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Would information acquisition increase enterprises' willingness to participate in the carbon market? An empirical investigation of equipment manufacturing enterprises in Henan Province, China

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The carbon market is the most important policy tool for achieving carbon peak and carbon neutralization. Enterprises are significant players in the carbon market, and this study aimed to identify if their willingness to participate is connected to the carbon market's stability and, at the same time, whether it is also relevant for policy design and implementation. Using the technology acceptance model (TAM) and 226 questionnaire data from equipment manufacturing enterprises in Henan Province, China, this study contributes to the empirical analysis of the impact mechanism of information acquisition on the enterprises' willingness to participate in the carbon market, with a particular focus on evaluating the three main transmission paths: the mediating role of perceived ease of use, the mediating role of perceived usefulness, and the chain mediating role of perceived ease of use and perceived usefulness; moreover, the results of the robustness tests also confirmed the soundness and validity of the research model. The study underlined that when appropriately designing the incentive mechanism for enterprises to participate in the carbon market, it may effectively enhance their willingness to participate in the carbon market by improving their perception of the ease of use and usefulness of the carbon market.

KEYWORDS

carbon market, equipment manufacturing industry, willingness to participate, information acquisition, technology acceptance model

1 Introduction

China, as the world's largest carbon emitter, undertook international emission reduction responsibilities and attempted to realize carbon peaking and carbon neutralization by establishing a unified national carbon market. In 2021, the carbon emission of China was 12 billion tons, and at the same time, the national carbon market was officially launched (Sun et al., 2022). The carbon market not only increased the use cost of high polluting energy but also provided economic incentives for enterprises to reduce carbon emissions. By 31 December 2021, the cumulative trading volume of the carbon emission quota in the national carbon market was 179 million tons.

Henan was the most populous province in China, and its GDP attained 5.89 trillion Yuan in 2021, approximately 11.07% of the country's total (Qin et al., 2022). The equipment manufacturing sector was one of the five important industries in Henan Province. There were 3,819 enterprises in this sector, nearly 19.28% of the total number of industrial enterprises in Henan Province. The energy consumption of this sector reached 2.92 million Tec, about 2.22% of the total energy consumption of the province. Simultaneously, the carbon emission was 13.07 million tons, around 2.08% of the province's carbon emission. How to reduce carbon emissions and energy consumption is still an urgent challenge for the equipment manufacturing industry in Henan Province.

From the traditional economic point of view, carbon emissions not only had externalities but also embodied the attributes of global public goods (Dixon, 2002). The introduction of the carbon trading market aims to internalize the externalities of carbon emissions through market-based means, which gives carbon emission rights the attributes of a commodity (Alexeeva and Anger, 2016). Furthermore, the trading of carbon emission rights means the transfer of property rights between economic agents by the use of carbon emission rights for a fee, or the trading of carbon emission rights, to optimize the allocation of resources and reduce carbon emission levels.

The government expected to use the carbon market as a policy tool to accelerate the low-carbon transformation of the equipment manufacturing industry while promoting the upgrading of industrial structures and low-carbon technological innovation. In the operation process of the carbon market, information was the key issue affecting the rational and effective allocation of resources, so the enterprises might use various approaches to obtain information for the purpose of making scientific decisions and, in addition, deciding whether to participate in the carbon market. In the meantime, the rational decisions of enterprises further made the carbon market operate stably and reliably.

In this context, the most important contributions of this study lay in three aspects. First, the technology acceptance model (TAM) considering information acquisition and enterprises' cognition was introduced; this model took into account the influence of external environmental factors on individual behavior, rather than only exploring the mechanisms that influenced individual behavior from a cognitive perspective, which expanded the viewpoint of research on enterprises' willingness to participate in the carbon market. Second, whilst the literature on the China emission trading scheme was steadily increasing, the issue of the pathways and mechanisms that influenced the willingness of enterprises to participate in the carbon market had not been addressed so far. As an important participant in the carbon market, a discussion on enterprises' willingness to participate could help provide empirical support for the development of China's carbon trading market from a microperspective. Finally, we found the mediating paths and effects of perceived ease of use and perceived usefulness through a mediating effects test. Therefore, policy ways to improve enterprises' willingness to participate in the carbon market could be proposed.

This article is organized as follows: Section 2 depicted a review of the literature. In Section 3, the research hypothesis and theoretical framework were described, which posed assumptions from the relationship among the information acquisition, enterprises' participation willingness, and the mediating role of enterprises' cognition, respectively, and an improved technology acceptance model was subsequently constructed. This was followed by the research design, which illustrated different parts such as sample selection and data collection, variable measure, reliability and validity test, and common method deviation test. Section 5 included four aspects: first, the variation expansion factor (VIF) test was performed on all explanatory variables to avoid multi-collinearity, and then, the hierarchical linear regression analysis was used to test the hypothesis. Third, the mediating paths and effects of perceived ease of use and perceived usefulness were analyzed through a mediating effects test. Robust testing was carried out in the final part. Section 6 discussed the findings and put forward the policy suggestions. Finally, we reflect on how our findings might help to advance research on the carbon peak and carbon neutralization.

2 Literature review

To actively respond to global climate change and further strengthen carbon emission reduction efforts, the construction of China's carbon market began in 2011 when China's National Development and Reform Commission issued the "Notice on Piloting Carbon Emissions Trading," and seven provinces and cities, including Beijing, Shanghai, and Guangdong province, were approved to carry out piloting work on carbon emission trading; these provinces and cities worked out local laws and regulations, established an MRV (monitoring, reporting, and verification) system, designed allowance allocation and trading

rules, etc. In December 2017, China's National Development and Reform Commission issued the "National Carbon Emissions Trading Market Construction Plan," which marked the construction of a unified national carbon market. Some scholars had analyzed the impact of China's carbon market in different regions and scenarios. The development status of domestic and international carbon markets was compared and found that the main problems of China's carbon markets were the lack of incentive mechanism, market fragmentation, defect of fairness, and a series of systemic problems (Zhao et al., 2017). The computable general equilibrium (CGE) model was used to analyze the economic impacts of China's carbon market (Wang and Wang, 2016; Huang H. et al., 2019). Other researchers explored the impact of permit distribution on the fairness of regional development (Jiang et al., 2014; Zhang et al., 2014; Hu et al., 2017; Li et al., 2018; Tan et al., 2019).

Originally, with the focus on the study of individual behavior, scholars have constructed a number of relevant theoretical models (Ajzen and Fishbein, 1977; Ajzen, 1991; Davis and Viswanath, 1996). The most typical ones were the theory of Reasoned Action (TRA), the theory of planned behavior (TPB), and the technology acceptance model (TAM). TRA was proposed to explain the determinants of human behavior, and this theory assumed that an individual's attitude toward a behavior and the subjective norms to which he or she was subjected could determine that individual's willingness to act. Zhao et al. (2018) studied the factors that influence enterprises' willingness to pay for carbon emissions in China through TRA and found the perception of the high pressure of energy costs would significantly decrease the enterprises' willingness to participate in the carbon market. Based on TRA, a questionnaire survey was conducted on selected power plants in China, and the study found that fossil fuel combustion, production technology, output adjustment, and environmental management aspects might have an impact on enterprises' willingness to participate in the carbon market (Chen et al., 2018). Furthermore, structural, regulatory, contextual, and cultural barriers hampered the process of translating enterprises' willingness to participate in the carbon market into behavior (Yong, 2012).

The TRA ignored the influence of behavioral controllability on an individual's willingness to act. Therefore, the TRA was extended by introducing perceived behavioral control and proposing TPB in order to improve the explanation and prediction of behavior. For enterprises in China's carbon trading pilot regions, these companies were more concerned about the volatility of carbon trading prices, and dramatic price fluctuations could reduce their willingness to participate in the carbon trading market (Fan et al., 2019). The completeness of carbon market policies and the transparency of carbon trading information were also important factors influencing enterprises' willingness to participate in the carbon market (Hu et al., 2017). Some companies paid close attention to the size of the carbon trading market and believed that participating in an inefficient or weakly efficient carbon trading market would increase the risk to their business (Zhao et al., 2017).

TRA and TPB only explored the mechanisms that influence individual behavior from a cognitive perspective, ignoring the influence of external environmental factors on individual behavior. The TAM was developed to explain a psychological mechanism of information communication technology (ICT) adoption based on the TRA (Davis, 1989). The theory suggests that an individual's external environment and cognitive characteristics jointly influenced his or her willingness to use a system and his or her behavior, and that the external environment influenced the individual's willingness to use it through his or her cognitive characteristics (Venkatesh, 2008). The cognitive characteristics of individuals and the external environment in which they lived not only influence their decision-making abilities but also motivated them to optimize their own resource allocation according to their needs, thus having a significant impact on their willingness to use and their behavior (Choshaly, 2019; Mi et al., 2019; Zhu et al., 2020; Mo et al., 2021). Unlike the two theories mentioned earlier, the TAM introduced external environmental factors (Chimborazo et al., 2021). Enterprise's participation behavior in the carbon market was rooted in social activity and influenced not only by the level of awareness of the carbon market, for example, perceived difficulty and benefits of participation, but also by the external environment in which the enterprise operates, for example, access to carbon market-related information. The TAM introduces external environmental factors and reveals the process of individual willingness to use and behavior in response to external environmental influences, offering more significant advantages than the TRA and TPB. Therefore, the TAM had been chosen as the conceptual model for this study. Furthermore, data quality is also a critical success factor for user acceptance of research information (Azeroual et al., 2020).

Information acquisition (IA) referred to the act of acquiring information for a certain goal (Meng and Zhong, 2012), and was determined by personal factors and salient elements in the target environment (Xie et al., 2012). The more exposure an individual had to something and the higher the level of exposure, the more information was available about it and the more willing he or she was to act accordingly (Li et al., 2020). Some scholars had found that information acquisition played an important influence on an individual's decision-making behavior and it also significantly and positively affects the firms' willingness to participate in the market or technology innovation (Guan and Chen, 2017; Ha et al., 2017; Guan et al., 2018; Guan et al., 2019).

Existing research had served as useful sources of inspiration. However, the following three deficiencies remain. First, research studies mostly focus on assessing the impact of China's carbon market on industry or region from an economic or environmental standpoint, only a few studies had looked at

the changes in behavior and the influencing factors of enterprises' participation in the carbon market from an individual perspective. Enterprises were important actors in the carbon market, and changes in their behavior necessarily impact the carbon market's stability. Second, most previous research methodologies relied on macro-analytical approaches such as CGE models or econometric models, with minimal use of micro-applications like TAM. Furthermore, few studies had looked at the influence of information acquisition on enterprises' participation in the carbon market, resulting in a lack of a multi-level and multi-dimensional assessment of China's carbon market. Thirdly, most research examined the role of China's carbon market using macroeconomic data, while just a few studies employed questionnaire surveys to do so. To close the gap, this study attempted to build a TAM model based on a questionnaire survey, using enterprises as the research target to investigate their willingness to participate in the carbon market and the action path of information acquisition.

3 Theoretical framework and hypothesis development

According to the information asymmetry theory, differences in the participants' capacity to get critical information prompted them to take different risks while receiving distinct market benefits, resulting in a variety of behavioral proclivities (Sun et al., 2019). As a result, enterprises were able to discover the demand trend for carbon quotas, the feedback of complaint information, and the changing trend in carbon market policy, reducing the uncertainty in the process of enterprises participating in the carbon market and increasing their willingness to participate in the carbon market, according to information acquisition. Through the carbon market information transmission network, enterprises could obtain relevant information, identify opportunities and integrate resources, allowing them to seize carbon market opportunities and promote "demand discovery" and "opportunity creation" in order to gain a competitive advantage in the carbon market (Zhu et al., 2017; Zhao et al., 2017). Information acquisition might help the government obtain enterprise involvement in the carbon market and the potential to reduce carbon emissions. Additionally, they suitably adapted the reward and punishment methods to optimize predicted welfare while increasing the enterprise's willingness and encouraging the enterprise's active participation in the carbon market (Zhou et al., 2019). On the basis of the presented discussion earlier, we proposed hypothesis H1:

H1: information acquisition will improve the willingness of enterprises to participate in the carbon market.

Perceptions were not only judgments based on subjective cognitions by individuals, but also expectations based on objective foundations (Shang et al., 2016). TAM revealed the mechanism by which external environmental factors influence the intention and behavior of system use through the cognitions of an individual. Some scholars classified the cognitions of an individual into perceived usefulness and perceived ease of use (Wagner, 2015). Perceived usefulness reflected the benefits that individuals probably obtained through the system (Shah et al., 2013), which were determined by a combination of external environmental factors and perceived ease of use. Perceived ease of use is the perceived difficulty of participating in the carbon market (Gregoriou et al., 2014), which is determined by external environmental variables such as information acquisition.

In the context of the research scenario, perceived usefulness and perceived ease of use were redefined as follows. In the carbon market, perceived usefulness was an enterprise's perception of the benefits of participating in the carbon market, such as improved resource efficiency, reduced carbon emissions, and economic benefits. Perceived ease of use was how easy it was for enterprises to participate in the carbon market, such as lower costs of participation, ease of access to information about the carbon market, and ease of diffusion of low-carbon production processes.

According to the embeddedness theory, the quality of information was an important factor in facilitating transaction generation (Yves and Pascal, 2014). If the information acquisition of the carbon market could allow enterprises to perceive the benefits of participating in the carbon market, then this would lead to the intention and behavior to participate. Depending on the social exchange theory (Chang et al., 2018), good information acquisition could deepen enterprises' understanding of the carbon market and make them feel that by participating in the carbon market they could achieve the goal of reducing their carbon emissions, thereby promoting their willingness and behavior to participate in the carbon market. At the same time, the information acquisition related to the carbon market could effectively improve the communication efficiency and the speed of information flow between participants and reduce the transaction cost caused by information asymmetry, thus ensuring that the enterprise's interests were not harmed (Fan and Todorova, 2017). In other words, information acquisition could effectively enhance an enterprise's perception of the economic and emission reduction benefits from the carbon market, and hence their perceived usefulness. Therefore, the following hypothesis was proposed.

H2: information acquisition has a positive impact on perceived usefulness.

Due to the nature of profit maximization (Tam et al., 2020) and the limited rationality of enterprise decision-makers (Albashrawi and Motiwalla, 2017), when enterprises believed that they could not obtain benefits from participating in the carbon market, or even the detriment of their development, they would develop defensive attitudes and behaviors (Dwivedi et al., 2019), reducing their willingness to participate in the carbon

market for the conflicts of interest. On the contrary, the willingness to participate in the carbon market would be further enhanced if enterprises believed that participation in the carbon market could improve resource efficiency, reduce carbon emissions, and achieve higher benefits. First, according to enterprises' experience, the higher the willingness to participate, the more enterprises believed that by participating in the carbon market, they could force them to improve their low-carbon production processes, optimize their energy consumption structure, and increase their resource efficiency. Second, on the one hand, the higher the willingness of high carbon emission enterprises to participate if the cost of purchasing additional carbon allowances was lower than the penalty they face when they exceed emissions. On the other hand, if the low-carbon emission enterprises made more profit from selling additional carbon allowances than from putting all of them into production, the higher their willingness to participate. Finally, the higher the willingness to participate if enterprises could reduce carbon emissions effectively improved the ecological environment of their region through participation in the carbon market. Therefore, the following hypothesis was proposed.

H3: perceived usefulness positively affects the willingness of enterprises to participate.

Hypotheses H1, H2, and H3 in the previous section hypothesized that information acquisition positively influenced perceived usefulness and willingness to participate in the carbon market, respectively, and that perceived usefulness had a positive effect on willingness to participate in the carbon market. We believe that perceived usefulness might play a mediating role between information acquisition and willingness to participate. According to social cognitive theory, there is a system of interaction between behavioral intentions, external environmental factors, and individual cognition. External environmental factors might affect the individuals' cognition, which in turn might affect their behavioral intentions (Xu et al., 2020). Therefore, based on the framework of "external environmental factors-subject cognition-behavior intentions," we could further explain the progressive impact of information acquisition on the perceived usefulness and even behavior intentions of enterprises. Information was one of them, and it had a significant impact on how enterprises made decisions. Through the collection, integration, and analysis of information in the carbon market, we might increase the perceived usefulness of carbon market participation. Additionally, when the enterprise perceives that participating in the carbon market could obtain its positive utility, the enterprise would integrate the necessary resources to enter the carbon market. This further reinforced the enterprises' inclination to the willingness to participate in the carbon market since it was consistent with the limited rationality of the decision-makers and the tendency of the enterprises to maximize their profits. Consequently, the following hypothesis was put out.

H4: perceived usefulness plays a mediating role between information acquisition and willingness to participate.

Perceived ease of use was used to measure the effort and time invested in upgrading the production process, updating equipment, training employees, and other preparations related to participation in the carbon market (Schwarz et al., 2014). Perceptions of ease of use depended on the information needed to make decisions. By having more comprehensive information to take effective actions, enterprises might reduce the difficulty of participation in the carbon market and enhance the perception of ease of use in the carbon market. First, the acquisition of participation information allowed enterprises to accurately understand the requirements for them to participate in the carbon market and take appropriate measures (e.g., process modification, monitoring equipment installation, and improving the cognitive level of employees) to actively reduce the difficulty of accessing the carbon market. Second, obtaining complaints and feedback information would enable government departments to accurately perceive the needs of enterprises in the carbon market, and make corresponding policy adjustments reducing the exclusion of enterprises from perceptions. Based on this, this study put forward the following hypothesis.

H5: information acquisition has a positive impact on perceived ease of use.

TAM identified that an individual's willingness to use the system depended on perceived ease of use, which is another important factor (Alazab et al., 2021). If the difficulties faced by enterprises in participating in the carbon market were significant, the incentive for enterprises to continue to participate in the carbon market would diminish, resulting in enterprises resisting the carbon market and reducing their willingness to participate. If it was less difficult for enterprises to participate in the carbon market, they could iterate and upgrade their production processes and raise the awareness levels of their employees without incurring too high a time and financial cost. Their enthusiasm and willingness to participate in the carbon market would also increase. On the basis of the previous discussion, the following hypothesis was shown.

H6: perceived ease of use positively affects the willingness of enterprises to participate.

Hypotheses H1, H5, and H6 in the previous section hypothesized that information acquisition positively influenced perceived ease of use and willingness to participate in the carbon market, respectively, and that perceived ease of use had a positive effect on willingness to participate in the carbon market. We believe that perceived ease of use might play a mediating role between information acquisition and willingness to participate. Enterprises realized they could achieve relevance through multi-dimensional and diversified information when they built and improved the resource base of carbon market information through information collection

and, eventually, formed the knowledge search space expansion. Furthermore, brook down the deficiencies caused by the "information cocoon" (Xie and Xia, 2020). They also discovered and assisted in exploring low-carbon production standards, acquired knowledge about low-carbon production, updated low-carbon production facilities, and optimized production processes and key node processes. As a result, the willingness of enterprises to participate in the carbon market was increased. The information comprised the market's current stock of carbon allowances and each participant's involvement. When analysts gathered, collated, and evaluated data from both within and outside of the firms to provide a more thorough, real-time understanding of current production processes, the information from previous participation represented the number of carbon emissions of the enterprises. Moreover, the more information analysts have access to, the more accurate the conclusions they will draw (Wang and Qi, 2022). The main production nodes that impacted an enterprise's carbon emissions might be identified after utilizing machine learning and simulation models to anticipate future trends in carbon emission and identify appropriate emission reduction pathways. Additionally, by lowering the time and capital expenditures associated with changing production lines to be low-carbon, the difficulties of participating in the carbon market would also be lowered, increasing the desire of the enterprises to do so. This suggested that learning more about the carbon market would help enterprises comprehend low-carbon operations, which would improve their perception of how simple it would be for them to utilize the market and lead to a greater desire to participate. So the following hypothesis was put out.

H7: perceived ease of use plays a mediating role between information acquisition and enterprise participation intention.

TAM depicted that the willingness of enterprises to participate would be affected by the perceived ease of use and perceived usefulness, and perceived ease of use had a positive impact on the perceived usefulness of enterprises (Krishnaraju et al., 2016). Moreover, the relationship between perceived usefulness and perceived ease of use has been confirmed in many kinds of literature (Abraham et al., 2013; Barnett et al., 2015; Andersen, 2016; Mou et al., 2017; Sharma, 2019; Mendoza-Tello et al., 2019). In the process of enterprises participating in the carbon market, if the cost of rectification, installation of relevant equipment, and improving employee's cognitive levels were low, it could reduce the difficulty of enterprises participating in the carbon market, so as to optimize the resource utilization efficiency of enterprises, reduce the carbon dioxide emission of enterprises, increase the benefits of enterprises, and improve the usefulness of participating in the carbon market. Therefore, this study put forward the following hypothesis.

H8: perceived ease of use has a positive impact on perceived usefulness.

This study made the case that a variety of information sources that enterprises acquired could help them improve their perceptions of the carbon market and would also affect their willingness to participate and behavioral decisions in the carbon market through enterprises' perceptions based on the relationships hypothesized by H1, H4, H7, and H8, respectively (perceived ease of use and perceived usefulness). Based on the information related to the carbon market, enterprises might organize their employees to learn relevant knowledge, forming low-carbon production awareness. The reinforcement of the awareness of each member of the organization helped the organization as a whole to respond to the market (Allison and Lucy, 2015). On the other hand, it could encourage enterprises to optimize key production processes and develop low-carbon production lines. In other words, information acquisition improved employee awareness and encouraged the upgrading of production processes to reduce carbon emissions, which decreased the difficulty of participation and enhanced their perceived ease of use while also increasing the perception that participating in the carbon market would be beneficial and increasing the perceived usefulness of the enterprise. In fact, the value of information acquisition must be realized by enhancing the awareness of enterprises on the carbon market. Everyone who participated in the carbon market might see that the costs are reasonable given the advantages, not only enterprises (Liu and Zhou, 2018). It means the perceived ease of use and perceived usefulness need to match each other, so as to improve the willingness of enterprises to participate in the carbon market. The aforementioned discussion suggested that the information resources gained by enterprises would increase their knowledge of the carbon market and the value of their involvement in the market, increasing their willingness to engage. So, in this study, hypothesis H9 was put out.

H9: perceived usefulness and perceived ease of use play chain mediating roles in the relationship between information acquisition and enterprise participation intention.

Based on the literature review and hypothesis formulation, the theoretical framework model of this study is constructed, as shown in Figure 1.

4 Research design

4.1 Data collection

This study took the equipment manufacturing industry in Henan Province as the research object and used the questionnaire method to collect data. The questionnaire was collected in two stages to ensure that the questionnaire has high content validity and to avoid errors caused by unclear concepts and difficult to understand items. The first stage was before formal investigation, the research group formed an initial questionnaire based on the existing literature and expert suggestions, combined with the actual situation of the equipment manufacturing industry and the research purpose,

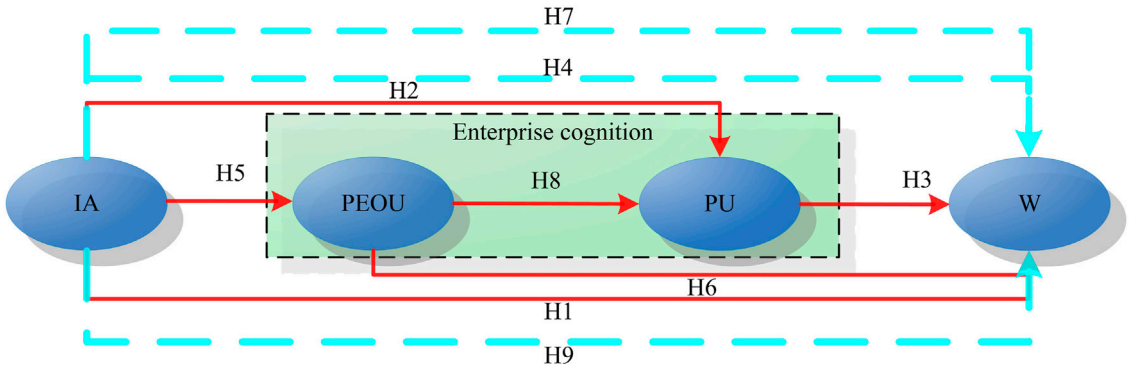

FIGURE 1
Figure of the theoretical framework model.

and then selected 20 enterprises for the pre-test. Based on the pre-test results and expert suggestions, the questionnaire was modified, adjusted, and improved to form the final questionnaire.

In the second stage, the research group randomly sampled the equipment manufacturing industry through a field survey and an online questionnaire. According to Hoogland and Boomsma, the minimum sample size should be at least 10 times the number of observed items (Hoogland and Boomsma, 1998). Moreover, the maximum likelihood estimator (MLE) would become over-sensitive if the sample size was too large, so the sample size was finally determined to be 20 times the number of observed items, that is, 240 random samples. In order to ensure the authenticity and validity of the questionnaire data, on the one hand, the sample companies were brought together for face-to-face interviews. On the other hand, the persons in charge of the sample companies were contacted by e-mail or telephone to fill in the questionnaires, and the IP addresses were checked to confirm whether any companies had repeatedly filled in the questionnaires. In addition, the respondents to this survey were the department heads or managers of the enterprises who were directly responsible for the deployment of "carbon peaks and carbon neutrality." These people had both a deeper understanding of their own operations and resource endowment and other information, as well as a higher level of carbon market awareness, effectively ensuring the credibility and validity of the questionnaire data. After excluding the unqualified questionnaires, 226 valid questionnaires were finally obtained, and the effective questionnaire rate was 94.17%.

The sample characteristics of enterprises were shown in Table 1. The results showed that most of the enterprises in this survey were private enterprises, accounting for 63.72%, at the same time, most of the enterprises surveyed were small and medium-sized enterprises, and the number of enterprises with a total number of employees of 1000 or fewer accounted for 69.92% of the total number of enterprises. Enterprises with an annual operating income of more than 20 million Yuan accounted for 95.13% of the total and the enterprise year was relatively short, enterprises with a company age of 25 years or less accounted for 76.54% of the total. Moreover, 94.69% of the enterprises surveyed said they understood the carbon market to some extent, 57.07% knew about the carbon market, and only 4.42% knew about the carbon market very well. Most surveyed enterprises believed they would face challenges in participating in the carbon market, accounting for 70.80% of the total sample. Only 4.87% made it clear that they would not participate in the carbon market if there were no mandatory requirements. But, most enterprises said they would participate in the carbon market if conditions permit. At the same time, during the interview, the research group found that enterprises felt it was difficult to participate in the carbon market, mainly because of the difficulty of obtaining information and the high cost. The overall distribution of samples was reasonable.

4.2 Variable measure

The questionnaire included 12 items aiming to assess IA (three items), PU (three items), PEOU (three items), and W (three items). Each item was measured using a seven-point Likert scale, 1 = strongly disagree; 2 = moderately disagree; 3 = somewhat disagree; 4 = neutral; 5 = somewhat agree; 6 = moderately agree, and 7 = strongly agree. The items used in this study were based on the relevant research of the technology acceptance model (TAM) and modified in combination with the research purpose of this study, to ensure that these items have good validity and reliability. The analyzed variables and the source from which items were adopted are listed in Table 2. The observation items of each latent variable and the reliability and validity indexes of latent variables are shown in Table 3.

Referring to the research of Xie and Wang (2020) and Xie et al. (2021), this study took the number of employees, annual operating income, and enterprise age as the control variables and

TABLE 1 Description of sample characteristics.

Attribute	Classification	Quantity	Percentage (%)
Nature of enterprise	State-owned enterprises	44	19.47
	Private enterprises	144	63.72
	Wholly foreign-owned enterprises	3	1.33
	Sino-foreign joint enterprises	13	5.75
	Others	22	9.73
Total number of employees (person)	Under 20	4	1.77
	20–300	59	26.11
	301–1000	95	42.04
	1001–2000	25	11.06
	More than 2000	43	19.03
Annual operating income (ten thousand Yuan)	Under 300	4	1.77
	300–2000	7	3.10
	2000–40000	88	38.94
	More than 40,000	127	56.19
Year of enterprise	1–5 years	22	9.73
	6–10 years	42	18.58
	11–25 years	109	48.23
	26–50 years	34	15.04
	More than 51 years	19	8.41
Do you understand the carbon market?	No knowledge	2	0.88
	Not really known	95	42.04
	Basic knowledge	119	52.65
	Very well informed	10	4.42
The difficulty of participating in the carbon market	Very small	3	1.33
	Small	4	1.77
	Comparatively small	7	3.10
	General	52	23.01
	Comparatively large	50	22.12
	Large	61	26.99
	Very large	49	21.68
Will you participate in the carbon market without a mandatory requirement?	No	11	4.87
	Yes	89	39.38
	Want to, but conditions do not allow	126	55.75

TABLE 2 Questionnaire item source.

Variable	Item source
Perceived usefulness (PU)	Chen and Li (2018), Hollebeek and Belk (2021), Castiblanco et al. (2021)
Perceived ease of use (PEOU)	Li (2020), Saengavut and Jirasatthumb (2021), Velicia et al. (2021)
Information acquisition (IA)	Gao et al. (2021), Chen and Pan (2021)
Willingness to participate (W)	Lieven and Lennerts (2013), Bagga et al. (2019)

reassigned them. The number of employees was divided into five categories from "under 20" to "more than 2000," and the assignment range was 1–5. The annual operating income was divided into four categories: "under 300 ten thousand Yuan" to "more than 40,000 ten thousand Yuan," and the assignment range was 1–4. The year of the enterprise was divided into five

TABLE 3 Reliability and validity indexes of latent variables.

Latent variable	Observed items and numbers	Factor load	AVE	Cronbach's α	C.R.
Perceived usefulness	Improving the resource efficiency of enterprises/PU1	0.826	0.593	0.915	0.812
	Reducing corporate carbon emissions/PU2	0.809			
	Higher returns for enterprises/PU3	0.665			
Perceived ease of use	Enterprises can afford the capital costs of participating in the carbon market/PEOU1	0.771	0.593	0.940	0.814
	Understand the basic process and information about participating in the carbon market/PEOU2	0.744			
	Knowledge of low-carbon alternative technologies and related knowledge/PEOU3	0.794			
Information acquisition	Ease of access to information on participation/IA1	0.799	0.660	0.972	0.853
	Ease of access to complaints and feedback/IA2	0.802			
	Ease of access to trading information/IA3	0.836			
Willingness to participate	Willingness to introduce low-carbon production technologies in order to participate in the carbon market/W1	0.650	0.529	0.933	0.769
	Enterprises willing to cooperate with carbon market rollout/W2	0.700			
	Enterprises willing to participate in the carbon market/W3	0.821			

TABLE 4 Descriptive statistics of variables and Pearson correlation coefficient.

Variable	Mean	S.E.	V1	V2	V3	V4	V5	V6	V7
V1	3.190	1.08	**1.000**						
V2	3.500	0.650	0.521***	**1.000**					
V3	2.940	1.030	0.401***	0.206***	**1.000**				
V4	5.510	1.230	−0.065	0.018	−0.010	**0.770**			
V5	5.370	1.230	−0.083	0.032	−0.093*	0.681***	**0.770**		
V6	5.750	1.170	0.001	0.100*	−0.060	0.604***	0.635***	**0.813**	
V7	5.880	1.110	0.010	0.120**	−0.063	0.692***	0.714***	0.810**	**0.727**

N = 226; "*", "**", and "***" indicated significance at 10%, 5%, and 1% levels, respectively. Values in bold on the diagonal are the square root of AVE.

categories from "1–5 years" to "more than 51 years," and the assignment range was 1–5. Table 4 presented the descriptive statistics and correlation coefficients of each latent variable.

The results exhibited that the square root of the average variance extracted values (AVE) of each variable was greater than the correlation coefficient with other variables, which indicated that there was a good discrimination effect between variables. In addition, there was a significant positive correlation between information acquisition, perceived ease of use, perceived usefulness, and willingness to participate, which proved that the regression analysis model could be constructed. In Table 4, V1 represented the total number of employees, V2 represented the annual operating income, V3 represented the year of the enterprise, V4 represented the perceived usefulness, V5 represented the perceived ease of use, V6 represented the information acquisition, and V7 represented the willingness to participate.

4.3 Data analysis

First, descriptive data were obtained using SPSS 25.0 and Pearson correlation coefficients were calculated in order to determine the correlation between the variables. Next, the data were tested for reliability, and the model was tested for fitness using maximum likelihood (ML) estimation in the AMOS 24.0. Finally, a two-step process was then used to examine the mediating effect. Step one, according to Baron and Kenny's research results (Baron and Kenny, 1986), the preliminary test of all the hypotheses in this study was carried out using hierarchical regression. Compared with the structural equation model method, the hierarchical regression analysis method could input independent variables into the regression equation in a predetermined order (Resmi and Kamalanabhan, 2010). Furthermore, it could also intuitively show the changes in *F*-statistics and *R*-square statistics of the whole model caused by the addition of specific variables, in order to judge whether

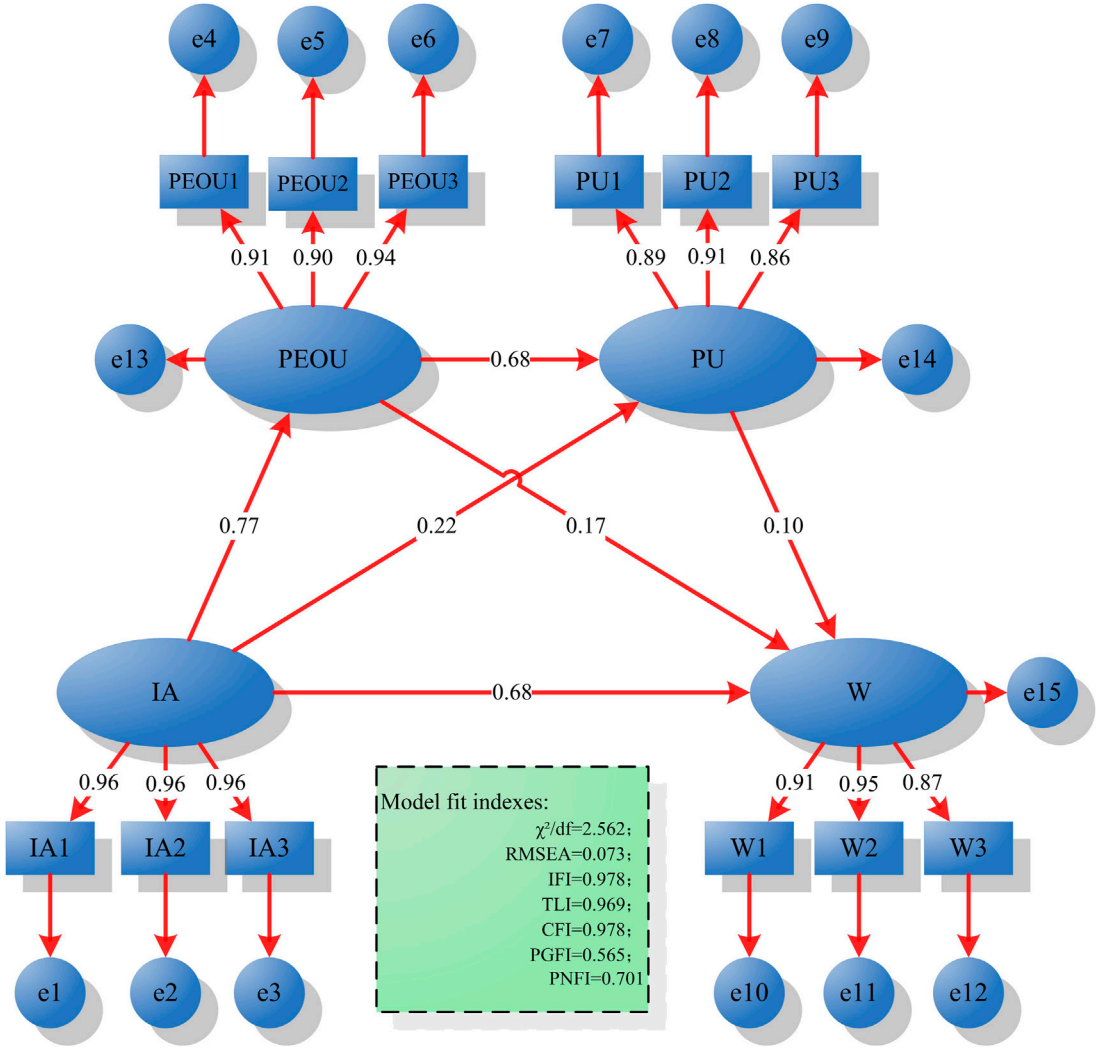

FIGURE 2
Model path diagram.

adding the variable can improve the model (Peter and Jong, 1999). Step two, a bootstrap chain mediation test using SPSS macro PROCESS for bias correction to examine the mediating role of the two dimensions of perceived ease of use and perceived usefulness, the bootstrap sample size is 5000. The bootstrap test with deviation correction has a more accurate confidence interval and higher test efficiency (Fritz and MacKinnon, 2007).

4.4 Reliability and validity test

SPSS 25.0 was used to test the reliability of the questionnaire data (see Table 3). The overall Cronbach's α coefficient for the questionnaire data was 0.965, which indicated that the total scale had good internal consistency. The Cronbach's α coefficient of each latent variable was between 0.915 and 0.972, these values were greater than the critical value of 0.7 (Yang and Wu, 2011). The results of the validation factor analysis showed that the factor loadings for each observed question item ranged from 0.650 to 0.836, all of which were greater than 0.5 (Mcquitty, 2004), which meant a high level of confidence in the question items of the study model. The composite reliability (C.R.) was between 0.769 and 0.853, the values being greater than the critical value of 0.7 (Yang and Wu, 2011), and keeping up with Cronbach's α coefficient. Furthermore, the AVE for each latent variable ranged from 0.727 to 0.813, all greater than 0.7 (Mcdonald and Ho, 2002), which indicated that the questionnaire scale had good combined reliability and convergent validity.

TABLE 5 Model fit indexes of different factor structures.

Fitted values	χ^2/df	RMSEA	IFI	TLI	CFI	PGFI	PNFI
Single-factor model	46.500	0.450	0.268	0.103	0.266	0.168	0.216
Two-factor model	27.303	0.342	0.585	0.481	0.583	0.275	0.462
Three-factor model	14.672	0.247	0.793	0.730	0.792	0.632	0.603
Four-factor model	2.562	0.073	0.978	0.969	0.978	0.565	0.701

4.5 Model matching index test

A goodness-of-fit analysis of the model of enterprises' willingness to participate in the carbon market was carried out, and the model path diagram is shown in Figure 2.

The χ^2/df in the absolute fitness index was 2.562, which was less than the critical value of 3, the 'df' indicated the degree of freedom (Bentler and Yuan, 1999). RMSEA indicated the root mean square error of approximation, it was 0.073 and less than the critical value of 0.08 (Yang and Wu, 2011). IFI indicated the incremental fit index, it was 0.978, TLI indicated the Tucker–Lewis index, it was 0.969, CFI indicated the comparative fit index, it was 0.978, and these values were all greater than the critical value of 0.9 (Mcdonald and Ho, 2002). PGFI indicated the parsimony goodness-of-fit index, it was 0.565. PNFI indicated the parsimony normed fit index, which was 0.701. Both values were greater than the critical value of 0.5 (Chang et al., 2014). Moreover, the confirmatory factor analyses such as the single factor model, two factors model, three factors model, and four factors model were conducted and the test results are shown in Table 5.

The single-factor model was one in which all question items are grouped into one latent variable and a model with only one latent variable was constructed, then the fit index of the model was solved. The two factors model classified the items related to information acquisition, perceived ease of use, and perceived usefulness as one latent variable, and the items related to willingness to participate were also grouped into one latent variable, and then the model was constructed, which contained both latent variables and the fit index of the model was solved. The three factors model was constructed by grouping question items related to information acquisition into one latent variable, the items related to perceived ease of use and perceived usefulness into one latent variable, and items related to willingness to participate into one latent variable, the model contained these three latent variables and then the fit index of the model was solved. The four-factor model used in this study was constructed by grouping items related to information acquisition into a latent variable, items related to perceived ease of use into a latent variable, items related to perceived usefulness into a latent variable, and items related to willingness to participate into a latent variable, and derived its fit index.

The four-factor model had higher adaptability than other models (χ^2/df = 2.562, RMSEA = 0.073, IFI = 0.978, TLI = 0.969, CFI = 0.978, PGFI = 0.565, and PNFI = 0.701); moreover, all indicators were greater than the critical value which indicated that the dosage table used in this study had good discriminate validity. Finally, the AVE values of all latent variables were between 0.529 and 0.660, which was within the acceptable range, indicating that the model had good aggregation validity.

4.6 Common method deviation test

First, this study used Harman single factor analysis to test the common method deviation. The test results depicted that the cumulative variance interpretation rate of the first non-rotating component was 26.360%, which was lower than the 50% of critical value, indicating that there was little possibility of serious common method deviation. Second, this study further judged whether there was a serious common method deviation by comparing the fitting degree of the single factor model and the four factors model (the model used in this study). The results exhibited that the fitting degree of the four factors model was better than the single factor model, indicating that there was no serious common method deviation in this study.

5 Results

5.1 Correlation test

To avoid serious multi-collinearity, this study performed a variation expansion factor (VIF) test on all explanatory variables of the model before regression analysis. The VIF values of information acquisition, perceived usefulness, and perceived ease of use were 2.411, 2.566, and 2.862, respectively, all of which were in the range of 1.0–3.0. This indicated that there was little possibility of multi-collinearity. At the same time, as shown in Table 4, the correlation coefficients between all explanatory variables (V4-V6) ranged from 0.604 to 0.681 and less than 0.7, which further verified that there was no significant multi-collinearity in this study. In addition, the annual operating income ($r = 0.12$, $p < 0.05$), perceived usefulness ($r = 0.692$, $p < 0.01$), perceived ease of use ($r = 0.714$, $p < 0.01$), and information acquisition ($r = 0.81$, $p < 0.01$) of enterprises are significantly positively correlated with the willingness of enterprises to

TABLE 6 Results of hierarchical linear regression.

Variable	Willingness of enterprises to participate					Perceived usefulness		Perceived ease of use
	M1	M2	M3	M4	M5	M6	M7	M8
Number of employees	−0.040 (0.085)	−0.006 (0.051)	0.014 (0.048)	0.014 (0.048)	0.019 (0.048)	−0.079 (0.067)	−0.032 (0.055)	−0.077 (0.064)
Annual operating income	0.157** (0.133)	0.047 (0.079)	0.046 (0.076)	0.054 (0.076)	0.051 (0.075)	−0.026 (0.106)	-0.028 (0.086)	0.003 (0.101)
Year of enterprise	−0.079 (0.078)	−0.022 (0.046)	−0.017 (0.044)	−0.04 (0.044)	−0.03 (0.044)	0.07 (0.062)	0.081** (0.050)	−0.019 (0.059)
Information acquisition		0.803*** (0.038)	0.61*** (0.053)	0.624*** (0.051)	0.569*** (0.055)	0.711*** (0.050)	0.258*** (0.060)	0.733*** (0.048)
Perceived ease of use			0.264*** (0.051)		0.165*** (0.062)		0.618*** (0.057)	
Perceived usefulness				0.252*** (0.048)	0.159*** (0.059)			
R^2	0.023	0.657	0.689	0.689	0.697	0.504	0.677	0.547
F	1.771*	106.014***	97.407***	97.474***	83.972***	56.213***	92.348***	66.742***

N = 226; "*", "**", and "***" indicated significance at the level of 10%, 5%, and 1%, respectively, and the standard error is in brackets.

participate, where r is the Pearson correlation coefficient between each variable and willingness to participate, p is the level of significance.

5.2 Hierarchical regression analysis

Hierarchical linear regression analysis was used to test the hypothesis. The results were displayed in Table 6 and the standard errors were in brackets. The results of model 2 (M2) showed that information acquisition had a significant positive impact on the enterprises' willingness to participate ($\beta = 0.803$, $p < 0.01$) in the carbon market, and hypothesis H1 was verified.

The results of model 6 (M6) depicted that information acquisition had a significant positive impact on perceived usefulness ($\beta = 0.711$, $p < 0.01$), and hypothesis H2 was verified. The results of model 4 (M4) showed that perceived usefulness had a significant positive impact on enterprises' willingness to participate ($\beta = 0.252$, $p < 0.01$), and hypothesis H3 was verified. According to the mediation effect test method of Baron and Kenny (Baron and Kenny, 1986), when comparing the results of M2 and M4, we found that if we add the perceived usefulness as a mediating variable, the regression coefficient of information acquisition on enterprise participation intention would decrease from $\beta = 0.803$ ($p < 0.01$) to $\beta = 0.624$ ($p < 0.01$), this indicated that perceived usefulness played mediating role in the relationship between information acquisition and enterprise participation intention, and the hypothesis H4 was verified.

The results of model 8 (M8) showed that information acquisition had a significant positive impact on perceived ease of use ($\beta = 0.733$, $p < 0.01$), and hypothesis H5 was verified. The results of model 3 (M3) exhibited that perceived ease of use had a significant positive impact on the willingness of enterprises to participate ($\beta = 264$, $p < 0.01$), and hypothesis H6 was verified. Comparing the results of M3 and M2, we found that if we add the perceived ease of use as a mediating variable, the regression coefficient of information acquisition on enterprise participation intention would decrease from $\beta = 0.803$ ($p < 0.01$) to $\beta = 0.61$ ($p < 0.01$). It pictured that perceived ease of use played a mediating role between information acquisition and enterprise participation intention, and hypothesis H7 is verified.

The results of model 7 (M7) showed that perceived ease of use had a significant positive impact on perceived usefulness ($\beta = 0.618$, $p < 0.01$), and hypothesis H8 was verified. Comparing the results of model 3 (M3) and model 5 (M5), we found that if we add the perceived usefulness as a mediating variable to the regression model composed of information acquisition, perceived ease of use, and enterprise participation intention, the regression coefficient of information acquisition on enterprise participation intention would decrease from $\beta = 0.61$ ($p < 0.01$) to $\beta = 0.569$ ($p < 0.01$). According to the test results of H4, H7, and H8, perceived ease of use and perceived usefulness played a chain mediating role between information acquisition and enterprise participation intention. Hypothesis H9 was verified.

5.3 Mediating effect test

In this study, we conducted repeated sampling based on the Bootstrap method of bias correction (Marinho and Araújo, 2021), and further analyzed the mediating paths and effects of perceived ease of use and perceived usefulness through a mediating effects test. The results are shown in Table 7.

The first action path was "IA→PEOU→W," both the indirect effect [$\beta = 0.183$, 95% error correction confidence interval was

TABLE 7 Test results of bootstrap mediation effect.

Action path	Effect	Coefficient		95% error correction confidence interval	
		Effect value	S.E.	Lower limit	Upper limit
IA →PEOU →W	Indirect effect	0.183	0.050	0.096	0.290
	Direct effect	0.578	0.053	0.474	0.682
IA →PU →W	Indirect effect	0.170	0.049	0.074	0.262
	Direct effect	0.591	0.051	0.491	0.691
IA →PEOU →PU	Indirect effect	0.270	0.060	0.152	0.387
	Direct effect	0.475	0.070	0.349	0.621
IA →PEOU →PU →W	Indirect effect	0.068	0.040	0.003	0.154
	Direct effect	0.539	0.055	0.431	0.647

(0.096, 0.290)] and direct effect [β = 0.578, 95% error correction confidence interval was (0.474, 0.682)] of information acquisition on willingness to participate did not contain 0, this meant that perceived ease of use played a partially mediating role between information acquisition and willingness to participate.

The second action path was "IA→PU→W," both the indirect effect [β = 0.591, 95% error correction confidence interval was (0.074, 0.262)] and direct effect [β = 0.591, 95% error correction confidence interval was (0.491, 0.691)] of information acquisition on willingness to participate do not contain 0, this indicated that perceived usefulness played a partial mediating role between information acquisition and willingness to participate.

The third action path was "IA→PEOU→PU," both the indirect effect [β = 0.270, 95% error correction confidence interval was (0.152, 0.387)] and direct effect [β = 0.475, 95% error correction confidence interval was (0.349, 0.621)] of information acquisition on perceived usefulness does not contain 0, this manifested that perceived ease of use played a partial mediating role between information acquisition and perceived usefulness.

The fourth action path was "IA→PEOU→PU→ W," both the indirect effect [β = 0.068, 95% error correction confidence interval (0.003, 0.154)] and direct effect [β = 0.539, 95% error correction confidence interval (0.431, 0.647)] of information acquisition on willingness to participate does not contain 0, this indicated that perceived ease of use and perceived usefulness also played the partial chain mediating roles between information acquisition and willingness to participate.

5.4 Robust test

The robustness of the mediating effects model was tested in the study, the chain incomplete mediating model which was constructed in this study, the non-chain mediating model, chain complete mediating model, and non-chain complete mediating model were constructed. The paths tested in the chain imperfect mediating model were IA→PEOU→PU→W, IA→PEOU→W, IA→PU→W, and IA→W. The paths tested in the non-chain mediating model were IA→PEOU→W, IA→PU→ willingness to participate, and IA→W. The paths tested in the chain complete mediating model were IA→PEOU→PU→W, IA→PEOU→W, and IA→PU→W. The paths tested in the non-chain complete mediating model were IA→PEOU→W and IA→PU→W.

Then, the great likelihood estimation method was used to calculate and compare the goodness-of-fit of the aforementioned models, the results are shown in Table 8. The chain incomplete mediating model had the smallest RMSEA value (RMSEA = 0.073), the smallest SRMR value (SRMR = 0.043), and the largest CFI value (CFI = 0.978), the largest TLI value (TLI = 0.969), and the variance difference was significant ($p < 0.01$). This indicated that the chain incomplete mediating model had the best goodness-of-fit and the results were robust and reliable.

6 Discussion

The equipment manufacturing industry was a significant growth pole in Henan Province's high-quality economic development, but its features of high energy consumption, huge carbon emissions, and large pollution limited its expansion. If the industry is guided to actively participate in the carbon market in order to force enterprises to undergo energy structure transformation, it would not only speed up the low-carbon transformation of the equipment manufacturing industry but would also help promote the upgrading of industrial structure and low-carbon technological innovation in all fields of Henan Province, thus assisting the province in reaching its carbon peak.

The study contributed to tackling how enterprises could overcome the limitations of managers' interpretations, production factors, and low-carbon perceptions when they

TABLE 8 Results of the robust test.

Fitting value	χ^2	df	χ^2/df	$\Delta\chi^2$	RMSEA	CFI	TLI	SRMR
Chain incomplete mediating model	122.995	48	2.562	—	0.073	0.978	0.969	0.043
Non-chain mediating model	200.545	49	4.091	77.550***	0.117	0.955	0.939	0.143
Chain complete mediating model	223.351	49	4.558	100.356**	0.126	0.948	0.93	0.103
Non-chain complete mediating model	292.214	50	5.844	169.219***	0.147	0.928	0.904	0.158

participated in the carbon market. The literature on the relationship between enterprises and carbon markets emphasized the influence of managers' perceptions on the mechanisms by which enterprises' willingness and behavior to participate in the carbon market. Little was known about the influence of external environmental factors on enterprises' behavior (Li et al., 2012; Fan et al., 2016; Mu et al., 2017; Ren and Lo, 2017) and how information acquisition affects enterprises' willingness to participate in the carbon market (Yu et al., 2018). As the behavior of enterprises' participation in the carbon market was rooted in social activities, we proposed that the information acquisition played an important role in improving the willingness of enterprises to participate in the carbon market. Information acquisition has a positive impact on perceived usefulness. At the same time, perceived usefulness and perceived ease of use all positively affected the willingness of enterprises to participate, furthermore, information acquisition had a positive impact on perceived ease of use, while perceived ease of use has a positive impact on perceived usefulness. We demonstrated these roles with a systematic empirical analysis of equipment manufacturing enterprises in Henan Province, China. Essentially, we found the dual impact mechanisms of information acquisition on enterprises' willingness to participate in the carbon market, such as "IA→PEOU→W" and "IA→PU→W", using the TAM. Moreover, the chain mediating effect of perceived ease of use and perceived usefulness of enterprises between information acquisition and participation intention was also empirically revealed in this study, which enriched the research on the antecedent variables of carbon market participation intention from the perspectives of the external environment and enterprise cognition, as well as the theoretical framework. These findings might serve as a good reference for enterprises when determining their carbon trading strategies.

However, there were several restrictions on this study. First, because there were so many different types of enterprises involved in the carbon market, the impact and significance of information acquisition, perceived ease of use, and perceived usefulness on willingness to participate might differ depending on the enterprise life cycle. Since the stage of the enterprise was not specified in this study, these points could be further examined in the future from the perspective of the enterprise life cycle. Second, heterogeneity existed among enterprises in various sectors and areas. Actually, from various geographical or industry viewpoints, the empirical links between information acquisition, perceived ease of use, perceived usefulness, and willingness to participate might be compared and analyzed. Finally, the processes of other external factors, such as participation risk (Chen et al., 2019) and government trust (Huang Y. H. et al., 2019), on enterprises' willingness to participate in the carbon market were also not taken into account in this work. As a result, several external environmental factors could be introduced in further research and their effect pathways could be thoroughly investigated.

7 Conclusion

This study demonstrated that information acquisition could significantly improve the willingness of enterprises to participate in the carbon market through a questionnaire survey and empirical analysis of equipment manufacturing enterprises in Henan Province. It also discovered the intermediary mechanism of perceived ease of use and perceived usefulness in the process of information acquisition to improve the willingness of enterprises to participate. Not only did perceived ease of use or perceived usefulness play a mediating role in the process of information acquisition to increase enterprises' willingness to participate in the carbon market, but also perceived ease of use and perceived usefulness combined to produce a chain mediating effect, in which the path is as follows: IA→PEOU→PU→W. Moreover, the results of the robustness tests also confirmed the soundness and validity of the research model.

The research findings have the following policy implications. First, it is important to create and improve the information sharing platform for the carbon market. Because information acquisition has a significant impact on the willingness of enterprises to participate in the carbon market, government departments can increase the willingness of enterprises to participate in the carbon market by lowering the cost and difficulty of acquiring information related to the carbon market and increasing the availability of information. Second, the carbon market's complaint and feedback systems should be reinforced, offline trading and registration centers are created,

and two-way communication between enterprises and the market is preserved. Third, a framework for policy incentives needs to be developed. Enterprises who enter the carbon market first will be given tax breaks and other financial aid, moreover, the amount of carbon quota trading and decrease in carbon emissions for each performance period are made public. Finally, as the main participants in the carbon market, enterprises must upgrade critical production processes and high carbon emission equipment with low-carbon technology and install carbon emission monitoring equipment, in order to successfully decrease the technical challenges associated with participation in the carbon market. Enterprises should simultaneously increase staff awareness of low-carbon issues and their expertise in low-carbon production.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material; further inquiries can be directed to the corresponding authors.

Ethics statement

The studies involving human participants were reviewed and approved by the Research Ethics Committee of the North China University of Water Resources and Electric Power. Written informed consent for participation was not required for this study in accordance with national legislation and institutional requirements.

Author contributions

Conceptualization: XM and RG; methodology: FX and TC; software: FX and CC; validation: FX and CC; formal analysis: FX and TC; investigation: FX and QL; resources: FX and CC; data curation: FX and CC; writing—original draft preparation: FX; writing—review and editing: XM and RG; visualization: FX and CC; supervision: XM and RG; project administration: XM and RG; and funding acquisition: XM. All authors have read and agreed to the published version of the manuscript.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher’s note

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