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DETERMINANTS OF TAXPAYER SATISFACTION WITH E-TAX FILING SERVICES: NEW EVIDENCE FROM ARTIFICIAL NEURAL NETWORKS APPROACH

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ABSTRACT

This paper aims to assess the factors affecting taxpayer satisfaction with e-tax filing services in the export-import and logistics industries. It employs a mixed-analytical approach combining Multiple Linear Regression (MLR) and Artificial Neural Networks (ANN) to capture both linear and nonlinear relationships between predictors and the dependent variable, thereby improving prediction accuracy. The results indicate that combining MLR and ANN provides a more precise measure of the relative influence of each predictor on taxpayer satisfaction. The research identifies key factors influencing e-taxpayer satisfaction, including Accessibility, Appearance, Safety, Effectiveness, and Interactivity. These factors are categorized into two groups: high-impact (Appearance, Accessibility, Safety) and low-impact (Interactivity, Effectiveness). The findings have significant theoretical and managerial implications, suggesting that tax authorities should design user-friendly interfaces for their electronic platforms and prioritize security to enhance taxpayer satisfaction. This study's innovative use of ANN combined with MLR provides new insights compared to prior research.

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1. Introduction

In recent years, the development of science and technology, with its modern and convenient inventions, has become an indispensable part of various fields such as administrative management, economic management, industrial automation, education, and training. Notably, the application of information technology in the tax sector—which is one of the main sources of revenue for the State Budget—stands out. To effectively fulfill its function of providing public services to taxpayers, the Tax sector has made considerable efforts to implement numerous solutions both in tax policy and the application of information technology in tax management, creating optimal conditions for taxpayers to fulfill their tax obligations.

One of the information technology applications that many taxpayers positively embrace is the electronic tax filing service. Traditionally, when the tax declaration deadline approached, taxpayers would visit the tax authorities in person to submit their paper declarations and then go to the State Treasury or a linked bank to pay their taxes to the State Budget. Nowadays, most enterprises can file taxes electronically without needing to visit the tax authorities. Besides several advantages such as simplifying procedures, saving time and costs for enterprises, enabling businesses to proactively pay taxes anytime and anywhere, minimizing errors when preparing payment slips, saving manpower, ensuring safety in management, and maximizing benefits for taxpayers, the economic, cultural, and social efficiency gained from online tax filing is substantial. However, electronic tax filing has some limitations, such as the requirement for precise tax declaration processes to avoid errors in information, incorrect email addresses, forgotten login passwords, invalid or unrecognized tax authority codes, missing tax information, or failure to receive payment slip notifications in the registered mailbox (emails might end up in the spam folder).

In practice, managing electronic tax transactions is still relatively new to tax authorities. Issues with information technology infrastructure, network congestion, and network failures also cause considerable inconvenience for taxpayers. Moreover, technical errors without adequate support lead to some online tax declaration files being unable to retrieve taxpayer information. Service quality is also limited, with software issues and accessibility errors causing difficulties in electronic tax filing and payment.

There have been numerous studies aimed at identifying the factors influencing taxpayers' satisfaction with electronic tax filing. However, these studies typically focus on identifying factors using linear data analysis methods, such as regression or structural equation modeling. Consequently, they have limitations in not fully addressing nonlinear relationships or measuring the relative importance of influencing factors. To address this, the present paper employs a mixed MLR-ANN research approach. This approach can better elucidate the relationships between taxpayers' satisfaction with electronic tax filing and the influencing factors.

2. Literature review

2.1. General concepts on electronic tax payment services and service quality satisfaction

Electronic tax payment services are services provided by tax authorities that allow taxpayers to fulfill their tax obligations via the Internet without having to visit the tax office directly. These services include functions such as tax declaration, tax payment, information lookup, and receiving notifications from the tax authorities. Some key benefits of these services include: time and cost savings – Taxpayers do not need to visit the tax office, saving travel costs

and waiting time; Simplicity and convenience – Tax procedures are performed quickly and easily online; Increased transparency – Taxpayers can look up information and monitor the tax payment process transparently.

Taxpayer Satisfaction

There are various perspectives on evaluating customer satisfaction. Customer satisfaction is their response to the perceived difference between their known experience and expectations (Spreng et al., 1996; Parasuraman et al., 1988). Zeithaml and Bitner (2000) suggest that customer satisfaction is customers' evaluation of a product or service that meets their needs and expectations. Satisfaction is the degree of a person's feeling state resulting from comparing perceptions of a product against their expectations (Kotler & Keller, 2006).

Unlike customers in private services, taxpayers do not have the option to choose their tax service providers. According to the management assignment, they can only receive public administrative services from their respective tax authorities. Tax services that are commensurate with the taxes contributed to the state budget will make taxpayers feel satisfied and more attached to the business location where the local tax authorities provide the best public administrative services. If they frequently encounter instability, hassle, or corruption, some taxpayers might choose another location to continue their business. Retaining taxpayers and helping them develop their businesses ensures a stable source of revenue for the state budget, promotes local socio-economic development, and enhances taxpayers' compliance with tax laws.

Therefore, the author defines taxpayer satisfaction as the evaluation of taxpayers regarding the tax administrative services provided by tax authorities that meet their needs and expectations.

The relationship between the quality of electronic tax payment services and taxpayer satisfaction

For electronic tax payment services, taxpayers expect this method to meet their needs by allowing them to quickly and accurately pay their taxes into the state budget. This enables them to fulfill their tax rights and obligations efficiently without spending excessive time on the tax payment process. It also helps minimize any errors they might make, which would otherwise require time-consuming corrections with the tax authorities (OECD, 2021).

From the perspective of the tax authorities, understanding the needs and expectations of taxpayers helps them develop effective solutions for managing electronic tax payments. When taxpayers' needs and expectations are met, they are more likely to feel satisfied, which in turn enhances their compliance with tax laws.

Moreover, the level of taxpayer satisfaction provides valuable feedback to tax authorities about any existing limitations in their tax management functions. This feedback can guide reform and improvement efforts to better serve taxpayers.

Thus, there is a close and intrinsic relationship between the quality of electronic tax payment services and taxpayer satisfaction. Meeting taxpayers' expectations with high-quality services not only improves their satisfaction but also promotes better compliance and strengthens the overall effectiveness of the tax administration.

Literature review on factors affecting the satisfaction of taxpayers toward electronic tax payment services

Literature on e-tax systems although limited is gradually evolving. A review of the e-tax literature indicates the presence of three key themes that received much attention from scholars. These include e-tax adoption factor,

usage of e-tax, and post-adoption issues of e-tax systems. For example, scholars like Connolly and Bannister (2008) and Schaupp et al. (2010) have looked at the adoption of e-tax systems. Likewise, Chu and Wu (2004) have examined the factors contributing to the usage of e-tax systems. Lai (2006), and Lai and Choong (2010) looked at the challenges faced by taxpayers for using e-tax systems. Post-implementation impacts like benefits and satisfaction have also received some attention (Saha, 2008).

As this paper is concerned with satisfaction, a brief but critical analysis of satisfaction literature related to e-tax, e-government, and IS in general is provided in order to understand how various scholars have conceptualized the 'satisfaction' construct in the IS and e-government literature.

The notion of satisfaction is not new; however, its application to the e-government context represents a relatively new phenomenon. In general, satisfaction within the e-government context is conceptualized by scholars in two broad ways. One group of scholars view satisfaction as an independent variable that influences other human behaviors (e.g. sustained usage, word-of-mouth recommendation).

In contrast, another group of e-government scholars considers satisfaction as a dependent variable. According to them, factors from different theoretical backgrounds are used to develop a satisfaction construct. Typical works representing this view of satisfaction include those of Abhichandani et al. (2005), Verdegem and Hauttekeete (2007), and Verdegem and Verleye (2007). Abhichandani et al. (2005) have proposed the EGOVSAT framework to measure user satisfaction with online transportation systems as an example of e-government services. The framework includes five factors (utility, reliability, efficiency, customization, and flexibility) to affect user satisfaction. In their work, Verdegem and Hauttekeete (2007) focus on the quality of access and quality of service indicators to formulate a conceptual model for measuring user satisfaction with e-government services in general. Based on their quantitative analysis, the following indicators are considered significant measures of user satisfaction with electronic government services in general: reduced administrative burden, reliability, security, usability, content readability, ease of use, content quality, cost-effective, privacy/ personal information protection, transparency, courtesy, responsiveness, accessibility, flexibility, and personal contact. Yet in another study, Verdegem and Verleye (2007) have developed a model to explain how satisfaction with e-government services in general is influenced by the actual use of e-government services. Their results indicate that nine indicators are considered to be significant in measuring the level of user satisfaction with regard to e-government services. Those indicators are: cost, awareness, security/privacy, content, usability, technical aspects, customer friendliness, availability, and infrastructure.

Chen (2010) conducted a study titled "Assessing Taxpayer Satisfaction with Online System for Individual Income Tax Filing". The research employed a mixed-method approach combining qualitative and quantitative methods. The study's findings indicated that the quality of online tax filing services is influenced by factors including (i) System Quality (comprising Accessibility, Interaction, and Ease of Use); (ii) Information Quality (comprising Information Effectiveness, Accuracy); and (iii) Service Quality (Response, Reliability, Empathy, Contact).

Othman (2012) conducted a study titled "*Factors Influencing Taxpayers' Decisions Regarding the Online Tax Payment System in Malaysia*". Utilizing a combination of qualitative and quantitative research methods, the study revealed that four key factors accounted for 52.4% of the variance in taxpayers' intentions to

use the e-Bayaran online tax payment system: (i) Perceived Usefulness; (ii) Subjectivity; (iii) Compensation; and (iv) Efficiency. These factors were identified as significant predictors of taxpayers' behavioral intentions.

Ha Nam Khanh Giao and Le Minh Hieu (2017) conducted a study titled "*Satisfaction with the Quality of Electronic Tax Transactions at the Tax Department of Ho Chi Minh City*". The research employed a mixed-method approach, combining qualitative and quantitative methods. The study identified six factors influencing taxpayers' satisfaction, ranked in descending order of importance: (i) Ease of Use; (ii) Website Quality; (iii) Reliability; (iv) Responsiveness; (v) Assurance; and (vi) Efficiency.

Poolsuk and Methavasaraphak (2019) investigated the factors influencing e-taxpayer satisfaction in Thailand, employing multiple linear regression analysis on survey data from 400 online taxpayers. The study found that perceptions of convenience, perceived benefits, information quality, and system quality significantly impacted satisfaction with the e-payment system. The findings also suggested that the Revenue Department should enhance and restructure the current e-filing system and refund permissions to improve ease of use and encourage future adoption among taxpayers.

Tran et al. (2021) conducted a study titled *"Factors Affecting the Satisfaction of Businesses Using Online Tax Payment Services at the Tax Department in Ho Chi Minh City, Vietnam*". This research used survey questionnaires and a convenient sampling method, surveying 300 enterprises utilizing online tax payment services within the city's Tax Department. The research model included the following factors: (1) Information and system quality; (2) Time efficiency; (3) Confidentiality of information and transactions; (4) Support service/customer service; (5) Helpful awareness; and (6) Trust in tax authorities. Findings revealed that confidentiality of information and transactions had the greatest influence, with a Beta coefficient of 0.321. Trust in tax authorities and helpful awareness followed with Beta values of 0.226 and 0.180, respectively. Time efficiency and support service/customer service had Beta values of 0.171 and 0.157, while information and system quality had a Beta of 0.138.

Muslichah et al. (2023) conducted a study titled "*The Impact of Tax E-Filing System Quality on Taxpayer Satisfaction: Perceived Usefulness as a Mediator*". Their findings revealed that the quality of the tax e-filing system positively influences both user satisfaction and perceived usefulness, with perceived usefulness showing a significant positive effect on user satisfaction. Additionally, the study confirmed that perceived usefulness serves as a mediating variable in the relationship between e-filing system quality and user satisfaction.

In summary, most studies focus on specific sets of factors influencing taxpayer satisfaction or acceptance of e-tax systems, such as service quality, system quality, perceived usefulness, and ease of use. However, there appears to be a gap in studies that comprehensively integrate all these factors into a single model to understand their combined effect on taxpayer satisfaction.

And the Artificial Neural Networks (ANN) analysis method can address the aforementioned gaps. This is also the reason why this paper employs the multiple regression - Artificial Neural Networks mixed method.

2.2. Hypotheses and research model

Based on the comprehensive review of existing studies and considering the specific characteristics of Ho Chi Minh City and Vietnam, the author proposes a research model and adjusted hypotheses inspired by Tran et al. (2021), Ha Nam Khanh Giao and Le Minh Hieu (2017), and Chen (2010), Verdegem and Hauttekeete (2007). Specifically:

Effectiveness

Effectiveness is proposed in the studies of Ha Nam Khanh Giao and Le Minh Hieu (2017), Othman (2012), Chen (2010), and Verdegem and Hauttekeete (2007). Effectiveness is the ability to achieve desired results or produce desired output. When something is considered effective, it means it produces a desired or expected outcome or creates a profound impression, birth. Effectiveness is defined as the result or achievement. It is whether the purpose is fulfilled or not. Efficient execution means the work is done according to expectations. Project managers are responsible for ensuring this happens. If a project team works hard but does not deliver what is required, they are not effective. For electronic tax filing services, effectiveness is the ability to produce results that taxpayers desire. The higher the effectiveness rated by taxpayers, the higher their satisfaction, and vice versa. Therefore, the author proposes the hypothesis:

Hypothesis H1: Effectiveness has a impact positive on satisfaction with the quality of electronic tax filing services.

Accessibility

Accessibility refers to the capacity to access a system at any given time (McKinney et al., 2002). It is a crucial factor in evaluating user satisfaction with online services (Yang & Fang, 2004). Regarding E-government satisfaction, Verdegem and Hauttekeete (2007) employed accessibility as a metric to assess citizens' contentment with e-government services. Moreover, accessibility has been linked to taxpayer satisfaction in the context of e-tax systems (Chen, 2010). Therefore, the author proposes the hypothesis:

Hypothesis H2: Accessibility has a positive impact on satisfaction with the quality of electronic tax filing services.

Appearance

Kim and Stoel (2004) highlight that appearance focuses on how effectively a system guides its users and how easy it is to navigate. They explore the impact of a system's appearance and design on users' perceptions of quality and satisfaction, finding that appearance is one of the most significant factors affecting user satisfaction with online systems. In the context of e-tax systems, we therefore believe that appearance would similarly influence taxpayer satisfaction.

Hypothesis H3: Appearance has a positive impact on satisfaction with the quality of electronic tax filing services.

Safety

Safety has been proposed in the studies of Ha Nam Khanh Giao and Le Minh Hieu (2017), Othman (2012), and Verdegem and Hauttekeete (2007). Safety is a state of being protected from harm or other undesirable outcomes. It can also refer to controlling recognized hazards to achieve an acceptable level of risk. In today's era, businesses in various fields, such as energy, transportation, retail, and manufacturing, use digital systems and high-speed connectivity to provide efficient customer service and cost-effective business operations. In addition to securing physical assets, businesses must also secure digital assets and protect systems from unauthorized access. An intentional breach and unauthorized access event into a computer system, network, or connected facility is called a cyberattack. If a cyberattack is successful, secure data may be exposed, stolen, deleted, or altered. Organizations implement cybersecurity strategies to mitigate the unintended consequences of cyberattacks, which can affect business reputation, financial status, operations, and customer trust. When businesses access the tax filing website, they are highly concerned

about whether the site is securely protected. If the tax filing website is not secure, taxpayers may fall victim to cybercriminals who can access their computers and steal other data. The higher the safety component is rated by taxpayers, the greater their satisfaction, and vice versa. Therefore, the author proposes the hypothesis:

Hypothesis H4: Safety has a positive impact on satisfaction with the quality of electronic tax filing services.

Feedback Capability

Feedback capability has been proposed in the studies of Othman (2012), and Chen (2010). Feedback involves providing actions regarding behavior in a positive manner, such as offering comments and opinions. Typically, feedback skills are expressed in two forms: constructive feedback (also known as positive feedback) and evaluative feedback, such as "praise and criticism." Feedback capability refers to the ability of taxpayers to receive responses from the Tax Authority when they have specific requests or questions. The higher the feedback capability is rated by taxpayers, the greater their satisfaction, and vice versa. Therefore, the author proposes the hypothesis:

Hypothesis H5: Feedback capability has a positive impact on satisfaction with the quality of electronic tax filing services.

Interactivity

This refers to "*the extent to which the communicator and the audience respond to, or are willing to facilitate, each other's communication needs*" (Ha & James, 1998, p. xxx). In the context of e-tax services, it can be defined as the ability of e-tax systems to intelligently respond to user needs. Research has shown that interactivity is a significant factor in measuring user satisfaction with online and e-tax services. It is one of the key dimensions that contribute to Web customer satisfaction. In the literature on e-tax services, interactivity is also considered a crucial dimension for assessing taxpayer satisfaction with e-tax systems (Alghamdi & Rahim, 2016; Chen, 2010; Verdegem & Hauttekeete 2007). Therefore, the author proposes the hypothesis:

Hypothesis H6: Interactivity has a positive impact on satisfaction with the quality of electronic tax filing services.

Thus, the proposed research model is as follows:

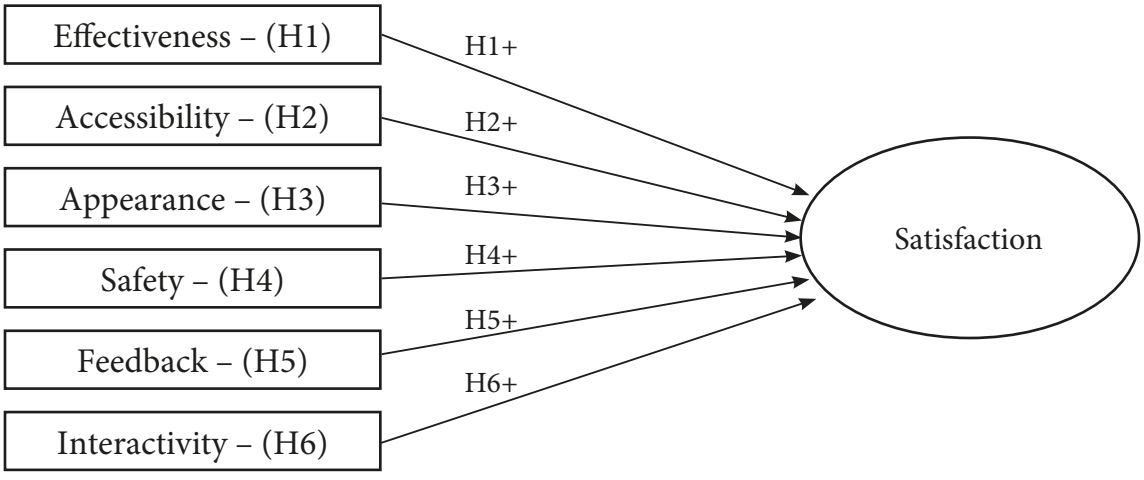

Figure 1. The research model

3. Methodology

Research method

To measure the relationships between factors affecting the quality of e-tax filing services and taxpayer satisfaction, the author employs multiple regression analysis.

Common linear statistical techniques, such as multiple regression analysis and structural equation modeling (SEM), are often inadequate for modeling the complex nature of human decision-making processes (Sim et al., 2014; Chan & Chong, 2012), as they tend to oversimplify the intricacies of adoption decisions by only examining linear models (Tan et al., 2014; Leong et al., 2013). To address this limitation, the use of artificial neural networks (ANN), a key artificial intelligence technique, is recommended. The ANN approach can identify not only linear but also complex non-linear and non-compensatory relationships (Leong et al., 2013), without requiring assumptions of normality, linearity, or homoscedasticity (Leong et al., 2015; Tan et al., 2014; Chong, 2013). Additionally, ANN models are highly robust and adaptable (Sim et al., 2014; Tan et al., 2014), offering greater predictive accuracy compared to linear models (Tan et al., 2014), and they typically outperform traditional statistical techniques, such as multiple regression analysis (MRA), in predicting technology adoption (Chong et al., 2015; Sim et al., 2014; Chong, 2013; Moosmayer et al., 2013) (*see Appendix 1 online*).

So, to assess the impact of observed variables on taxpayer satisfaction, the author uses artificial neural network analysis. Therefore, this study utilizes a mixed-method approach, combining MLR (Multiple Linear Regression) and ANN to conduct this study.

Data collection method

The research sample was collected through the non-probability sampling method. The survey subjects were representatives of tax-paying businesses in export-import and logistics industries provided by the Ho Chi Minh City Tax Department. These are also businesses that frequently engage in tax transactions, particularly import-export taxes. A total of 250 survey questionnaires were distributed, and 205 valid responses were collected after screening.

Measurement method

Since the article is designed to evaluate the factors influencing satisfaction, employing a quantitative research method through surveys as the primary data collection tool, the scales are assessed using rating scales. Chen (2010) used a 5-point Likert scale to evaluate the factors affecting taxpayer satisfaction with the online filing system for personal income tax returns, with (1) being least important, (2) not important, (3) neutral, (4) important, and (5) almost important. Similarly, Ha Nam Khanh Giao and Le Minh Hieu (2017), in evaluating satisfaction with the quality of electronic tax transactions with the Tax Department of Ho Chi Minh City, also used a 5-point scale, with (1) being not important and (5) very important. Building on the approach of previous studies, this research adopts a 5-point Likert scale with (1) being completely unimportant, (2) unimportant, (3) neutral, (4) important, and (5) completely important.

4. Research results

4.1. Descriptive statistical analysis of research data

By Economic Type Criterion: Among the types of enterprises, joint-stock companies have the highest number in the survey sample, with 102 units, accounting for 49.8%; followed by single-member limited liability companies with 75 units, representing 36.6%; 20 multi-member limited liability companies accounting for 9.8%; and 8 private enterprises, accounting for 3.9% of the total observations.

By Registered Business Capital Criterion Business organizations: have 91 enterprises with registered business capital from 50 to 100 billion VND, corresponding to 44.4%; 48 enterprises with registered capital from 100 to 200 billion VND, accounting for 23.4%; 44 enterprises with capital ranging from 200 to 500 billion VND, corresponding to 21.5%; and only 22 enterprises with registered business capital over 500 billion VND, accounting for 10.7% of the total observations.

4.2. Evaluating the scale's reliability

The results of Cronbach's Alpha reliability test for the electronic tax filing service quality scales indicate that all six components of the e-SQ scale meet the required threshold, with Cronbach's Alpha values greater than 0.6. Additionally, none of the components have an item-total correlation coefficient below 0.3. The taxpayer satisfaction scale also demonstrates adequate reliability, making it suitable for further analysis in the Exploratory Factor Analysis (EFA) stage (*see Appendix 2 online).*

4.3. Assessing the validity of the scale

Assessing the validity of the scale for the independent variables

The results of the Exploratory Factor Analysis (EFA) with 18 independent observed variables are as follows:

Table 1. KMO, Bartlett's Test and Rotated component matrix for the independent variables

	Component					
	1	**2**	**3**	**4**	**5**	**6**
AP1	0.890					
AP 3	0.800					
AP 2	0.779					
AP 4	0.742					
EF1		0.870				
EF2		0.859				
EF3		0.858				
IN3			0.848			
IN1			0.846			
IN2			0.843			
AC3				0.873		
AC 2				0.753		
AC 1				0.730		
ST3					0.872	
ST2					0.744	
ST1					0.663	
FB2						0.894
FB1						0.893
Kaiser-Meyer-Olkin measure of sampling adequacy						0.723
Bartlett's Test of Sphericity	Approx. Chi-Square					1633.928
	df					153
	Sig.					0.000

The KMO coefficient is 0.723 (0.5 ≤ KMO ≤ 1), indicating that the EFA is suitable for the data. The Chi-square statistic from Bartlett's test is 1633.928 with a significance level of 0.000. Therefore, EFA can be used to assess the scale validity in this study for the factors. Additionally, the factor rotation shows that all 18 observed variables are grouped into 6 factors, with no observed variable having a factor loading less than 0.5.

Assessing the validity of the scale for the dependent variables (taxpayer satisfaction)

The results of the factor analysis on taxpayer satisfaction indicate that the three observed variables used to explain the taxpayer satisfaction scale are appropriate. The KMO coefficient is 0.714 (0.5 ≤ KMO ≤ 1), suggesting that EFA is suitable for the data. Bartlett's test of sphericity yields a Chi-square value of 234.338 with a significance level of 0.000 (Table 2).

Table 2. KMO, Bartlett's Test of the dependent variables and Factor loadings of the dependent variables

	Component 1	
SA2	0.889	
SA1	0.861	
SA3	0.844	
Kaiser-Meyer-Olkin measure of sampling adequacy	0.714	
Bartlett's Test of Sphericity	Approx. Chi-Square	234.338
	df	3
	Sig.	0.000

After conducting data analysis through the steps of Cronbach's Alpha reliability analysis and Exploratory Factor Analysis, the research model includes 6 independent variables (Effectiveness, Appearance, Feedback Capability, Safety, Accessibility, and Interactivity) to measure the dependent variable, which is Taxpayer Satisfaction. Therefore, the overall research model remains unchanged, and the hypotheses continue to be tested using regression analysis.

4.4. Hypothesis testing

To test the hypotheses and evaluate the relationships between the factors influencing the satisfaction of e-taxpayers, the author uses a multiple regression analysis method with the following procedure:

Correlation Matrix Analysis

The results of the correlation coefficient analysis between the independent variables and between them and the dependent variable, using the Spearman method, show that the correlation coefficients between the dependent variable and the independent variables are at a moderate level (See details in Appendix 2)

Assessing the fit of the multiple linear regression model

The results show that the coefficient of determination R^2 is 0.619, and the adjusted R^2 is 0.607. This model explains 60.7% of the variation in the dependent variable due to the independent factors. This means that 60.7% of the changes in taxpayer satisfaction with the quality of e-tax filing services are accounted for by the six independent factors in the model, while the remaining 39.3% of the variation is explained by factors outside the model. The model's significance value (sig.) is 0.000, which is less than 0.05, indicating a 99% significance level. Additionally, there is no autocorrelation,

as indicated by the Durbin-Watson coefficient of 1.848 (1 < 1.848 < 3).

Results of the first regression model analysis

The results of the regression analysis indicate that, among the six factors in the research model, the factor 'Feedback Capability' is not statistically significant in the analysis model, with a significance value (Sig) of 0.129, which is greater than 0.05. Therefore, there is no basis to prove a linear relationship between the 'Feedback Capability' factor and taxpayer satisfaction. As a result, this factor is excluded from the research model. Consequently, the author conducts a second regression analysis.

Results of the model fit test after the second regression analysis

To generalize this model to the entire population, an F-test must be considered through Analysis of Variance (ANOVA), as shown in Appendix 4 *(see Appendix 4 online)*. Since the significance value (Sig.) is 0.000, we reject the null hypothesis that the overall coefficient of determination R^2=0, which means that at least one independent factor affects the dependent factor. The multiple linear regression model is suitable for the dataset and is acceptable.

Theoretical model results

The results of the linear regression analysis have addressed the objectives of the study and the proposed hypotheses, demonstrating a positive linear relationship between the independent variables and the dependent variable, as well as identifying which component has the strongest impact on taxpayer satisfaction (Table 3). In summary, the results of the two rounds of multiple linear regression analysis indicate that 5 out of the 6 surveyed factors affect taxpayer satisfaction, including Effectiveness, Accessibility, Website Design, Security, and Contact. With an adjusted R^2 of 0.607, this means that these factors explain 60.7% of taxpayer satisfaction when using e-tax filing services. Additionally, five hypotheses are supported by the survey data.

Table 3. The results of the multiple linear regression model

Model	Coefficients			Statistics t	Sig.	VIF
	Unstandardized	Std. Error	Standardized			
EF	0.082	0.037	0.098	2.209	0.028	1.015
AP	0.245	0.054	0.246	4.505	0.000	1.542
ST	0.146	0.057	0.126	2.564	0.011	1.253
AC	0.522	0.055	0.492	9.483	0.000	1.386
IN	0.149	0.037	0.184	4.006	0.000	1.092
Constant	-0.341	0.297		-1.148	0.252	
Model fit						
R^2		0.619				
Adjusted R^2		0.607				
Durbin-Watson		1.848				
Statistics F (sig)		63.377 (0.000)				

4.5. Artificial neural network analysis

Because of ANN's "black box" nature, its approach is not suitable for hypothesis testing and examining causal relationships (Chong, 2013; Leong et al., 2013). Therefore, in this study a linear and compensatory SEM model is complemented with a nonlinear and non-compensatory ANN model (Tan et al., 2014; Leong et al., 2013) i.e. a hybrid, two-stage approach was adopted (Tan et al., 2014; Chong, 2013; Leong et al., 2013; Chan & Chong, 2012): in the first stage, SEM was used to determine statistically significant determinants of dependent variables, whereas in the second stage identified significant predictors were used as inputs to the neural network models in order to quantify the importance of each of them and to predict smart-watch adoption. ANN is a parallel distributed processor made up of simple processing units, called neurons or nodes, used for storing knowledge and making it available for use (Haykin, 2001). ANN architecture is based on human brain structure i.e. neurons are analogous to the biological neurons in the brain. The knowledge, acquired through the learning process, is stored in interneuron connection strengths called synaptic weights. To quantify the relationships between predictors and dependent variables in this study, the most common and popular neural network model – feedforward back-propagation multilayer perceptron (MLP) was used (Ooi & Tan, 2016; Sim et al., 2014; Tan et al., 2014; Chong, 2013; Leong et al., 2013; Chan and Chong, 2012; Negnevitsky, 2011). A typical neural network is made up of several hierarchical layers, i.e. one input, one output, and one or more hidden layers between the input and the output. The first question in ANN design, after selecting the type of ANN, is to determine the number of hidden layers, which depends on the complexity of the problem to be solved. In most cases, like in technology acceptance neural network models (Ooi & Tan, 2016; Chong et al., 2015; Sim et al., 2014; Tan et al., 2014; Chong, 2013; Leong et al., 2013) one hidden layer is sufficient, as it is able to represent any continuous function, while with two hidden layers even discontinuous functions can be modeled (Negnevitsky, 2011). Each layer consists of neurons, connected with the neurons of the following layer through an adaptable synaptic weight. In the feed-forward networks, the signals are fed forward from the input layer, through the entire network, to the output layer. The inputs to each neuron are multiplied by its synaptic weights and summed, and this signal is transformed to the output value using a nonlinear activation function such as sigmoid, hyperbolic tangent, or arctangent (Leong et al., 2013). The knowledge is stored in the network by iteratively exposing it to patterns of known inputs and outputs (supervised learning), and during this process, the error, i.e. the difference between known output and the output predicted by the network, is calculated, propagated back in the opposite direction through the network, and used to adjust all synaptic weights so to minimize the estimation error. Another question in ANN design is to determine the number of neurons in each layer. It is easy to set the number of neurons in the input and the output layers, as they correspond to the number of inputs, i.e. predictors, and the number of outputs, i.e. dependent variables. The selection of the number of neurons in the hidden layer is more complex, as it can depend on the number of hidden layers, the sample size, the neural network architecture, the complexity of the activation function, the training algorithm, etc. (Sheela & Deepa, 2013). It affects both prediction accuracy and speed of network training. Generally, the higher number of hidden neurons gives higher estimation accuracy (Negnevitsky, 2011), but only to some point, after which further increase can dramatically increase the computational load without estimation accuracy improvement. Also, the high number of hidden neurons may lead to the

overfitting problem, when the network simply memorizes all training examples, without the ability to generalize. Unfortunately, there is no general rule to determine the number of hidden neurons, so usually trial-and-error (Chong et al., 2015; Chong, 2013; Chan & Chong, 2012) and the rules of thumb are used. One of the most common rules of thumb is that the optimal number of neurons in the hidden layer is usually between the number of input and output neurons (Blum, 1992). In this study, neural networks are modeled in SPSS 27. Taking into account that only statistically significant predictors obtained by MLG can be used in ANN models, the research model presented in Figure 2 can be decomposed in the ANN model, as presented in Appendix 2.

Referring to Figure 2, the ANN model has one hidden layer, with the number of hidden neurons generated automatically by SPSS which is 2. In both, hidden and output layers, sigmoid is used as an activation function. In addition, all inputs and outputs are normalized to the range [0, 1], in order to obtain better model performances (Negnevitsky, 2011). A ten-fold cross-validation procedure was performed to avoid over-fitting problems, with 90% of the data used for network training and the remaining 10% used for testing (Ooi & Tan, 2016; Sim et al., 2014; Tan et al., 2014; Chong, 2013; Leong et al., 2013; Chan & Chong, 2012). The predictive accuracy of the model was assessed based on the values of Root Mean Square of Error (RMSE) (Chong, 2013; Leong et al., 2013; Ooi & Tan, 2016; Sim et al., 2014; Tan et al., 2014), and RMSEs of both training and testing data sets for this model and all ten neural networks, as well as the averages and standard deviations for both data sets are computed and presented in Table 4.

Table 4. RMSE values of artificial neural networks

Network	Sum of square errors training	Sum of square errors testing	RMSE Training	RMSE Testing
1	8.430	7.494	0.2518	0.3296
2	10.006	6.074	0.2693	0.3011
3	8.527	4.868	0.2417	0.2872
4	5.717	6.218	0.1965	0.3362
5	6.016	4.260	0.2023	0.2734
6	9.935	6.068	0.2627	0.3154
7	7.663	6.089	0.2323	0.3109
8	6.087	8.183	0.2123	0.3419
9	6.365	8.063	0.2095	0.3697
10	5.230	5.002	0.1991	0.2618
Mean			0.2277	0.3127
Standard deviation			0.0274	0.0331

The results of running the ANN model in SPSS indicate that the model provides a quite accurate prediction, as the average RMSEs of all neural networks, for both training and testing data sets, are very small. Therefore, it can be concluded that the forecasting method using ANN with the research dataset is both significant and reliable (Ooi & Tan, 2016;

Leong et al., 2015; Sim et al., 2014; Tan et al., 2014; Leong et al., 2013).

The relative importance of every determinant is a measure of how much the predicted output value varies with different values of the determinant (Chong, 2013). It is used in sensitivity analysis to compute normalized importance as the ratio of the relative importance of each variable to its highest relative importance, expressed in percentages (Ooi & Tan, 2016; Sim et al., 2014; Tan et al., 2014; Leong et al., 2013;). The results of the sensitivity analysis for the model are presented in Table 5.

Table 5. Neural network sensitivity analysis

	SA				
Network	**EF**	**AP**	**ST**	**AC**	**IN**
1	0.105	0.317	0.166	0.240	0.172
2	0.115	0.256	0.250	0.279	0.100
3	0.130	0.237	0.189	0.265	0.180
4	0.198	0.222	0.181	0.264	0.134
5	0.162	0.274	0.183	0.256	0.124
6	0.133	0.333	0.189	0.257	0.089
7	0.096	0.298	0.208	0.250	0.148
8	0.177	0.228	0.139	0.346	0.109
9	0.097	0.260	0.231	0.234	0.177
10	0.141	0.284	0.203	0.240	0.131
Average importance	0.135	0.271	0.194	0.263	0.136
Normalized importance (%)	49.98%	100.00%	71.58%	97.12%	50.35%

According to the results derived from the sensitivity analysis of the ANN, as presented in Table 5, it is evident that among the factors in the correlation, AP has the highest impact on SA, followed by AC, ST, IN, and finally EF. These results are consistent with those from the multiple linear regression analysis but also show a difference in the ranking of influence between AP and AC. While AC had the highest impact in the multiple linear regression analysis, AP was found to have the highest impact in the ANN analysis.

Additionally, the sensitivity analysis results in Table 5 also demonstrate that, when considering the significant correlation between factors, they can be categorized into two groups based on their impact on SA. The first group includes factors with a high impact (AP, AC, and ST), as their percentage of normalized importance exceeds 70%. The second group consists of less important factors (IN and EF), with a percentage of normalized importance around 50%.

4.6. Discussion

The findings of this study have verified and expanded the understanding of factors influencing taxpayer satisfaction with e-tax filing services through a mixed-method approach combining MLR and ANN. Key points of the discussion are as follows:

Key impactful factors (AP, AC, ST)

Both linear regression and ANN analysis identified Appearance (AP) as the most influential factor in user satisfaction (with normalized importance reaching 100% in ANN). This finding aligns with prior studies by Kim and Stoel (2004) and Ha Nam Khanh Giao and Le Minh Hieu (2017), emphasizing that an intuitive and user-friendly interface is critical to enhancing user experience.

Accessibility (AC) also scored high, particularly in ANN analysis, with normalized importance reaching 97.12%. This underscores that ease of access to the system plays a vital role in improving user experience, as highlighted by Verdegem and Hauttekeete (2007) in the context of e-government services.

Safety (ST) was reaffirmed as an essential factor, consistent with previous studies like Tran et al. (2021), particularly as users increasingly prioritize information security in online transactions.

Moderately impactful factors (IN, EF)

Interactivity (IN) and Effectiveness (EF), while having a positive impact, were found to be less influential, with normalized importance at 50.35% and 49.98%, respectively. This result diverges somewhat from Chen (2010), where "interactivity" was classified as a key factor. However, this variation could be attributed to advancements in technology systems and shifts in user expectations.

Comparison between MLR and ANN results

While linear regression analysis identified Accessibility (AC) as the most impactful factor, ANN ranked Appearance (AP) as the top factor. This difference reflects the ability of ANN to capture non-linear relationships, which traditional linear methods cannot fully address.

Comparison with previous studies

The findings of this study align with earlier works, such as Ha Nam Khanh Giao and Le Minh Hieu (2017) and Verdegem and Hauttekeete (2007), in reaffirming the roles of interface design, safety, and accessibility. However, the mixed-method approach of this study has provided new insights, particularly in categorizing factors into high-impact and low-impact groups, a distinction that has not been emphasized in previous research.

5. Inclusions and implications

This study employed two different techniques, the Multiple linear regression analysis which enabled the assessment of the linear relationships between the independent variables and dependent variables; in addition, the ANN analysis allows for the measurement of nonlinear relationships between observed variables. In this sense, this research suggests a mixed-analytical approach combining MLR and ANN while enabling the capture of linear and complex nonlinear relationships between predictors and the dependent variable. Thus, the prediction accuracy is improved as it delivers a more precise measure of the relative influence of each predictor.

The research findings provide several theoretical and managerial implications for tax authorities in Vietnam, as follows:

First, the research findings indicate that we can combine the methods of linear regression analysis and ANN in evaluating customer satisfaction with electronic tax transactions.

Second, the research findings show that the satisfaction of e-taxpayers consists of the following factors: AP, AC, ST, IN, and EF. These results are generally consistent with the studies by Verdegem and Hauttekeete (2007), Chen (2010), and Ha Nam Khanh Giao and Le Minh Hieu (2017).

Third, the study reveals that there are two groups of factors influencing taxpayer satisfaction: the high-impact group, which includes AP, AC, and ST, and the low-impact group, which includes IN and EF. Based on these findings, tax authorities using electronic systems need to design user interfaces for their electronic platforms (websites, mobile apps) that are engaging, user-friendly, and easy for taxpayers to use. Furthermore, the websites should allow taxpayers quick and easy access. Additionally, security is also a significant concern for taxpayer satisfaction in electronic tax transactions. These are new insights discovered from applying the ANN method combined with the MLR method in this study, compared to previous research.

Limitations and future research directions

Although this paper has assessed the factors influencing e-taxpayer satisfaction, there are still some limitations: (1) The use of non-probability sampling and the focus on Ho Chi Minh City, which limits the representativeness of the research findings; and (2) There are other factors that may affect the satisfaction of e-taxpayers that were not considered in this study. These limitations suggest avenues for future research.

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