TAM-Based Acceptance Model for Port Shore Power System

Bo Gao[1], Yanshi Cao[2], Xinghua Hu[2,*],Xiaochuan Zhou[3]
[1]*Zhejiang Institute of Communications, Zhejiang, China*
[2]*School of Traffic and Transportation, Chongqing Jiaotong University, Chongqing, China*
[3]*Chongqing YouLiang Science & Technology Co., Ltd, Chongqing, China*
**Corresponding Author.*

Abstract

Shore power has become an important berthing way for sustainable shipping. The goal of this research is to determine the influencing factors of port shore power promotion. The technology acceptance model (TAM) was used to construct a theoretical model of shore-power acceptability. In theory, 4 independent criteria were discovered as contributing to actual usage of shore-power for shipping sustainability by influencing ports' attitudes toward shore-power and their intention to use. A questionnaire based on the port enterprises in China was conducted, with over 500 people participating. Data were analyzed by MPLUS. The attitude and behavioral intention toward using shore power show the beneficial influence on the sustainable development of shore power in the future. The results show that subjective norms and perceived risk play a relatively important role among all related variables in TAM. This study contributes to popularizing the shore power technology by demonstrating how different variables affect the usage of shore power, and are highly significant for sustainable development of ports and shipping.

Keywords: *shore power, influencing factor, TAM model, structural equation modeling.*

I. Introduction

The rapid development of maritime trade makes ports trade facilitators and plays a fundamental role in the global supply chain and economic system [1]. Ports facilitate trade and transportation, but they also contribute to air pollution and carbon emissions. The main function of the port is to provide transfer service for ships. In the past, auxiliary engines were used to generate electricity when ships berthing. Auxiliaries used to generate electricity contribute significantly to air pollution, leading to the air quality in port waters and land decreasing. Therefore, ports are seen as an important field to reduce fossil energy consumption, pollution and carbon emissions [2]. Statistics show that the emissions of carbon dioxide, nitrogen oxides and sulfur oxides from the port industry reach 3%, 5% and 13%, respectively [3] of total emissions from human activities, where the aforementioned substances are the main pollution sources for sea air [4]. In particular, the existence of seaports may have adverse environmental impacts on the ocean, soil and air, leading to the deterioration of marine and terrestrial ecosystems [5]. In such a scenario, shore power came into being, and now, shore power has become the most important approach to better the environmental footprint of ports [6], which is even expected to reduce global emissions [7]. However, in existing studies, there is little data empirical research on the use of shore power, which is of vital importance for the promotion of shore power. Based on the questionnaire data, this paper studies the willingness of ports to use shore power, providing a much-needed empirical account of the transition to shore power in ports. This study therefore provides a theoretical basis for the scientific popularization of shore power.

To reduce the damage caused by vessel emissions and maintain the ecological environment of port waters, the Chinese government vigorously promotes the development of clean energy. From the application prospects of maritime fuel cells, fuel cells have the limitations of high initial investment costs and the short life, which means vigorously development is required for marine clean energy to replace traditional fuel [8]. In addition, the short life of fuel cell determines its inapplicability to the berthing state of ships, which means that it has little contribution to port ecology. Different from fuel cells, the shore power facilities set up inside the port only serve the berthing of ships. Therefore, academic research on the application of shore power technology to port ships to achieve energy

conservation and emission reduction has been fruitful. Researchers studied the development and change of shore power from the perspectives of political policy [9], financial subsidy [10] and multi-player games [11]. In a report, Ganzl [12] indicated that the development of port power would help reduce noise and emissions, making ports and shipping more sustainable. Although shore power technology is maturing, relatively few studies have been performed on the use and acceptance of shore power in China and abroad. Against the strategic background of peak carbon and carbon neutrality, determining the attitudes toward port power use can promote the sustainable development of shore power technology and green ecological port.

II. Research Model

At present, the promotion of shore power is relatively slow in China. The main objective of this study is to demonstrate the effect of certain factors on the use of shore power in ports, and to promote the extensive and sustainable use of shore power in ports. As an emerging technology, shore power is still gradually replacing traditional auxiliary engines, but has not yet reached the stage of development that is widely accepted. Thus the Technology Acceptance Model (TAM) theory proposed by Davis suits this study well [13], as the most widely recognized and established models to explain technology acceptance [14]. Based on TAM, we created a model that depicts the effects of perceived risk (PR), attitude towards shore power use (ATT), perceived usefulness (USF), subjective norms (SUB) and perceived ease of use (EOU) on shore power use (behavioral intention: BEH) in ports, and variable definitions is shown in Table 1.

Table 1 Definition of Model Core Variables

Core variable	Variable definition
Perceived Usefulness	The degree of improving port efficiency by shore power system.
Perceived Ease-of-use	The degree to which a person believes that using shore power system would be free of physical and mental effort [15].
Perceived Risk	Personal perception of the uncertainty of a decision outcome.
Subjective Norms	Support degree of the social environment for shore power use and operation.

2.1 USF and EOU

Perceived usefulness (USF) and perceived ease of use (EOU) were identified as two main factors motivating users to adopt technologies [16]. As is defined, perceived usefulness refers to the degree to which a person believes that using a particular system would enhance his/her job performance [16]. And perceived ease of use was defined as an individual’s belief that operating a particular system is easy and needs less effort. In this study, USF was defined as the degree, believed by ports to improve port efficiency by shore power system. When the USF is strong, it will promote a good ATT, and therefore increase the port's intention to use it. However, once the user believes that a new technology is considered difficult to use, it means that even though increased usefulness is provided, users tend to reject its use. Similarly, EOU refers to how the port uses the shore power system, so that users experience less difficulties or complex situations. When ports believe that it is easy to use shore power, they will have a positive ATT, and accept this technology.

2.2 PR

In the 1970s, the theory of reasoned action proposed by Ajzen and Fishbein, indicating that the behavioral intention is considered to be determined by attitude and subjective norms (SUB) [17]. SUB refers to the social pressure that people feel to take a particular behavior or not. In other words, when predicting the behavior of others, Salientindividuals or groups, usually the government, that influence an individual's behavioral decisions can have a significant impact on whether or not an individual takes a particular behavior. Moser believes that the perceived social pressure of consumers must have an impact on green consumption intentions [18], suggesting that the perceived social pressure of ports can influence their shore power use behavior. And compared with Westerners, Easterners care more about how they are perceived by others and whether their actions are ethical. Therefore, in

the context of Chinese culture, subjective norms will have an important impact on shore power use intention [19].

2.3 SUB

According to the existing research, perceived risk (PR) refers to the consumer's perception of the uncertainty involved when the severity of the adverse consequences is the result of their actions. In this paper, PR mainly comes from the technical defects, specification defects and cost defects of shore power technology. When shore power providing service, above defects will increase the PR, arouse the negative emotions of the users, and then affect the behavioral intention. That is, when uncertain and ambiguous situations arise that make consumers uncomfortable, they tend to stay away from these situations [20]. Once consumers experience the negative consequences of using shore power, their satisfaction will be decreased, and they eventually avoid those negative consequences by resisting this technology.

2.4 ATT and BEH

In the context of technology adoption research, attitude (ATT) is defined as an individual's overall emotional response to the use of new technology, and behavioral intention (BEH) is defined as a cognitive picture of a person's readiness to perform an action. In TAM, ATT is described as the individual's positive or negative emotions towards the target behavior (BEH). That is, in the process of using shore power technology, consumers' external perception of shore power technology is fed back to their attitudes. According to the feedback results, attitudes will then affect behavioral intentions, thus influencing consumers' decisions on whether to use shore power in the future.

2.5 Research hypothesis

In this study, we created a model that depicts the perceived usefulness and perceived ease of use, proposed by Davis [21]. In addition, on the basis of the related studies mentioned above, perceived risk and subjective normative variables are reasonably introduced, and 9 hypotheses of SUB, PR, USF and EOU influencing shore power use through ATT are established, as shown in Fig 1.

H1: The perceived usefulness of shore power technology has a positive impact on the attitude towards using shore power.
H2: The perceived ease of use has a positive impact on the attitude towards using port shore power.
H3: The perceived risk of shore power technology has a negative impact on the attitude towards using port shore power.
H4: Subjective norms have a positive impact on port-side attitudes toward using port shore power.
H5: The perceived usefulness of shore power technology has a positive impact on the port-side behavior intention toward using shore power.
H6: The perceived ease of use has a positive impact on the behavior intention toward using shore power.
H7: The perceived risk of shore power technology has a negative impact on the behavior intention toward using shore power.
H8: Subjective norms have a positive impact on the behavior intention toward using shore power.
H9: The port-side attitude toward using shore power positively influences the port-side behavior intention.

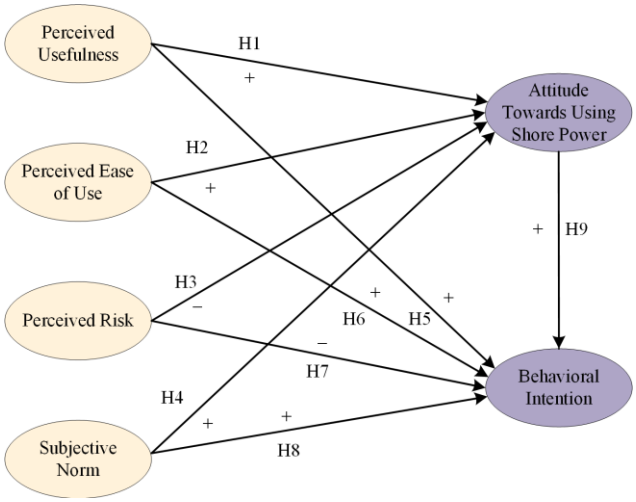

Fig 1: Acceptance model of port shore power utilization.

2.6 Model building

To quantitatively describe the causal relationship between the variables and the influence of the variables on construction behavior for the port power system, a mathematical analysis is conducted based on a structural equation model. This model has two main parts: (1) a measurement model and (2) a structural model.

(1) Measurement model

$$\underset{(16\times1)}{X} = \underset{(16\times4)}{\Lambda_X}\ \underset{(4\times1)}{\xi} + \underset{(16\times1)}{\delta} \quad (1)$$

$$\underset{(6\times1)}{Y} = \underset{(6\times2)}{\Lambda_Y}\ \underset{(2\times1)}{\eta} + \underset{(6\times1)}{\varepsilon} \quad (2)$$

(2) Structural model

$$\underset{(2\times1)}{\eta} = \underset{(2\times2)}{B}\ \underset{(2\times1)}{\eta} + \underset{(2\times4)}{\Gamma}\ \underset{(4\times1)}{\xi} + \underset{(2\times1)}{\zeta} \quad (3)$$

X is a 16×1 vector composed of observation variables of the exogenous latent variables (Perceived Ease-of-Use, Perceived Risk and Subjective Norm), ξ is a 4×1 vector composed of observation variables of the exogenous latent variables, Y is a 6×1 vector composed of observation variables of the endogenous latent variables, and η is a 2×1 vector composed of three endogenous latent variables. B is a 2×2 coefficient matrix between the latent variables, and ζ is a 2×1 residual vector. The mean value of the error terms ε and δ of the measurement equation is 0; the mean value of the residual term ζ of the structural equation is 0; the error terms ε and δ are independent of the factors η and ξ; and the residual ζ is also unrelated to ε, δ and ξ.

III. Sample Survey

3.1 Participants

Based on a literature review of research on shore power technology, the technology acceptance model (TAM), a questionnaire on the intention of shore power usage was designed in this study. To construct a representative questionnaire, the survey scope covered people of different genders, age groups and positions in relevant fields at various ports. With questionnaire administered to different ports, a total of 555 questionnaires were collected, with an effective recovery rate of 92.61%. The proportion of the male and female respondents for this survey is relatively balanced, as is the proportion of port types. The subjects in this survey are mainly aged between 25 and 40 and work in port comprehensive management, and the specific characteristics of the respondents are shown in

Table 2.

Table 2 Statistical description of questionnaire respondents

Items	Classification	Number of samples	Percentage
Gender	male	281	54.67%
	female	233	45.33%
Age	<25	69	13.42%
	25~40	286	55.64%
	41~60	146	28.40%
	>60	13	2.53%
Type of port	Inland ports	269	52.33%
	Coastal ports	245	47.67%
Profession	Port integrated management	255	49.61%
	Port operation and management	118	22.96%
	Port equipment maintenance	87	16.93%
	Others	54	10.51%

3.2 Questionnaire compilation

As previously mentioned, current academic research about shore power is mostly focused on the popularization and application of shore power systems, some examples of which are quantitative studies on the impact of environmental taxes and the cost price of onshore power systems [22], game research of governments, ships and ports using onshore power systems for economy and emissions reduction [23], and research on technical problems associated with connecting ships to port shore power systems [24]. Although the research field is different, the study on the impact of the application of electricity technology in this paper has something in common with most TAM-based articles, especially the questionnaire. As suggested by Bollen [25], the questionnaire survey should try to quote the questionnaire with good reliability and validity used by others. Therefore, measurement items for USF (4 items) and EOU 4 items) were adapted from Alrahmi [26], Alturki et al, and Guo et al [27]. PR was composed of 4 items and adapted from Seo [28]. SUB (4 items) was adapted by Li et al [29]. The latent variables were measured on a Richter five-point scale, with 1 representing complete agreement, 2 representing agreement, 3 representing basic agreement, 4 representing partial agreement, and 5 representing total disagreement. See Table3 for the description of the specific model variables.

Table3 Description of model variables

Construct	Item	Measure
Perceived Usefulness	USF1	I think the shore power system will improve the berthing rate of port ships
	USF2	From a port-side perspective, I think the shore power system will increase convenience
	USF3	I think the shore power system will help increase port revenue
	USF4	I think shore power system helps to maintain the sustainable development of the ports
Perceived Ease-Of-Use	EOU1	I think the operation of a shore power system (a ship-shore connection) is relatively simple
	EOU2	From a port-side perspective, I think the approval process for shore power construction is simple
	EOU3	I think it will be easy to maintain the normal and continuous operation of the power supply
	EOU4	I think it is easy to build the power expansion of shore power system
Perceived Risk	PR1	I think the port will refuse to build a shore power system without the inspection and verification of the safety and stability of the shore power equipment by a third party with professional qualifications
	PR2	We (the port) will refuse to build a shore power system if it is likely to cause damage to the ship client equipment

Construct	Item	Measure
	PR3	A potential interface mismatch resulting from inconsistent interface standards for shore power would significantly reduce my willingness to build a shore power system
	PR4	I think the current shore power operation and maintenance costs are beyond the bearing range of the port
Subjective Norms	Sub1	A subsidy created by the current national policy for onshore power projects has played a role in making our port willing to use an onshore power system
	Sub2	The management of pollution abatement by environmental supervision departments would enhance my willingness to use the shore power system
	Sub3	The absence of barriers to the secondary sale of electricity would enhance my willingness to build a shore power system
	Sub4	The use of shore power in other ports will enhance my willingness to use shore power
Attitude Towards Using Shore Power	Att1	I believe it is beneficial to use shore power for sustainability
	Att2	I feel positive about using port shore power
	Att3	In the process of port operation, we prefer to use shore power
Behavioral Intention	Beh1	If conditions permit, I am inclined to use shore power system into action in a wider range
	Beh2	I think we will build shore power systems in all new working areas of ports in the future
	Beh3	I will recommend shore power for berthing ships.

Ⅳ. Data Analysis and Results

4.1 Reliability and validity analysis

The Cronbach coefficient was used as the criterion for measuring the reliability of the questionnaire. All the α values were greater than 0.7, meeting the reliability requirements. All the factor loading coefficients in the confirmatory factor analysis (CFA) ranged from 0.719~0.886 (greater than 0.5), indicating good fitness of the measurement model and demonstrating good explanatory ability of the dimensions of the questions. All the items were reserved. The mean variance extraction values (AVE) were greater than 0.5, met the standard proposed by Richard Bagozzi [30], which demonstrated that the measurement model had good interpretation ability. The observation variables of the four latent variables of perceived usefulness, perceived ease of use, perceived risk and subjective norms were selected reasonably and had high aggregation validity. The specific parameter and discriminant validity results are shown in Table4. and Table 5 lists the square root of AVE and the factor correlation coefficients. For each factor, the square root of AVE was significantly larger than its correlation coefficients with other factors, suggesting an excellent discriminant validity.

Table4 Results of reliability and convergent validity analysis

Cod	Item	Factor loading	SMC	C.R.	AVE	Cronbach α
ATT	ATT1	0.747	0.558	0.794	0.563	0.793
	ATT2	0.755	0.570			
	ATT3	0.749	0.561			
USF	USF1	0.794	0.630	0.864	0.614	0.863
	USF2	0.786	0.618			
	USF3	0.814	0.663			
	USF4	0.738	0.545			
EOU	EOU1	0.879	0.773	0.926	0.758	0.925
	EOU2	0.886	0.785			
	EOU3	0.875	0.766			
	EOU4	0.841	0.707			

PR	PR1	0.733	0.537	0.872	0.630	0.872
	PR2	0.831	0.691			
	PR3	0.756	0.572			
	PR4	0.850	0.723			
SUB	SUB1	0.884	0.781	0.880	0.648	0.879
	SUB2	0.731	0.534			
	SUB3	0.798	0.637			
	SUB4	0.799	0.638			
BEH	BEH1	0.794	0.630	0.802	0.576	0.801
	BEH2	0.761	0.579			
	BEH3	0.719	0.517			

Table5Matrix of correlation constructs and discriminant validity

	CR	AVE	ATT	USF	EOU	DAG	SUB	BEH
ATT	0.794	0.563	0.750					
USF	0.867	0.620	0.421	0.787				
EOU	0.926	0.758	0.555	0.324	0.871			
PR	0.872	0.630	0.490	0.423	0.412	0.794		
SUB	0.880	0.648	0.537	0.532	0.359	0.334	0.805	
BEH	0.802	0.576	0.521	0.311	0.215	0.434	0.433	0.759

4.2 Structural equation model validation

Parameter estimation was carried out using the Maximum likelihood (ML) method and the MPLUS calculation model, and the questionnaire data were fitted. The fitting degree of the model is shown in Table 6. The fitting degree index results were that the chi-square free ratio was less than 3. Kline considers a chi-square freedom ratio within 3 to be acceptable [31]. All the comparative fit index (CFI) and non-normed fit index (TLI) values were greater than 0.9, which means the model fit acceptable[32].The root mean square error of approximation (RMSEA) and standardized root mean square residual (SRMR) values were less than 0.05, indicating hypothesis model and data fit well. Actually, RMSEA is an important index used to estimate SEM statistical tests [33], which are becoming increasingly popular these years.

Table6Model fit index

Fit index	Key value	Model indexes	Result
ML $\chi 2$	The small the better	667.9	—
Df	The large the better	239	—
$\chi 2$/Df (Normed Chi-sqr)	1< ML X2/Df <3	2.795	Support
CFI	>0.9	0.949	Support
TLI	>0.9	0.937	Support
RMSEA	<0.08	0.045	Support
SRMR	<0.08	0.041	Support

Note: MPLUS does not calculate the GFI index

4.3 Model interpretation

The standardized path coefficients among the potential variables in the structural model are shown in Table 7. Except that the influence relationship between perceived ease of use and behavioral intention is not significant, the coefficient of the influence relationship between variables reaches the significance level of 95% confidence ($P<0.05$). Therefore, Hypothesis 6 is not valid, indicating the other hypotheses about latent variables are all valid.

The final model results are shown in Fig 2, where the numbers on the path represent the corresponding path coefficients. It's demonstrated that perceived usefulness is positively and substantially associated with attitudes toward shore power usage (β=0.270, p<0.001). As a result, Hypothesis 1 is validated, indicating that the perceived usefulness has an influence on attitudes toward using shore power for berthing. In addition, the findings revealed that the EOU was positively and substantially connected to ATT (β=0.234, p<0.01). As a result, Hypothesis 2 is validated, demonstrating that perceived ease of use has an influence on attitudes toward using shore power. Furthermore, the findings revealed that PR was negatively and substantially associated with ATT (β=-0.472, p<0.001). As a result, Hypothesis 3 is validated, demonstrating that perceived risk has an influence on attitudes toward using shore power. In addition, the findings revealed that the SUB was positively and substantially connected to ATT (β=0.617, p<0.001). As a result, Hypothesis 4 is validated, demonstrating that subjective norms have an influence on attitudes toward shore power usage. Moving on to the fifth hypothesis, the findings reveal that USF is positively and substantially associated with BEH (β=0.210, p<0.05). As a result, Hypothesis 5 is validated, demonstrating that the perceived usefulness has an influence on attitudes toward behavioral intention of shore power usage. Moreover, the findings revealed that the SUB was not connected to ATT (β=0.082, p=0.540), demonstrating that the correlation of subjective norms and attitudes toward shore power is not significant. The seventh hypothesis indicated that PR was negatively and substantially connected to BEH (β=-0.488, p<0.01). As a result, Hypothesis 7 is validated, suggesting that perceived risk was positively and substantially associated with the behavioral intention. Similarly, Hypothesis 8 validated that the subjective norms were positively and substantially associated with behavioral intention (β=0.609, p<0.01). implying that subjective norms are beneficial for behavioral intention in shore power use. The findings also reveal that ATT is favorably and substantially associated with behavioral intention (β=0.794, p<0.001). As a result, Hypothesis 9 is accepted.

The effects of the considered variables on the use intention are as follows, in decreasing order of magnitude: Attitude (0.749, ***), subjective norms (0.609, **), perceived risk (-0.488, **), perceived usefulness (0.210, *). The result indicates that with an ideal port-side attitude toward shore power use, excessive perceived risk or unsatisfactory subjective norms will directly affect the port-side behavioral intention, resulting in uncertainty in shore power use and deteriorating shore power promotion.

Table 7 Hypothesis test results

Impact path	Std.	S.E.	Std./S.E.	P-Value	Hypothesis
H1：USF→ATT	0.270	0.084	3.217	***	Supported
H2：EOU→ATT	0.234	0.080	2.910	0.004	Supported
H3：PR→ATT	-0.472	0.107	-3.986	***	Supported
H4：SUB→ATT	0.617	0.083	7.429	***	Supported
H5：USF→BEH	0.210	0.094	2.226	0.026	Supported
H6：EOU→BEH	0.082	0.133	0.613	0.540	Rejected
H7：PR→BEH	-0.488	0.181	-2.696	0.007	Supported
H8：SUB→BEH	0.609	0.187	3.255	0.001	Supported
H9：ATT→BEH	0.794	0.134	5.907	***	Supported

Note：***means p<0.001; **means p<0.01; *means p<0.05; EOU means Perceived Ease-Of-Use; USF means Perceived Usefulness; ATT means Attitude toward using shore power; PR means Perceived Risk; BEH means Behavioral Intention; SUB means Subjective Norms.

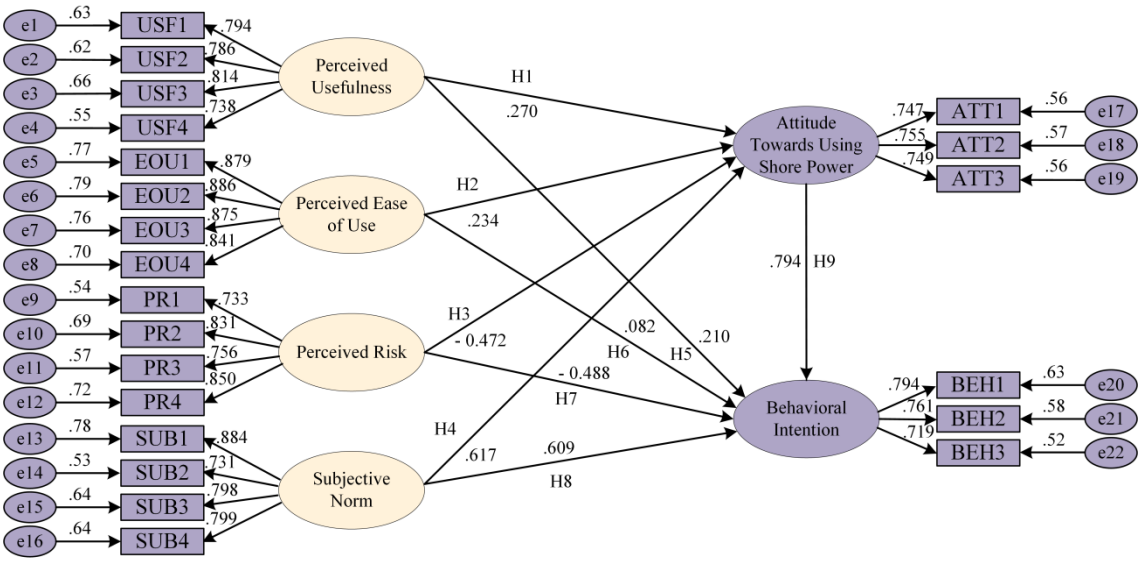

Fig 2: Model results.

4.4 Discussion

According to the study's findings, most hypotheses (except H6) had a significant positive influence on behavioral intention, via ATT using shore power. The traits indicated a strong direct relationship with using attitudes and behavioral intention. This might be due to positive shore power using the environment in China. Although the divergent port distribution and wide variety leads to difficulty obtaining the ideal questionnaire data and the academic vacancy of the TAM in the field of onshore power technology, similar findings still have been observed in previous studies [26], suggesting that there is similar relationship structure in the field of technical adoption. For the mobile learning field, the positive effect of other variables on attitude variables is used to explore how to promote student progress and educational sustainability on the basis of TAM [34]. For the electronic commerce field, it has experimentally been proven the role of trust and risk in purchase intentions for online behaviors, proving the practicability of perceived risk variables introduced in the TAM model [35]. Similarly, in a study on the adoption intentions of mobile libraries, subjective norms were introduced as prior variables affecting the attitude variables [36]. Based on the above research, a model framework was proposed that the PR and SUB affect the attitude of shore power use, and ultimately affect shore power use.

According to the path analysis results, as shown in Fig 2, ATT has the greatest influence on BEH. The standardized regression coefficient of attitude on behavioral intention was 0.794, indicating that ATT was a powerful factor determining the BEH. The results verified Davis' view in TAM theory that attitude influences and greatly determines behavioral intention. In addition to attitude, subjective norms and perceived risk also have significant effects on behavioral intention. The standardized regression coefficient of subjective norms on behavioral intention was 0.609, which is probably on account of the high costs of shore power usage, as current Chinese policy and social environment are difficult to effectively control or reduce the high cost, thus affecting usage of shore power. From another perspective, on the condition that subjective norms can be controlled at a reasonable threshold, then the shore power system can be effectively extended. The standardized regression coefficient of perceived risk on behavioral intention was -0.488, which is probably resulted by the relatively underdeveloped technology, as the shore power technology in China started over 20 years behind foreign countries. In terms of technical stability and safety guarantee system of shore power, there is still much room for progress. The standardized regression coefficient of perceived usefulness on behavioral intention was 0.270, which is consistent with extensive TAM theory in the model structural. To some extent, USF, as a reflection of the usefulness of shore power system, has a theoretical logical relationship between perceived usefulness and the ultimate use intention of shore power system. From the research results of this paper, this logical relationship can be demonstrated. Different from this scenario, we previously assumed the logical relationship between EOU and

BEH in the process of model building, and believed that EOU had a positive influence on BEH. However, according to the calculation results, the mathematical relationship between EOU and BEH was finally determined to be invalid.

In addition to the path of direct impact on behavioral intention, further analysis of ATT was considered as well due to ATT's decisive impact on BEH. In general, the ATT variable was determined by multiple factors in TAM. As mentioned, variables such as SUB and PR have a direct and significant impact on BEH, affecting actual use behavior by influencing use attitude meanwhile. The standardized regression coefficient of perceived ease of use on ATT was 0.234 and perceived usefulness on ATT was 0.270, indicating EOU and USF had a positive and significant effect on ATT. The results of path coefficients are relatively close, meaning that the two variables have similar influences on ATT. Different from the path of USF and EOU affecting BEH, the path coefficient of USF and EOU affecting ATT exists and the value is relatively close, while the path of USF affecting BEH is proved to be invalid. The reason for this result, we believe, is related to the current onshore power promotion policy in China. In order to protect the environment and reach a carbon peak by 2030, the government will give more consideration to the promotion of shore power. However, the perceived usefulness of shore power is not enough to support the shore power system of the port side, which also leads to some disadvantages in the use environment of shore power in China, such as the empty berthing phenomenon of some port power.

Based on the proposed model, the results demonstrate that the subjective norm, perceived risk, perceived usefulness and perceived ease of use significantly determined behavioral intention to actual shore power use. SUB and PR are identified as key factors, which have the largest impact on shore power use. In addition, it was ensured that ATT did directly influence ports' actual use of shore power, since it has the largest path coefficient in the model, implying that once the users became aware of the benefit of shore power system promoted by SUB, they would form a positive attitude toward shore power and subsequently the intention to use it. Equally, once they become aware of the risks of using shore power systems, passive attitude to shore power systems will be taken. Therefore, to get the best shore power receiving effect at the lowest possible cost, model analysis of the two variables should be reasonably used.

Ⅴ. Conclusions

In this study, TAM is used to construct an acceptance model for the usage of a shore power system at a port by introducing two extra core variables: perceived risk and subjective norms, validating the model framework of "perception-attitude-behavior". Five constructs were identified as contributing the most to the use of shore power (BEH) by ports, namely USF, EOU, PR, ATT and SUB, which were extracted from the TAM. Actually, TAM has been used to analyze people's attitude and intentions related to shore power in China. Up to now, Tam has not been used to analyze people's attitude and intention related to shore power in China. Therefore, the combination of TAM and shore power is an important contribution, of great significance for researchers using PR and SUB to maintain the sustainable use of shore power. One limitation of the report is the port staff survey data, which makes it impossible to reflect the actual effect thoroughly. Actually, the ship's attitude towards the use of power across the river, compared with the port, may be different. We also consider some open research questions in the area of shore power and the future directions for the field. If necessary, new influencing variables should also be added to shore power research model to further enhance the model. Finally, comparison and research with the views of other countries may help to expand the findings of this study and realize the continuous utilization and development of shore power.

Acknowledgements

This research was supported by Science and Technology Project of Zhejiang Provincial Department ofTransportation (Grant No. 2020012).

References

[1] J.Lam, E. Voorde, “Green Port Strategy for Sustainable Growth and Development”, International Forum on Shipping, Ports & Airports: Transport Logistics for Sustainable Growth at a New Level, pp. 417-427, 2012.

[2] M.J Moya, V. B. Paja, J.A.G. Maldonado, “Energy Efficiency and Co2 Emissions of Port Container Terminal Equipment: Evidence from the Port of Valencia”, Energy Policy, vol. 131, pp. 312-319, 2019.

[3] D.V. Singh, E. Pedersen, “A Review of Waste Heat Recovery Technologies for Maritime Applications”, Energy Conversion and Management, vol. 111, pp. 315-328, 2016.

[4] I.J.S. Veldhuis, R.N. Richardson, H.B. Stone, “Hydrogen Fuel in a Marine Environment International”, Journal of Hydrogen Energy, vol. 32, pp. 2553-2566, 2006.

[5] R.M. Darbra, N. Pittam, K.A. Royston, J.P. Darbra, H. Journee, “Survey on Environmental Monitoring Requirements of European Ports”, Journal of Environmental Management, vol. 90, pp. 1396-1403, 2009.

[6] K.Y. Bjerkan, H. Seter, “Reviewing Tools and Technologies for Sustainable Ports: Does Research Enable Decision Making in Ports”, Transportation Research Part D-Transport and Environment, vol. 72, pp. 243-260, 2019.

[7] W.J. Hall, “Assessment of CO2 and Priority Pollutant Reduction by Installation of Shoreside Power”, Resources Conservation and Recycling, vol. 54, pp. 462-467, 2010.

[8] F. Yang, G. Li, Q. Shen, G. Yang, “Development Trend of Green Shipping and Application Prospect of Fuel Cell Ships”, Ship Engineering, vol. 42, pp. 1-7, 2020.

[9] K.Y. Bjerkan, H. Seter, “Policy and Politics in Energy Transitions. A Case Study on Shore Power in Oslo”, Energy Policy, vol. 153, pp. 112259, 2021.

[10] H. Lu, L. Huang, “Optimization of Shore Power Deployment in Green Ports Considering Government Subsidies”, Sustainability, vol. 13, pp. 53-67, 2021.

[11] L. Xu, Z. Di, J. Chen, J. Shi, C. Yang, “Evolutionary Game Analysis on Behavior Strategies of Multiple Stakeholders in Maritime Shore Power System”, Ocean and Coastal Management, vol. 202, pp. 105508, 2021.

[12] T. Gunzl, “Cruise Port with Shore Power - Sustainable Development of Cruise Shipping in Rostock-Warnemunde”, Bautechnik, vol. 96, pp. 638-642, 2019.

[13] S.A. Kamal, M. Shafiq, P. Kakria, “Investigating Acceptance of Telemedicine Services through an Extended Technology Acceptance Model (Tam)”, Technology in Society, vol. 60, pp. 101212, 2019.

[14] S. Lew, W.H. Tan, X.M. Loh, J.J. Hew, K.B. Ooi, “The Disruptive Mobile Wallet in the Hospitality Industry: An Extended Mobile Technology Acceptance Model”, Technology in Society, vol. 63, pp. 101430, 2020.

[15] F.D. Davis, R.P. Bagozzi, P.R. Warshaw, “User Acceptance of Computer Technology: A Comparison of Two Theoretical Models”, Management Science, vol. 35. pp. 982-1003, 1989.

[16] F.D. Davis, “A Technology Acceptance Model for Empirically Testing New End-User Information Systems: Theory and Results”, USA: Ph. d. dissertation Massachusetts Institute of Technology Publishing, 1985.

[17] I. Ajzen, “Understanding Attitudes and Predicting Social Behavior”, State of New Jersey: Journal of Experimental Social Psychology Publishing, 1980.

[18] A.K. Moser, “Thinking Green, Buying Green? Drivers of Pro-Environmental Purchasing Behavior”, Journal of Consumer Marketing, vol. 32, pp. 167-175, 2015.

[19] Z. Shi, W. Zheng, Z. Kuang, “The difference of face measurement between reflective model and formative model and the face influence on green product preference”, Chinese Journal of Management, vol. 14, pp. 1208-1218, 2017.

[20] J.K. Dan, D.L. Ferrin, H.R. Rao, “Trust and Satisfaction, Two Stepping Stones for Successful E-Commerce Relationships: A Longitudinal Exploration”, Information Systems Research, vol. 20, pp. 237-257(2009).

[21] F.D. Davis, “Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology”, MIS Quarterly, vol. 13, pp. 319-340, 1989.
[22] X. Song, Y. Zhou, W. Wang, G. Tang, “Research on Retrofit Strategy of Shore Power System for Feeder Ships and Its Economic Influencing Factors”, Journal of Shanghai Maritime University, vol. 36, pp. 43-47, 2015.
[23] J. Wu, J. Lv, Y. Lin, “Research on Port Emission Reduction Strategy for Ships Using Shore Power Based on Three-Phase Game Model”, Journal of Mathematics in Practice and Theory, vol. 50, pp. 27-37, 2020.
[24] X. Li, K. Sun, “On Shore Side Power for Vessels in Ports”, Journal of Shanghai Maritime University, pp. 10-14, 2006.
[25] Bollen, A. Kenneth, “Structural Equations with Latent Variable, New York”, Wiley Interscience Publishing, 1989.
[26] M.A. Alrahmi, W.M. Alrahmi, U. Alturki, A. Aldraiweesh, S. Almutairy, A.S. Aladwan, “Exploring the Factors Affecting Mobile Learning for Sustainability in Higher Education”, Sustainability, vol. 13, pp. 7893, 2021.
[27] K. Guo, H. Wang, Y. Zhao, “What Motivates Consumers to Articulate Themselves on Online Reputation Systems: an TAM Based Empirical Study”, Business Review, vol. 26, pp. 180-190, 2014.
[28] K.H. Seo, J.H. Lee, “The Emergence of Service Robots at Restaurants: Integrating Trust, Perceived Risk, and Satisfaction”, Sustainability, 2021.
[29] Z. Li, X. Ma, Y. Ma, “The Effect of Subjective Norms and Public Media Influence on Green Consumption Intention”, Soft Science, vol. 33, pp. 113-119, 2019.
[30] R.P. Bagozzi, “Evaluating Structural Equation Models with Unobservable Variables and Meas Error: A Comment”, Journal of Marketing Research, vol. 18, pp. 2375, 1981.
[31] R. Kline, R.B. Kline, R. Kline, “Principles and Practice of Structural Equation Modeling”, USA: Journal of the American Statistical Association Publishing, 2011.
[32] B. Tabachnick, L. Fidell, “Using Multivariate Statistics (4th Ed.)”, USA: Allyn and Bacon Publishing.
[33] R. MacCallum, C. Browne, M.W. Sugawara, M. Hazuki, “Power Analysis and Determination of Sample Size for Covariance Structure Modeling” Psychological Methods, 1996.
[34] Al-Rahmi, A. Mugahed, A. Shamsuddin, U. Alturki, A. Aldraiweesh, F.M. Yusof, W.M. Al-Rahmi, A.A. Aljeraiwi, “The Influence of Information System Success and Technology Acceptance Model on Social Media Factors in Education”, Sustainability, vol. 13, pp. 7770, 2021.
[35] X. Tong, “A Cross- National Investigation of an Extended Technology Acceptance Model in the Online Shopping Context”, International Journal of Retail & Distribution Management, vol. 38, pp. 742-759, 2010.
[36] C. Gan, C. Song, “Empirical analysis on internet to adopt mobile library based on TAM”, Documentation, Information & Knowledge, vol. 03, pp. 66-71, 2015.