Smart services' quality scale

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Abstract: Despite the increasing interest on smart industries, research on smart services quality remains limited and focusing only on technological and engineering characteristics. Until now, little is known about customer expectations of superior smart services performance, which makes the identification of smart services quality from the customers' perception an important research topic that is not yet considered in the literature. Therefore, this study aims to conceptualise smart service quality with a particular emphasis on the active role of customers' co-creation in smart services. The paper updates the service quality literature by validating SMART-QUAL measurement scale suggested to be used within the smart context. The new developed measurement scale is composed of 13 items consisting of three dimensions namely: functional value, smartness level, and privacy control.

Keywords: innovation; internet of things; IoT; service-dominant logic; SDL; co-creation; quality; smart services; SMART-QUAL.

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1 Introduction

Smart services have been widely discussed in the literature in recent years. Since such services are relatively new developments; best practices have not been well defined yet and relevant research fields that can provide an in depth understanding of smart services are still under-researched.

The shift from goods-dominant logic into service-dominant logic (SDL) view has led to a greater concentration on the consumer who has become actively involved in value co-creation network. Industry 4.0 is considered the turning point in today's business. Its impact is prevailing in the fact that the emergence of "internet of things (IoT) allows people and things to be connected anytime, anyplace with anything and anyone ideally using any path/network and any service" (Alcácer and Cruz-Machado, 2019) with a virtual representation on a digital platform. The key challenge is to understand how traditional quality concepts are aligned with emergent changes due to Industry 4.0, which requires an emphasis on data-driven service quality (Sony et al., 2021).

In the context of this study, smart service is defined as a digital service platform characterised by technology-mediated continuous interactions resulting in real-time information exchange from various sources connected within a digital ecosystem. Therefore, smart services are recognised to be highly dynamic and quality-based service solutions, convenient for customers and realised with technology, thus co-creating value in all phases. It is evident that the customer plays a significant role in smart services' success. But existing research to date focus on investigating the technological adoption aspects from a stream of technical engineering viewpoints, and neglect other complementary research perspectives (Beverungen et al., 2019; Dreyer et al., 2019; Chouk and Mani, 2019). Smart service systems' logic is built upon intelligent data processing mechanisms that monitor, optimise, and autonomously adapt their actions in nearly real-time based on day-to-day digital network activities.

Thus, co-create value propositions that are tailored to the needs of individual customers, creating more personalised service experiences with little or no intervention from the service providers, which challenge the basic concepts of pre-engineered service quality. Additional, further research is required to re-conceptualise service quality dimensions in smart settings, especially that there is a lack of knowledge regarding smart service quality perceptions (Beverungen et al., 2019; Neuhüttler et al., 2019a). Drawing on an integration of service innovation and the distinctive characteristics of smart services and the dynamic interactions between various actors in the service system, this study focuses on re-conceptualisation of smart service quality from a customer perception to introduce a refined and updated smart service quality measurement scale that is not yet considered in the literature.

2 Smart services a type of service innovation

The preliminary review of service innovation body of knowledge in the last two decades, uncovered that previous studies in the arena of service innovation primarily comprise four theoretical perspectives:

1. The assimilation or technological perspective, which pinpoints that innovation in services is same as manufacturing with an emphasis on its relationships with technology.
2. The demarcation or differentiation perspective, which emphasises that distinctive innovation activities in service mainly focus on service specificities.
3. The inversion perspective, which claims that knowledge-intensive business services play active role in innovation, therefore some industries can be seen as source of innovation.
4. The integration or synthesis perspective, which asserts the necessity of using same analytical framework for both manufacturing and service industries.

Nowadays you can see manufacturing firms 'servitising' and service firms 'productising' which means there is no distinction between innovation for goods and services or for technological and non-technological forms of innovation thus from this point of view, we can build a better understanding of innovation processes and practices (Djellal et al., 2013).

The concept of service innovation is considerably new field of research and to some extent poorly understood. Sometimes it is seen as the process of developing new services while in fact, service innovation tends to focus on the outcomes of the process. The most recent advanced theoretical progress in service innovation is the integrative approach known as 'SDL'. It consists of replacing the distinction between goods and services with the idea that 'all is service'. It recognises the importance of value-in-use perspective that focuses on service outcomes to create new service experience, which means that value is experiential (Leroi-Werelds, 2019). Therefore, it can be concluded that service innovation is viewed in terms of what it does to the customer by generating value, not in terms of the new features added (Patrício et al., 2018; Djellal and Gallouj, 2018).

Djellal et al. (2013) define service as mobilisation of internal or external competences and techniques to produce final service characteristics. This point of view is grounded on client competencies, service provider's characteristics, technical characteristics, and final users' service characteristics. They argue that it is possible to make changes to service characteristics by increasing, eliminating, replacing, associating, dissociating, and formatting certain characteristics, which will consequently result in different modes of innovation. In light of this thinking, Durst et al. (2015) claim that in a knowledge-based economy, service innovation encompasses not only, the introduction of new service concept in the market but also, introducing new ways customers are involved for value co-creation, new service delivery systems, and new technologies which reflect the multidimensional facets of service innovation.

Previous research mostly ignored the effect of service innovation on the customers' perception of value. Therefore, it is proposed that service innovation should be observed from the perspective of changes in value of offerings rather than focusing only on aspects connected to the offerings' characteristics. As a result, the customer and new value creation are considered central in understanding service innovation. Thus, it can be deduced that the notion of service innovation implies 'newness' and 'value co-creation' which denotes that service innovation would evolve from new value propositions and value co-creating experiences of the benefiting parties (Snyder et al., 2016).

It is evident that technological evolutions have always been a game changer. Therefore, the IoT has opened numerous opportunities to service innovation by creating new value for one or more actors connected in the service network; due to the increasing connectivity of consumers to a multitude of technologies in their daily lives which make them access the service anytime, anywhere and using any device (Chouk and Mani, 2019). Thus, it is concluded that the data generated from IoT-based services is what really matters to develop individual configurable offerings to create new customer value. IoT is characterised by smart technologies' configurations, thus push organisations to reconsider its interactions with customers and restructure actors' network roles to develop data-driven services enabled by technologies and systems that provide better decision making due to data detectability and enhance end-to-end seamless smart services experience (Pawar et al., 2021).

The underlying logic of smart services is typically built around rethinking the 'smartness of offerings'. Lee and Shin (2017) assert that a product/service with human like intelligence ability of learning, adaptation, reaction, and self-direction is commonly identified smart. Therefore, by connecting the physical and digital world, we create a smart ecosystem empowered by continuous flow of information to capture and co-create new forms of value for every single customer connected in the network. Smart services are seen as intelligent digital technologies able to learn, adapt and make decisions considering real-time data processed (Romero et al., 2020).

It is important to note that smart service interpretation can be derived from SDL fundamental premises related to value, resources, and customer role. Tommasetti et al. (2015) pinpoint that a vital determinant of value-in-use emerges from the customers' experiential perceptions of value. Furthermore, the intangible resources related to knowledge and human capabilities to contribute in value creation are central in SDL. Accordingly, the customer active involvement in value co-creation is indispensable as it implies the customer role in developing value jointly with the service providers. By recognising the active role of customer in co-creation activities as a dominant principle in service dominant-logic (Roy et al., 2019), it can be concluded that the willingness of customers to interact, participate and engage in smart service co-creation is crucial. Whereas, smart services expose different levels of intelligent behaviours triggered by the active consumption of smart service consequently, co-creating smart experiences (Roy et al., 2019)

Smart services represent a special type of services that are composed of three core elements: physical, smart and connectivity components. The dynamic interactions between connected network actors with different activity levels of interactions ranging from low to high (Wünderlich et al., 2013) are considered at the heart of smart services. Moreover, it is argued that it is different from e-services and is an entirely new approach of service offerings that it is characterised by

1. embeddedness that allows data transmission and information generation
2. integration of big data analytics
3. full or partial services' automation aligned with human interactions
4. the customer perception of greater services' customisation by reacting on emergent contextual conditions and requests (Götz et al., 2018).

3 Rethinking service quality within smart context

Quality has always been viewed as a multi-dimensional concept that can be defined from different perspectives. Going back to 1988, in an attempt to better understand quality, Garvin has put forward five approaches arising from interdisciplinary research. Garvin (1988) states that quality can be examined and defined from the point of view of

1. manufacturing-based approach which implies the degree of conformance to specifications
2. product-based approach which is concerned with precise and measurable variables found in the product attributes
3. user-based approach that describes quality in terms of customers' needs and expectations fulfilment

4 value-based approach which refers to quality as the degree of excellence at an acceptable price or the control of variability at an acceptable cost

5 transcendent approach denotes the feelings towards a product or service, quality is intuitively understood.

Although the quality discipline is considered interdisciplinary and grew across overlapping phases during the last three decades, it was noticed that service quality has always been challenging to define, measure and assure than products' quality due to the intangibility, perishability, inseparability, inconsistency and involvement features of services which make service quality more subjective (Romero et al., 2020).

Most of the service quality literature was built from the 'what' aspects of service discussing the outcomes' delivered rather than the 'how' aspects that focus on ways used to deliver service and the image attributed by customers (Prakash, 2019). SERVQUAL is the most widely accepted service quality model to measure service quality in a variety of contexts. Both SERVQUAL and SERVPERF scales are extensively used for overall evaluation of service performance by conceptualising 'conformity and disconformity' with respect to five dimensions comprising: reliability, responsiveness, assurance, tangibles and empathy that were identified as the most important service quality determinants perceived by customers (Prakash and Mohanty, 2013). Yet, the influence of internet was highly visible in many industries thus; traditional services have been rapidly replaced by e-services that are defined as value exchange via electronic channels with a specific focus on transaction assessment from the perspective of the system, information and service (Moon and Armstrong, 2020). Consequently, differ from traditional services in how the transaction processes are implemented.

Loiacono et al. (2000) proposed WebQual scale to rate websites on 12 dimensions including: informational fit to task, interaction, trust, response time, design, intuitiveness, visual appeal, innovativeness, flow-emotional appeal, integrated communication, business processes, and substitutability. Also, Yoo and Donthu (2001) developed SITEQUAL for measuring site quality in terms of four dimensions: ease of use, aesthetics design, processing speed, and security. Whilst, Barnes and Vidgen (2002) proposed WebQual index consisting of five dimensions: usability, design, information, trust and empathy. However, all these scales were criticised that they are more concerned with desirable websites characteristics and transaction-specific assessment aspects of a site rather than measuring the perceived service quality experienced by customers (Parasuraman et al., 2005).

It should be clearly emphasised that e-service quality is not the same as website quality. Consideration of e-service quality issues should go beyond website qualities. But, since websites are the primary communication interfaces with the customers in the e-context, the employee's factors were removed with more emphasis on multiple aspects of value exchanges via electronic channels such as technological features, processes, and flow of web-based services. Therefore, in response to the emergent need to redefine a comprehensive e-quality measurement scale Parasuraman et al. (2005) developed E-S-QUAL to measure electronic services quality in terms of four dimensions namely efficiency, system availability, fulfilment, and privacy. Furthermore, because e-recovery is an important aspect of online services they proposed E-RecS-QUAL a separate scale that focuses on the quality of online support throughout measuring three dimensions including: responsiveness, compensation, and contact.

Despite the fact that a vast amount of research has been conducted in this area, until now there was no relevant scale or model measuring e-service quality. Mostly, all scales were built up on SERVQUAL rational with added dimensions reflecting the integral characteristics of e-services to measure e-channels performance levels (Chen et al., 2017; Firdous and Farooqi, 2019).

Moving into a smarter environment that is marked up with new digital technological developments (i.e., augmented reality, virtual reality, big data, cloud computing and IoT), more people are adopting new smart services that feature awareness and connectivity. It is thus deduced that smart services' differentiating characteristics evolve around ubiquity, intelligence, connectivity, autonomous, and higher levels of interactivity with actors in the service system which will definitely affect the customer's perception of smart service quality (Roy et al., 2019).

Smart service is characterised mainly by its ability to learn, adapt, react and make decisions to the individual's context in real-time (Dreyer et al., 2019). While on the other hand, e-service is hypothesised in literature as an interactive service for value exchange electronically in an effective and efficient way; thus focus on transaction processes via diverse online channels and its outcomes (Chen et al., 2017). Thus, it is crucial to pinpoint that although smart services are defined as digital services but it is not synonymous to e-services.

Until now research regarding smart service quality is still in its infancy stage, and little is known about quality perceptions of these new data-driven service systems. Although limited research tried to draw on strong similarities detected between different quality concepts to link to smart services, but still failed to reflect smart services' core characteristics (Neuhüttler et al., 2019b). One of the comprehensive few attempts to fill this research gap is the research conducted by Neuhüttler et al. (2019a) who introduced a quality matrix structure that is built upon existing service quality literature to describe smart services elements using an integrative quality framework. However, their approach is more oriented towards adopting manufacturing perception of new services development by outlining a generic checklist of quality categories that has not been validated from the customers' perception.

It is important to put in mind that servitisation has brought new dynamics into customer-service provider interactions to co-create value (Romero et al., 2019). The inclusion of the customer role in co-creation as proposed by SDL, necessitates an extension to service quality definition to reflect its dependability on customers' acceptance and involvement in value created (Alzaydi et al., 2018). Therefore, additional research is still required to conceptualise smart service quality determinants to be able to update existing quality measurement scales so that it reflects smart services' specific quality attributes perceived by the customers as will be detailed further in the next sections.

4 Conceptualising smart service quality

It became a trend to include smart services into different contexts (i.e., smart retail, smart healthcare, smart cities, smart tourism and smart factory); however until now little is known about customer expectations and evaluation of smart services, which makes understanding customers' perceived quality of smart services an important research topic (Neuhüttler et al., 2019a). Therefore, the point of departure in this study is to draw on the findings from Prakash (2019) systematic literature review of 828 articles published during 1984 to 2017. Whereas, the quality attributes/dimensions that exhibit strong similarities as agreed upon in the literature and that reflect the core qualities of services are used for operationalising and measuring service quality across different industry sectors as illustrated in Table 1. Whilst the quality elements related to specific industry applications are omitted.

Table 1 Initial set of quality attributes and dimensions per sector extracted from literature

Sector	*Set of attributes*	*Dimensions for operationalisation*
Manufacturing (total 140 studies)	Innovative techniques, channel relationships, prompt delivery, inter-organisational communication, flexibility, trust and security	Service reliability, credibility, service competence, financial trust, control of flow, low lead time, interaction and availability
Banking (total 134 studies)	Responsiveness, availability, assurance, reliability, regular functionality, prompt grievance handling, communication, and safe and secure	Gives helpful advice, wide range of services, competitive charges, speed of decisions, functionalities, access, flexibility, privacy incentives, fulfilment and efficiency
E-commerce and IT (total 147 studies)	Responsiveness, assurance, reliability, trustworthiness, cyber security and promptly handling complaints	Information quality, system availability, efficiency, privacy, fulfilment, usefulness, ease of use, accuracy, timeliness and customisation
Retail (total 59 studies)	Ease accessibility, assurance, accurate information provided to customers and resolving customers grievances	Performance, service and relationships, convenience, prices and customer care
Healthcare and pharmaceutical (total 178 studies)	Reliability, assurance, responsiveness and communication	Availability as and when required, handling complaints and completeness of information
Tourism and hospitality (total 63 studies)	Reliability, accessibility, flexibility and trustworthiness	Professionalism, customisation, credibility and recovery options
Higher education (total 107 studies)	Communication and prompt feedback	Access, quality and availability of resources and effective use of technology

Source: Prakash (2019)

Moreover, it is worth mentioning that a study conducted by Hizam and Ahmed (2019) determined that IoT-based quality services model should incorporate items from SEVQUAL, E-SERVQUAL and SSQUAL. Accordingly, it can be observed that most of the work depicted in the literature discloses similar or overlapping quality dimensions that can be used in all contexts regardless the type of industry. But still none of the previously discussed approaches fully encapsulated the essence of smartness. Riegg et al. (2016) state that "a service is defined smart if it exposes at least one of the levels of smartness (human-machine interactions) in the identified capabilities (agency, learning, context-consideration, self-description) in at least one of the functional and non-functional aspects" (see Table 2).

Table 2 Smart services capabilities and levels of smartness

Capabilities	*Levels of smartness*		*Levels of smartness description*
Agency	1 2 3	Cooperate Plan Execute	At the basic level the service cooperates with other actors in the network to achieve its goal; in the second level it plans independently from given information within a set of known services which it is allowed and designed to interact with, but whatever the service plans it still requires the acknowledgement of the user; at the highest level execution, it extends its activity room autonomously.
Learning	1 2 3	Adapt Improve Self-X	At the basic level the service learns users' preferences and adapt their behaviour to a given context; in the second level the service improves its operation and offers respective options and asks users for feedback usually the user or the system has the possibility to intervene; at the final level it optimises itself without user intervention and can handle complex situations with the provided information autonomously.
Context consideration	1 2 3	Include Process React	At the basic level the service is able to pick-up and include some parts of the context information, yet continues and acts according to users' preferences; at the second level it fully processes the context information and uses it as defined in their mode of operations to select best choices for the user; at the final level it reacts autonomously to changing context since it continuously monitors information received during execution.
Self-description	1 2 3	Static Semantic Dynamic	The service on the basic level provides static description about itself; the second level describes services which are able to provide their semantic description; in the final stage services are not only able to semantically describe themselves but also to dynamically update this information.

Source: Adapted from Riegg et al. (2016)

In spite of the immersive research on service quality in both the conventional and digital contexts; yet, not much of attention is paid on updating a scale that incorporates smart services distinctive characteristics and evaluates its quality dimensions. It can be concluded that there is a need to update the existing service quality measurement with new combinations related to smart service context.

5 Scale development procedure

5.1 Measurement scale items

The researcher relied on literature review as primary source of information to map the dimensional structure of 'smart service quality' construct in order to include items that reflect theoretical understanding of each dimension (Carpenter, 2018). In line with the above mentioned discussion, it is argued that adding specific items that measure the quality of customer intelligent experience (Fan et al., 2020) will help identify new updated combinations of quality attributes perceived in smart services. The researcher aims to update the existing service quality measurement scales by incorporating new set of attributes that are deemed to be necessary for evaluating smart service quality based on the review of relevant literature.

The specific measurement items included are adapted from existing measurement scales identified in the literature as they reflect specific aspects that describe smart service quality domain discussed earlier (see Table 3). Due to the adoption of items from various sources, experts' theoretical evaluation of the scale items and its relationship to the measured latent variable prior to proceeding into data collection phase was necessary. Four experts were asked to complete the survey and give their comments on ambiguity or confusing items, which led to some suggestions to improve clarity of the items and deleting some items that were found either repetitive or irrelevant to the construct domain (Hair et al., 2019). The final list of scale items was refined into 42 items rephrased to fit the study context, and rated on a seven-point Likert-type. Participants were asked to indicate their level of agreement with the statements in a scale ranging from 'strongly disagree' to 'strongly agree'. It is argued that the adapted scales practically in all cases, should be converted to a seven-point or higher points to increase the responses' variability, thus obtain more accurate statistical analysis (Hair et al., 2019).

As shown in Table 3, items adapted from Yi and Gong (2013) and Alves and Wagner Mainardes (2017) will measure the customer participation and citizenship behaviours which can explain the active consumers' role in smart services' value co-creation. Moreover, items were adapted from Merz et al. (2018) to measure the customer connectedness with smart services' network. On the other hand, items were adapted from Considine and Cormican (2016) and Alves and Wagner Mainardes (2017) to measure the customer perceived benefits attained. Furthermore, items developed by Fan et al. (2020) and Marimon et al. (2019) are adapted to give more insight into the experience of customers with smart services' interactions. To measure the level of smartness, measurement items developed by Lee and Shin (2018) are adapted. Finally, the researcher finds it important to measure trust, safety, privacy, and control as major implications of smart services. Therefore, scale items were adapted from Marimon et al. (2019), Merz et al. (2018) and Xu (2007).

It is a very common practice to use adequate sample sizes in factor analysis, whereas 42.8% of articles published used a sample size ranging from 101–200 participants (Carpenter, 2018). Accordingly, data collection was performed via SurveyCircle (2020), an online research platform using two consecutive rounds of simple random sampling (Singh, 2003), whereas the first sample ($n = 156$) was used for exploratory purposes to identify the underlying dimensions of the smart service quality, while the second sample ($n = 308$) was used for confirmatory purposes to examine and confirm the measurement scale. See Table 4 for data set characteristics.

The sample was tested for suitability to proceed with EFA, the Kaiser-Meyer-Olkin (KMO = 0.871) indicating that sampling adequacy was met, while the Bartlett's test of sphericity was significant (approx. chi-square = 3,127.836; df = 78; $p = 0.00$) suggesting the correlation matrix was significantly different from the identity matrix and therefore factorable.

Table 3 Scale items adapted from the literature

Scale items	*References*
Smart services are simple and easy to use	Lin and Hsieh (2011)
Smart services must have a clear privacy policy stated	
Smart services provide me with accurate, comprehensive and real-time information	
I can get my task done in a short time using smart services	
Smart services make it easy for me to find what I need	Marimon et al. (2019) and Merz et al. (2018)
Smart services make it easy for me to successfully complete my transactions	
Smart services quickly respond to my inquiries and resolve my complaints	
Smart services must have adequate security features to conduct online transactions	
Smart services give me access to a variety of products and offer complementary services	
Smart services offer me different options according to my needs and requirements	
Smart services allow me to connect with other people	
Smart services help me coordinate my daily tasks from any device, anytime, everywhere	Wiedmann et al. (2010)
Smart services keep me in touch from any device, anytime, everywhere	
Smart services make life easier	
I will always like to be sure that smart services are secure before using it	
Smart services enable me to order products in a way that meets my needs	Treasure and Holmes (2009) and Roy and Bhatia (2019)
Smart services interact with me at the times promised	
Smart services enable me to choose between different options and compare different offerings	
Smart services will perform the required task right from the first time	
Smart services learn my preferences and provide me with customised services to satisfy my needs	Considine and Cormican (2016)
Smart services can do a lot, have multiple functions and perform multiple tasks	
Smart services can make relevant decisions by itself without any external intervention	Lee and Shin (2018)
Smart services can manage given and collected information by itself without any intervention	
Smart services manage information, notifications and decisions by itself without my interference	
Smart services can react to changes and adapt its behaviour to optimise its performance	
I feel unsafe about providing personal information to use smart services	Xu (2007)
I feel I don't have control over the amount of information collected by smart services	
I feel I don't have control over how my personal information is used by smart services	
I feel I don't have control over who can access my personal information	

Table 3 Scale items adapted from the literature (continued)

Scale items	*References*
I feel insecure that my personal information can be released and I can't control it	Xu (2007)
I am concerned that smart services are collecting too much personal information	
I am concerned that smart services don't have appropriate measures to prevent unauthorised access to my personal information	
I will gain new knowledge and expertise by using smart services	Verleye (2015) and Alves and Wagner Mainardes (2017)
Smart services will entertain and stimulate my mind	
Smart services will expand my personal and social network	
I will search for information about smart services either online or offline	
I will always find someone to help me with any problems related to smart services	
I will provide all required information to use smart services	
I will give my opinion and share ideas about smart services, either online or offline	
I will follow the instructions and guideline necessary to use smart services	Yi and Gong (2013)
I will assist others if they need help to use smart services and give them advice	
I will encourage friends and relatives to use smart services	

Table 4 Datasets characteristics

Samples demographics	*Sample 1 (n = 156)*		*Sample 2 (n = 308)*	
	Number	*%*	*Number*	*%*
Gender				
Male	55	35.3%	106	65.6%
Female	101	64.7%	202	34.4%
Age				
Less than 20	3	1.9%	9	2.9%
20–29	62	39.7%	157	51.0%
30–39	51	32.7%	89	28.9%
40–49	28	17.9%	34	11.0%
50–59	11	7.1%	16	5.2%
60 and above	1	0.6%	3	1.0%
Nationality				
Egyptian	69	44.2%	75	24.4%
Other	87	55.8%	233	75.6%

5.2 *Measurement scale reliability and validation*

The valid and reliable measurement of a construct require multiple indicators to accurately define and measure the latent variable (Hair et al., 2019). Since the researcher is not able to detect the direct relationship between items; but can determine the existence of satisfactorily inter-correlation with one another by exploring the latent variable dimensional structure using exploratory factor analysis (EFA) the most recommended approach for new scale development. The researcher followed Carpenter (2018) recommendations to use principal axis factoring (PAF) as he suggests that it is a robust extraction method when sample size is small and not normally distributed. Moreover, affirms that the results from common factor analysis are more generalisable than principal components analysis and reliable to successively perform a confirmatory factor analysis (CFA). As for the rotation method, an oblique strategy was deployed using promax (Russell, 2002) since it was expected that there are some correlations among factors especially that it is assumed that multiple dimensions are related to 'smart service quality' construct.

The EFA reduced the pool of pool of 42 items; the EFA resulted in three structured factors explaining 72.798 % of total variance. Thus, the overall scale is considered acceptable since it explains at least 50% of variance (Carpenter, 2018). The factors with eigenvalue greater than 1 were extracted and all cross loading items >0.40 were removed. A total of 13 scale items with loadings >0.65 are retained indicating its best fitting factors. All retained items reported satisfactory item-to-total and inter-item correlations within their factor >0.50 (Worthington and Whittaker, 2006).

The definitive dimensions with its operational definitions were established upon examining the structure of items making up each factor, the average variance extracted (AVE) results are >0.5, and the composite reliabilities (CRs) results are >0.7 demonstrating convergent validity. The measurement scale is reliable displaying Cronbach's alpha (α) > 0.7 for all dimensions (Fornell and Larcker, 1981; Hair, 2011; Taber, 2018). The final SMART-QUAL scale is presented in Table 5.

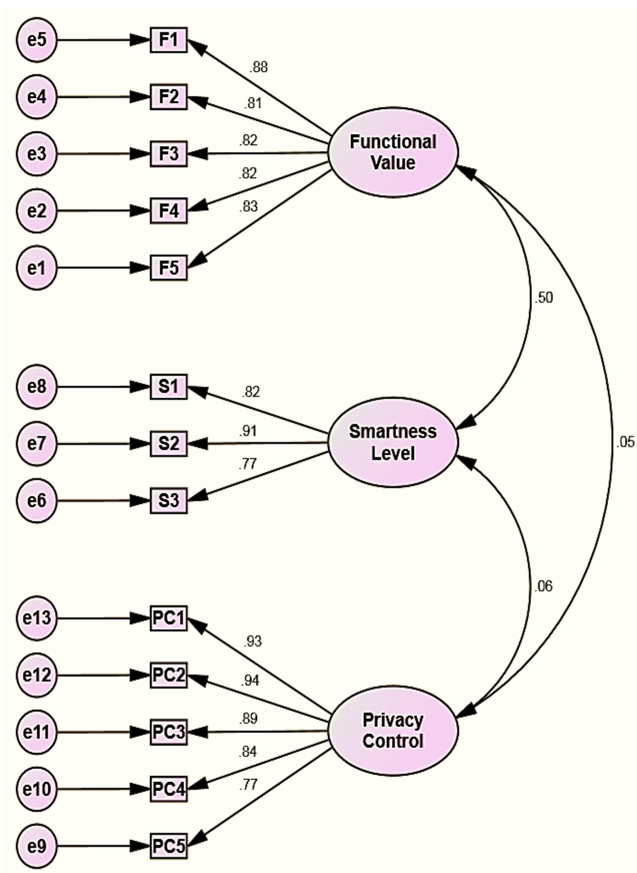
Table 5 SMART-QUAL scale

	Dimension(s) definition and items	*Items loading*	*CR*	*AVE*	*α*
1	Functional value		0.92	0.69	0.918
	Accessible, convenient and easy to use service that reduces time and effort				
	Smart services make it easy for me to find what I need	0.90			
	Smart services make it easy for me to successfully complete my transactions	0.82			
	Smart services provide me with accurate, comprehensive, real-time information	0.82			
	Smart services enable me to order products in a way that meets my needs	0.82			
	I can get my task done in a short time using smart services	0.80			
2	Smartness level		0.87	0.69	0.873
	Human like intelligence abilities of learning, adaptation, reaction and self-direction				
	Smart services can manage given and collected information by itself without any intervention	0.87			
	Smart services manage information, notifications and decisions by itself without my interference	0.81			
	Smart services can make relevant decisions by itself without any external intervention	0.81			

Table 5 SMART-QUAL scale (continued)

Dimension(s) definition and items	*Items loading*	*CR*	*AVE*	*α*
3 Privacy control		0.94	0.77	9.43
Extent of control users have over information communicated and their privacy protection				
I feel I don't have control over who can access my personal information	0.93			
I feel I don't have control over how my personal information is used by smart services	0.93			
I feel I don't have control over the amount of information collected by smart services	0.88			
I feel insecure that my personal information can be released and I can't control it	0.86			
I am concerned that smart services don't have appropriate measures to prevent unauthorised access to my personal information	0.78			

Figure 1 SMART-QUAL path diagram (see online version for colours)



The next step consisted of conducting a CFA on a separate sample to validate the proposed scale using structural equation modelling (SEM) – AMOS 24 (see Figure 1). The results confirmed that all indicators load significantly on the latent factors, all validation and reliability indices were above the recommended thresholds.

The chi-square test metrics are (χ^2 = 120.928, df = 62.000; p < 0.001) whereas χ^2/df = 1.950 (<5) thus, reflecting a measure of model fit. Moreover, the SEM fit indices consisting of CMIN/DF = 1.950 (>1), CFI = 0.981 (>0.95), SRMR = 0.033 (<0.08), RMSEA = 0.056 (<0.06) and PClose = 0.252 (>0.05) indicate an excellent model fit of the data (Gaskin and Lim, 2016). Thus confirm that the three factors structure of SMART-QUAL scale have acceptable convergent validity AVE > 0.5; discriminant validity where MSV < AVE and the square root of AVE greater than inter-construct correlations and reliability with CR > 0.7 (see Table 6).

Table 6 CFA validity results and factor correlation matrix

	CR	*AVE*	*MSV*	*MaxR (H)*	*Privacy control*	*Functional value*	*Smartness level*
Privacy control	0.943	0.769	0.004	0.955	*0.877*		
Functional value	0.919	0.696	0.249	0.922	0.050	*0.834*	
Smartness level	0.874	0.698	0.249	0.893	0.063	0.499	*0.836*

6 Discussion

This research contributes to the service quality body of knowledge by providing a conceptualisation of smart service quality and introducing SMART-QUAL a multidimensional scale developed from a user-based perspective of smart services quality determinants. The service quality literature served as a theoretical foundation for the newly developed SMART-QUAL. The scale is in accordance with smart services characteristics related to data transmission, information flow in real-time and the capacity to fully or partially act and interact with users in a manner that is appropriate to the task and context; reflecting that smart services main components awareness, connectivity and intelligence (Götz et al., 2018; Roy et al., 2019; Dreyer et al., 2019) are driving measures for perceived smart service quality. Thus, it is suggested that SMART-QUAL measurement scale can help service providers understand how customers assess smart service quality and enable them to determine the driving or resistance forces for customers' willingness to participate in smart services co-creation.

The three dimensional scale consists of:

1 'Functional value' which is related to the core functional qualities and utility of smart service. These include namely convenience and availability aspects that take into consideration the ease of use, simplicity, service accessibility to perform the required task with less time and effort.

2 'Smartness level' which is related to the customer perception of smartness qualities a smart service can display. These include human like abilities to acquire, interpret, and apply knowledge in order to adapt and react to changing conditions in an appropriate manner and selecting suitable behaviour modes.

3 'Privacy control' which is related to the customer perception of his ability to control the amount of information communicated across the smart service network to protect his/her privacy. Smart service is characterised by extended human-object-machine connectedness. Consequently, this will include on-going information collection, exchange, digital accessibility, and discoverability between network actors. Thus, users' privacy control aspects are perceived vital quality indicator in smart contexts.

This study will be of interest for academia whereas it adds a theoretical contribution to the literature as first attempt to conceptualise smart service quality and to provide a newly developed measurement instrument that can be used for future research in quality models within other smart contexts. Whilst for practitioners, this research has practical implications as it gives service providers and managers an indicator of the most significant smart service quality dimensions perceived by customers thus enable them to profile their customers based on these dimensions, to further investigate the 'how' aspects to innovate these dimensions by creating new values for their target customers, and to use the measurement instrument as benchmark with other service providers operating in smart services contexts. Moreover, the scale is short and simple to use, which make it easy to be universally adapted in different smart settings and can used by any organisation regardless its size or type.

It must be pointed out that there are some limitations that can pave the way for future research. The present study did not address smart services in specific sector rather examined the concept in general, so future research examining one specific smart service or different types of smart services in specific industry can yield new insights. Additionally, it can be valuable to set future research directions into validating SMART-QUAL scale in different contexts, examining SMART-QUAL scale across different socio-cultural settings might be beneficial to generate a better understanding of smart service quality dimensions in various situations, since customers' expectations can vary over time across different situations.

Moreover, It was remarkable that 'co-creation' and 'perceived benefits' scale items were not included in the scale, although it was repeatedly discussed the active customers role to co-create value and their willingness to participate in smart services consumption are crucial in SDL (Alzaydi et al., 2018). Similarly, 'trust' items were excluded from the scale, although it was stressed in the literature its importance in digital contexts (Prakash, 2019). Therefore, future research can be conducted to fully understand the co-creation process in a smart service ecosystem within different types of service sectors and the role of trust among smart service network actors. Furthermore, research to redefine smart service experience can add valuable insights into designing and innovating customer journey within smart contexts.

References

Alcácer, V. and Cruz-Machado, V. (2019) 'Scanning the Industry 4.0: a literature review on technologies for manufacturing systems', *Engineering Science and Technology, an International Journal*, Vol. 22, No. 3, pp.899–919.

Alves, H. and Wagner Mainardes, E. (2017) 'Self-efficacy, trust, and perceived benefits in the co-creation of value by consumers', *International Journal of Retail and Distribution Management*, Vol. 45, No. 11, pp.1159–1180.

Alzaydi, Z.M., Al-Hajla, A., Nguyen, B. and Jayawardhena, C. (2018) 'A review of service quality and service delivery: towards a customer co-production and customer-integration approach', *Business Process Management Journal*, Vol. 24, No. 1, pp.295–328.

Barnes, S.J. and Vidgen, R.T. (2002) 'An integrative approach to the assessment of e-commerce quality', *Journal of Electronic Commerce Research*, Vol. 3, No. 3, pp.114–127.

Beverungen, D., Müller, O., Matzner, M., Mendling, J. and vom Brocke, J. (2019) 'Conceptualizing smart service systems', *Electronic Markets*, Vol. 29, No. 1, pp.7–18.

Carpenter, S. (2018) 'Ten steps in scale development and reporting: a guide for researchers', *Communication Methods and Measures*, Vol. 12, No. 1, pp.25–44.

Chen, Y.C., Shen, Y.C., Lee, C.T.Y. and Yu, F.K. (2017) 'Measuring quality variations in e-service', *Journal of Service Theory and Practice*, Vol. 27, No. 2, pp.427–452.

Chouk, I. and Mani, Z. (2019) 'Factors for and against resistance to smart services: role of consumer lifestyle and ecosystem related variables', *Journal of Services Marketing*, Vol. 33, No. 4, pp.449–462.

Considine, E. and Cormican, K. (2016) 'Self-service technology adoption: an analysis of customer to technology interactions', *Procedia Computer Science*, Vol. 100, pp.103–109.

Djellal, F. and Gallouj, F. (2018) 'Fifteen advances in service innovation studies', in Scupola, L.F.A. (Ed.): *Integrated Crossroads of Service, Innovation and Experience Research-Emerging and Established Trends, Services*, pp.39–65, Edward Elgar Publishing, Cheltenham.

Djellal, F., Gallouj, F. and Miles, I. (2013) 'Two decades of research on innovation in services: which place for public services ? ଝ', *Structural Change and Economic Dynamics*, Vol. 27, No. C, pp.98–117, Elsevier BV.

Dreyer, S., Olivotti, D., Lebek, B. and Breitner, M.H. (2019) 'Focusing the customer through smart services: a literature review', *Electronic Markets*, Vol. 29, No. 1, pp.55–78.

Durst, S., Mention, A.L. and Poutanen, P. (2015) 'Service innovation and its impact: what do we know about?', *Investigaciones Europeas de Direccion y Economia de La Empresa, AEDEM*, Vol. 21, No. 2, pp.65–72.

Fan, X., Ning, N. and Deng, N. (2020) 'The impact of the quality of intelligent experience on smart retail engagement', *Marketing Intelligence and Planning* [online] https://doi.org/10.1108/MIP-09-2019-0439.

Firdous, S. and Farooqi, R. (2019) 'Service quality to e-service quality: a paradigm shift', *Proceedings of the International Conference on Industrial Engineering and Operations Management*, March, Vol. 2019, pp.1656–1666.

Fornell, C. and Larcker, D.F. (1981) 'Structural equation models with unobservable variables and measurement error: algebra and statistics', *Journal of Marketing Research*, Vol. 18, No. 3, pp.382–388.

Garvin, D. (1988) *Managing Quality: The Strategic and Competitive Edge*, Free Press, New York.

Gaskin, J. and Lim, J. (2016) *Model Fit Measures, AMOS Plugin*, Gaskination's StatWiki.

Götz, C., Hohler, S. and Benz, C. (2018) 'Towards managing smart service innovation: a literature review', in Satzger, G., Patrício, L., Zaki, M., Kühl, N. and Hottum, P. (Eds.): *Exploring Service Science*, pp.101–111, Springer International Publishing, Cham.

Hair, J.F. (2011) 'Multivariate data analysis: an overview', in Lovric, M. (Ed.): *International Encyclopedia of Statistical Science*, pp.904–907, Springer, Berlin, Heidelberg.

Hair, J.F., L.D.S., Gabriel, M., da Silva, D. and Braga Jr., S. (2019) 'Development and validation of attitudes measurement scales: fundamental and practical aspects', *RAUSP Management Journal*, Vol. 54, No. 4, pp.490–507.

Hizam, S.M. and Ahmed, W. (2019) 'A conceptual paper on SERVQUAL-framework for assessing quality of internet of things (IoT) services', *International Journal of Financial Research*, Vol. 10, No. 5, pp.387–397.

Lee, W.J. and Shin, S. (2018) 'Effects of product smartness on satisfaction: focused on the perceived characteristics of smartphones', *Journal of Theoretical and Applied Electronic Commerce Research*, Vol. 13, No. 2, pp.1–14.

Leroi-Werelds, S. (2019) 'An update on customer value: state of the art, revised typology, and research agenda', *Journal of Service Management*, Vol. 30, No. 5, pp.650–680.

Lin, J.S.C. and Hsieh, P.L. (2011) 'Assessing the self-service technology encounters: development and validation of SSTQUAL scale', *Journal of Retailing*, Vol. 87, No. 2, pp.194–206.

Loiacono, E.T., Watson, R.T. and Goodhue, D. (2000) *WebQualTM: A Web Site Quality Instrument*, No. 2000-126-0, Athens.

Marimon, F., Llach, J., Alonso-Almeida, M. and Mas-Machuca, M. (2019) 'CC-QUAL: a holistic scale to assess customer perceptions of service quality of collaborative consumption services', *International Journal of Information Management*, April, Vol. 49, pp.130–141.

Merz, M.A., Zarantonello, L. and Grappi, S. (2018) 'How valuable are your customers in the brand value co-creation process? The development of a customer co-creation value (CCCV) scale', *Journal of Business Research*, September, Vol. 82, pp.79–89, Elsevier.

Moon, Y. and Armstrong, D.J. (2020) 'Service quality factors affecting customer attitudes in online-to-offline commerce', *Information Systems and E-Business Management*, Vol. 18, Springer, Berlin, Heidelberg [online] https://doi.org/10.1007/s10257-019-00459-y.

Neuhüttler, J., Ganz, W. and Dieter, S. (2019a) 'An integrative quality framework for developing industrial smart services', *Service Science*, Vol. 11, No. 3, pp.157–171.

Neuhüttler, J., Woyke, I., Ganz, W. and Spath, D. (2019b) 'An approach for a quality-based test of industrial smart service concepts', in Ahram, T.Z. (Ed.): *Advances in Artificial Intelligence, Software and Systems Engineering*, pp.171–182, Springer International Publishing, Cham.

Parasuraman, A., Zeithaml, V.A. and Malhotra, A. (2005) 'E-S-QUAL a multiple-item scale for assessing electronic service quality', *Journal of Service Research*, Vol. 7, No. 3, pp.213–233.

Patrício, L., Gustafsson, A. and Fisk, R. (2018) 'Upframing service design and innovation for research impact', *Journal of Service Research*, Vol. 21, No. 1, pp.3–16.

Pawar, A., Kolte, A. and Sangvikar, B. (2021) 'Techno-managerial implications towards communication in internet of things for smart cities', *International Journal of Pervasive Computing and Communications*, Vol. 17, No. 2, pp.1742–7371.

Prakash, A. and Mohanty, R.P. (2013) 'Understanding service quality', *Production Planning and Control*, Vol. 24, No. 12, pp.1050–1065.

Prakash, G. (2019) 'Understanding service quality: insights from the literature', *Journal of Advances in Management Research*, Vol. 16, No. 1, pp.64–90.

Riegg, A., Klose, M., Matei, A., Reinfurt, L., Ditze, M. and Hudert, S. (2016) *A Conceptual Reference Model for Smart Services*, White Paper [online] https://cba-lab.de/custom/attachments/1000366/reference_model_smart_services_whitepaper_soa_innovation_lab_pdf (accessed 1 August 2020).

Romero, D., Gaiardelli, P., Pezzotta, G. and Cavalieri, S. (2019) 'The impact of digital technologies on services characteristics: towards digital servitization', in Ameri, F., Stecke, K.E., von Cieminski, G. and Kiritsis, D. (Eds.): *Advances in Production Management Systems. Production Management for the Factory of the Future*, pp.493–501, Springer International Publishing, Cham.

Romero, M., Guédria, W., Panetto, H. and Barafort, B. (2020) 'Towards a characterisation of smart systems: a systematic literature review', *Computers in Industry*, March, Vol. 120 [online] https://doi.org/10.1016/j.compind.2020.103224.

Roy, S.K., Singh, G., Hope, M., Nguyen, B. and Harrigan, P. (2019) 'The rise of smart consumers: role of smart servicescape and smart consumer experience co-creation', *Journal of Marketing Management*, Vol. 35, Nos. 15–16, pp.1480–1513.

Roy, S.S.S. and Bhatia, S. (2019) 'Service quality versus service experience: an empirical examination of the consequential effects in B2B services', *Industrial Marketing Management*, February, Vol. 82, pp.52–69.

Russell, D.W. (2002) 'In search of underlying dimensions: the use (and abuse) of factor analysis', *Personality and Social Psychology Bulletin*, Vol. 28, No. 12, pp.1629–1646.

Singh, S. (2003) 'Simple random sampling', *Advanced Sampling Theory with Applications: How Michael 'Selected' Amy*, Vol. 1, pp.71–136, Springer, Dordrecht, Netherlands.

Snyder, H., Witell, L., Gustafsson, A., Fombelle, P. and Kristensson, P. (2016) 'Identifying categories of service innovation: a review and synthesis of the literature', *Journal of Business Research*, Vol. 69, No. 7, pp.2401–2408, Elsevier Inc.

Sony, M., Antony, J. and Douglas, J.A. (2021) 'Motivations, barriers and readiness factors for Quality 4.0 implementation: an exploratory study', *TQM Journal*, pp.1754–2731, https://doi.org/10.1108/TQM-11-2020-0272.

SurveyCircle (2020) *Research website SurveyCircle*, Mannheim, Germany, published 2016 [online] https://www.surveycircle.com (accessed August 2020).

Taber, K.S. (2018) 'The use of Cronbach's alpha when developing and reporting research instruments in science education', *Research in Science Education*, Vol. 48, No. 6, pp.1273–1296.

Tommasetti, A., Vesci, M. and Troisi, O. (2015) 'The internet of things and value co-creation in a service-dominant logic perspective', in Colace, F., De Santo, M., Moscato, V., Picariello, A., Schreiber, F.A. and Tanca, L. (Eds.): *Data Management in Pervasive Systems*, pp.3–18, Springer International Publishing, Cham.

Treasure, T. and Holmes, L. (2009) 'Measuring the quality of e-service: scale development and initial validation', *Journal of Electronic Commerce Research*, Vol. 10, No. 1, pp.13–28.

Verleye, K. (2015) 'The co-creation experience from the customer perspective: its measurement and determinants', *Journal of Service Management*, Vol. 26, No. 2, pp.321–342.

Wiedmann, K.P., Hennigs, N., Varelmann, D. and Reeh, M.O. (2010) 'Determinants of consumers' perceived trust in IT-ecosystems', *Journal of Theoretical and Applied Electronic Commerce Research*, Vol. 5, No. 2, pp.137–154.

Worthington, R.L. and Whittaker, T.A. (2006) 'Scale development research: a content analysis and recommendations for best practices', *The Counseling Psychologist*, Vol. 34, No. 6, pp.806–838.

Wünderlich, N.V., Wangenheim, F.V. and Bitner, M.J. (2013) 'High tech and high touch: a framework for understanding user attitudes and behaviors related to smart interactive services', *Journal of Service Research*, Vol. 16, No. 1, pp.3–20.

Xu, H. (2007) 'The effects of self-construal and perceived control on privacy concerns', *Twenty Eighth International Conference on Information Systems*, ICIS, Montreal, pp.1–14.

Yi, Y. and Gong, T. (2013) 'Customer value co-creation behavior: scale development and validation', *Journal of Business Research*, Vol. 66, No. 9, pp.1279–1284.

Yoo, B. and Donthu, N. (2001) 'Developing a scale to measure the perceived quality of an internet shopping site (Sitequal)', *Quarterly Journal of Electronic Commerce*, Vol. 2, No. 1, pp.31–46.