Smart City Dimensions, E-Service Quality and Public Satisfaction in UAE: A Confirmatory Factor Analysis

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Abstract

Several governments worldwide, including the UAE, are faced with an increasing challenge of urbanisation in social spaces. Resorting to smart cities to resolve urbanisation, the UAE, and the Abu Dhabi Emirate has made significant strides in this regard. An integrative model for improved public satisfaction with the initiative is considered important. However, there is no empirical study that validate the measurement models for such integrative model. Accordingly, this paper conducted a confirmatory factor analysis for the measurement models of the smart city technology dimension, human dimension and institutional dimensions, e-service quality, public satisfaction, trust and policy domains which are the input of the integrative structural model. Particular reference is made to the e-service initiatives of '*TAMM*' and Jobs Abu Dhabi. A quantitative research method was adopted, considering a sample of 384 users of the two selected smart service initiatives. The finding of the research suggest a good fit with the following indices; *CMIN* = 553.724, *AGFI* = 0.877, *RMSEA* = 0.050, *df* = 277, *PGFI* = 0.713, *CAIC* = 1033.501, *P* = 0.000, *NFI* = 0.919, *MIN*/*DF* = 1.891, *RFI* = 0.905, *RMR* = 0.039, *TLI* = 0.953, *GFI* = 0.903, and *CFI* = 0.960. concluded that the smart city technology dimension, human dimension and institutional dimensions, e-service quality, public satisfaction, trust and policy domains are distinct and valid measurement models that can be used for the development of integrative model for Abu Dhabi, UAE smart city initiative.

Keywords
Smart city, e-service quality, public satisfaction, trust, policy domains.

1. Introduction
The 21st century world is becoming more sophisticated with so many attendant urbanisation issues. Countries adopts smart city initiative to contend with the issues. As the UAE rely on smart cities to solve these emerging problems, one rather challenging outcome is maintaining public satisfaction and, even more importantly, service quality as an immediate outcome of service delivery. However, the very underlying blocks of smart city are not well understood and have remained ambiguous; this, therefore, serves as one of the key research gaps that must be closed to pave the way for practitioner contributions to be established. The UAE and Abu Dhabi, in particular, understand the need to tackle the challenge of urbanisation through the Smart City initiative. The planning regimes and general policy model start with a leadership vision and the installation of key strategic paths, as witnessed in the Zayed Smart City Project introduced from 2018 to 2022 (Abu Dhabi Government, 2018). The Zayed Smart City is not the only project in the pipeline, as other projects such as Onwani, a physical address system, and Masdar City have gained increased recognition. The Masdar "Smart" City Project, for instance, is the first of such renewable energy policy in 2009. According to Mezher and Park (2012), this initiative aims to "advance renewable energy and sustainable technologies through education, RandD, investment and commercialisation".

The Smart Abu Dhabi Initiative, a broader government orientation that encompasses all e-government and smart government initiatives, involves the transformation of all government e-services, including the introduction of the TAMM, a one-stop portal to serve the complete list of government services into a single city application. Other applications, including the Jobs Abu Dhabi, City Guard, and free Wi-Fi in Taxis, are programs partly enrolled and at different stages of implementation to ensure an uninterrupted connection to all systems and people within the Emirate. All government payments in the Abu Dhabi Emirate have recently been channelled through the new Abu Dhabi Digital Payment Platform or the ADPay (Fintech, 2018). Towards the end of 2017 alone, the Abu Dhabi Government set for itself a benchmark of 100 Smart Government Initiatives and 1000 smart or e-services by the end of the year to contribute to the main objective of creating a Smart City out of the entire city of Abu Dhabi.

Even though the purpose of the Smart City Initiative of the Abu Dhabi Government includes future sustainability and the need to ensure that the people are happy and satisfied, little is achieved or known in terms of citizens satisfaction with these introduced measures. Adoption, for instance, has remained a central problem in Abu Dhabi (AlNuaimi et al., 2011). Despite having the highest mobile phone subscription as a percentage of the population in the world, the highest mobile phone penetration and over 97% smartphone penetration, popular applications introduced by Abu Dhabi Digital Authority (ADDA) such as TAMM and CITY GUARD have less than 1000 downloads on Google Play as at the time of the present study. Most popular applications like the SMART PASS have just about 50,000 installs out of a population of over 9 million people. In simple terms, the UAE and Abu Dhabi Government, in particular, is keen on the Smart City agenda, but the actual adoption required to propel the Emirate towards the creation of this Smart City is far from reach. According to AlNuaimi et al. (2011), the quality of the information systems of e-services, which serves as the root of the Smart City is questionable. Quality has been observed as a significant and very important factor within the Abu Dhabi Smart Government model that inhibits the smooth implementation and adoption of government e-services (AlNuaimi et al., 2011; Albassam and Alshawi, 2010). To add to this, Albassam and Alshawi (2010), also within the context of Abu Dhabi, support the assertion that perceived service quality is a major issue within the context of information systems and technology-related service delivery.

With no intention to add to already abundant resources on smart city policy domains and their application, Nam and Pardo (2011a) recommend the need to conceptualise smart city from technology, people, and institutions. This smart city model or concept proposed by Nam and Pardo (2011a) has a serious lack of empirical evidence to cement its underlying propositions, and this remains the knowledge gap to which this present study seeks to contribute (Nam and Pardo, 2011a; Nam and Pardo, 2011b; Chourabi et al., 2012). Focusing on this knowledge research gap, Dameri (2017) remains one of the few, and recent studies have given some light to the empirical potential that the tri-dimensional Model Smart City holds. Nonetheless, this model was initially conceptualised by Nam and Pardo (2011a). Until the present study, no study has supported this model empirically; studies have not operationalized the tri-dimensional model of smart city, also referred to as the Chourabi model of the smart city.

Another issue of concern is how public satisfaction is influenced by e-service quality in the smart city setting. The study of Aleksic et al. (2017) postulated that the service quality of smart government services affects their satisfaction. However, these limited studies are confined to Dubai, with none exploring the situation in Abu Dhabi. This research filled this important gap. Also, the relationship between e-service quality and public satisfaction is not always straightforward. The public trust in government and its services, including their views on certain policy domains, play an important role in shaping their satisfaction. It can be deduced that public satisfaction in smart city setting is influenced by e-service quality which is also influenced by the smart city dimension. The relationship between e-service quality and public satisfaction is moderated by trust and smart city policy domain. The validity of these constructs under a single model has not been empirically established. This research attempt to empirically confirm the validity of the smart city dimensions (technology, people and process), e-service quality, and the moderators (trust and policy domains) in single smart city model using confirmatory factor analysis. The next section of the paper present brief review of literature followed by methodology, result and finally conclusion.

2. Literature Review

2.1 Smart City Dimensions

Smart City represents the leveraging and interoperability of technology in governance across multiple policy domains of the city to create a Single coherent technology-supported city system. Smart City strategies require implementing innovative and technology-oriented ways of interacting and engaging with various in the management of resources and provision of key services (Nam and Pardo, 2011a; Nam and Pardo, 2011b). As noted in the background, the smart city dimensions include technology, human, and institutional process. The dimensions are discussed in the next following subsections.

2.1.1 Technology Dimension

Technology cannot be denied as one of the most critical aspects of the smart city conceptualisation. Technology has been termed the core enabler of the smart city, helping bring together the two broad areas of hardware and software, gathering of data relevant for smart service delivery. Technology enables gathering data in real-time such that smart city systems are adequately informed and efficient (Ericsson, 2013). Nonetheless, for technology to be optimised, there is a need for the adequacy of infrastructure. Such infrastructure includes high-speed internet supplied through broadband internet or fibre optic internet technologies. The availability of wireless networks and wireless systems also ensure innovation in building technology systems. Technology forms the underlying block for smart city building and development (Boston Consulting Group, 2014).

2.1.2 Human Dimension

The human resource dimension of the smart city entails focussing on human infrastructure, creativity, quality of human resources, among other human capability development required to fuel the smart city system (Dameri, 2017). Humans are vital to the smart city environment since they remain the main object and clients of the smart city (Ebrahim and Irani, 2005). The participation of citizens, for instance, plays an integral role and boosts significantly cultures, values and knowledge that strives in the city (Caragliu et al., 2011). As observed in technology, private companies play a fundamental role in the training development of human resources to address the technological challenges faced by businesses.

2.1.3 Institutional Dimension

The final dimension of the smart city model is the institutional or institutional processes dimension. This area represents the government, businesses and the various embedded operational processes involved in public administration. Originally, Nam and Pardo (2011a) refer to the smart city's underlying processes, including the governance, policy, regulation, partnership, corporation, among others. Ensuring strategic alliances, strong partnership and corporation across other service stations remain critical for the success of this dimension. Collaboration, cooperation, and engagement through participation remain critical aspects of smart city institutional processes.

2.2 E-service quality

Service quality remains one of the major aspects of e-service success (Yang *et al*., 2004). Santos (2003) observes that two main perspectives have been assumed to conceptualise service quality; these include the disconfirmation and the performance-only approaches. In the area of e-services, the same has been observed. Different e-service quality models have been proposed in diverse contexts with several dimensions of e-service quality proposed. Even though a wide variety of such models have been proposed, similarities may be observed across dimensions or models. E-services quality remains costly and difficult to achieve. Several studies have argued that higher perceived website quality induces higher customer satisfaction and overall profitability of the online service being offered. This evidence is common to several papers, including Hoffman *et al*. (1995), Lohse and Spiller (1999), Vanitha *et al*. (1999). Due to the relevance of service quality to e-service delivery, common areas of interest argued include the web-design and associated aesthetics. Supporting empirical evidence include Li *et al*. (1999) and Mandel and Johnson (1999). The website or application design includes but not limited to the structure, function, interface, content and very appearance of the site, and the simplicity of use. The speed of the site is another important factor raised in the usage of e-services. Parasuraman *et al*. (2005) argue that websites must help customers find what they are looking for in the shortest possible time. It also includes the ability to control what one is doing, locate their current location on the platform, and implement installed commerce channels in a usable manner (Kim and Eom, 2002).

2.3 Public Satisfaction

The concept of satisfaction is wide and broad and related to private and public dealings and engagements. There is no single unique definition of satisfaction because it is experienced differently by different product end-users (Khan, Khan and Junejo, 2017). It is a subjective evaluation based on the experience and expectation of the end-user. Thus, Satisfaction refers to the overall assessment of a product or service by the end-user after using the product or service. In order words, it means users' evaluation of their consumption of a service, product, or brand (Aleksic *et al*., 2017). When related to the public, it refers to the citizens' satisfaction with the products and services provided by the government. Accordingly, public satisfaction refers to the emotional state emanating from the assessment of services offered by the government to the citizens (Alshamsi et al., 2019). Thus, public satisfaction is an important tool used to assess the government's performance in providing public goods and services. Public satisfaction concerning smart city is the users' assessment of the e-services quality provided by the government to the citizens.

2.4 Trust

Trust remains a fundamental aspect of both smart city studies and e-service quality models. More specific studies, including Lee and Turban (2001), Gallivan and Depledge (2003), have observed the essential role of trust in the use and adoption of technology systems. Even though trust has remained a definition factor mainly in service quality delivery and e-service quality in the present study, trust has been considered in a unique application to government e-services (Bélanger and Carter, 2008).

2.5 Policy domain

Policy domain has been considered as a moderator of public satisfaction in smart city setting. The need for this observation is based on Pérez-González and Díaz (2015) observation of secondary data on 12 different policy domains; the results indicated that different sectors have different outcomes in the government or agency's performance. This led to varied outcomes and was interpreted as different satisfaction levels among the citizens of Spain.

3. Methodology

This research adopted quantitative research design to collect and analyse the required data for the achievement of the research aim. Being explanatory, this study focuses on the natural correlation which exists between variables to confirm the structure of the research constructs. The survey research strategy is mainly considered in the present study. The population of the study comprises users of the two Abu Dhabi smart city initiatives. These initiatives include CITY GUARD and JOBS ABU DHABI. While City Guard has about 10,000 plus active users, Jobs Abu Dhabi has about 845,477 professionals and employers. Together, the population of the study is about 855,477. The sample size is determined based on the population of the study. To estimate the sample size, Roasoft (2014) was used to arrive at a sample of 384. This sampling method has been affirmed theoretically and strongly supported by Cooper *et al*. (2006) and Bernard and Bernard (2013). This sample size was used, keeping in focus the need for generalizability.

Primary data was collected from the respondents of the research using structured questionnaire. The questionnaire was designed using a five-point likert scale. The Likert scale permits the collection of responses in an orderly and uniform manner such that quantitative analysis is made possible. The reliability of the instrument was tested using Cronbach's alpha statistics. All the constructs of the research have alpha value above the required threshold of 0.7 (Pallant, 2011). To properly cleanse the data, outliers are inspected, missing data are dealt with, common method variance is also analysed to ensure that excessive variance within the data does not ruin the main findings and underpinning conclusions. Other tests for multivariate and multi-collinearity are conducted to help ensure that the collected data are in the right conditions for analyses. Normality, overall variance and distribution of the data are carefully observed.

Prior to the confirmatory factor analysis (CFA), the structure of the data was first evaluated using Exploratory Factor Analysis (EFA). Thereafter, the resultant items after EFA were subjected into CFA using structural Equation Modelling to confirm the dimensionality of the research constructs.

4. Results

Prior to the main analysis, the preliminary information about the characteristics of the data has been observed. The characteristics of the data revealed that most of the respondents were males, mostly educated up to A level and mostly within the age bracket of 35-44 years as indicated by 52.4%, 67%, and 51.2 % respectively. The dimensionality of the data was first evaluated using EFA. The result of the Exploratory Factor Analysis (EFA) is presented in the following subsection.

4.1 Exploratory Factor Analysis (EFA)

The suitability and adequacy of the data for exploratory factor analysis was assess using the Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy and the Bartlett's Test of Sphericity, and the Goodness-of-fit. These measures are presented in Table 1 and Table 2 respectively.

Table 1. KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.886
Bartlett's Test of Sphericity	Approx. Chi-Square (X^2	7501.650
	df	496
	Sig.	.000

Table 2. Goodness of fit Test

Chi-Square	df	Sig.
575.443	293	.000

The result shows that KMO test was above 0.8, and Bartlett's Test of Sphericity was statistically significant (Table 1). The goodness of fit statistic was also statistically significant, and the chi-square was within an acceptable range. CMIN (chi-square/df) = 1.96 which is between 1 and 3 as necessary for a parsimonious model (Table 2). The factor analysis extracted 7 factors as presented in Table 3.

Table 3. Extracted Factors

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Sq. Loadings[a]
Factor	Total	% of Var.	Cum %	Total	% of Var	Cum %	Total
1	6.410	24.655	24.655	3.160	12.154	12.154	4.928
2	6.105	23.479	48.135	6.083	23.395	35.549	4.554
3	2.088	8.032	56.166	3.762	14.467	50.017	4.464
4	1.450	5.579	61.745	1.771	6.813	56.830	4.220
5	1.351	5.196	66.941	1.123	4.319	61.149	4.169
6	1.306	5.024	71.965	1.017	3.912	65.061	4.233
7	1.086	4.176	76.141	.829	3.189	68.250	3.153
8	.678	2.609	78.749				
9	.520	2.001	80.750				
10	.516	1.985	82.735				
11	.486	1.868	84.603				
12	.458	1.761	86.364				
13	.429	1.650	88.014				
14	.380	1.460	89.475				
15	.350	1.347	90.822				
16	.318	1.225	92.047				
17	.295	1.136	93.183				
18	.261	1.005	94.188				
19	.253	.971	95.159				
20	.251	.964	96.123				
21	.222	.852	96.976				
22	.196	.752	97.728				
23	.190	.730	98.458				
24	.154	.592	99.050				
25	.137	.528	99.578				
26	.110	.422	100.000				
Extraction Method: Maximum Likelihood.							
a. When factors are correlated, sums of squared loadings cannot be added to obtain a total variance.							

The result shows that a total of 7 factors are extracted. The table indicates that a total of seven factors passed with Eigenvalues above 1. Over 60% of the overall variance was explained in the model by the selected seven factors. This is a good observation that the model is adequately explained and ready for analysis (Gaskin, 2012). The Pattern Matrix of the extracted factors is presented in Table 4.

Table 4. Pattern Matrix – EFA

	Factor						
	1	2	3	4	5	6	7
SCT1					0.763		
SCT2					0.909		
SCT3					0.780		
SCH6	0.850						
SCH7	0.687						
SCH8	0.818						
SCH9	0.757						
SCH10	0.900						
SCP11						0.837	
SCP12						0.812	
SCP13						0.786	
SQ1			0.965				
SQ2			0.686				
SQ3			0.757				
SQ5			0.790				
PS1				0.687			
PS2				0.772			
PS3				0.787			
PS4				0.658			
PD1							1.003
PD2							0.854
Trust1		0.800					
Trust2		0.934					
Trust3		0.896					
Trust4		0.673					
Trust5		0.622					
Extraction Method: Maximum Likelihood. Rotation Method: Promax with Kaiser Normalization.							
a. Rotation converged in 6 iterations.							

The result in table 4 shows the items that are retained after the factor analysis. The factors Technology dimension (3items), Human dimension (5 items), Institutional dimension (3 items), e-service quality (4 items), Public satisfaction (4 items), trust (5 items), and policy domains (2 items). The retained items are used for the Confirmatory Factor Analysis (CFA).

4.2 Confirmatory Factor Analysis (CFA)

The result of the confirmatory factor analysis is presented in this section. The result CFA model is specified with the items that are retained after the exploratory factor analysis. The result of the CFA for the initial measurement model is presented in Figure 1.

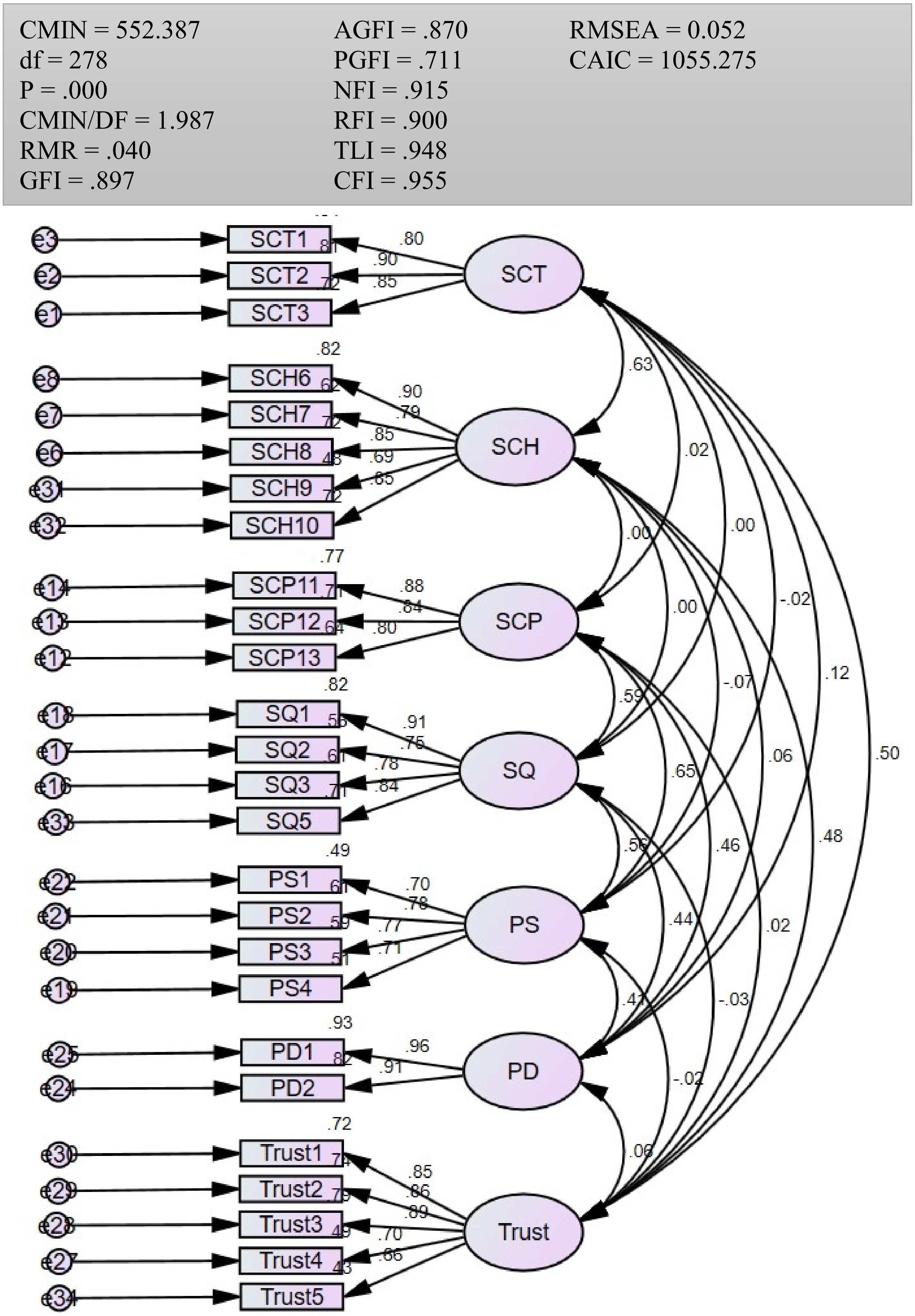

Figure 1. CFA of Initial Measurement Models

The initial measurement model estimated required one modification based on Key modification indices above 10. The rest of the modifications were below 20 with the exception of covariance between e1, e2 and e29. After this modification, the new model demonstrated a slight improvement in the results, as presented in Figure 2. None of the factors was removed as all loadings were above .6, even though .5 was key as the main threshold for the exclusion of bad loading items. Mainly, RMR and GFI statistics improved after the modification. Baseline comparisons, such as NFI, RFI, IFI, TLI, and CFI, also improved slightly. RMSEA also reduced slightly, and CAIC was better when compared with the original CFA model.

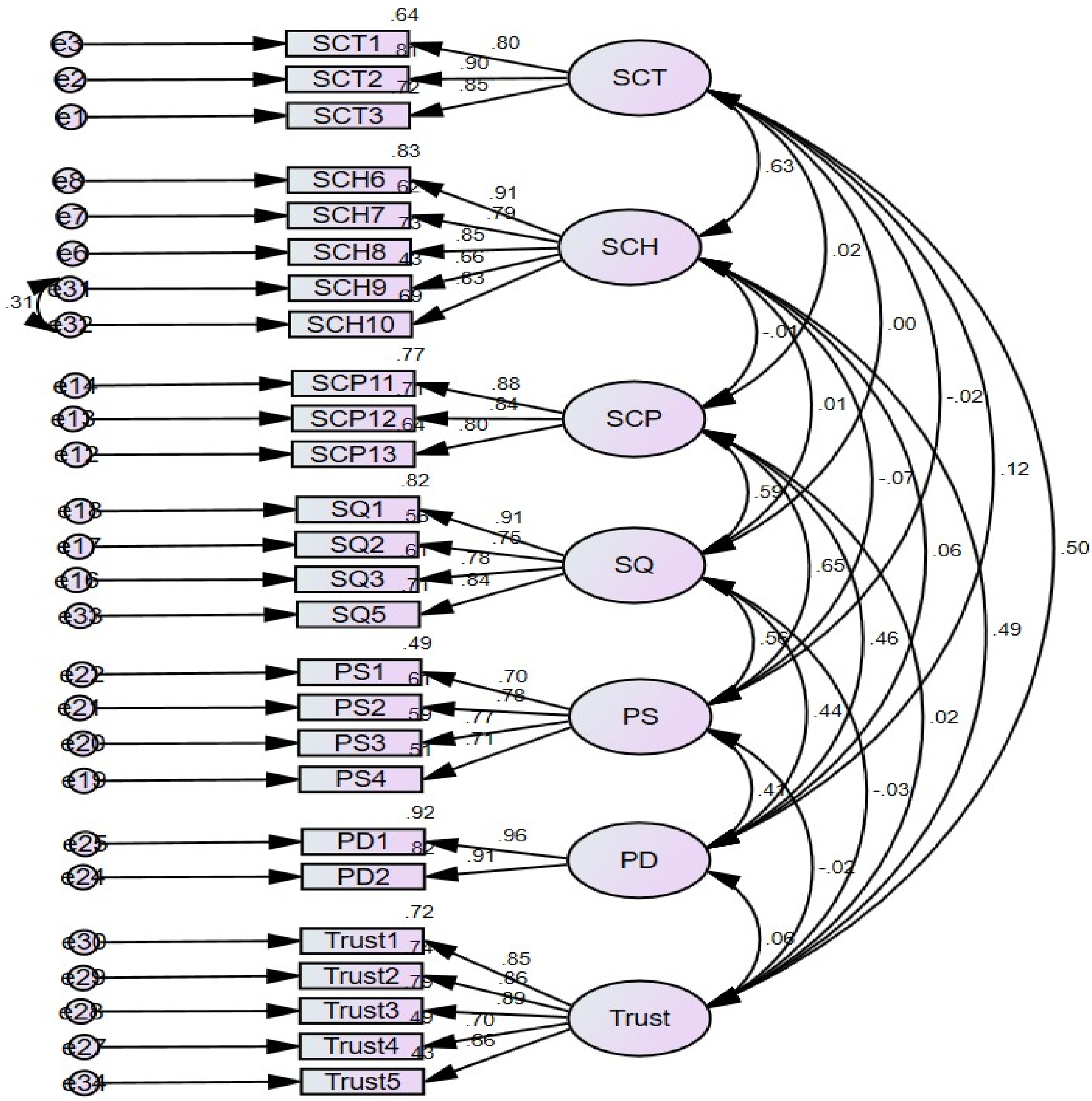

Figure 2. Final CFA Model

The fitness indices of the model is presented in Table 5.

Table 5. Model Fit Indices – CFA

Measurement	Recommended	Score	Remarks
Chi Square (X^2) value	-	553.724	Acceptable
Sig. Threshold for (X^2)	>0.05	0.0000	Acceptable
CMIN (X^2 /df)	$1.0 < X^2$ / df < 3.0	1.891	Highly Acceptable
Goodness of Fit (GFI)	> 0.90	0.903	Highly Acceptable
Average GFI	> 0.80	0.877	Highly Acceptable
Root Mean Squared (RMR)	< 0.08	0.039	Highly Acceptable
Root Mean-Square Error of App. (RMSEA)	< 0.08	0.050	Highly Acceptable
Tucker-Lewis Index (TLI)	> 0.95	0.953	Highly Acceptable
Comparative Fit Index (CFI)	> 0.95	0.960	Highly Acceptable
Normed Fit Index (NFI)	> 0.95	0.919	Acceptable
Consistent Akaike Information Criterion (CAIC)	-	1033.501	Improved

The key model fit indices are analysed as part of the present study analysis to better understand the CFA model (Table 5). The model fit indices provide highly satisfactory results for nearly all the indicators. None of the indicators fell below the recommended ranges as presented in Table 5. The reliability was tested with the help of Composite Reliability, whilst Validity was tested with the help of Average Variance Extracted (AVE). All test for validity using AVE were above .5 whilst composite reliability for all factors were above .7. All the factor scores in the form of standardized regression estimates were also above .6, and all of them significantly predicted their latent factors. This data supports that the model is ready and adequate.

5. Conclusion

This study analysed the dimensionality of the research constructs for the development of an integrative model for the smart city initiative that will link e-service quality and public satisfaction in Abu Dhabi, UAE. By focusing on the two smart city e-service initiatives of TAMM and JOBS ABU DHABI, and the theoretical models of SMART City Dimensions (technology, human, and institutional), e-SERVQUAL, public satisfaction, trust and policy domain, this research investigated the suitability of the constructs in the development of the model. Prior to the confirmatory factor analysis, the threshold. Validity and reliability also proved statistically significant and highly acceptable. Based on these results, it can be concluded that the smart city technology dimension, human dimension and institutional dimensions, e-service quality, public satisfaction, trust and policy domains are distinct and valid measurement models that can be used for the development of integrative model for Abu Dhabi, UAE smart city initiative. Further study will therefore use the validated constructs for the development of the integrative structural model using Structural Equation Modelling (SEM).

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