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A Model for Evaluation Smart City Readiness using Structural Equation Modelling: a Citizen's Perspective

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***Abstract*— Smart City is the use of ICT-based governance and cloud is now a trend throughout the world. Various increasingly complex city problems are expected to become increasingly more efficient by applying the concept of smart cities in city governance. However, in its implementation, many crucial problems significantly affect the success of the implementation of smart cities, including the lack of competent human resources, ICT policies and governance that have not been efficient, lack of government commitment and the lack of community participation. This study aims to model smart city readiness factors in community perspectives. The method in this study is quantitative descriptive research using a combination of the Technology Readiness Index model, the Technology Acceptance Model and the Delone McLean Model. Data collection is done by conducting surveys and interviews with 200 citizens. Data analysis using Structural Equation Modeling with the help of AMOS 23.0 software. The results showed that there were a significant relationship and relevance between the variables in the model used in the TRI, TAM and Delone McLean models. This study contributes to the relationship modelling of the factors that determine the success of applying the smart city concept. This research provides recommendations to the government and stakeholders to pay more attention to the crucial factors in the success of developing smart cities.**

Keywords-Smart City Readiness, Technology Readiness Index, Technology Acceptance Model, Delone & McLean Model, Structural Equation Model

I. INTRODUCTION

The concept of smart cities is currently becoming a trend and is expected to be a solution to a variety of increasingly complex and accumulative urban problems, such as congestion, energy needs, garbage accumulation problems, poor quality of public services.[1]. Major cities in Indonesia have tried to apply the concept of smart cities to solve the above problems, including the cities of Bandung, Bogor and Surabaya. In 2016, the Digital Community Center (CfDS) of the Faculty of Social and Political Sciences, Gadjah Mada University titled Surabaya City as the top-ranking city in Indonesia from 12 smart cities throughout Indonesia [2][3].

Four districts on Madura Island, namely Bangkalan, Sampang, Pamekasan and Sumenep Regencies have also initiated initiation in the implementation of smart cities by collaborating with the Faculty of Computer Science, Universitas Brawijaya Malang to create and compile a Master Plan to build smart cities, but in practice there are many problems in starting smart city development.

There are quite complicated problems in the attempt to implement smart cities in Indonesia, among them are irregularly done[4], do not have an appropriate framework[5], models are limited because each city has specific problems and needs.[6]. The other problems of implementing smart cities is the absence of understanding and outlook of SCity Construction [3], lack of unified systems and data management[7], lack of contribution [8], participation and synchronization of SCity stakeholders[9], disorganized policies [10]and ego issues, sectoral ego and governmental leadership[11].

In the process of developing smart cities, there is no process of identifying factors to examine the readiness to implement smart city technology. In previous research, several researchers have conducted studies on government readiness in the acceptance of smart city technology[12], but are still unconnected. This study seeks to identify the readiness of citizens and communities in the readiness and acceptance of the application of smart cities. in this study used a combination of Technology Readiness Index (TRI) methods[13][14] as well as the Technology Acceptance Model (TAM) method and Delone McLean Model (D&M) to measure citizen's readiness and acceptance of technology adoption[15][16].

The results showed that there were a significant relationship and relevance between the variables in the model used in the TRI, TAM and Delone McLean models. This study contributes to the relationship modelling of the factors that determine the success of applying the smart city concept. This can be used as a way to avoid the factor of unpreparedness of local governments in the readiness and acceptance of new technology by the application of smart cities.

II. LITERATURE REVIEW

A. Smart City Concept

Smart City is a city governance concept that has used sensors and internet of things (IoT) to collect, manage and interpret data efficiently. Current data has become an essential part of resources that must be processed and managed so that it becomes useful and strategic information. This data includes data collected from communities and devices which are then processed and analysed to monitor and manage traffic, waste management, crime detection, transportation systems, electricity generation, water supply networks, school information systems, libraries, hospitals and community services others. [17][18]

The concept in intelligent city design brings together information and communication technology and various other physical devices and connects to IoT networks for operational technical and municipal services that are connected with citizens and society in general.[19]. There are several important factors that influence the success of the application of smart cities, such as aspects of technology, management and organisation, economics, citizens, government policies, infrastructure, and the environment. In intelligent city governance, there are six dimensions, which are the main pillars of smart cities: Smart Government, Smart Economy, Smart Environment, Smart Living, Smart People, Smart Mobility[20]. Professor Rudolf Giffinger et al. In 2007 sparked the concept of smart city ranking and ranking in Europe by providing six dimensional concepts and smart city indicators, namely Smart economy, smart people, smart governance, smart mobility, smart environment and smart living.[21]

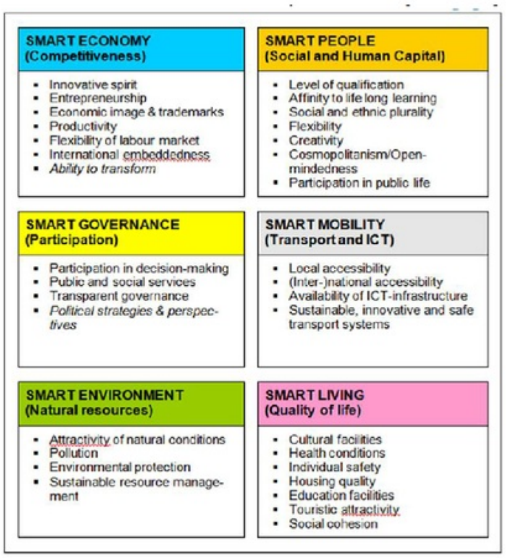

Fig. 1. Smart City Dimensions of Smart Cities according to Giffinger, 2007

B. Technology Readiness Index

Technological readiness shows the tendency of people to use new technology to achieve goals in life at home and work. This construct is seen as an overall state of mind that results from mental images and inhibitors that collectively determine a person's tendency to use new technology.[22].

The Technology Readiness Index (TRI), which was introduced by A. Parasuraman in 2000, consists of 36 attributes that measure the construct and its components. The sleek and updated version with 16 attributes, "TRI 2.0," was introduced by Parasuraman and Colby in 2015.[23].

The technology readiness model is somewhat different from the well-known acceptance model, the Technology Acceptance Model (TAM), where TRI measures the beliefs a person has about new technologies in general, while TAM measures acceptance of specific technologies. Technology readiness is a multidimensional psychographic construction, which offers ways to classify consumers based on the positive and negative technological beliefs underlying them.[23].

Technology readiness has four essential dimensions: *Optimism*, positive sights about technology and the belief that it offers people increased control, flexibility and efficiency. *Innovativeness*, the inclination to become a technology pioneer and thought leader. *Inconvenience*, it is considered a lack of control over technology and a feeling of being overwhelmed by it. *Insecurity*, technological distrust and scepticism about its ability to work well.

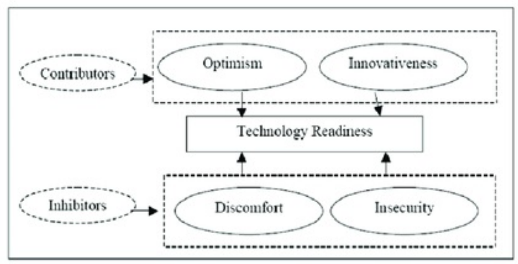

Fig. 2. Technology Readiness Index Model

C. Delone & McLean Model

The Delone and McLean are models that are used to measure the success of an information system, as an alternative model of IS success. This model seeks to provide a comprehensive understanding of IS success by identifying, describing, and explaining the relationships between the six construct variables, which are the most dimensions for the success of evaluating an information system. The earliest development of this theory was first carried out by William H. DeLone and Ephraim R. McLean in 1992[13], then refined by the original author ten years later in response to feedback received from other scholars working in the area[24][14]. This IS success model has been widely cited in thousands of scientific papers and is considered one of the most influential theories in contemporary information systems research.

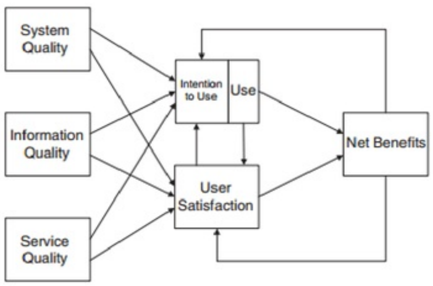

Fig. 3. Delone & Mc Lean Model

D. *Technology Acceptance Model*

Technology Acceptance Model or TAM is a revision of the Theory of Reasoned Action (TRA) into the Information System field. TAM believes that the usefulness and ease of use that is felt to determine the individual's intention to use a system by considering values serving as mediation from the actual use of the system. The perceived usefulness can be seen as a result of the direct impact of perceived ease of use. The researchers then simplified TAM by removing the attitude variables that exist in TRA[16][15][25]. Efforts to develop TAM, in general, are then carried out by using three approaches, namely by introducing constructs of the related models, by introducing additional or alternative constructs of beliefs, and by examining the antecedents and moderators of perceived usefulness and convenience[26]. In the latest study of Gefen and Larsen[27] showed that contractual relationships in TAM emerged from semantic relationships between questionnaire items. A theory that explains their findings is explained by the Semantic theory of the response of the survey conducted.

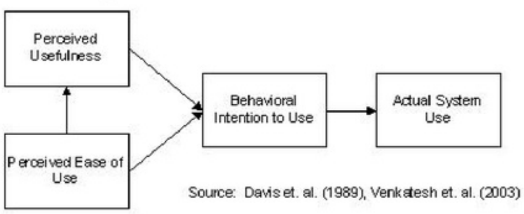

Fig. 4. Technology Acceptance Model

III. Methodology

The research method is included in the type of quantitative descriptive research. Researchers make observations and direct observations on the object of research. The process of observing and retrieving data is done using primary and secondary data. Primary data was obtained by interviewing and giving questionnaires to the people in Sampang district and Pamekasan to measure the readiness to implement smart cities. The questionnaire was prepared based on research with 5 Likert scales. Constructs in the research model is a combination of models in the Technology Readiness Index (TRI), Technology Acceptance Model (TAM), and Delone McLean (D&M). Whereas data-processing uses Structural Equation Modeling and Path Analysis with aids of AMOS 23.0 software.

A. *Proposed Research Conceptual Framework*

The proposed conceptual framework of this research was carried out by combining and rebuilding 14 construct variables from the Technology Readiness Index, TAM models da Delone & Mc Lean. The 14 contracted variables are Optimism (O), Innovativeness (I), Insecurity (IN), Discomfort (D), System Quality (SysQ), Servis Quality (ServQ), Information Quality (IQ), Perceived of Use (PU), Perceived Ease of Usefulness (PEOU), Intention to Use (IU), User Satisfaction (US), Actual Use (AU), Net Benefit (NB), and Smart City Readiness (SCR).

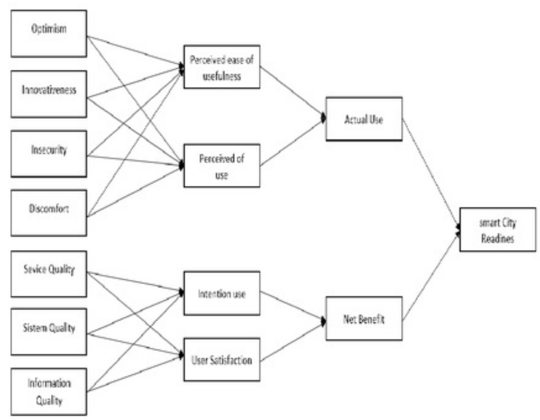

Fig. 5. Proposed Research Conceptual Framework

TABLE I. MAIN CONSTRUCT PROPOSED MODEL

No	Variables	Definitions	Indicators	Symbols
1	Optimism (O)	A positive view of technology and believe that technology can provide an increase in control, flexibility, and efficiency in life	Controlled system	O1
			Improve the performance	O2
			efficient	O3
2	Innovativeness (I)	The technology to be pioneering or at the forefront of technology use	According to the need	I1
			responsive	I2
			Can be developed	I3
			Attractive appearance	I4
3	Insecurity (IN)	Worries that the user is working on technology and making transaction or sanding information	Security	IN1
			Data availability	IN2
			Accurate data	IN3
4	Discomfort (D)	Technology users burden the perception of lack of control of technology and the presence of pressure	Difficult to learn	D1
			Difficult to understand	D2
			Not ease to master	D3
			Lack of experience	D4
			New system	D5
5	System Quality (SysQ)	Measurement of the quality of the information system itself, whether software or hardware	Ease to learn	SysQ1
			Safe and stable system	SysQ2
			System response time	SysQ3
6	Service Quality (ServQ)	Comparison of user expectation with the perception of the real services they receive	Technical ability	ServQ1
			empathy	ServQ2
			present	ServQ3
			responsive	ServQ4
7	Information Quality (IQ)	The quality of information that is measured	completeness	IQ1
			accurate	IQ2

		subjectively by the user which is then called perceptual information quality	reliability	IQ3
				IQ
8	Perceived of Use (PU)	A measure where the use of the system is believed to brings benefits to the people who use it	Faster use	PU1
			The performance	PU2
			Increase effectiveness	PU3
			effectiveness	PU4
9	Perceived Ease of Usefulness (PEOU)	A measure where one believes that a system brings convenience to users	Ease to learn	PEOU1
			Controlled	PEOU2
			Clear and understood	PEOU3
			Flexible	PEOU4
10	Intention to Use (IU)	Differences in use into the use of the system which means the use of information and use of the information system itself	Daily use	IU1
			User frequency	IU2
			Light of use	IU3
			Various Uses	IU4
11	User Satisfaction (US)	Is a response and feedback that emerges from the user after using the information system	Information satisfaction	US1
			Overall frequency	US2
			Various information	US4
12	Actual Use (AU)	Measurement of frequency and duration of use of technology	continue	AU1
			Use more	AU2
			Use in general terms	AU3
13	Net Benefit (NB)	The result or benefit felt by individuals and organisation after implementing an information system	Speed of completing work	NB1
			performance	NB2
			effectivity	NB3
			Increasing efficiency	NB4
14	Smart City Readiness (SCR)	The level of readiness of a city becomes a smart city	Human Resources	SCR1
			Technology	SCR2
			Government	SCR3
			Citizen	SCR4
			Private & Business Sector	SCR5
			Educational sector	SCR6

In this study, I will test the 20 research hypotheses as follows:

TABLE II. CONCEPTUAL RESEARCH HYPOTHESIS

Hypothesis	Relations	Hypothesis
H1	I→PU	Innovativeness variable has a positive and significant effect on Perceived of Use
H2	O→PU	Optimism variable has a positive and significant effect on Perceived of Use
H3	IN→PU	Insecurity variable has a positive and significant effect on Perceived of Use
H4	D→PU	Discomfort variable has a positive and significant effect on Perceived of Use
H5	I→PEOU	Innovativeness variable has a positive and significant effect on Perceived Ease of Usefulness
H6	O→PEOU	Optimism variable has a positive and significant effect on Perceived Ease of Usefulness
H7	IN→PEOU	Insecurity variable has a positive and significant effect on Perceived Ease of Usefulness
H8	D→PEOU	Discomfort variable has a positive and significant effect on Perceived Ease of Usefulness
H9	IQ→IU	Information Quality variable has a positive and significant effect on Intent to Use
H10	SysQ→IU	System Quality variable has a positive and significant effect on Intent to Use
H11	ServQ→IU	Service Quality variable has a positive and significant effect on Intent to Use
H12	IQ→US	Information Quality variable has a positive and significant effect on User Satisfaction
H13	SysQ→US	System Quality variable has a positive and significant effect on User Satisfaction
H14	ServQ→US	Service Quality variable has a positive and significant effect on User Satisfaction
H15	PU→AU	Perceived of Use variable has a positive and significant effect on Actual Use
H16	PEOU→AU	Perceived Ease of Usefulness variable has a positive and significant effect on Actual Use
H17	IU→NB	Intent to Use variable has a positive and significant effect on Net Benefit
H18	US→NB	User Satisfaction variable has a positive and significant effect on Net Benefit
H19	AU→SCR	Actual Use Variabel has a positive and significant effect on Smart City Readiness
H20	NB→SCR	Net Benefit variable has a positive and significant effect on Smart City Readiness

B. Demographic Respondent

In this study, data were collected on 200 respondents who were then classified based on age, occupation and understanding of internet facilities. Data collection results are described as follows:

TABLE III. RESPONDENT'S AGE

Age (Year)	Frequency	Percentage(%)
17-25	65	32.5
26-35	80	40
36-45	55	27.5
Total	200	

TABLE IV. RESPONDENT'S OCCUPATION

Occupation	Frequency	Percentage(%)
Government employees	20	10
entrepreneur	40	20
Student	40	20
Housewife	15	7.5
Employee	25	12.5
Labor	25	12.5
Farmers	20	10
Fisherman	20	10
Total	**200**	

TABLE V. UNDERSTANDING OF THE INTERNET

Understanding of the internet	Frequency	Percentage(%)
Lack of understanding	75	37.5
Understand enough	65	32.5
Very understanding	60	30
Total	**200**	

IV. RESULT AND DISCUSSION

After the questionnaire from the community and the local government was collected, the validity test, reliability test, were conducted. Validity testing is done to see whether each question is built based on a valid construct. While reliability testing is used to see whether the questionnaire made can be counted or not. A good and reliable questionnaire instrument will have close results for measuring the same object. Whereas convergent validity is used to measure correlation scores from correlations between indicator score scores.

Validity Test is used to measure the accuracy of the instrument in this study, then testing the validity. Namely, test convergent validity and discriminant validity test. if the outer loading value of each indicator is> 0.5, then it can be said to be valid

TABLE VI. VALIDITY TEST RESULT

Latent variables	Reflective Indicator	Outer Loading	Information
Optimism (O)	O1	0.774	Valid
	O2	0.600	Valid
	O3	0.521	Valid
Innovativeness (I)	I1	0.600	Valid
	I2	0.572	Valid
	I3	0.531	Valid
	I4	0.596	Valid
Insecurity (IN)	IN1	0.549	Valid
	IN2	0.600	Valid
	IN3	0.610	Valid
Discomfort (D)	D1	0.787	Valid
	D2	0.596	Valid
	D3	0.736	Valid
	D4	0.638	Valid
	D5	0.699	Valid
Information Quality (IQ)	IQ1	0.531	Valid
	IQ2	0.369	Invalid
	IQ3	0.498	Invalid
	IQ4	0.634	Valid
System Quality (SysQ)	SysQ1	0.335	Valid
	SysQ2	0.776	Valid
	SysQ3	0.674	Valid
	SysQ4	0.626	Valid
Servis Quality (ServQ)	ServQ1	0.514	Valid
	ServQ2	0.690	Valid
	ServQ3	0.573	Valid
	ServQ4	0.631	Valid
Perceived of Use (PU)	PU1	0.682	Valid
	PU2	0.573	Valid
	PU3	0.469	Invalid
	PU4	0.565	Valid
Perceived Ease of Usefulness (PEOU)	PEOU1	0.434	Invalid
	PEOU2	0.599	Valid
	PEOU3	0.702	Valid
	PEOU4	0.522	Valid
Intention to Use (IU)	IU1	0.441	Invalid
	IU2	0.684	Valid
	IU3	0.696	Valid
	IU4	0.608	Valid
User Satisfaction (US)	US1	0.745	Valid
	US2	0.752	Valid
	US3	0.535	Valid
Actual Use (AU)	AU1	0.417	Valid
	AU2	0.639	Valid
	AU3	0.645	Valid
Net Benefit (NB)	NB1	0.476	Invalid
	NB2	0.525	Valid
	NB3	0.459	Valid
	NB4	0.482	Valid
Smart City Readiness (SCR)	SCR1	0.607	Valid
	SCR2	0.360	Valid
	SCR3	0.231	Valid
	SCR4	0.522	Valid
	SCR5	0.365	Valid
	SCR6	0.478	Valid

Based on the table above, the results of the convergent validity test conducted in this study indicate that most indicators of latent variables have outer loading values above 0.5. however, there are still indicators that still have an output value below 0.5, IQ2, IQ3, PU3, PEOU1, IU1, and NB1

TABLE VII. DISCRIMINANT TEST RESULT

	SysQ	IQ	D	IN	I	O	ServQ
SysQ	0.396						
IQ	0.13	0.398					
D	0.454	0.337	0.454				
IN	0.305	0.312	0.310	0.326			
I	0.346	0.351	0.349	0.316	0.364		
O	0.243	0.365	0.261	0.246	0.310	0.307	
ServQ	0.285	0.375	0.313	0.252	0.312	0.366	0.372
IU	0.264	0.277	0.267	0.290	0.281	0.215	0.231
US	0.329	0.360	0.352	0.313	0.341	0.309	0.328
PEOU	0.272	0.293	0.285	0.269	0.284	0.246	0.261
PU	0.406	0.422	0.413	0.325	0.429	0.378	0.392
NB	0.296	0.320	0.312	0.295	0.309	0.268	0.285
AU	0.240	0.247	0.243	0.191	0.245	0.230	0.238
SCR	0.318	0.344	0.334	0.315	0.332	0.288	0.306

TABLE VIII. DISCRIMINANT TEST RESULT (CONTINUED)

	IU	US	PEOU	PU	NB	AU	SCR
SysQ							
IQ							
D							
IN							
I							
O							
ServQ							
IU	0.246						
US	0.273	0.247					
PEOU	0.233	0.329	0.251				
PU	0.312	0.401	0.313	0.485			
NB	0.255	0.316	0.277	0.358	0.307		
AU	0.169	0.231	0.175	0.289	0.203	0.212	
SCR	0.272	0.385	0.295	0.384	0.328	0.220	0.334

Test the validity of discrimination, based on the table above; it can be seen that the value of cross-loading is variable> 0.5. So that it can be concluded that some latent variables fulfil discriminant validity. however, there are still several variables that have values below 0.5 including variables IQ, US, IU, and AU

TABLE IX. RELIABILITY TEST RESULT

Latent variable	Symbols	Composite Reliabilities	Information
Optimism	O	0.307	Unreliable
Innovativeness	I	0.364	Unreliable
Insecurity	IN	0.326	Unreliable
Discomfort	D	0.454	Unreliable
Intention to use	ITU	0.996	Reliable
User satisfaction	US	0.798	Reliable
Perceived ease of usefulness	PEOU	1.200	Reliable
Perceived of use	PU	1.063	Reliable
Net benefit	NB	1.021	Reliable
Actual use	AU	0.825	Reliable
Smart city readiness	SCR	1.048	Reliable

After testing the validity, then performed reliability testing. This test is done by calculating the composite reliability value. If the value of the reliability test is> 0.5, then the latent variable can be considered good or reliable. Based on table data, it shows that the variable has a value of> 0.5, which means that it is considered reliable.

Confirmatory Factor Analysis Test the structural model in AMOS was evaluated using path analysis, here is the CFA and the model in this research study

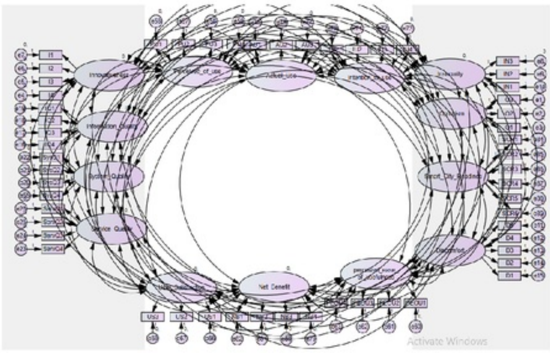

Fig. 6. Confirmatory Factor Analysis Model using AMOS 23.0

Based on research results can be seen in the following results

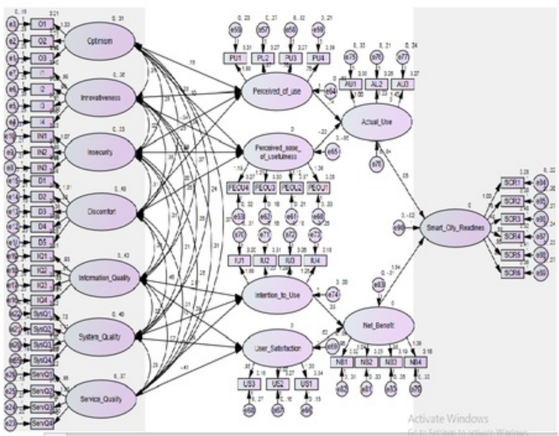

Fig. 7. SEM Model Result using AMOS 23.0

TABLE X. HYPOTHESIS TEST RESULT

Hypothesis	Relations	Critical Ratio	Noted	Result
H1	I→PU	7.228	>1.96	Accepted
H2	O→PU	2.276	>1.961	Accepted
H3	IN→PU	2.286	>1.96	Accepted
H4	D→PU	0.683	<1.96	Rejected
H5	I→PEOU	2.510	>1.96	Accepted
H6	O→PEOU	1.648	>1.96	Accepted
H7	IN→PEOU	7.779	>1.96	Accepted
H8	D→PEOU	0.605	<1.96	Rejected
H9	IQ→IU	5.568	>1.96	Accepted
H10	SysQ→IU	1.283	>1.96	Accepted
H11	ServQ→IU	4.482	>1.96	Accepted
H12	IQ→US	5.039	>1.96	Accepted
H13	SysQ→US	3.465	>1.96	Accepted
H14	ServQ→US	1.985	>1.96	Accepted
H15	PU→AU	8.560	>1.96	Accepted
H16	PEOU→AU	3.358	>1.96	Accepted
H17	IU→NB	4.667	>1.96	Accepted
H18	US→NB	8.715	>1.96	Accepted
H19	AU→SCR	1.985	<1.96	Accepted
H20	NB→SCR	9.675	>1.96	Accepted

Based on Table X above, the final results are presented as Innovativeness (I), Optimism (O), Insecurity (IN) variables that have a positive and significant effect on the Perceived of Use (PU) variable while the Discomfort (D) variable does not have a positive effect on Perceived of Use (PU).

Innovativeness (I), Optimism (O), Insecurity (IN) variables have a positive and significant effect on the Perceived Ease of Usefulness (PEOU) variable while variable Discomfort (D) does not have a positive effect on Perceived Ease of Usefulness (PEOU).

Variable Information Quality (IQ), System Quality (SysQ), Service Quality (ServQ), have a positive and significant effect on Intention to use (IU). Information Quality (IQ), System Quality (SysQ), Service Quality (ServQ) variables, have a positive and significant effect on User Satisfaction (US).

The Perceived of Use (PU) variable, Perceived Ease of Usefulness (PEOU) has a positive and significant effect on actual Use (AU).

The Intention to Use (IU), User Satisfaction (US) variables has a positive and significant effect on Net Benefit (NB). Moreover, finally the Actual Use Variable (AU) and Net Benefit (NB) have a positive and significant effect on Net Benefit (NB).

In the end, based on the results of this study the following modeling results are obtained:

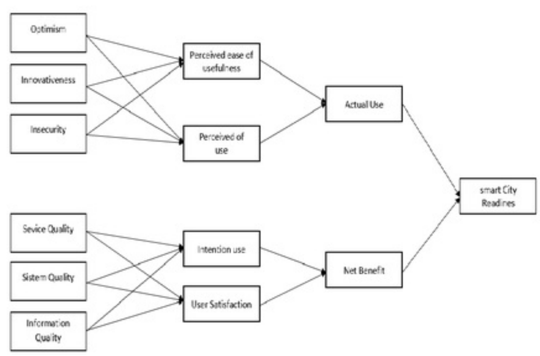

Fig. 8. Final Model

In this final model, the results show that all relations between variables in the proposed model are proven except that the Discomfort variable is not proven to have a positive and significant effect on the PEOU and PU variables

V. CONCLUSION

Smart City Readiness on districts as a concept must be started consistently and continuously following the previously prepared master plan. It is necessary to prepare the community and local government in accepting and adopting new technologies. This study identifies factors that influence regional readiness for the application of smart cities.

Based on the analysis carried out 18 out of 20 hypotheses were accepted while the rest were rejected. Therefore, it can be concluded that the factors that influence the public and civil servants in Sampang and Pamekasan districts are influenced by Optimism (O), Innovativeness (I), Insecurity (IN), Discomfort (D), Information Quality (IQ), System Quality (SysQ), Servis Quality (ServQ), Perceived of Use (PU), Perceived Ease of Usefulness (PEOU), Intention to Use (IU), User Satisfaction (US), Actual Use (AU), Net Benefit (NB).

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