RESEARCH ARTICLE

RSP Science Hub

International Research Journal on Advanced Science Hub
2582-4376
Vol. 04, Issue 12 December
www.rspsciencehub.com

Check for updates

http://dx.doi.org/10.47392/irjash.2022.071

Analysis Affect Factors of Smart Meter A PLS-SEM Neural Network

Minh Ly Duc[1], *Que Nguyen Kieu Viet*[1]

[1] *Faculty of Commerce, Van Lang Univeristy, 700000, Ho Chi Minh City, Vietnam*

Email: Vietnam.lyducminh10937@gmail.com

Article History

Received: 8 November 2022
Accepted: 14 December 2022

Keywords:

PLSSEM;
ANN;
IPMA;
Smart Meter

Abstract

Smart electricity meters measure, control, analyze, and predict the amount of electricity used. Do the same for water and gas power. Automatically svae this monitoring data to the energy provider, for billing and tracking services. In developed countries, there has not been a consensus to accept the use of smart electricity meters, in addition to the benefits mentioned above, there are many possible risks when using smart meters. This paper examines information technology system (IS) related factors and engineering model related factors following technical readiness such as optimism, innovation insecurity, and discomfort. Accompanying that is the expectation of a smart meter, for the Vietnamese people's intention to continuously use smart meters. The oriented approach is applied to evaluate the intention model of continuous use of smart meters, through the survey results of 500 answer samples of Vietnamese people. We propose to use a 2-layer research model to analyze the results of the user survey about the smart meter system. Most of the previous studies on smart meter systems focused on analyzing the impact of factors affecting applications, using single-step Structure Equation Modeling (SEM). The purpose of this study based on the Technology Acceptance Method (TAM) theory, describes the Artificial Neural Network (ANN) method to perform in-depth analysis, yielding more accurate results than the SEM model. The study measures the relationship between the readiness for new technologies (optimision, innovation, discomfort, and insecurity). Technology acceptance (Perceived ease of use, Perceived usefulness). Expectations confirmed and Information systems acceptance (service quality, system quality, and information quality). This paper outlines the research model of the multi-analysis approach by combining Partial Least Squares Structure Equation Modeling (PLS-SEM) and Artificial Neural Network (ANN) analysis. First, the PLS-SEM model evaluates the factors affecting the intention to use the smart meter system. Second, ANN ranks the impact factors of important predictors from the PLS-SEM model. The findings from the PLS-SEM and ANN approach research model confirm the results obtained from PLS-SEM by ANN. In addition, ANN performs linear and non-linear relational modeling with high prediction accuracy compared with the SEM model. In addition, an Importance Performance Map Analysis (IPMA) analyzes the results accurately for factors' important performance.

1. Introduction

A smart meter is a digital system that records the amount of energy used, helping to effectively manage the smart grid, helping the user to make an easy decision or decide to continue to use the electricity (Rodríguez-Pajarón, Bayo, and Milanović). On the other hand, smart meters help to estimate temperature set points because of the heat transfer coefficient for large buildings. At the same time, smart meters also help energy users and suppliers in controlling and predicting energy loads and deciding on whether to continue using electrical energy or suspend various regulatory policies (Kumar et al.). on how to view the data of the smart watch. However, in developing countries, the data exchange is done between the user and the electricity supplier. Synchronizing smart devices helps to distinguish the electric energy efficiency of each device and facilitates data transmission between smart devices in the home for better, more efficient operation.This is a new smart technology, smart devices are controlled by a control button in the center and improve the efficiency of electrical energy use, saving energy costs (S. Zhou Hidalgo-Gonzalez, Johnston, and Kammen Ahmad). Many energy supply companies have restructured their production processes from providing energy derived from fossil fuels and nuclear to renewable energy sources such as wind, solar, geothermal, and biomass. ... and energy-using companies consider process optimization and optimal use of energy sources to reduce electricity consumption and use energy more efficiently. This requires the integration of information technology and telecommunications systems into the power grid to form a "smart grid" technology (Jain and Bhullar). Such systems further enhance the power sector's efficient supply chain load management. Consumers can access energy usage data at websites because they can use the application to analyze the power consumption, they have been using to decide whether to continue using or not (S. Chakraborty and Das). Stop using energy or temporarily stop using some smart devices in their home to increase flexibility in measuring and monitoring energy use. The use of smart meters can determine the hourly cost of energy usage to the user. Users can convert peak hours of electronic use to suitable time frames to reduce energy costs and use electrical energy at a cheaper price. In addition, the very important function of smart grids and smart meters also supports the management of complex power networks (W. Zhou et al. Balwani et al.). Other benefits that smart grids or smart meters bring are environmental factors, namely improving energy efficiency, mitigating climate change, and balancing by supply and demand (Velayudham, Ganesh, and Kanimozhi). If the smart grid or smart meter is widely used in Vietnam, it will contribute to positive climate change or solve climate change related problems. A user survey in Hong Kong and the results showed that 97.4% of smart meter users perceive benefits related to the environment. Also, data security, data quality, data availability. The cost-effective energy use and ability of smart meters to connect with other smart devices play an integral role in the smart grid. They are the premise to move towards implementing a smart grid with smart metering.

It is important to clearly identify the factors that influence a customer's intention to continue using a smart meter that demonstrate the usefulness of the device while meeting the user's expectations. Specifically, technical readiness about optimism, innovation, insecurity, and discomfort and factors that smart electrical measuring devices can create for information technology (IS) models involve factors such as Service quality, system quality, and information quality are also factors affecting the intention to use continuously of users. Information technology-related factors contribute significantly to the user's intention to continue using. Identify problem points affecting users' intention to use continuously and provide directions to improve user satisfaction with smart electrical meters and improve users' intention to use continuously. In general, developed countries have been perfecting the use of smart electricity metering devices in the smart grid. However, in developing countries like Vietnam, which is gradually entering the use of smart devices in the smart grid, many negative factors arise, and the benefits from smart metering devices are not high to the user's intention to continue using. Some challenges when using smart grids or smart meters in Vietnam such as in high locations, rural areas, not equipped with enough smart metering equipment, related to smart infrastructure. User awareness about smart metering equipment is still limited, which is a significant influencing factor between energy suppliers and smart grid service devices and users.

This study, in addition to understanding and raising users' awareness of smart metering devices, also provides a clearer understanding of the potential for developing the application of smart devices to the power grid in Vietnam. The research is organized according to the following organization: Part 2 records related studies and outlines the theoretical basis. Part 3 presents the content of Hypothesis Development, part 4 out-lines the research method. Section 5 presents and analyzes the data and research results. Section 6 discusses and analyzes the conclusions and directions for future research.

2. Literature review

A smart meter is a device connected to a Wi-Fi system and has many advantages over a traditional electricity meter, it helps to measure and monitor energy consumption in real-time with accuracy $\pm$ 1%. In addition, users can open and close the smart meter's switch flexibly thanks to its Wi-Ficonnection system (Alkawsi, Ali, and Baashar T. Zhang, O Siebers, and Aickelin Morrell et al.). This makes deploying a smart home system simple and affordable for many families in Vietnam. The size of the smart electricity meter is relatively small with the portable assembly feature that is easy to install and replace when necessary to make your home smarter, and more convenient, the most important feature (Shirani et al. Chou and Yutami England and Alouani). The most important thing is to control power consumption accurately and reduce power consumption when away from home, helping to reduce the family's electricity costs. The accuracy of smart electricity meters is $\pm$1% compared to traditional electricity meters is $\pm$2%. In addition, the smart meter can also measure the consumption of the smallest consuming devices such as chili lamps, and night lights with high accuracy. The LCD network is designed to be able to see parameters such as U, I, Q of the power supply or connect to a mobile phone via Wi-Fi network (Parvez et al.). The function of energizing up to 60A over the Internet anywhere and anytime (Artale et al.), ensuring absolute safety for your home along with the development of a voice processing application program in the computer science industry that helps the clock Smart electricity meter is allowed to schedule on and off automatically and easily by connecting with virtual assistants, processing by voice such as Alexa, Google Assistant.

2.1. Technology Acceptance Model (TAM)

Technology Acceptance Model (TAM) (Shuhaiber and Mashal) was developed by Davis (1986) based on the theory of reasonable action (TRA) to predict the acceptability of an information technology system. The purpose of validating the modification of an information technology system to make it acceptable to users is based on two main factors: (1) perceived usefulness and (2) perceived ease of use. Perceived ease of use). Perceived usefulness is the extent to which users believe that using the system will improve their performance. Perceived ease of use refers to the extent to which users believe that using the system will be easy. The Technology Acceptance Model (TAM) depends on the behavioral intentions of consumers.

2.2. Information Technology Model (IS)

A smart meter is integrated with digital control and Wi-Fi connection, to control and monitor electricity consumption in real-time (Sharma, A. K. Chakraborty, and Chakraborti Steiner et al. Wang, Hu, and J. Zhang). The information technology network system requires quality assurance because the equipment to operate the network system such as the internet connection is not interrupted, by the information transmission line of the smart device is large enough to transmit data between devices. Smart equipment in the power system and the maintenance system needs to have a good implementation plan and ensure stable operation of the system (Gerpott and Paukert), (T. Zhang, O Siebers, and Aickelin). However, in Vietnam in rural, highland, deep-lying areas, islands, etc., the information technology infrastructure system is still limited, which can be said to be outdated. That is the main reason for the difficulty in smart meter implementation. Information transmission systems such as those of Wi-Ficonnected devices affect the information quality of smart devices when transmitting data between smart devices. Speed of responseand data transmission of information systems. In particular, the transmission of power consumption data from the smart meter to the user's management device such as a smartphone is the top concern of the user. In addition, the user has the function of opening and closing the electric ladder switch through the transmission line. If the quality of information is not guaranteed to work well, the user's requirements will not be satisfied. Although smart meter suppliers regularly have customer appreciation programs for providing quality service, providing digital technology related services, which positively affects perceived intention. of the user. Many previous studies show that the information technology model depends on 3 main factors: (1) service quality, (2) system quality and (3) information quality that affects intentions. Determining useful product users, using digital control platform to share knowledge about digital control technology products, not many studies have shown. Specifically, with smart meter products, the sharing platform about smart meter products in Vietnam is very limited. This study helps to contribute to a clearer understanding of the knowledge sharing platform on product usage, using digital technology, specifically smart electricity meters. Based on the above research and discussion, the following hypotheses are formed (Fig. 1).Hypothesis 1 (H1): Service quality of the information technology model has a direct positive impact on the intention to use continuously of users.Hypothesis 2 (H2): The system quality of the information technology model directly affects the user's intention to use continuously.Hypothesis 3 (H3): The information quality of an information technology system directly affects the user's intention to use it continuously.

2.3. Technology Model

Meters are determined by four factors Optimization, Innovation, Insecurity, and Discomfort. These four factors affect the technology acceptance model (TAM) (Akman and Mishra). Technology acceptance theory shows that users perceive technology in two ways, which are positive and negative. Users accept to use the product in a more positive way, finding the smart meter product useful for them (Figure. 1). However, users facing the negative side will be hesitant to accept the use of smart meters. They do not agree to change the traditional electricity meter to a smart meter. The awareness of Vietnamese people about smart meters is not high and they have not clearly seen the benefits as well as the usefulness and ease of operation of smart electricity meters.Users can use smartphones to connect to smart meters through the network, and users can control their power consumption over time, helping them save costs when automatically adjusting the power consumption according to the actual time. In addition, the innovation factor of smart electricity meters in increasingly optimizing operating methods, controlling the operation of digitally controlled products, for example: using voice to control intelligent electrical system control. Outside the house, where there is a Wi-Fi network connection system and a smartphone, the user can control the opening and closing of smart power consuming devices in the house through smart electricity meters (Osama, Alfonse, and Salem).

Users use personal information to operate and open smart devices in a smart grid or a smart home. This is useful information that hackers can infiltrate and steal user information to serve negative benefits for users, like hackers can open the user's home door when they are away, or hacker using personal information of users to steal banking information, ... The head of the household (who is primarily responsible) for the management of appliances that use electricity or is responsible for paying living expenses in the family. At the age of about 47 ~ 55 years old, people who use smartphones are often aware that seeing with their eyes and touching with their hands is afraid to change their living environment like they are afraid to change from a traditional electricity meter to a smart meter. Because they are still concerned about security or clarity about the results of digital control technology products, namely smart electricity meters (Leiva, Palacios, and Aguado). This is annoying user content related tosmart meters. The technical model of the digital control product consists of four main elements. (1) Optimization: New technology brings positivity to activities, improves control over life, and brings flexibility and efficiency to life. **(2)** Innovation: New technology offers new ideas and uses, increasing the flexibility of products using digital controls. **(3)** Insecurity: The intended purpose of the technology does not meet the individual standards of the user. Causing negative user intent toward a digitally controlled product. **(4)** Discomfort: Digital control technology makes it difficult for users to operate, causing inconvenience to users.

Users consider the theoretically related positive and negative factorsto perceive the intention to continuously use the smart meter product. On the other hand, users' expectations about a digitally controlled product affect technology acceptance theory (TAM), and expectations also directly affect users' intention to use continuously. The theory of expectation was proposed by Victor Vroom in 1964 and was supplemented and edited to complete the theory of expectation by Porter and Lawler in 1968. Expectation theory shows that the act of using a smart meter brings a result and its attractiveness to the user. Specifically, users using smart meters meet the expectation of optimizing the cost of using electrical energy, eliminating waste of energy sources. This 4-factor technical model affects the theory of user acceptance of technology, in terms of 2 negative and positive aspects. Expectation theory (Markard and Erlinghagen) shows that users accept the use of technology such as smart electricity meters, bringing the benefits of controlling electricity consumption and saving electricity costs for users. At the same time, the information technology model that supports users when using smart electricity meters is easier and meets users' expectations in smart electricity meters. Based on the above discussion, the following hypotheses are formed.

Hypothesis 4 (H4): The optimization factor has a positive impact on the theory of technology acceptance and indirectly has a positive impact on the user's intention to use continuously.Hypothesis 5 (H5): The innovation factor directly affects the theory of technology acceptance and indirectly affects the continuous use intention of users.Hypothesis 6 (H6): Insecurity factors directly affect technology acceptance theory and indirectly affect users' intention to use continuously.Hypothesis 7 (H7): The discomfort factor directly affects the theory of technology acceptance and indirectly affects users' intention to use continuously.Hypothesis 8 (H8): The Perceived ease of use factor directly affects the Perceived usefulness factor and indirectly affects the user's intention to use continuously. (H10).Hypothesis 9 (H9): The factor in the theory of expectation is the Expectation Confirmation factor that directly affects the Perceived usefulness factor and indirectly affects the user's intention to use continuously. (H12).Hypothesis 11 (H11): Perceived usefulness has a direct impact on the user's intention to use continuously.

3. Research Method

The data carried out in this study were collected from people living in the Ho Chi Minh City area and the Tay Ninh province area in Vietnam. The survey sample is conducted in a random manner because it is easy for the survey participants. Survey participants are married and have their own houses and are using electric energy, making monthly electricity payments to the electricity supplier. Most survey participants found it useful to monitor electricity usage results with traditional and smart electricity meters. The survey scale is measured in the survey table from previous studies by domestic and foreign authors in Vietnam. Each research variable participates in at least 3 measurement variables. The questionnaire is made entirely in Vietnamese and according to the Likert 5 scale. To ensure the appropriate design of the questionnaire, the questionnaire was sent to 3 experts in the field of computer science related to energy. electricity for comments and the author has completed the questionnaire according to the comments of experts.A total of 500 questions were collected and 45 questions were discarded because there were incorrect or invalid answers, it is possible that these people did not carefully read the questionnaire with a total of 455 valid questionnaires used in Smart PLS 3.0 and IBM SPSS Statistic 20 software, to analyze the research model. The collected results show that 71% are female and 29% are male. The age range falls between 25 and 60 years old. The main level of education is 12, accounting for 72%.Composite reliability (CR) is the index applied to evaluate the reliability and validity of the scale; Cronbach's Alpha value is the index used to evaluate the reliability of other factors. The evaluation criteria of the CR index and Cronbach's Alpha index must be greater than 0.8 for the survey results to be assessed as reasonable values and then included in the PLS-SEM analysis model. Table 2 shows that the results of the survey panel analysis are that the CR index and Cronbach's Alpha index are both greater than 0.8 and the AVE index is greater than 0.5. This proves that the survey panel has a valid scale analysis value and has a high level of reliability for the research model. the square root of the AVE index is larger than the correlation coefficient, proving the validity of the data.

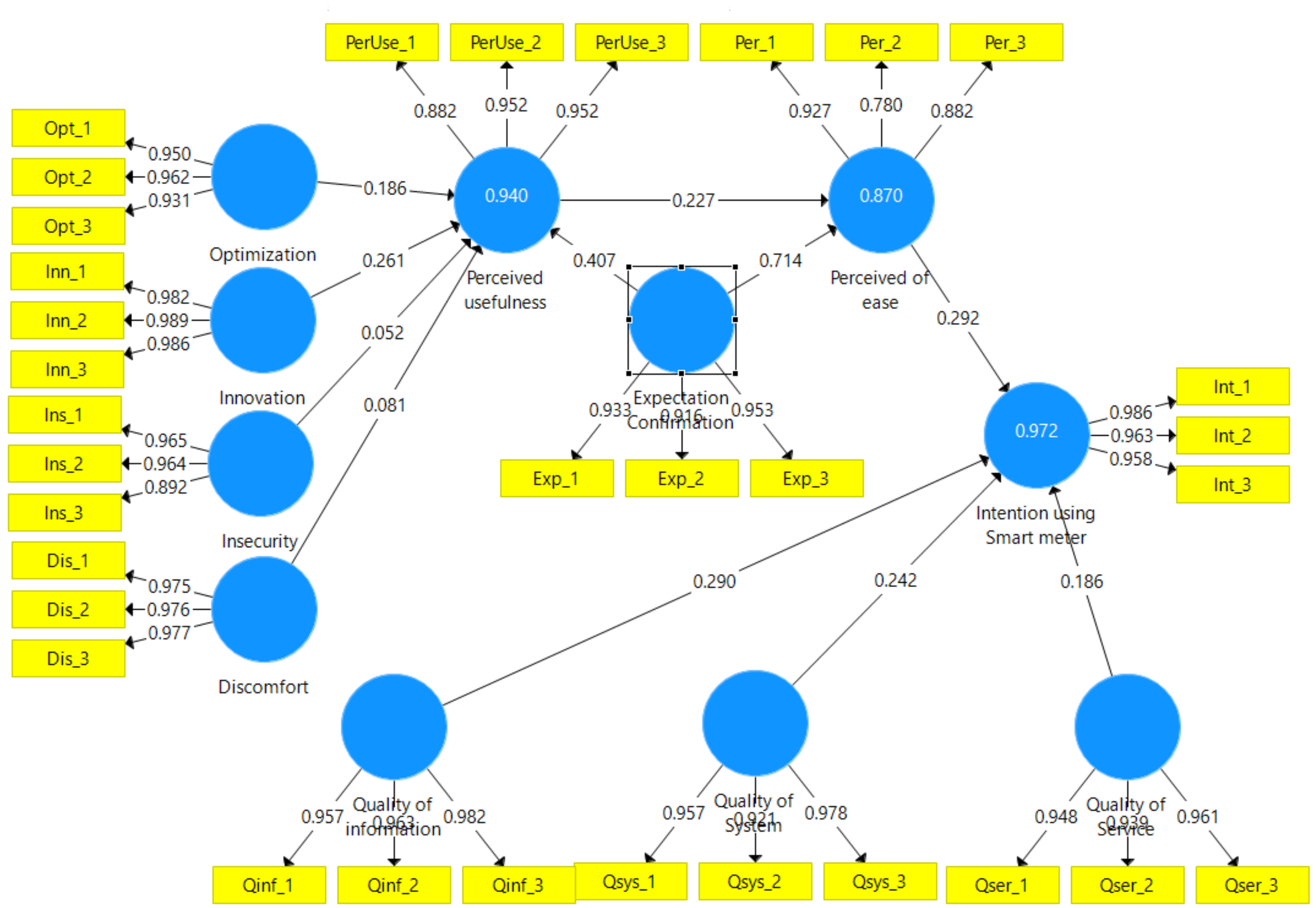

FIGURE 1. Research model

3.1. Structural Model

Using the T-test statistical analysis model to evaluate and confirm the model's path coefficient, the R-squared value is used to evaluate the user's intention to continuously use the smart electricity meter in Vietnam. Smart PLS 3.0 software is used to study the PLS-SEM model. The model is evaluated with data consistency requirements. The research results, after being analyzed, show that the quality related to the information system such as service quality, system quality, and information quality has a direct impact on the intention to continuously use the watch product. the smart meter of users. According to the analysis results from Table 4, the system quality factor (P-Value = 0.102) and the information quality factor (P-Value = 0.213) of the information technology model are not supported (table 1).

3.2. Artificial Neural Network Analysis

ANN (Artificial Neural Network) (Alkawsi et al.) is used as the second mesh in the analysis to complement the PLS-SEM model. In this study, we use the ANN model for in-depth analysis of the information technology model that affects the intention to continuously use a smart meter (E. Glass and V. Glass). ANN shows the prediction results with higher accuracy than the PLS-SEM model because of the non-linear relationship analysis data. SEM analysis sometimes offers an oversimplified analysis of process complexities. In addition, ANN is recommended to be used to test the interest of the factors. Therefore, the combined use of the PLS-SEM model with the ANN model the main purpose is that they complement each other. During ANN analysis, data is supported by Multilayer perception (MLP). ANN analysis is performed in 3 layers: input layer, hidden layer, and output layer. In our study, we used IBM SPSS 20 to run the ANN model. The ANN-1 model has an output class of Int-1 and has 3 inputs of the information technology model: quality of service, quality of the system, and quality of information. The ANN-2 model has an output factor of TAM and has four inputs from the technical model: optimiza-

TABLE 1. Result of hypothesis analysis

Hypothesis	Path	Estimate	T-value	S. E	P-value	Result
H1	Qser Int	0.156	4.21	0.058	0.003	Supported
H2	Qsys Int	0.631	3.50	0.035	0.102	Supported
H3	Qinf Int	0.549	4.03	0.047	0.213	Supported
H4	Opt Eas + Use	0.513	4.13	0.039	0.000	Supported
H5	Inn Eas + Use	0.498	4.51	0.0421	0.001	Supported
H6	Ins Eas + Use	0.397	4.01	0.032	0.002	Supported
H7	Dis Eas + Use	0.441	4.05	0.039	0.003	Supported
H8	Eas Use	0.332	3.98	0.041	0.000	Supported
H9	Exp Eas + Use	0.339	4.01	0.052	0.001	Supported
H10	Eas Int	0.423	3.98	0.041	0.006	Supported
H11	Use Int	0.391	4.07	0.052	0.008	Supported
H12	Exp Int	0.419	3.95	0.061	0.003	Supported

tion, Innovation, Insecurity, and Discomfort. The ANN-3 model has an output factor of Int-2 and has three inputs, Perceived Ease of use, Perceived usefulness, and Expectation confirmation.The ANN-1 model shows the neurons (Node) automatically generated and activated by the sigmoid function used for both the hidden layer and the output layer. To ensure the accuracy of the prediction results of the ANN as measured by 10 times cross-validation for the purpose of preventing data from overfitting errors, we divide the data into two parts as follows: a part 85% of the data is for training and 15% of the data is for testing. The accuracy of the predictive model is calculated according to the index after the square of the square root for both the training part (85%) and the test part (15%) of the dataset, the RMSE index (Root square error) is calculated by the formula (1) and (2). In which, SSE is the sum of squared error and MSE is the mean squared prediction.Analysis results from table 2 to table 4 of RMSE values for training and test data of the dataset representing the ANN model, exactly the model generated relationship between predictors and output factors. Low RMSE results in more accurate predictions and better data visualization.

5-7 show the sensitivity analysis index. Figures 2-4 show the system quality factor of the information technology model and the Insecurity factor, and the Discomfort factor of the technical model are the effects of the important factors on the intention to continue using the smart meter system of users, in particular smartphone users. Considering the importance of the next standardized variable, the service quality factor, the information quality factor of the

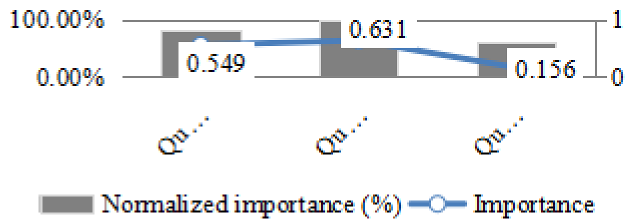

FIGURE 2. Normalized variable relation importance (Output: SAT-1)

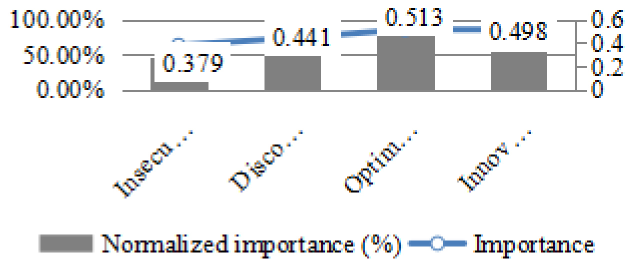

FIGURE 3. Normalized variable relation importance (Output: TAM)

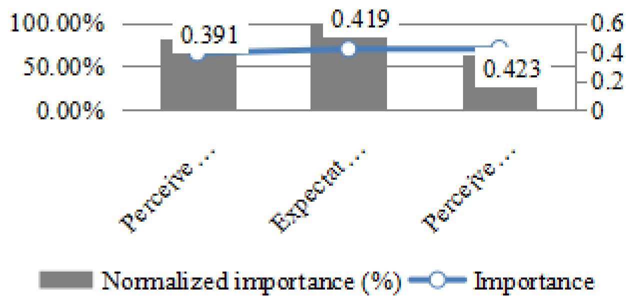

FIGURE 4. Normalized variable relation importance (Output: SAT-2)

TABLE 2. RMSE values for the ANN-1 model

Input factors: Quality of Service, Quality of System and Quality of Information. Output factor: Intention to use of continuously				
Neural Network	Training (85% of data sample 455) ; N = 387		Testing (15% of data sample 455) ; N = 68	
	SSE	RMSE	SSE	RMSE
ANN1	0.1199	0.0318	0.1101	0.0887
ANN2	0.1231	0.0316	0.1080	0.0873
ANN3	0.1274	0.0317	0.1160	0.0911
ANN3	0.1321	0.0321	0.1290	0.0910
ANN4	0.1316	0.0323	0.1170	0.0960
ANN5	0.1153	0.0299	0.1060	0.0918
ANN6	0.1241	0.0298	0.1090	0.0879
ANN7	0.1127	0.0301	0.1190	0.0921
ANN8	0.1213	0.0299	0.1180	0.0906
ANN9	0.1135	0.0303	0.1090	0.0910
ANN10	0.1124	0.0289	0.0998	0.0897

TABLE 3. RMSE values for the ANN-2 model

Input: Optimization, Innovation, Discomfort, Sercurity Output: TAM				
Neural Network	Training (85% of data sample 455) ; N = 387		Testing (15% of data sample 455) ; N = 68	
	SSE	RMSE	SSE	RMSE
ANN1	0.1161	0.0301	0.1172	0.0359
ANN2	0.1152	0.0304	0.1181	0.0293
ANN3	0.1098	0.0305	0.1109	0.0301
ANN3	0.1151	0.0291	0.1106	0.0351
ANN4	0.1012	0.0287	0.0991	0.0299
ANN5	0.1053	0.0298	0.0983	0.0342
ANN6	0.1041	0.0296	0.1173	0.0335
ANN7	0.1091	0.0308	0.1131	0.0347
ANN8	0.1043	0.0305	0.1129	0.0298
ANN9	0.1031	0.0299	0.0991	0.0345
ANN10	0.1132	0.0189	0.1012	0.0298

information technology model and the optimization factor, the Innovation factor of the technical model, and the perceived factor. ease of use, perceived usefulness of the TAM model, and theoretical expectations, respectively, affect user satisfaction.

8-10 compare the results of ANN analysis with PLS-SEM analysis, based on the coefficient-ranked path strength of the PLS-SEM and the significance of the ANN's normalized relative index. Comparison results from Table 8 (Output: INT-1) service quality factors are ranked for both ANN and PLS-SEM models. However, PLS-SEM analysis, the first and second results are ranked in order of two factors: quality of system and quality of information, ANN analysis shows that the information quality factor ranks first and the system quality factor second. The

TABLE 4. RMSE values for the ANN-1 model

Input: Perceived ease of use, Perceived usefulness, Expectation confirmation Output: Intention to use Continuously				
Neural Network	Training (85% of data sample 455) ; N = 387		Testing (15% of data sample 455) ; N = 68	
	SSE	RMSE	SSE	RMSE
ANN1	0.113	0.0312	0.115	0.0338
ANN2	0.109	0.0308	0.119	0.0347
ANN3	0.115	0.0313	0.109	0.0395
ANN3	0.117	0.0301	0.112	0.0381
ANN4	0.108	0.0299	0.115	0.0373
ANN5	0.109	0.0308	0.117	0.0352
ANN6	0.115	0.0309	0.109	0.0361
ANN7	0.119	0.0313	0.108	0.0339
ANN8	0.118	0.0309	0.117	0.0342
ANN9	0.109	0.0314	0.109	0.0359
ANN10	0.0996	0.0301	0.129	0.0299

TABLE 5. Normalized variable relation importance (Output: Int-1)

Predictors (Output: Int-1)	Average relative importance	Normalized relative importance (%)	Ranking
Quality of System	0.631	100	1
Quality of Information	0.549	81.94	2
Quality of Service	0.156	61.79	3

TABLE 6. Normalized variable relation importance (Output: TAM)

Predictors (Output: TAM)	Average relative importance	Normalized relative importance (%)	Ranking
Insecurity	0.397	45.46	4
Discomfort	0.441	67.23	3
Optimization	0.513	100	1
Innovation	0.498	89.21	2

TABLE 7. Normalized variable relation importance (Output: Int-2)

Predictors (Output: Int-2)	Average relative importance	Normalized relative importance (%)	Ranking
Expectation confirmation	0.419	83.09	2
Perceived ease of use	0.423	100	1
Perceived usefulness	0.391	64.26	3

TABLE 8. Comparison beween PLS-SEM and ANN analysis (Output: INT-1)

	Path means	PLS-SEM Ranking	ANN normalized relative importance (%)	ANN Ranking	Matched?
QSys	0.631	1	81.94	2	No
QInf	0.549	2	100	1	No
QSer	0.156	3	61.79	3	Yes

TABLE 9. Comparison between PLS-SEM and ANN analysis (Output: TAM)

	Path means	PLS-SEM Ranking	ANN normalized relative importance (%)	ANN Ranking	Matched?
Insecurity	0.379	4	45.46	4	Yes
Discom-fort	0.441	3	67.23	3	Yes
Optimiza-tion	0.513	1	100	1	Yes
Innovation	0.498	2	89.21	2	Yes

TABLE 10. Comparison between PLS-SEM and ANN analysis (Output: INT2)

	Path means	PLS-SEM Ranking	ANN normalized relative importance (%)	ANN Ranking	Matched?
Expectation confirmation	0.419	2	83.09	2	Yes
Perceived ease of use	0.423	1	100	1	Yes
Perceived of usefulness	0.391	3	64.26	3	Yes

ANN model measures linear and nonlinear relationships between variables with high accuracy. Table 9, (Output: TAM), the factors of optimization, innovation insecurity, and discomfort are ranked from 1 to 4 for both ANN and PLS-SEM models. The ANN model measures linear and nonlinear relationships between variables with high accuracy. Table 10, (Output: INT-2), Expectation confirmation, Perceived ease of use, and Perceived usefulness factors are ranked 1 to 3 for the PLS-SEM analysis model. However, the analysis results from ANN give completely opposite results and are ranked in order from 1 to 3 as follows: Perceived usefulness, Expectation confirmation, and Perceived ease of use. The ANN model measures linear and nonlinear relationships between variables with high accuracy.

4. Discussion and Conclusion

This study, the input variables from the engineering model (optimization, innovation, insecurity, and discomfort) and the inputs from the TAM (perceived ease of use and perceived usefulness) model and the expected factor. The above factors are ranked based on the results of sensitivity analysis of the ANN model to determine the results of PLS-SEM. The detected results from the ANN model help verify the results from the PLS-SEM model analysis. However, ANN model gives more accurate analysis results because ANN measures linear and non-linear relationships between variables. The factors of the technical model (optimization, innovation, insecurity, and discomfort) are ranked in order from 1 to 4 for both ANN and PLS-SEM analysis models. However, the analysis results between ANN and PLS-SEM are not uniform. Specifically, the elements of the information technology model (QSys, QInf, QSer) are ranked in order from 1 to 3 for the PLS-SEM analysis model. However, the results from the ANN analysis model of the elements of the information technology model (QInf, QSys, QSer) and are ranked in order from 1 to 3, This result shows that the service quality factor ranks third among the three factors, the system quality factor and the information quality factor are ranked from 1 to 2 for the PLS-SEM model and ANN gives the opposite result, which is information quality (QInf) first and system quality factor (QSys) ranked second.This study shows that the factors related to technology (optimization, innovation, insecurity, and discomfort) directly affect the theoretical model of technology acceptance of users. Users have high expectations for a smart meter product with high technical factors and ease of use. At the same time, the smart meter system also ensures ease of use and useful utility. Technical factors indirectly affect people's intention to continue using the smart meter system and directly affect the theory of technology acceptance. However, the factors related to the information technology model (quality of information, quality of system, and quality of service) have a direct impact on the satisfaction or intention to continue using the smart meter system. Users are still afraid and not secure when accepting the use of the smart meter system.

The PLS-SEM model is clearly analyzed using the importance-performance map analysis (IPMA) chart to assess the relevant impact factors more clearly in the PLS-SEM model. IPMA histogram performs analysis based on two parameters, performance, and significance.The IPMA analysis chart (Figure 5) shows the results related to the target structure determination in the PLS-SEM path model. The system quality factor of the information technology model directly affects customer satisfaction and indirectly on the intention to continuously use the smart meter system. However, this factor has a positive impact on the user's intention to use the identification system continuously. This is one of two elements of the information technology model (quality of system, quality of information) that requires suppliers and manufacturers of smart meter systems to think more about it. improve product quality, the good service quality factor of the product supplier applying smart meter technology and according to ANN's ranking shows the consensus on the service quality factor, but in terms of information quality and system quality, they do not agree with the PLS-SEM model. Regarding the three elements of the information technology model (quality of information, quality of system and quality of service).

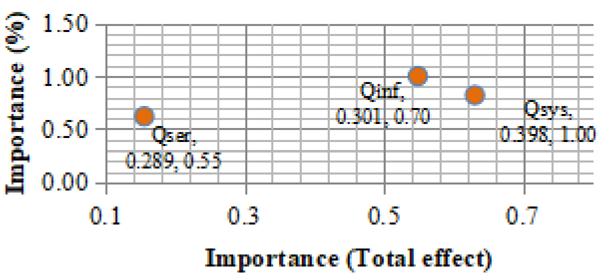

FIGURE 5. The correlation between the performance and the importance of the INT-1

Figure 6, IPMA diagram with output factor TAM, shows that the optimization factor directly affects the technology acceptance theory model (TAM) and indirectly affects the satisfaction of people and the intention to continuously use the user's identification system. At the same time, the factors of innovation, insecurity, and discomfort have a relative impact on the theoretical model of technology acceptance. The importance of four factors (optimization, innovation, insecurity, and discomfort) of the engineering model affecting the theoretical model of technology acceptance and the correlation between the ANN analysis and the analysis results of the PLS-SEM model.

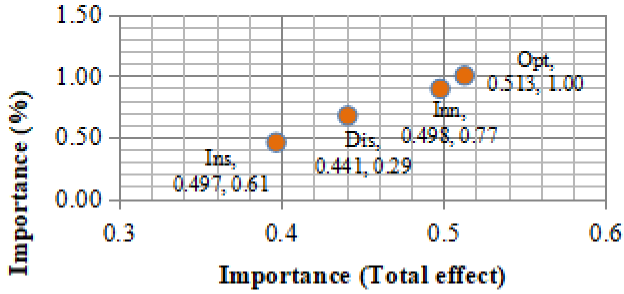

FIGURE 6. The correlation between the performance and the importance of the TAM factor

The Theoretical Technology Acceptance Model (TAM) consists of two main elements: perceived ease of use and perceived usefulness. In which, the perceived ease of use factor that affects the user's continuous intention to use is higher than that of usefulness but is ranked as the 2nd and 3rd according to the PLS-SEM model, the first is the confirmation factor (Figure 7).

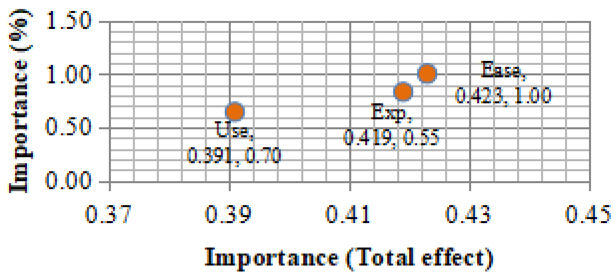

FIGURE 7. The correlation between the performance and the importance of the INT-2 factors

ANNs can model relationships of complex linear and non-linear relationships and gives more accurate prediction results than the PLS-SEM model. This study discovered that the important factors related to the information technology model are very few for users of products using digital control technology.From a theoretical point of view, very few studies accept the use of a poor-quality information technology system.The education level in developing countries is still low, and the information technology and internet infrastructure are still limited.The 2-step research model, including two models, PLS-SEM and ANN, helps to create the following benefits: ANN helps to evaluate and verify the analysis results from the PLS-SEM model. In addition, ANN is also capable of modeling complex linear and non-linear relationships with high predictive accuracy compared to the PLS-SEM model. In summary, the 2-step analysis model PLS-SEM Neural network gives better and more accurate analysis results than the 1-step analysis model PLS-SEM. In addition, the analysis results from IPMA show that the findings from the PLS-SEM model provide an understanding of the relative importance and performance of each factor, and the ANN helps to further verify the outcome factors. analysis results from the PLS-SEM model.

Limitation of the research topic. The data were collected in 2 areas, Ho Chi Minh City and Tay Ninh province, Vietnam. The limited point of data space is also a possible reason for our study to be less generalizable. In the future, expand the data to the whole country or across the country with a larger data set. On the other hand, the smart meter system is considered a system that has been used in the present and in the future. The establishment of policies and regulations governing the smart meter system is also a direction that needs to be considered for future research. In addition, the element of information technology control rights or factors related to the security of users' personal information or creating a firewall to prevent components with nefarious intentions such as hacking. personal information of users, this is also a hot topic for researchers and scientists. Finally, the Technology Organizational Environment (TOE) model used in the activity examines various factors influencing the acceptance and use of smart meter systems.

Acknowledgements

Sincere thanks to VSB–Technical University of Ostrava, Faculty of Electrical Engineering and Computer Science, Department of Cybernetics, and Biomedical Engineering, 708 00, Ostrava-Poruba, Czechia

References

Ahmad, T. "Non-technical loss analysis and prevention using smart meters". *Renewable and Sustainable Energy Reviews* 72 (2017): 573–589. 10.1016/j.rser.2017.01.100.

Akman, Ibrahim and Alok Mishra. "Sector diversity in Green Information Technology practices: Technology Acceptance Model perspective". *Computers in Human Behavior* 49 (2015): 477–486. 10.1016/j.chb.2015.03.009.

Alkawsi, Gamal Abdulnaser, Nor'ashikin Ali, and Yahia Baashar. "An Empirical Study of the Acceptance of IoT-Based Smart Meter in Malaysia: The Effect of Electricity-Saving Knowledge and Environmental Awareness". *IEEE Access* 8 (2020): 42794–42804. 10.1109/ACCESS.2020.2977060.

Alkawsi, Gamal Abdulnaser, et al. "A hybrid SEM-neural network method for identifying acceptance factors of the smart meters in Malaysia: Challenges perspective". *Alexandria Engineering Journal* 60.1 (2021): 227–240. 10.1016/j.aej.2020.07.002.

Artale, Giovanni, et al. "PQ and Harmonic Assessment Issues on Low-Cost Smart Metering Platforms: A Case Study". *Sensors* 20.21 (2020): 6361–6361. 10.3390/s20216361.

Balwani, Mayurkumar Rajkumar, et al. "Development of a Smart Meter for Power Quality-Based Tariff Implementation in a Smart Grid". *Energies* 14.19 (2021): 6171–6171. 10.3390/en14196171.

Chakraborty, Soham and Sarasij Das. "Application of Smart Meters in High Impedance Fault Detection on Distribution Systems". *IEEE Transactions on Smart Grid* 10.3 (2019): 3465–3473. 10.1109/TSG.2018.2828414.

Chou, Jui-Sheng S and I Gusti Ayu Novi Yutami. "Smart meter adoption and deployment strategy for residential buildings in Indonesia". *Applied Energy* 128 (2014): 336–349. 10.1016/j.apenergy.2014.04.083.

England, B S and A T Alouani. "Multiple loads-single smart meter for measurement and control of smart grid". *2019 IEEE Innovative Smart Grid*

Technologies-Asia (ISGT Asia) (2019): 2440–2444. 10.1109/ISGT%20Asia.2019.8881529.

Gerpott, Torsten J and Mathias Paukert. "Determinants of willingness to pay for smart meters: An empirical analysis of household customers in Germany". *Energy Policy* 61 (2013): 483–495. 10.1016/j.enpol.2013.06.012.

Glass, Ephram and Victor Glass. "Power to the prosumer: A transformative utility rate reform proposal that is fair and efficient". *The Electricity Journal* 34.9 (2021): 107023–107023. 10.1016/j.tej.2021.107023.

Hidalgo-Gonzalez, Patricia L, Josiah Johnston, and Daniel M Kammen. "Cost and impact of weak medium term policies in the electricity system in Western North America". *The Electricity Journal* 34.3 (2021): 106925–106925. 10.1016/j.tej.2021.106925.

Jain, Alok and Suman Bhullar. "Online management and assessment of power quality issues through smart metering in smart grid architecture". *Energy Reports* 8 (2022): 613–631. [18]10.1016/j.egyr.2022.05.140.

Kumar, L Ashok, et al. "Design, power quality analysis, and implementation of smart energy meter using internet of things". *Computers & Electrical Engineering* 93 (2021): 107203–107203. 10.1016/j.compeleceng.2021.107203.

Leiva, J, A Palacios, and J A Aguado. "Smart metering trends, implications and necessities: A policy review. " *Renewable and sustainable energy reviews* 55 (2016): 227–233. 10.1016/j.rser.2015.11.002.

Markard, Jochen and Sabine Erlinghagen. "Technology users and standardization: Game changing strategies in the field of smart meter technology". *Technological Forecasting and Social Change* 118 (2017): 226–235. 10.1016/j.techfore.2017.02.023.

Morrell, Thomas J, et al. "Modeling of Electric Distribution Feeder Using Smart Meter Data". *2018 IEEE/PES Transmission and Distribution Conference and Exposition (T&D)* 1 (2018): 1–5.

Osama, Sarah, Marco Alfonse, and Abdel-Badeeh M. B M Salem. "An efficient algorithm for extracting appliance-time association using smart meter data". *Heliyon* 5.8 (2019): e02226–e02226. 10.1016/j.heliyon.2019.e02226.

Parvez, Imtiaz, et al. "Online power quality disturbance detection by support vector machine in smart meter". *Journal of Modern Power Systems and Clean Energy* 7.5 (2019): 1328–1339. 10.1007/s40565-018-0488-z.

Rodríguez-Pajarón, Pablo, Araceli Hernández Bayo, and Jovica V Milanović. "Forecasting voltage harmonic distortion in residential distribution networks using smart meter data". *International Journal of Electrical Power & Energy Systems* 136 (2022): 107653–107653. 10.1016/j.ijepes.2021.107653.

Sharma, Navonita, Ajoy Kumar Chakraborty, and Abanishwar Chakraborti. "Smart meter design with incorporated dynamic control of grid connected three phase inverter". *2017 7th International Conference on Power Systems (ICPS)* (2017): 677–683. 10.1109/ICPES.2017.8387377.

Shirani, Fiona, et al. "'I'm the smart meter': Perceptions of smart technology amongst vulnerable consumers." *Energy Policy* 144 (2020): 111637–111637. 10.1016/j.enpol.2020.111637.

Shuhaiber, Ahmed and Ibrahim Mashal. "Understanding users' acceptance of smart homes". *Technology in Society* 58 (2019): 101110–101110. 10.1016/j.techsoc.2019.01.003.

Steiner, Richard, et al. "Testing Electric Utility Smart Meters with High Harmonic Current Waveforms". *2020 Conference on Precision Electromagnetic Measurements (CPEM)* 1 (2020): 1–2.

Velayudham, T, S Ganesh, and R Kanimozhi. "Locating ground fault in distribution systems using smart meter". *2017 International conference of Electronics, Communication and Aerospace Technology (ICECA)* 2 (2017): 104–109. 10.1109/ICECA.2017.8212774.

Wang, Yanyang, Kefan Hu, and Jiaming Zhang. "Harmonic control system of smart meter based on ZigBee". *Journal of Physics: Conference Series* 1738.1 (2021): 012028–012028. 10.1088/1742-6596/1738/1/012028.

Zhang, Tao, Peer-Olaf O Siebers, and Uwe Aickelin. "Simulating user learning in authoritative technology adoption: An agent based model for council-led smart meter deployment planning in the UK". *Technological Forecasting and Social Change* 106 (2016): 74–84. 10.1016/j.techfore.2016.02.009.

Zhou, S. "The effect of smart meter penetration on dynamic electricity pricing: Evidence from the United States". *The Electricity Journal* 34.3 (2021): 106919–106919. 10.1016/j.tej.2021.106919.

Zhou, Wei, et al. "Bayesian Learning-Based Harmonic State Estimation in Distribution Systems With Smart Meter and DPMU Data". *IEEE Transactions on Smart Grid* 11.1 (2020): 832–845. 10.1109/TSG.2019.2938733.

Embargo period: The article has no embargo period.

To cite this Article: Ly Duc, Minh, and Que Nguyen Kieu Viet. "**Analysis Affect Factors of Smart Meter A PLS-SEM Neural Network**." International Research Journal on Advanced Science Hub 04.12 December (2022): 288–301. http://dx.doi.org/10.47392/irjash.2022.071