting different research methods (Pappas, 2018), both qualitative and quantitative including for example a longitudinal analysis. Such extension would allow to compensate the possible geographical bias in the resulted solutions. Future researchers could also expand the validity of this study by focusing on different industries to contribute to a more comprehensive understanding of the adoption decisions of IoT and smart technologies.

Future avenues could exist in the exploration of specific strategies to facilitate the implementation and adoption of IoT at the different stage of the value chain and within the different aspects of the serviscape. Moreover, future research could also focus on the investigation of the role played by cognitive biases and personality (Abatecola et al., 2018; Caputo, 2014) toward the usage and adoption of smart technologies.

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