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The Role of Payment Technology Innovation in Environmental Sustainability: Mediation Effect From Consumers' Awareness to Practice

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Based on the traditional internal factor model, high environmental awareness should bring higher engagement in environmental practices. In reality, however, many studies have found no significant correlation between the two. To explain this, frontier research is focusing on what external factors influence environmental sustainability. As a typical example of such external factors, this article focuses on the innovation of Internet payment technology. Based on a survey of 623 individuals living across mainland China, we conduct path analysis, stepwise regression analysis, and a mediation test on Internet payment technology, environmental awareness, environmental protection practices, and demographics such as age, income, and sex. We find that Internet payment technology plays a significant mediator role between environmental awareness and environmental behaviors, and that demographics also affect sustainability. Internet payment technology can expand the range of ways in which consumers participate in environmental protection and encourage them to put more green practices through emotional and physical incentives. We thus demonstrate the positive impact of technological innovation on environmental sustainability and unfold the underlying mechanism. Besides providing a reference for other researchers, our study also proposes some applications relevant to the scientific community.

Keywords: payment technology innovation, environmental sustainability, consumers' awareness, consumers' practice, mediation effect

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1 INTRODUCTION

Planned behaviors based on psychological factors and their improved models are the traditional research foundations for individual participation in environmental protection behaviors. The theoretical model posits that personal environmental awareness or perception positively affects the degree of participation in environment-friendly practices. Yet according to a survey conducted by the Ministry of Ecology and Environment of the People's Republic of China, 2018, there is a phenomenon of "high awareness, low practice" in waste classification, green consumption, and participation. In environmental behavior research, the inconsistent or weak influence of environmental attitudes on environmental behaviors has been partially verified and gradually attracted more research attention (Brand, 1997). Blake (1999) proposes that external factors mediate between environmental attitudes and environmental behaviors, such as personality and feasibility. This is inconsistent with the traditional theoretical model of internal factor research, so

the original analysis alone cannot explain the complicated relationship between environmental awareness and environmental behavior. To solve this problem, some scholars began to pay attention to the influence and mechanism of individual demographics and external situational factors, that is, new technology, such as the Internet and other media (Garz, 2014; Ellison et al., 2015; Peng et al., 2019). Similarly, many studies contend that technological innovation can directly affect sustainability (Murty and Kumar, 2003; Yin et al., 2014; Gkika et al., 2020; Iqbal et al., 2022). To build on these earlier works, this article innovatively focuses on the digital technology of Internet payments, exploring its role in sustainability. With the rapid development of Internet technology in recent years, especially the increasing green and low-carbon life scenes based on network payment technology, many new platforms have emerged for public participation in environmental protection. These platforms have brought new opportunities and possibilities for the public to implement green and low-carbon behaviors (Liu and Hao, 2017; Li and Liu, 2018). Internet payments can reduce the printing of paper receipts, while online shopping and online utility payments can greatly reduce the need to drive to make purchases, thereby reducing CO_2 emissions. Therefore, Internet payment technology has a natural spillover effect in the field of environmental protection, and should be investigated as an external situational factors (Yang et al., 2018). This research is motivated by the unresolved questions of whether and how Internet payment technology spillover significantly impacts on individual environmental perception and green practices.

Our focus on China is motivated by the following considerations. Based on population dynamics, Balsa-Barreiro et al. (2019) analyzed the shifting locations of centers of gravity of four basic global indicators during 1960–2016: gross domestic product (GDP), CO_2 emissions, total population, and urban population. They found that the centers of gravity of GDP and CO_2 emissions have shifted eastward: the weight of CO_2 emissions to GDP is ×2 in China and ×1.6 in the Asian region, compared to ×0.5 in Japan, ×0.6 in the United States, and ×0.3 in the European Union. This demonstrates that the economic growth model of some countries in Southeast Asia consumes high levels of resources. This has been particularly true of China: according to 2018 data from the United Nations Environment Programme, China is the country with the largest CO_2 emissions, accounting for over one-quarter of the global total. Therefore, studying China's environmental issues is especially valuable for global sustainability.

This study uses data from China to empirically analyze the impact of Internet payment technology on personal environmental awareness and green practices, aiming to open the black box of the internal mechanism of action to yield theoretical and practical implications.

2 LITERATURE REVIEW AND HYPOTHESES

2.1 Theories on Psychological Influencing Factors

2.1.1 Theory of Planned Behavior

In 1975, Fishbein and Ajzen proposed the theory of reasoned action (TRA), which posits how attitudes form based on cognitive information and consciously affect individual behavior. The basic assumption is that people are rational and will synthesize various kinds of information to consider the meaning and consequences of their actions before acting in a certain way (Fishbein and Ajzen, 1975). Ajzen's later research (2011) found that human behavior is affected by external environment. On this basis, he expanded the TRA by adding the new concept of perceived behavioral control (PBC), thus developing a new behavioral theory model: the theory of planned behavior (TPB). This posits that human behavior results from deliberate thoughts, and that behavior is produced and changed through a complex psychological process. The TPB has been endorsed by several scholars. Hopkins and Potcovaru (2021) found that consumer attitudes, values, needs, and expectations were affected by external factors such as COVID-19. Also focusing on effects of the pandemic, Priem (2021) found that COVID-19-related lockdowns limited the financial behavior of individual investors. Regarding environmental behavior, the main determinant according to the TPB is willingness to engage in environmental behavior, while three other factors are also influential: environmental attitude, subjective norms, and PBC (Ajzen, 2011). Since the TPB was first applied in environmental research, increasing numbers of scholars have begun to study the willingness of individuals to pay the price for improving environmental conditions, engaging in environment-conscious behaviors, and execution practices. Scholars contend that the TPB fully affirms the role of environmental attitudes but somewhat weakens the influence of external behavior constraints. For example, in Kaiser and Gustcher's (2003) survey of 895 Swiss residents, PBC did not have an obvious effect on environmental behavior.

2.1.2 Norm Activation Model

Due to the limited explanatory power of the TPB on environmental awareness and behavior differences, Schwartz (1977) proposed the norm activation model. It assumes that social norms must first become individual norms before they can influence an individual's pro-social behavior. The activation of individual norms depends on two factors: the individual's awareness of the consequences of the action (AC) and ascription of responsibility for these consequences (AR). Therefore, according to this model, only when AC and AR are high will individual norms be activated, leading the individual to take environmental actions (Schwartz, 1977). As the norm activation theory does not fully consider differences in environmental behaviors caused by individual heterogeneity, it is often used to research mandated forms of environmental protection behavior in areas such as recycling, energy conservation, and yard-waste landfill. Therefore, there are certain limitations to the application of this model (Black et al., 1985).

2.1.3 Value-Belief-Norm Theory

Stern (2000) combined norm activation theory with value theory to propose the value-belief-norm (VBN) theory. It emphasizes the causal chain of value→belief→personal norms: values on environmental behaviors lead to beliefs that then activate behavioral norms. The individual's sense of responsibility for

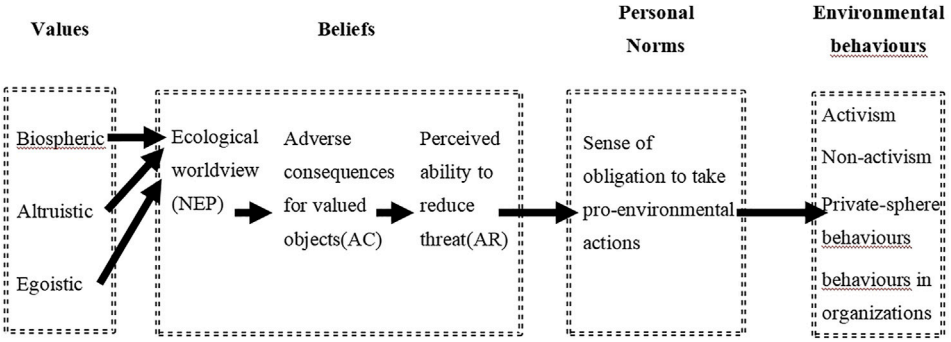

FIGURE 1 | A schematic representation of variables in the VBN theory of environmentalism.

taking environmental actions, and finally the environmental actions. Relevant values include biospheric values, altruistic values, and egoistic values, of which the latter will negatively affect environmental behavior. The theoretical model is depicted in **Figure 1**.

The VBN theory incorporates values into the analysis model, explores the types of values and their effects, and broadens the influencing factors of environmental behavior research. However, there has been insufficient discussion of external factors and individual heterogeneity (Bamberg and Moser, 2007).

Based on the three branches of theory considered above, environmental awareness is an important internal factor that positively affects environmental behavior. Birtus and Lăzăroiu (2021) studied the neurobehavioral economics of the COVID-19 pandemic from the perspective of consumer cognition, perception, sentiment, choice, and decision-making; they found a significant positive relationship between consumer cognition and decision-making. Similarly, Rydell and Kucera (2021) examined the relationship between cognitive attitudes, behavioral choices, and purchasing habits during the COVID-19 pandemic; they also found that cognitive attitudes directly affected behavioral choices. Accordingly, we propose the following hypothesis:

H_1. Environmental awareness and sustainability are positively related.

2.2 External Situational Factors: The A-B-C Model of Behavior

As mentioned earlier, the problem of "high awareness, low practice" for environmental protection is contrary to traditional psychological theory. Therefore, while the classical theoretical model analyzes the individual's internal psychology, environmental behavior research increasingly considers external factors, concentrating especially on the inconsistent or weak influence of environmental attitudes on environmental behaviors. Scholars have focused on other factors that mediate this relationship, such as norms, values, and external situational factors (Peng, 2013). Guagnano et al. (1995) proposed an A-B-C model for predicting waste recycling behavior. The model integrates internal (psychological) processes with external conditions, and considers environmental behaviors (B) to be the result of the individual's general and specific environmental attitude (A) and of external conditions (C). Specifically, when external conditions are favorable and environmental attitudes positive, environmental behaviors will occur; when external conditions are unfavorable and individuals hold negative environmental attitudes, environmental behaviors will not occur; when external conditions are relatively neutral, environmental attitudes have a strong effect on environmental behavior. The A-B-C model proposes that environmental behaviors result from the combined influence of environmental attitudes and external conditions, and points out that the effect of environmental attitudes on environmental behaviors depends on the specific external conditions. This theory opened a new direction of environmental behavior research, thus attracting scholars to start investigating external factors (Steg et al., 2005; Scherbaum et al., 2008). Therefore, this study adopts the A-B-C model.

2.2.1 Influence of Demographic Features

Many studies have shown that demographics such as gender, age, social status, education level, and residence attributes can impact on environmental behaviors. Wang and Zhong (2016) found that individual gender and age factors significantly impacted on residents' private environmental behavior in China. Mi et al. (2019) studied the driving force of environmental knowledge among people with different education levels; they found that people with higher education levels had greater willingness to engage in low-carbon purchasing behavior. Gong and Lei (2007) used factor analysis and multiple linear regression to study the impact of gender on the environmental behaviors of residents in different fields; they found that women were more inclined than men to adopt environmentally friendly behaviors. Empirical research by Li (2006) showed that gender and education level have important influences on individual environmental behaviors. In Al Mamun et al. (2018) study of green consumption behaviors, low-income households were found to engage significantly less than did high-income households. Nakamura (2020) contends that sustainability behavior is not

always uniform across residents of a specific region. In sum, these demographics need to be considered.

2.2.2 Influences of External Situational Variables

Situational variables are external factors that impact on an individual's implementation of environmental behaviors. For instance, environmental pollution, environmental governance behaviors, social norms, behavioral costs, and mass media are all considered to have significant impacts (Yuan, 2016; Štreimikienė et al., 2021). De Young (1990) found that Michigan residents' garbage collection behaviors were significantly influenced by whether community public facilities such as recycling bins had been set up, whether these facilities were convenient to use, and whether engaging in these behaviors was time-consuming. Based on a questionnaire survey, Men and Xiong (2018) found that government input indirectly affects the public's ecological behaviors by influencing the public's environmental knowledge and environmental awareness. Kyriakopoulos et al. (2020) investigated the environmental behaviors of business and accounting students at the University of West Attica, Greece. They found that environmental education had a significant positive effect on environmental behavior, while also increasing the significance of the effect of ecological sensitivity on environmental behavior. Other studies contend that in addition to school education, family environmental awareness positively affects students' green behaviors (Ntanos et al., 2018). Wang and Han (2016) found that the interweaving of economic development and environmental pollution impacted on public environmental protection behavior. On this basis, scholars began to pay attention to the impact of the Internet on environmental attitudes and behaviors.

2.3 Internet and Environmental Behaviors

As research into Internet payment technology and environmental protection is relatively new, there are few existing theoretical discussions. Research on the Internet and environmental behaviors is mostly based on information dissemination attributes, the popularization of environmental protection information, the supervision of environmental behavior, the fear of vicious environmental protection news, and the spread of positive environmental protection information (Krätzig and Warren-Kretzschmar, 2014). Hong (2013) and Stockemer (2018) found that for residents who frequently use the Internet to browse information, the increased transparency of government information induced greater participation in decision-making on environmental protection and in environmental supervision, forming a positive environmental attitude. Through increasing participation in environmental protection decision-making, Internet use has promoted the democratization process and strengthened the cooperative relationship between the government and netizens. In addition, the Internet provides an important channel for the government to promote the idea of "environmental protection and benefiting the people." Environmental protection improves physical health, in turn improving one's income-earning ability, which may induce a positive attitude toward the environment (Wang and Ye, 2016). Analyzing China's comprehensive social survey data, Peng et al. (2019) found that regular use of the Internet to browse information promoted residents' environmental protection attitudes and environmental literacy; moreover, residents' environmental literacy was improved more by regular Internet use than by formal (academic) education.

Drawing on information transfer theory to explain why internal environmental literacy lags behind external environmental literacy, Ellison et al. (2015) and Okazaki and Taylor (2013) pointed out that information flow is impeded by blockages and the inability to enjoy equal access to information. The emergence of online media has broken the pattern of unevenly distributed information, helping to build an advanced, better-structured system of environmental knowledge and deepen environmental knowledge reserves, thereby reducing the external gap in and improving the overall level of environmental literacy. Fischer and Reuber (2011) contend that network information interaction is inclusive: netizens at different levels can chat about hot topics on environmental protection, exchanging knowledge and views, thereby enhancing one another's environmental literacy.

Most studies in this field explore whether information dissemination on the Internet is related to environmental protection, green and sustainable development, and the majority find positive correlations. However, Internet payment technology represents a step beyond information media: as a tool to replace or supplement traditional payment methods, it has potential technological spillover effects on environmental awareness and practice. Therefore, this article extensively investigates the impact of Internet payment technology. As a sub-concept in the Internet category, Internet payment technology can be expected to positively affect environmental behaviors. Based on the conclusions of the cutting-edge research (Barbu et al., 2021; Ionescu, 2021; Bin, 2022), we propose the following hypothesis:

H_2. Use of Internet payment technology and sustainability are positively related.

2.4 Mediation Effect of Internet Payment Technology

Internet payment technology is rapidly becoming a global hotspot and the focus of in-depth scholarly research. Kshetri (2017) pointed out it has already achieved all-round impact on residents' lives in the emerging economies of China and India. China has become a major country in the application of Internet payment technology. According to data from iResearch Consulting (2020), the transaction amount of Internet payments in China was USD 31.7 trillion in 2019, ranking first in the world. According to the 43rd "Statistical Report on the Development of China's Internet," as of December 2018, China had 827 million Internet users and the penetration rate of Internet payment technology had reached 59.6% (Cyberspace Administration of China, 2019).

With the rapid development of Internet payment technology, it has become an important platform for residents to participate

in environmental protection (Policy Research Center for Environment and Economy, 2019a). Internet payment technology promotes public green consumption in four main ways. First, it guides consumers to buy green products. Internet payment technology significantly reduces the cost for consumers to obtain green information on products (Chen and Wu, 2020; He et al., 2021), and comparative advantages of green products by a wide range of consumer groups (Lv, 2018). Internet payment technology also improves the competitiveness of green products in the market, guiding consumers to purchase these products through the transmission and sequencing of information. Second, it can give the public ways and incentives to implement green behaviors in different consumption scenarios (He, 2018; Li, 2018; Luo et al., 2019). For example, some online payment platforms enable users to accumulate "green energy" that they can ultimately exchange for the planting of a real sapling in the desert (Ren et al., 2019; Wu et al., 2019; Xia, 2019). Third, as Internet payment technology relies on the sharing economy of payment platforms and the rise of idle goods trading platforms, it facilitates the reuse of consumer goods and optimizes resource allocation (Huang, 2018). Fourth, Internet payment technology increases the online proportion of consumption and payment and reduces related travel, thereby lowering carbon emissions (Wang et al., 2018).

Green consumption behaviors based on Internet payment platforms are continuing to increase. In terms of green product consumption, over 65 million people bought green commodities on the Alibaba platform in 2015 ("Alibaba Green Consumption Big Data Report"), which indicates the substantial scale of the online green consumer population. The overall purchase of energy-saving home appliances increased by 25% year-on-year from 2013 to 2015 (Chinese Internet Data Information Network, 2016). In 2018 (vs. 2017), sales volume on the Taobao platform increased by over 100% for eco-friendly shopping bags, by 51% for environment-friendly home improvement building materials, and by over 50% for energy-saving and environment-friendly LED lights. As of the end of August 2019, the carbon emissions saved by use of Internet payments amounted to nearly 7.93 million tons, equivalent to saving 11.6 billion kWh of electricity—approximately equal to the annual electricity consumption of all residents in a super city. Paying through the Internet also saved 373 billion plastic bags, which would cover an area of nearly 160,000 km^2 (larger than Greece). It would take at least 100 years for these plastic bags to completely degrade (Policy Research Center for Environment and Economy, 2019b).

In summary, Internet payment technology provides more opportunities for environment-conscious people to participate in environmental practices through diversified platforms and channels, at a lower cost and in a convenient and friendly way. Therefore, there is a logical basis for Internet payment technology positively affecting environmental behaviors, especially as a mediating mechanism. May et al. (2021) examined the relationship between corporate social responsibility, employee green behaviors, and environmental sustainability. They found that organizational trust and identity may play an intermediary role. This enlightened us that external factors may mediate the relationship between perception and behavior. We thus propose the following hypothesis:

H_3. Use of Internet payment technology mediates the effect of environmental awareness on sustainability.

The above theoretical analysis and literature review revealed that while most research still uses the traditional internal factor model, attention is increasing on the mediator role of external situational factors. Studies focusing on the role of the Internet are primarily at the stage of qualitative analysis, and thus lack quantitative empirical evidence. To address this gap, this study adopts the A-B-C model and investigates Internet payment technology as an innovative external situational variable, aiming to discover whether it mediates between environmental awareness and sustainability.

Based on the above analysis, **Figure 2** depicts the research framework.

3 METHODS

3.1 Questionnaire Design and Data Processing

This article uses the classic five-point Likert scale, adding self-designed questions to Peng et al.'s (2019) questionnaire on the relationship between the Internet and the environment. In order to filter out invalid responses, we also designed logically related questions that do not enter the model. We distributed our online questionnaire to residents of 31 provinces in mainland China. Through the largest online questionnaire distribution platform in China, a total of 1,083 questionnaires were distributed in May 2020, which were taken back in August 2020. After excluding invalid responses and those with missing information, 623 were retained for analysis of the study variables. Sustainability is the explained variable; environmental awareness is the explanatory variable; Internet payment technology is the intermediary variable; and demographics are the control variables. Data were processed using SPSS 25.0. The confidence interval is set to 95%.

3.1.1 Dependent Variable

The concept of sustainability includes green, environmental practice, recycling ,etc. In designing the questionnaire, we focused on the attributes of environmental practices, referring to the degree of residents' actual participation in environmental protection activities. Such activities include the use of old objects, low-carbon transportation, tree planting, garbage recycling, and other public welfare projects targeting environmental protection (Liu and Hao, 2017). Sustainability was quantified through seven questions each covering a distinct aspect: reducing paper shopping receipts, reducing dependence on plastic packaging, not using disposable tableware, low-carbon travel, item reuse, tree planting, and other environmental protection projects. Each question was answered on a 5-point scale; the higher the score, the higher is the degree of environmental sustainability. Summing up the scores of each question produced the overall score for sustainability (SS).

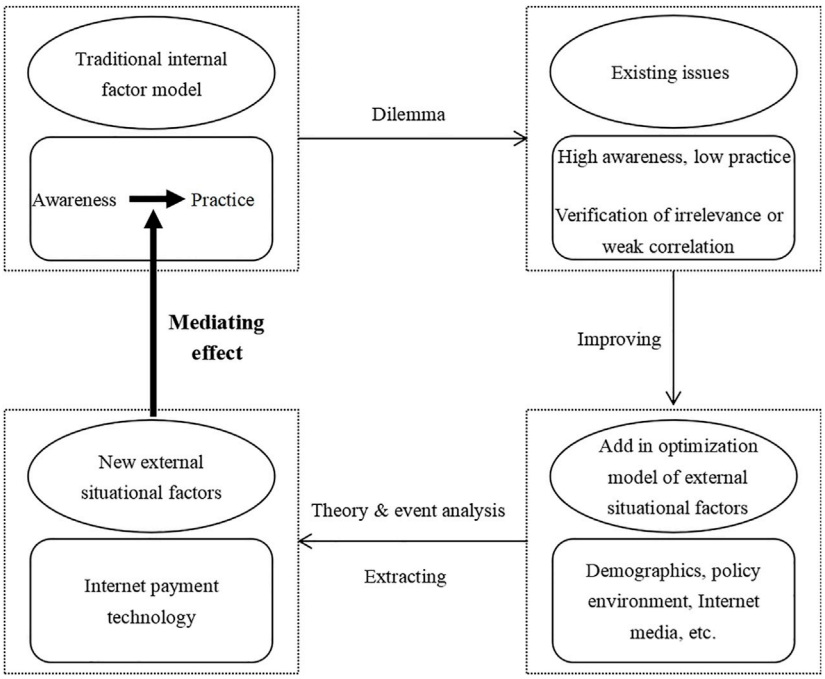

FIGURE 2 | Research logic framework.

3.1.2 Independent Variable

Environmental awareness refers to residents' views on, attitudes toward, and knowledge of environmental protection (Stern and Dietz, 1994). This research quantifies environmental awareness through 15 questions covering seven aspects: consumers' willingness to purchase green products, extra costs for green added value, awareness of environmental knowledge, environmental protection norms of people around them, ease of participating in environmental protection, environmental value recognition, and basic conditions of environmental protection. Each question was answered on a 5-point scale; the higher the score, the higher is environmental awareness. Summing up the scores for each question produced the overall score for environmental awareness (EA).

3.1.3 Mediator

Scholars often measure Internet payments by the total transaction amount (Weeks, 2018; Yao et al., 2018). Although this indicator is somewhat representative, it does not capture the per capita transaction amount of Internet payments, the number of such transactions per capita, and the transaction penetration rate, all of which reflect the application degree of Internet payment technology (Dorn, 2018). To include more comprehensive information and take into account the reliability of the data, we quantified the use of Internet payment technology (IPT) using the Internet Payment Development Index developed by the Institute of Internet Finance, Peking University (China Center for Economic Research, 2018). This index has been adopted by the National Development Institute, and so has recognized authority. It provides a value for each region in each year. To ensure the consistency and validity of the data from 2016 to 2019, we average the cross-year data and match the region data with the residence location of each respondent.

3.1.4 Control Variables

Based on previous findings on which demographics influence environmental perceptions and practices (Wang and Zhong, 2016; Li, 2006; Gong and Lei, 2007), this study includes five control variables: sex (SE), age (AG), education level (EL), monthly household income (HI), and urban-county-rural distribution (UCR). They are classified and scored based on the scale results.

The definitions and descriptions of all study variables are presented in **Table 1**.

3.2 Reliability and Validity Tests of the Questionnaire

To ensure the consistency and rationality of the questionnaire items (Brener et al., 2002; Ratko et al., 2020), the scales measuring the dependent variable, independent variable, and mediator (22 items in total) were subject to the following tests of reliability and validity.

3.2.1 Reliability

Reliability is achieved when repeatedly measuring the same object using the same method produces consistent results (Long and Johnson, 2000). We used the Cronbach's α coefficient to test the

TABLE 1 | Variable definitions.

Category	Variable	Definition
Dependent variable	SS	Sustainability, calculated using responses to seven questions on a 5-point Likert scale. The higher the total score (out of 35), the higher is environmental sustainability
Independent variable	EA	Environmental awareness, calculated using responses to 14 questions on a 5-point Likert scale. The higher the total score (out of 70), the higher is environmental awareness
Mediator	IPT	Internet payment technology, measured using the Internet Payment Development Index developed by the Institute of Internet Finance, Peking University. There is a separate index value for each of the 31 provinces in mainland China
Control Variables	SE	Sex, measured as 1 point for male (336/623 respondents) and 2 points for female (287/623)
	AG	Age, measured by young to old according to five-point-scale, on which a higher score means older. (≤19, 89 respondents; 20–29, 153; 30–39, 141; 40–49, 138; ≥50, 102)
	EL	Education level, measured from low to high on a 5-point scale, on which a higher score denotes a higher education level. (≤High school, 31 respondents; diploma, 48; undergraduate, 373; master degree, 137; PhD, 34)
	HI	Monthly household income, measured monthly on a 5-point scale, on which a higher score denotes a higher income. (<¥ 5,000, 111 respondents; ¥ 5,000–¥ 10,000, 303; ¥ 10,001–¥ 20,000, 82; ¥ 20,001– ¥ 30,000, 77; >¥ 30,000, 50)
	UCR	The urban-county-rural distribution of respondents, with 1 point for urban residents, 2 points for county residents, and 3 points for rural residents. (Urban, 435 respondents; County, 129; Rural, 59)

TABLE 2 | First validity test.

Component	Factor loading					Communality
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	
Green consumption tendency	–0.226	0.045	–0.029	–0.260	0.490	**0.361**
Reduce unnecessary travel	0.005	–0.103	0.830	–0.020	0.060	0.703
Willingness to bear the premium of green products	0.085	0.182	0.041	0.758	0.084	0.624
Environmental knowledge reserve	0.108	0.492	0.123	0.340	–0.135	0.403
Choice of disposable tableware	–0.070	–0.154	0.054	0.033	0.856	0.765
Choice of low-carbon travel mode	0.041	0.576	–0.181	0.032	0.289	0.450
Recycle old objects	0.017	0.707	–0.027	–0.037	–0.111	0.515
Willingness to pay for green value added	–0.174	0.075	0.082	–0.650	0.244	0.525
Reduce usage of plastic packaging and paper receipts	–0.011	0.069	0.857	0.011	–0.041	0.742
Number of times participated in environmental protection practices	0.203	0.728	0.051	0.018	–0.085	0.581
Environmental awareness of people around you	0.718	–0.047	0.117	0.020	0.000	0.532
Environmental orientation of people around you	0.734	0.014	0.139	0.051	–0.152	0.585
Personal understanding of the importance of environmental protection	0.761	0.050	0.026	0.062	–0.066	0.591
Activation of personal environmental norms	0.798	0.005	–0.005	0.204	–0.140	0.699
Difficulty of engaging in environmental projects	0.771	0.090	–0.073	0.104	–0.084	0.625
Confidence in implementing environmental protection	0.838	0.098	0.001	0.143	–0.141	0.753
External opportunities to implement environmental protection	0.783	0.154	–0.018	0.094	–0.025	0.646
Willingness to incur additional costs for purchasing environment-friendly products	0.735	–0.026	–0.057	0.339	–0.021	0.659
Plan to implement environmental behavior	0.854	0.089	–0.000	0.136	–0.086	0.763
Degree of effort involved in environmental protection projects	0.848	0.028	0.037	0.133	–0.067	0.744
Role of the Internet in spreading environmental knowledge	0.726	0.221	–0.116	–0.196	0.014	0.628
Effectiveness of incentives for sustainable behavior	0.737	0.236	–0.188	–0.182	0.028	0.668
Eigenvalue (Unrotated)	7.835	1.755	1.583	1.375	1.014	—
% of Variance (Unrotated)	35.614%	7.977%	7.195%	6.251%	4.610%	—
Cumulative % of Variance (Unrotated)	35.614%	43.591%	50.786%	57.037%	61.648%	—
Eigenvalue (Rotated)	7.388	1.845	1.579	1.498	1.253	—
% of Variance (Rotated)	33.582%	8.384%	7.179%	6.807%	5.696%	—
Cumulative % of Variance (Rotated)	33.582%	41.966%	49.145%	55.952%	61.648%	—
Kaiser-Meyer-Olkin	0.913					—
Bartlett's Test of Sphericity						—
	6,770.304					
df	231					—
p-value	0.000					—

Bold indicates <0.4 which means it didn't pass the empirical test.

TABLE 3 | Final validity test.

Component	Factor loading					Communality
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	
Reduce unnecessary travel	0.004	–0.111	0.828	–0.022	0.066	0.702
Willingness to bear the premium of green products	0.092	0.172	0.039	0.761	0.188	0.654
Environmental knowledge reserve	0.116	0.476	0.127	0.382	–0.104	0.413
Choice of disposable tableware	–0.111	–0.124	0.044	–0.035	0.887	0.817
Choice of low-carbon travel mode	0.021	0.582	–0.177	–0.004	0.194	0.408
Recycle old objects	0.016	0.699	–0.017	–0.022	–0.192	0.527
Willingness to pay for green value added	–0.194	0.110	0.085	–0.663	0.294	0.583
Reduce usage of plastic packaging and paper receipts	–0.008	0.058	0.858	0.021	–0.022	0.741
Number of times participated in environmental protection practices	0.202	0.730	0.061	0.045	–0.054	0.582
Environmental awareness of people around you	0.716	–0.055	0.115	–0.002	–0.070	0.534
Environmental orientation of people around you	0.741	0.009	0.139	0.030	–0.176	0.601
Personal understanding of the importance of environmental protection	0.764	0.051	0.026	0.044	–0.062	0.593
Activation of personal environmental norms	0.807	0.000	–0.007	0.191	–0.121	0.702
Difficulty of engaging in environmental projects	0.774	0.091	–0.074	0.102	–0.052	0.626
Confidence in implementing environmental protection	0.845	0.096	0.001	0.141	–0.107	0.754
External opportunities to implement environmental protection	0.783	0.154	–0.018	0.095	–0.002	0.646
Willingness to incur additional costs for purchasing environment-friendly products	0.740	–0.030	–0.060	0.334	0.028	0.663
Plan to implement environmental behavior	0.859	0.094	–0.001	0.133	–0.008	0.764
Degree of effort involved in environmental protection projects	0.853	0.033	0.035	0.127	0.011	0.745
Role of the Internet in spreading environmental knowledge	0.721	0.246	–0.114	–0.192	0.133	0.648
Effectiveness of incentives for sustainable behavior	0.731	0.256	–0.185	–0.174	0.113	0.677
Eigenvalue (Unrotated)	7.746	1.751	1.563	1.321	1.003	—
% of Variance (Unrotated)	36.885%	8.338%	7.441%	6.289%	4.777%	—
Cumulative % of Variance (Unrotated)	36.885%	45.223%	52.664%	58.953%	63.730%	—
Eigenvalue (Rotated)	7.402	1.844	1.575	1.461	1.101	—
% of Variance (Rotated)	35.247%	8.780%	7.502%	6.956%	5.245%	—
Cumulative % of Variance (Rotated)	35.247%	44.027%	51.529%	58.485%	63.730%	—
Kaiser-Meyer-Olkin	0.913					—
Bartlett's Test of Sphericity	6,674.733					—
df	210					—
p-value	0.000					—

reliability of the questionnaire (Bland and Altman, 1997). The calculation formula is:

$$\alpha = (k/(k-1))*\left(1-\left(\sum Si^2\right)/\left(ST^2\right)\right) \quad (1)$$

where k is the total number of questions in the scale; Si^2 is the variance of the ith question; and ST^2 is the variance of the total score of all questions (Jackson et al., 2020). The Cronbach's α of the whole questionnaire is 0.832, which is greater than the threshold of 0.8, confirming that reliability is sufficiently high (Eisinga et al., 2013; Lisawadi et al., 2019).

3.2.2 Validity

Validity measures whether the design of the questions is scientific (Mayer-Davis et al., 2019). We used factor analysis to test whether the relationship between each factor and its corresponding questions is good. First, we measured the communality of each factor to screen for invalid questions. The results are shown in **Table 2**.

The communality of "green consumption tendency" (used to evaluate environmental awareness) is smaller than 0.4, which shows that the information of this question cannot be effectively expressed (Mayer-Davis et al., 2019). Therefore, we removed this item and ran the validity analysis again. The results are shown in **Table 3**.

All questions now had communality values above 0.4, indicating that the information of research subject can be effectively extracted. The Kaiser-Meyer-Olkin (KMO) value is 0.913, which exceeds the threshold of 0.6 required to indicate valid data. In addition, the rotated cumulative percentage of variance is 63.730%, which exceeds the 50% threshold required to indicate that the information amount of the research subject can be effectively extracted (Chung et al., 2004). In summary, the test results reported in **Table 3** confirm that the questionnaire measures have good validity. After excluding the question with low communality, seven questions are used to evaluate sustainability and 14 to evaluate environmental awareness.

3.3 Mediation Effect

Although measurement software can directly analyze a mediation effect, it does not intuitively reflect the identification process of each stage of the effect. To test the mediation effect, we adopted from the field of psychology the causal step method, following the three steps shown in **Figures 3**, **4**. This method has been used by many psychologists (Coman et al., 2017; Fairchild et al.,

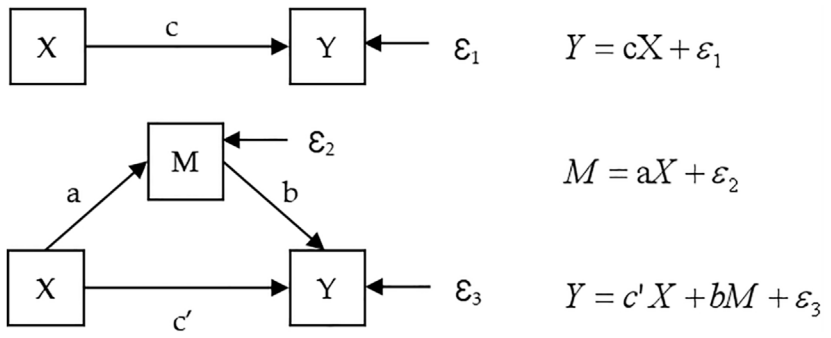

FIGURE 3 | Model of mediating effect.

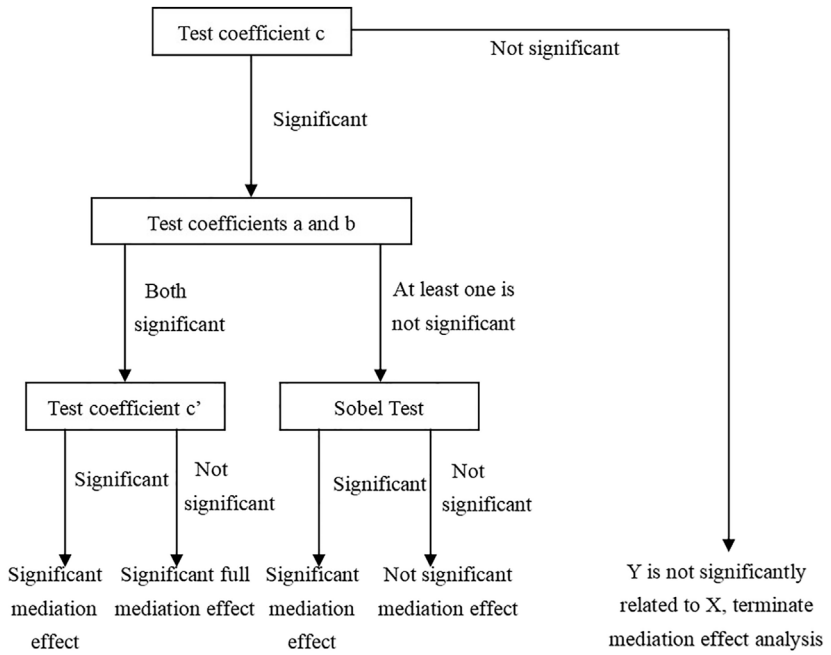

FIGURE 4 | Mediating effect test process.

2019; Liu et al., 2021). Compared with measurement software, it can better reflect the intermediate process and internal mechanism of the mediation effect, highlighting causal links (Intasao and Hao, 2018; Zhao et al., 2020). The explanatory variable is EA (X), the mediating variable is IPT (M), and the explanatory variable is SS (Y).

We first explored the influence of the independent variable on the dependent variable ($Y = cX + \varepsilon_1$). If coefficient c is not statistically significant, the mediation effect analysis is immediately terminated and we conclude that the variable does not play a mediator role. If c is significant, we proceed to the second step of analyzing the correlation between independent variable and the mediating variable ($M = aX + \varepsilon_2$). If coefficient a is significant, we proceed to the third step. If a is not significant, we also perform the Sobel test after calculating coefficient b in that third step. The third step of the analysis is to test the multivariate correlation between the independent variable, mediator, and dependent variable ($Y = c'X + bM + \varepsilon_3$), determining the significance of coefficients b and c'. Combining the results of the second and third steps, if both a and b are significant, then a significant coefficient c' confirms a significant partial mediation effect, whereas a non-significant coefficient of c' confirms a significant full mediation effect.

Based on the above analysis of the classic mediation effect model, the correlation between the independent variable and the mediator also needs to be considered. Peng et al. (2019) found that residents who often use the Internet to browse information have a higher level of environmental literacy. Accordingly, we propose the following hypothesis:

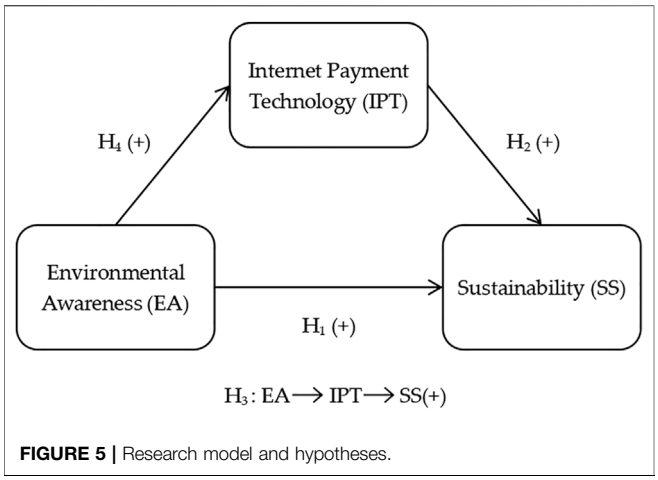

FIGURE 5 | Research model and hypotheses.

H_4. Environmental awareness and use of Internet payment technology are positively related.

The research model and hypotheses are depicted in **Figure 5**.

4 RESULTS

4.1 Descriptive Analysis

Table 4 presents the descriptive statistics of all the study variables. The standard deviations of EA, SS, and IPT are large, suggesting a high degree of heterogeneity in respondents' perception and behavior, and there is a clear gap between environmental protection attitudes and behaviors among different people which can be inferred from the value of the standard deviation. This high degree of heterogeneity in the sample somewhat increases the credibility of the experiment (Beck, 1992; Liu and Hao, 2017; Stockemer, 2018). Because the range of values is far greater for IPT than for the other variables, we use the logarithm of IPT in our analyses (ln (IPT)).

The descriptive statistics also manifest the phenomenon of "high awareness, low practice" in the field of sustainable development. Specifically, the mean scores of EA and SS were 48.717 points and 17.241 points, respectively 70% and 49% of the maximum possible scores.

4.2 Path Analysis: Demographics

This section uses path analysis to test the correlations between demographic variables (i.e., the five control variables) and EA and SS, respectively.

4.2.1 Demographics and Environmental Awareness

Table 5 reports the regression coefficients between demographic variables and EA. Gender, age, and income are each positively correlated with EA, consistent with prior findings (Zelezny et al., 2000; Hunter et al., 2004). Conversely, there is no significant correlation between either education level or urban-county-rural areas and EA. Based on these findings, we infer that women, older individuals, and households with a higher monthly income tend to have higher environmental awareness.

TABLE 4 | Descriptive statistics.

Variable	N	Min.	Max.	Mean	SD	Median
SE	623	1.000	2.000	1.543	0.499	2.000
AG	623	1.000	5.000	2.952	1.057	3.000
EL	623	1.000	5.000	3.294	0.773	3.000
HI	623	1.000	5.000	2.835	1.232	3.000
UCR	623	1.000	3.000	1.220	0.554	1.000
SS	623	7.000	27.000	17.241	2.950	17.000
EA	623	14.000	66.000	48.717	8.211	49.000
IPT	623	85.100	318.500	121.791	32.608	117.400

4.2.2 Demographics and SS

Table 6 reports the regression coefficients between demographic variables and SS. Only monthly household income is significantly correlated with SS, showing a positive relationship. This indicates that higher family income is associated with higher actual participation in environmental protection (Olli et al., 2001). This may be because more income equates to higher disposable funds, which can be invested in green consumption or environmental protection projects.

4.3 Stepwise Regression

We used SPSS 25.0 to perform a stepwise regression testing the mediation effect. Following the logic of regression analysis explained in **Section 3**, the mediation effect is tested in four steps:

Step 1. Verify the correlation between EA and SS.

Step 2. Verify the correlation between EA and ln(IPT).

Step 3. Verify the correlation between EA, ln(IPT), and SS.

Step 4. If appropriate, carry out a Sobel test.

The results are reported in **Table 7**. First, in Model 2 we find a significant positive correlation between EA and SS ($B = 0.128$, $p < 0.05$), indicating that people with higher environmental awareness engage more in environmental practices. This supports H_1. It should be noted that this result does not conflict with the "high awareness, low practice" phenomenon in a given individual: the positive correlation is for the overall sample.

Second, in Model 1 we find no significant correlation between EA and ln (IPT) ($p = 0.079$), indicating that residents' environmental awareness is not significantly related to their use of Internet payment technology. Thus, H_4 is not supported and a Sobel test must be conducted to observe whether the mediation effect is significant.

Third, Model 3 shows significant positive correlations between EA and SS ($B = 0.125$, $p < 0.05$) and between ln (IPT) and SS ($B = 1.841$, $p < 0.05$) in the overall mediation effect model, thus further verifying H_1 and supporting H_2. Moreover, adding ln (IPT) in Model 3 increases the value of R^2 to 0.457, compared to 0.443 in Model 2, indicating a higher goodness of fit.

Fourth, we use the Sobel test to verify the mediation effect, reporting the results in **Table 8**. The confidence interval of the Sobel test is 4.49%, from which we can conclude that the partial

TABLE 5 | Path analysis: demographic variables and environmental awareness.

X	→	*Y*	Unstandardized coefficients	SE	*Z*	*p*	Standardized coefficients
SE	→	EA	1.793	0.671	2.671	0.008	0.109
AG	→	EA	0.947	0.337	2.812	0.005	0.122
EL	→	EA	−0.440	0.440	−1.001	0.317	−0.041
HI	→	EA	0.649	0.286	2.265	0.023	0.097
UCR	→	EA	0.714	0.639	1.118	0.263	0.048

TABLE 6 | Path analysis: demographic variables and sustainability.

X	→	*Y*	Unstandardized coefficients	Std. Error	*Z*	*p*	Standardized coefficients
SE	→	SS	−0.361	0.242	−1.489	0.137	−0.061
AG	→	SS	−0.193	0.122	−1.591	0.112	−0.069
EL	→	SS	0.128	0.159	0.807	0.420	0.034
HI	→	SS	0.243	0.103	2.350	0.019	0.101
UCR	→	SS	0.384	0.231	1.664	0.096	0.072

TABLE 7 | Stepwise regression.

	Model 1				Model 2				Model 3			
	ln (IPT)				SS				SS			
	B	Std. Error	*t*	*p*	*B*	Std. Error	*t*	*p*	*B*	Std. Error	*t*	*p*
Constant	4.630**	0.072	64.018	0	11.441**	1.04	11.006	0	2.918	2.854	1.022	0.307
SE	−0.01	0.016	−0.616	0.538	−0.590*	0.229	−2.572	0.01	−0.572*	0.228	−2.511	0.012
AG	−0.01	0.008	−1.299	0.195	−0.314**	0.115	−2.731	0.006	−0.295*	0.114	−2.58	0.01
EL	0.025*	0.01	2.392	0.017	0.184	0.149	1.233	0.218	0.138	0.149	0.929	0.353
HI	−0.030**	0.007	−4.357	0	0.16	0.098	1.64	0.102	0.215*	0.098	2.181	0.03
UCR	0.094**	0.015	6.229	0	0.292	0.217	1.347	0.179	0.119	0.222	0.537	0.592
EA	0.002	0.001	1.758	0.079	0.128**	0.014	9.383	0	0.125**	0.014	9.203	0
ln (IPT)									1.841**	0.575	3.202	0.001
R^2	0.432				0.443				0.457			

Note: *p < *0.1;* **p < *0.05.*

TABLE 8 | Sobel test.

Sobel's SE = $\sqrt{[(a{\cdot}SEb)^2 + (b{\cdot}Sea)^2]}$ =	0.002
Z = Indirect Effect + Sobel's SE =	1.696
Portion of ($X \rightarrow Y$) due to *M* = (c − c′)/c =	4.49%

mediation effect is significant. To ensure the stability of the experimental results, we use the bootstrap procedure with 1,000 samples. As reported in **Table 9**, the results show that the 95% confidence interval does not include both a positive number and a negative number (95% CI: 0.000–0.007), thus indicating that ln (IPT) has a mediation effect between EA and SS. EA first affects ln (IPT), then SS through ln (IPT). The results provided support for H_3.

For the control variables, we see in Model 3 (**Table 7**) that there are significant negative correlations between SE and SS ($B = -0.572$, $p < 0.05$) and between AG and SS ($B = -0.295$, $p < 0.05$), whereas HI and SS are significantly positively correlated ($B = 0.215$, $p < 0.05$). By contrast, neither EL nor UCR are significantly correlated with SS.

5 DISCUSSION

Based on the A-B-C model, this study investigated the mechanism between environmental awareness and sustainability by considering the potential mediator role of Internet payment technology. We proposed and tested several hypotheses based on theoretical analysis and prior studies. Stepwise regression yielded the following main findings.

First, environmental awareness can significantly promote sustainability. This is consistent with traditional theories of environmental behavior research, such as the TPB, norm activation theory, and value-belief-norm theory. Focused on psychological influencing factors, these theories posit that individuals need high awareness of the results of environmental actions for individual norms to be activated,

TABLE 9 | Bootstrap sampling test.

Path	Effect	Boot Std. Error	Boot LLCI	Boot ULCI	*z*	*p*
EA →ln (IPT) →SS	0.003	0.002	0	0.007	1.796	0.073

Note: LLCI: lower limit confidence interval; ULCI: lower limit confidence interval.

leading them to adopt environmental behaviors (Kim and Chung, 2011; Lao and Wu, 2013; Ntanos et al., 2018; Kyriakopoulos et al., 2020). This study's findings provide empirical proof. Specifically, it can be discussed and explained from three aspects. First, sustainable practices benefit the community, society, and future generations. For individuals, it has a typical spillover effect and outstanding externalities. Based on the economic man assumption, sustainability is inconsistent with personal short-term profit-seeking. Therefore, the value norm of environmental awareness is the most important internal factor for environmental protection behaviors (Fretwell and Greig, 2019). Second, people with higher environmental awareness are more inclined to pay attention to positive environmental information, advocate environmental values, and disseminate environmental knowledge. They also tend to implement more environmental practices to set an example for others (Sadorsky, 2012; Mohiuddin et al., 2018). Third, people with higher environmental awareness often pay more attention to and are more anxious about negative information on sustainability (Cho et al., 2007). Therefore, they are more likely to be motivated by crisis and, thus, more actively implement environmental behaviors.

The second main finding is that environmental awareness does not significantly affect the use of Internet payment technology. Although Internet payment technology can function as an external factor promoting sustainability, it primarily functions as a payment tool (Kim, 2018). Therefore, this findings is consistent with practice in real life. We explored residents' motivations for using Internet payment technology. Only 16% of people reported using Internet payment technology from the perspective of sustainable development; the vast majority of respondents indicated other reasons, such as convenience and simplicity.

Third, Internet payment technology was significantly positively related to sustainability. This reflects the role it plays in guiding consumers to buy green products, significantly reducing the cost of obtaining green information about products, and enabling the social functions, green responsibilities, and comparative advantages of green products to be accepted by a wide range of consumer groups. Internet payment technology can also give the public ways and incentives to implement green behaviors in different consumption scenarios. According to Lao (2019) statistics, China's 500 million plus users of Internet payment technology have collectively achieved a reduction in carbon emissions of 7.92 million tons, as well as the planting of 122 million trees, whose planting area is 1.5 times the size of Singapore.

Fourth, Internet payment technology plays a mediator role between environmental awareness and sustainability. The empirical results have a certain practical basis. Internet payment technology provides richer scenes and platforms for green consumption and green public welfare, which gives residents more convenient opportunities to engage more extensively in sustainable development, thus enabling environmental awareness to more fully affect environmental protection practices. We summarize in **Table 10** the ways in which Internet payment technology can facilitate or promote sustainability actions. Internet payment technology gives residents greater and broader opportunities to engage directly in environmental protection, via platforms enabling diversified green consumption and sustainable practices. This technology also shortens the distance between individuals and sustainability, and broadens the channels for participating in environmental behaviors (Romm, 2002).

TABLE 10 | Opportunities for sustainability supported by Internet payment platforms.

Category	Behavior
Green travel	Walking
	Shared bike
	Bus
	Metro
Reduced travel	Online train ticket purchasing
	Online movie ticket purchasing
	Green government services
	Utility bill payment
	Doctor appointment
	Green office work
Reduced paper and plastic usage	International tax refund
	Offline payment
	Electronic receipt
	Green take-away food
	Paperless reading
	Plastic reduction
	Take-away coffee
Highly economical energy consumption	Electronic Toll Collection payment
Recycling	Package recycling
	Green packaging
	Used goods recycling

Fifth, we found that some demographics significantly affect sustainability. Regarding gender, our path analysis found that females have higher environmental awareness (consistent with Liang et al., 2018) but males are more likely to engage in environmental practices (consistent with Hong, 2005). In terms of age, older individuals were found less likely to engage in sustainability, confirming that young people are still the main protagonists in sustainable development. As regards income,

higher monthly household income was associated with a greater likelihood of participating in sustainability. Combining the results of the path and regression analyses, we infer that young males with high income levels are most likely to engage in environmental practices.

6 CONCLUSION

6.1 Contributions

This article focus on a new research perspective, integrating Internet payment technology as a new external situational factor in an A-B-C-model. Our study makes the following theoretical and practical contributions.

First, to enhance research on the external contextual factors influencing sustainability, through the mediation effect analysis, we compare goodness of fit in models with and without the external situational factor of Internet payment technology. It verifies the importance of this external factor, thereby expanding theoretical models focused on internal (psychological) factors.

Second, this study verifies the role of technological innovation in breaking the traditional environmental protection and green development model. Specifically, it provides empirical data supporting the mediator role of Internet payment technology in the field of sustainability.

Third, by analyzing demographic variables, we profile which populations have higher environmental awareness and engage more in sustainability. Women who are older and have higher monthly household income tend to have higher environmental awareness, whereas younger males with high income levels are more likely to participate in sustainable development. These results not only verify the conclusions of previous studies (Li, 2006; Gong and Lei, 2007) but also provide a basis to further refine understanding of how demographics impact on sustainability.

Fourth, this study empirically proves the mediator role played by Internet payment technology between environmental awareness and environmental behaviors, thereby clarifying the internal mechanism of action. Our serial mediation model of environmental awareness–Internet payment technology–sustainability can be used as a reference in subsequent research.

Sustainability is an important issue for all mankind. According to Balsa-Barreiro et al. (2019), CO_2 emissions are highly correlated with GDP. Compared with Western countries, developing countries have lower resource utilization efficiency. China is the largest developing country and the second largest economy. Accordingly, raising China's level of environmental sustainability will benefit the world. Moreover, relevant experience provides a valuable reference for other developing countries. From the perspective of population dynamics, the marginal utility of carbon-reduction effects will be much higher in the East than in the West. This study provides some inspiration for global environmental governance and green development. First, our data show that Internet payment technology can increase residents' participation in environmental protection. Our study thereby presents new ideas for sustainable development in other countries and encourages the innovative application of Internet payment technology. Second, this article reveals which demographics are associated with higher environmental awareness and higher sustainability. This should help governments and enterprises to more accurately identify target groups, more effectively promote green products and green public welfare projects.

6.2 Limitations and Future Research Directions

This study has certain limitations. First, we did not examine the endogenous variables of sustainable development, such as the internal factors proposed by the value-belief-norm theory (personal values, beliefs, world views, and responsibility). Instead, we grouped internal factors to measure the overall level of an individual's environmental awareness. Future research should consider more internal factors within the research model. Second, the scores assigned to each question are averaged without weighting to generate the values of each variable. In future research, factor analysis or a Pareto test can be used to assign weights to scale questions, thereby obtaining more accurate experimental results. Third, we did not discuss the correlations between some control variables and the independent variable, and did not consider possible endogenous effects. Future research should explore the endogeneity among variables to further refine the model.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusion of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

Ethical review and approval was not required for this study in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

JA and HD were responsible for writing the initial draft of the manuscript, developing the main propositions and conducting the study. HD and SJ were responsible for modifying and improving the manuscript. MY was responsible for reviewing and editing the manuscript. All authors have read and approved the submitted version.

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