

Analysis of Influencing Factors of Vortex Ring Device Market Acceptance Based on Structural Equation Model

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Keywords: Truncated Vortex Convection Enhancement Device, Market Acceptance, Structural Equation Modeling

Abstract: The vortex ring is a concentrated type of vortex, which has the characteristics of stable propagation, low energy consumption, and long propagation distance. It can improve the problems of high energy consumption and uneven temperature in the current air-conditioning system. The truncated vortex ring convection enhancement device manufactured and developed in my country, as an additional product of air conditioning, can improve the problems existing in the existing air conditioning system. Based on the structural equation model, this paper selects five dimensions to analyze the influencing factors of the market acceptance of the vortex ring device. The model uses promotion conditions, perceived ease of use, perceived usefulness, and perceived value as influencing factors, and behavior willingness as the basis for measuring acceptance, and discusses the impact of each factor on consumer market acceptance in different paths. The results show that the four factors of promotion condition, perceived ease of use, perceived usefulness, and perceived value all directly or indirectly affect the market acceptance of vortex ring devices. This research has reference significance for the early improvement and promotion of the vortex ring device.

1. Introduction

The vortex ring is a concentrated type of vortex with characteristics of stability, low speed, and long-distance travel. Wuhan Sotin Technology Co., Ltd. innovatively applied the vortex ring technology to the additional product device for air conditioning temperature regulation, and created a new temperature regulation device with both rapid temperature regulation and comfort - the truncated vortex ring convection enhancement device. Applying the vortex ring to the air supply process of heating or cooling equipment can greatly increase the air supply distance and reduce the loss of air along the way under the same wind speed by changing the existing air supply method. In addition, the disturbance of the indoor temperature field by the vortex ring can alleviate the uneven distribution of the indoor temperature field, so that the heating and cooling air can be fully utilized in the personnel activity area, thereby improving the energy utilization rate and reducing the energy consumption by about 18%. Indoor temperature regulation effect.

At present, the development of Wuhan Sotin Technology Co., Ltd. has entered a growth stage. The company is focusing on the goal of promoting the vortex ring device on a large scale in the market. At the same time, the public does not know much about this emerging air supply technology. The acceptance of the product largely affects the market prospects of the product. Therefore, based on theoretical analysis and questionnaire survey, this paper uses the structural equation model as the main tool to investigate the market's acceptance of vortex ring temperature regulation technology, and strives to provide certain theoretical support for promoting the expansion of Wuhan Sotin Technology Co., Ltd. and the promotion of vortex ring devices.

2. Model establishment and research assumptions

2.1 Model establishment

The establishment of the model in this paper refers to TAM (Technology Acceptance Model), that is, the Technology Acceptance Model, which was proposed by Davis in 1986 [1]. The model believes that the two main determinants of technology acceptance are Perceived usefulness and Perceived ease of use. User refers to the ease with which the technology is perceived by the user. In addition, the technology acceptance model believes that the use behavior is directly determined by the behavioral intention, and the behavioral intention is determined by the perceived usefulness and perceived ease of use.

In addition, the model refers to VAM (Value-Based Adaption Model), that is, the value acceptance model [2]. The empirical research of Hee-Woong Kim et al. in 2005 found that consumers' acceptance of the Internet is determined by their Perceived Value directly decides, from which the model is proposed. The definition of perceived value was first proposed by Peter Drucker (1990), but did not give a clear definition. Wu Xiaogen (2011) defined it as the comprehensive evaluation of products and services by users [4].

Finally, the model takes the Facilitating Conditions in UTAUT (Unified Theory of Acceptance and Use of Technology) theory as the starting point of the model. Promotion conditions represent the multifaceted level of support that users receive when using the product. This theory was proposed by Venkatesh et al. in 2003 [3].

Therefore, based on the above theories, this paper selects Behavioral Intention (BI) as a latent variable representing product acceptance of vortex ring devices, and selects Facilitation Condition (FC), Perceived Ease of Use (PE), Perceived Usefulness (PU), Perceived Value (PV) as an influencing factor of acceptance. Combining the above five dimensions, the market acceptance model of the vortex ring device is established. The model is shown in the following figure 1:

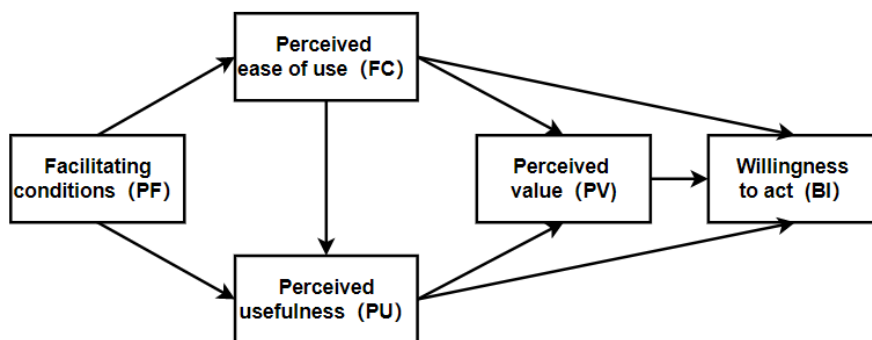


Figure 1. Neural network structure

2.2 Research hypothesis

Based on the above model, this paper establishes 8 assumptions as shown in the following table, as shown in Table 1.

Table 1. Items of acceptance and influencing factors of vortex ring device

Number	Hypothetical content	Influence relationship
H1	Facilitating Conditioning Affects Perceived Ease of Use	Positive influence
H2	Facilitating conditioning affects perceived usefulness	Positive influence
H3	Perceived ease of use affects perceived usefulness	Positive influence
H4	Perceived ease of use affects perceived value	Positive influence
H5	Perceived usefulness affects perceived value	Positive influence
H6	Perceived ease of use affects behavioral intention	Positive influence
H7	Perceived usefulness affects behavioral intention	Positive influence
H8	Perceived value affects behavioral intention	Positive influence

3. Survey design

The survey design of this paper is divided into two parts, which are the personal basic information of the respondents and the acceptance of the vortex ring device and its influencing factors. The former includes gender, age, income, industry, frequency of air-conditioning use, and perception of existing air-conditioning defects, while the latter considers five dimensions: promotion conditions, perceived ease of use, perceived usefulness, perceived value, and behavioral willingness. Before filling out the questionnaire, the respondents will read a text description introducing the truncated vortex ring convection enhancement device, and after having a basic understanding of the product information, the respondents will fill in the questionnaire. The questionnaire items for the acceptance of the vortex ring device and its influencing factors are as shown in Table 2.

Table 2. Items of acceptance and influencing factors of vortex ring device

Dimension	Number	Item
Facilitating Conditions (FC)	FC1	I can understand the principle of this vortex ring
	FC2	I can learn about related technologies through various channels
	FC3	I can master the use of this product through the people around me
Perceived Ease of Use (PE)	PE1	I think this vortex ring air supply device has practical value
	PE2	I think it is easy to learn to operate and control this product
	PE3	I think the use of the vortex air supply is not error-prone
Perceived usefulness (PU)	PU1	I think this product can improve the cooling efficiency of air conditioners
	PU2	I think this product can reduce the cost of electricity
	PU3	I think this product can make the environment more comfortable
	PV1	I think this product technology can be better adapted to different scenarios
Perceived Value (PV)	PV2	I think the application of this product is more efficient and more responsive
	PV3	I think this product technology is less expensive to use
	BI1	I would love to experience the effects of this product if given the chance
Intention to Behavior (BI)	BI2	I would like to know more about the service content of this product
	BI3	If this product technology is mature, I am willing to buy this product service
	BI4	I am happy to tell and promote this product technology to my friends

Among them, Facilitating Condition (FC) represents the knowledge, resources and technical support that the respondent can obtain; Perceived Ease of Use (PE) represents the respondent's evaluation of the ease of use of the vortex ring device after reading the relevant materials; Perceived usefulness The performance (PU) represents the respondents' evaluation of the effect of the vortex ring device in real life after reading the relevant materials; the perceived value (PV) represents the respondents' evaluation of the vortex ring device compared with existing similar products. Evaluation of strengths; Behavioral Intention (BI) represents the willingness of respondents to understand, purchase and promote Vortex products. The questionnaire uses a five-point Likert scale, and the results of each dimension are the average of the items within the dimension. The questionnaire design form is easy to carry out further data analysis.

4. Descriptive statistics and reliability and validity tests

4.1 Descriptive Statistics

A total of 329 valid samples were collected in this paper, and the distribution and collection of the survey were conducted through the Questionnaire Star platform. The descriptive statistics of the survey are shown in Table 3.

Table 3. Descriptive statistics

Attributes	Category	Number	Percentage
Gender	Male	158	48.0
	Female	171	52.0
Generation	Under 18	2	0.6
	18-25	94	28.6
	26-30	137	41.6
	31-40	69	21.0
	41-50	19	5.8
	51-60	5	1.5
	Over 60	3	0.9
Industry	Government agency	17	5.2
	Business unit	122	37.1
	Private Enterprise	150	45.6
	Self-employed	25	7.6
	Else	15	4.6
Monthly income (yuan)	Below 5000	39	11.9
	5000-10000	123	37.4
	10000-20000	129	39.2
	20000-50000	28	8.5
	50000 above	10	3.0

It can be seen from the above table that the gender distribution of the respondents is even; most of the age groups are divided into young and middle-aged groups. These groups use air conditioners more frequently than the elderly, and are more sensitive to the experience of air conditioners than children; Most of the respondents are employed in public institutions or famous enterprises; most of the respondents' monthly incomes are in the range of 5,000-20,000 yuan. The respondents represent the main consumer groups in the air-conditioning market, and the sample has high credibility.

Table 4. Descriptive Statistics of Existing Defects in Air Conditioning Systems

	Response		Percentage
	Number	Percentage	
Power consumption for prolonged use	103	15.40	31.30
Uneven temperature distribution	195	29.10	59.30
Air conditioner blowing directly is uncomfortable	215	32.10	65.30
Indoor dryness	149	22.30	45.30
Else	7	1.00	2.10
Total	669	100.00	203.30

From Table 4, it can be seen that the number of people who think that the existing air-conditioning system has a problem of excessive power consumption for a long time accounts for 31.3% of the total number of respondents; the number of people who think that the existing air-conditioning system has uneven temperature distribution problems accounts for 59.3%; 65.3% of the people thought that the air-conditioning system had a problem of discomfort caused by direct wind blowing; 45.3% of the people thought that the existing air-conditioning system had the problem of indoor dryness and water shortage. It can be seen that most air-conditioning users are not satisfied with the existing air-conditioning system. The vortex ring device can effectively solve the problems of air conditioning power consumption, uneven temperature distribution and uncomfortable direct air blowing by the unique air supply principle, which meets the market demand.

4.2 Reliability test

The reliability test uses the Cronbach's reliability coefficient to check the consistency of the questionnaire research variables on each measurement item. There are 5 factors in this research,

namely: promotion conditions, perceived ease of use, perceived usefulness, perceived value, and behavioral willingness. The following is a reliability analysis for each variable, and the measurement results are shown in the following table 5.

Table 5. Reliability Test

Dimension	Item	CITC	Cronbach's α after item deletion	Cronbach's α
Facilitating conditions	FC1	0.664	0.791	0.831
	FC2	0.671	0.785	
	FC3	0.736	0.719	
Perceived ease of use	PE1	0.687	0.819	0.849
	PE2	0.693	0.820	
	PE3	0.783	0.728	
Perceived usefulness	PU1	0.688	0.688	0.802
	PU2	0.603	0.780	
	PU3	0.656	0.721	
Perceived value	PV1	0.662	0.687	0.792
	PV2	0.664	0.685	
	PV3	0.578	0.776	
Willingness to act	BI1	0.739	0.777	0.845
	BI2	0.643	0.819	
	BI3	0.660	0.812	
	BI4	0.682	0.803	

It can be seen from Table 5 that the Cronbach's Alpha coefficients of promotion conditions, perceived ease of use, perceived usefulness, perceived value, and behavioral willingness are 0.831, 0.849, 0.802, 0.792, and 0.845, which are all greater than the standard of 0.7, indicating that the variables have good internal consistency reliability. CITC is greater than the standard of 0.5, indicating that the measurement items meet the research requirements. In addition, deleting any question in each dimension did not increase the Cronbach's Alpha value, which also indicated that the variable had good reliability.

4.3 Validity test

Exploratory factor analysis was performed using SPSS 23.0 to test the construct validity of the scale. First, KMO and Bartlett's sphericity test were performed on the scale, and the results are shown in Table 6.

Table 6. KMO and Bartlett's test

Kaiser-Meyer-Olkin measure of sampling adequacy		0.875
Bartlett's test for sphericity	Approximate chi-square	2414.333
	df	120
	Sig.	.000

Among them, KMO = 0.875, greater than 0.7, Bartlett's sphericity test value is significant (Sig.< 0.001), so the data collected by the questionnaire meets the premise requirements of factor analysis. Principal component analysis was used to extract factors, and the eigenvalues greater than 1 were used as factors to extract common factors. When the factors were rotated, the maximum variance orthogonal rotation was used for factor analysis. The results are shown in Table 7.

It can be seen from Table 7 that a total of 5 factors are obtained from the factor analysis results, and the total explanatory power reaches 72.78%, which is greater than 50%, indicating that the selected 5 factors are well representative. The factor loading factor is shown in the table above. The factor loading of each measurement item is greater than 0.5, and the cross-loading is less than 0.4. Each item falls into the corresponding factor, indicating that the scale has good construct validity.

Table 7. Factor Analysis Results

Item	Component				
	Preference	Perceived ease of use	Advance condition	Perceived usefulness	Perceived value
BI1	0.831	0.080	0.158	0.115	0.169
BI3	0.809	0.118	0.099	0.033	0.113
BI4	0.755	0.202	0.124	0.193	0.126
BI2	0.728	0.130	0.009	0.214	0.220
PE3	0.162	0.865	0.147	0.090	0.179
PE1	0.189	0.803	0.172	0.113	0.152
PE2	0.128	0.780	0.241	0.120	0.200
FC3	0.109	0.189	0.854	0.070	0.133
FC2	0.148	0.159	0.806	0.137	0.101
FC1	0.075	0.165	0.801	0.167	0.135
PU3	0.144	0.041	0.106	0.819	0.181
PU2	0.113	0.105	0.075	0.796	0.120
PU1	0.202	0.163	0.212	0.790	0.136
PV2	0.176	0.148	0.111	0.110	0.829
PV1	0.260	0.182	0.152	0.207	0.751
PV3	0.154	0.203	0.138	0.167	0.725
Eigenvalues	2.759	2.304	2.297	2.195	2.089
Percent variance	17.240	14.399	14.357	13.719	13.058
Accumulation	17.246	31.645	46.002	59.721	72.78

5. Hypothesis testing based on structural equation model

5.1 Construction of structural equation model

This paper uses structural equation modeling for hypothesis testing. Before testing, an initial model of structural equations must be constructed. The initial model can be divided into structural model and measurement model. The core task is to determine the relationship between all latent variables involved in the initial model. The latent variables in this paper are: Facilitating Condition (FC), Perceived Ease of Use (PE), Perceived Usefulness (PU), Perceived Value (PV), and Behavioral Intention (BI). The initial model shown in the figure below is now constructed to lay the foundation for further empirical verification.

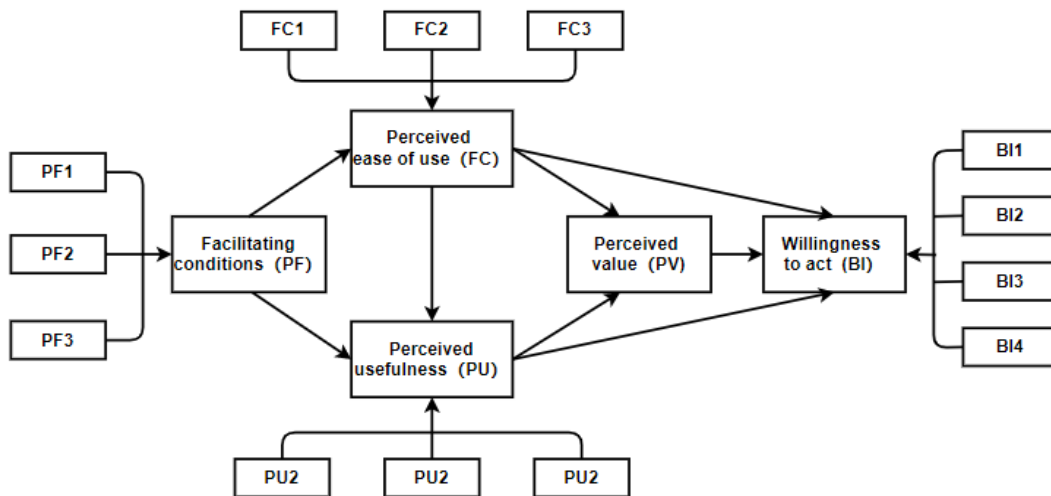


Figure 2. Initial model diagram of vortex ring device acceptance

5.2 Construction of structural equation model

In this paper, SPSS software is used to analyze the model fit index according to the model shown in Figure 1. The obtained evaluation parameters are shown in Table 8.

Table 8. Model Fit Test Results

Model Fit Metrics	optimal standard value	Statistics	fit
CMIN	—	112.017	—
DF	—	96	—
CMIN/DF	<3	1.167	Well
RMR	<0.08	0.038	Well
GFI	>0.8	0.96	Well
AGFI	>0.8	0.943	Well
NFI	>0.9	0.954	Well
IFI	>0.9	0.993	Well

It can be seen from Table 9 that CMIN/DF is 1.167, which is less than 3 or less, GFI, AGFI, NFI, IFI, TLI, and CFI all reach the standard of 0.9 or more, RMR is 0.038, which is less than 0.08, RMSEA is 0.023, less than 0.08. The indicators all meet the research standards, so it can be considered that this model has a good fit.

5.3 Model Hypothesis Testing

The path coefficient analysis is carried out on the structural equation model, and each path coefficient is measured. The specific results are shown in Table 9.

Table 9. Structural equation model path coefficients

	Standardized coefficient	Unstandardized coefficients	S.E.	C.R.	P
Perceived ease of use<---Facilitating conditions	0.527	0.494	0.064	7.771	***
Perceived usefulness<---Facilitating conditions	0.325	0.364	0.086	4.225	***
Perceived usefulness<--- Perceived ease of use	0.226	0.269	0.089	3.02	0.003
Perceived value <--- Perceived ease of use	0.419	0.512	0.08	6.366	***
Perceived value <--- Perceived usefulness	0.375	0.384	0.068	5.654	***
Willingness to act <--- Perceived ease of use	0.169	0.202	0.085	2.376	0.018
Willingness to act <--- Perceived usefulness	0.220	0.220	0.072	3.068	0.002
Willingness to act <--- Perceived value	0.368	0.360	0.084	4.293	***

Note: *** means the significance level is less than 0.001.

It can be seen from Table 10 that the standardized coefficient of the promotion condition on perceived ease of use is 0.527 ($P < 0.05$), reflecting a significant positive effect between the two; the standardized coefficient of promotion condition on perceived usefulness is 0.325 ($P < 0.05$), reflecting a significant positive effect between the two; the standardized coefficient of perceived ease of use on perceived usefulness was 0.226 ($P < 0.05$), reflecting a significant positive effect between the two; perceived ease of use had a significant positive effect on perceived value The standardized coefficient of perceived usefulness was 0.419 ($P < 0.05$), reflecting a significant positive effect between the two; the standardized coefficient of perceived usefulness on perceived value was 0.375 ($P < 0.05$), reflecting a significant positive effect between the two; The standardized coefficient of perceived ease of use on behavior willingness was 0.169 ($P < 0.05$), reflecting a significant positive effect between the two; the standardized coefficient of perceived usefulness on behavior willingness was 0.22 ($P < 0.05$), reflecting the difference between the two Significant positive impact; the standardized coefficient of perceived value on behavioral intention is 0.368 ($P < 0.05$), reflecting a significant positive impact between the two.

Overall, the path coefficients derived from the structural equation model are consistent with the assumptions made above. When promoting vortex ring products, we can start from four aspects: promotion conditions, perceived ease of use, perceived usefulness, and perceived value, continuously optimize product services and functional attributes, and widely deploy truncated vortex ring convection enhancement devices in the air-conditioning industry.

6. Hypothesis testing based on structural equation model

(1) Aim at the target market and expand publicity. At this stage: Although the drawbacks of traditional air conditioning technology for air supply and temperature regulation have led to a gradual increase in the public's demand for improving air conditioning comfort, due to the vortex ring temperature regulation, there are certain access thresholds, and the market There are fewer similar products, resulting in limited market awareness of the technology. In order to expand the market, Wuhan Sotin Technology Co., Ltd. needs to face potential customer groups, use a variety of publicity and marketing methods to expand technology promotion channels, and promote product awareness. Specifically, the means can include but are not limited to: initially cooperating with well-known enterprises to provide them with technical services, using the marketing channels of leading enterprises to promote vortex ring technology while improving the intellectual property protection system, and providing intellectual property protection for later market development; Open an experience store online, and provide users with an intuitive experience through the tangible display of appearance, quality and service, and cultivate potential customers' desire for experience; online, introduce key words in search engines, use Douyin, Weibo, WeChat and other The online sales platform narrows the distance with customer groups through small videos, entries, Weibo topics, etc.

(2) Reduce the difficulty of using the product and optimize the service level of the product: Perceived ease of use and perceived usefulness have a significant positive impact on improving technology acceptance. The vortex ring technology itself is highly professional, and in the process of promotion, users may refuse to use it because they have little understanding of the technology and think that the operation is too difficult. Therefore, Wuhan Sotin Technology Co., Ltd. should simplify the operation mode of the product from the aspects of installation, use and maintenance, so as to improve the willingness of consumers to use it. Improving the comfort of air conditioners, solving the problem of uneven temperature field distribution and reducing energy consumption are the design principles of vortex ring temperature control products. Effectively reducing user electricity costs and improving the experience of air conditioner use will greatly increase the market acceptance and purchase demand of the product. Merchants need to continuously improve product technical strength, expand product application scenarios, improve product service system from purchase to after-sales, and establish a good brand image, thereby enhancing product market acceptance.

Acknowledgements

The authors gratefully acknowledge the financial support from National Innovation and Entrepreneurship Training Program for College Students (202110497025).

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