Article

Residents' Willingness and Influencing Factors on Action Personal Carbon Trading: A Case Study of Metropolitan Areas in Tianjin, China

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Abstract: Personal carbon trading offers a powerful and innovative instrument with which to achieve reductions in carbon emissions. Meanwhile, residents' personal carbon trading willingness and the factors influencing such willingness have critical effects on the acceptance of personal carbon trading. Therefore, the present research uses a questionnaire survey in metropolitan areas of Tianjin China and the results indicated that most of the interviewees (74.92%) agreed or strongly agreed that they would participant in personal carbon trading. Moreover, according to the results of multiple regression models, governmental policies and residents' environmental awareness and motivations were positively related to their personal carbon trading willingness. However, personal barriers to personal carbon trading were negatively related to personal carbon trading willingness. Control variables, such as gender and incomes, were not significantly related to personal carbon trading willingness. Thus, monitoring residents' emission and trading patterns, emphasizing effective, transparent, and fair policies, as well as mitigating uncertainty could all be effective ways to increase the acceptance of personal carbon trading.

Keywords: China; climate change; personal carbon trading; climate policy

1. Introduction

Climate change poses many challenges for sustainable development and energy policy [1,2], and greenhouse gas emissions from human beings will exacerbate global climate change. Therefore, sustained reductions in carbon emissions are required from all sectors of the economy, including households and individuals. Especially in developed countries, the energy consumption of residents and households is already the main source of energy consumption. For example, household energy use and personal travel accounted for 45% of national CO_2 (carbon dioxide) emissions from energy use on average in major developed countries [3]. In developing countries, the energy consumption of residents is increasing, and it will become the main type of energy consumption in the future. For example, in China, the share of consumption has increased, accounting for about 65% of GDP (Gross Domestic Product) growth in 2015. Meanwhile, the associated share of CO_2 emissions has also changed, with consumption-related emissions having increased since 2010 [4]. Furthermore, China tends to shift gradually from an investment to a consumption-driven economy [5]. Carbon emissions from residential consumption are likely to be the main driving force for a new round of carbon emissions in China [6].

Thus, individual carbon trading policy for residents can play a significant role in carbon emission reductions, and it can represent the primary way to reduce greenhouse gases in the future. Moreover, personal carbon trading (PCT) might provide a framework for delivering long-term, sustainable

reductions in carbon emissions in a way that other policies cannot [7]. PCT is a general term that is employed to describe a variety of downstream cap-and-trade policies, which stipulate rights and responsibilities for carbon emissions from personal activities such as household energy use and personal travel. In PCT, after an initial allocation of carbon permits to individuals based on carbon reduction targets, individuals can buy or sell permits according to their desired carbon consumption and prevailing permit prices. PCT appears to be capable of reducing individual carbon consumption or personal carbon footprints [8,9].

However, without residents' support, PCT is less likely to be implemented. The main element of the policy is residents. If residents' willingness to participate in PCT is very low and is hindered by many factors, the effect of the policy will not be fully realized, or the policy may even fail, especially in a huge energy-consuming country such as China. Thus, it is important to understand residents' willingness and their personal barriers to action with respect to PCT. In the present study, the author attempted to obtain insights into the following issues: What is the level of residents' PCT willingness? What are the underlying factors that determine the level of residents' PCT willingness? The results obtained in this study may provide useful information for policymakers in promoting PCT. The present study will contribute to the literature in by (1) analyzing willingness regarding PCT in a developing country, (2) explaining the main factors that affect PCT willingness, and (3) proposing a guiding policy for metropolitan areas in developing countries. The remainder of this paper is organized as follows: Section 2 describes the literature and research hypotheses, Section 3 describes the research background and discusses the methodology used in the study, and Section 4 presents the results and discussion, followed by a conclusion and policy analysis in Section 5.

2. Literature Review and Hypotheses

Many previous studies have explored different aspects of PCT willingness, and several themes can be identified, as noted in the following. Subsequently, research hypotheses based on these previous studies are proposed.

2.1. Personal Barriers to PCT

The existing literature has analyzed barriers to PCT from multiple perspectives. First, research has focused on how residents' habits affect PCT. According to the findings of North [10], residents tend to rely on their previous habits to facilitate their decision-making process. Once a habit is formed, it may be difficult to break [11]. People's reluctance to deviate from the status quo [12] may thus prevent them from accepting an emission trading system. This might explain why people, even when it is in their interest to do so, often fail to change their behavior but instead rely on their previously high carbon habits. In fact, evidence suggests that the size of individuals' carbon footprint inversely correlates with their support for PCT [13]. In particular, the cost of verifying one's self-reported personal carbon footprint is an important concern among individuals, and this might directly relate to their likelihood of non-compliance [14]. Furthermore, the administration costs of PCT will inevitably be higher than those of an upstream scheme [15]. Inspired by the studies mentioned above, this study proposes the following research hypothesis:

Hypothesis 1 (H1). *Personal barriers to PCT negatively affect PCT willingness.*

2.2. Governmental Polices

Implementing PCT is a key element within a policy portfolio to reduce personal carbon footprints [16]. As individuals tend to be risk averse, a policy that leads to uncertainty may negatively affect its acceptance [17]. There is continuing debate regarding how an initial allocation of carbon permits should be distributed to individuals and whether children should receive additional permits [18].

　　　　Meanwhile, PCT has equity and distributional impacts [19,20]. A PCT scheme in the UK would still create groups of net losers with low income who could not be easily compensated, which may affect the political acceptability of such a scheme [15]. Some lower income households would almost inevitably lose out [19]. However, in China, PCT is a progressive scheme in which poorer consumers are mostly winners [21]. Raymond and Cason [14] found that increased perceived fairness among residents may increase honest emission reporting and reduce monitoring costs. These results partly support the finding of Bamberg and Rolle [22] that people tend to accept pricing measures that they perceive to be fair. Gaining public support for pricing measures is thought to be a crucial factor in the political implementation process [23].

　　　　Furthermore, whether a policy can effectively solve environmental issues [24] will affect the acceptance of PCT. In France, Raux, Croissant and Pons [16] found there was no significant difference between PCT and a carbon tax with regard to changing travel behavior. Guzman and Clapp [25] indicated that PCT could work in the context of a Canadian province with an existing climate mitigation policy. In China, the PCT scheme reduces volatility in driving costs and sets an equilibrium carbon price determined by the market, which could be more beneficial in achieving total carbon emission control than existing policy instruments [26]. Evidence on the effectiveness of PCT relative to a simpler carbon tax is mixed [8]. Policies are rated as more acceptable when they are perceived as effective in the sense that they can solve the problems they are designed to address [27]. Therefore, this study proposes the following hypothesis:

Hypothesis 2 (H2). *Governmental polices positively affect residents' PCT willingness.*

2.3. Environmental Awareness

　　　　There is no unified view on the interaction between environmental awareness and environmental behavior [28]. Although environmental awareness does not necessarily lead to specific environmental behavior, it does generally have a positive impact on environmental behavior [29]. Residents' individual psychological characteristics have nonetheless been shown to affect their carbon trading behavior [30], and pro-environmental attitudes have been found to positively correlate with support for PCT [31]. People also act in an environmentally friendly way based on normative considerations, and they feel that acting environmentally friendly is their moral duty [32]. Further, according to Wallace, Irvine, Wright, and Fleming, supporters of renewable energy show a higher level of support for PCT [33]. Based on the studies mentioned above, this study proposes the following hypothesis:

Hypothesis 3 (H3). *Individuals' environmental awareness positively affects their PCT willingness.*

2.4. Motivations

　　　　Studies on emission reporting have focused on negative motivations such as the fear of costly punishments [34,35]. PCT relies on an enforcement system in which the penalty level determines the price at which constrained actors will breach the cap [36]. Schultz [24] indicated that people feel social pressure to act in an environmentally friendly way or that they act pro-environmentally because doing so allows them to perceive themselves as morally good people. PCT attempts to change households' behavior by appealing to economic motivations, such as saving energy and saving money [8]. The likelihood of selling units in a PCT scheme has a strong effect on individuals' support for PCT [33]. Therefore, this study proposes the following hypothesis:

Hypothesis 4 (H4). *Individuals' motivations positively affect their PCT willingness.*

　　　　Figure 1 illustrates how the hypotheses fit together in a structural model. In this model, willingness regarding PCT is affected by four factors: barriers, government policies, residents' environmental

awareness, and residents' motivation. Apart from the assumption that barriers are negatively related to residents' PCT willingness, the other three factors are assumed to have positive correlations with residents' PCT willingness.
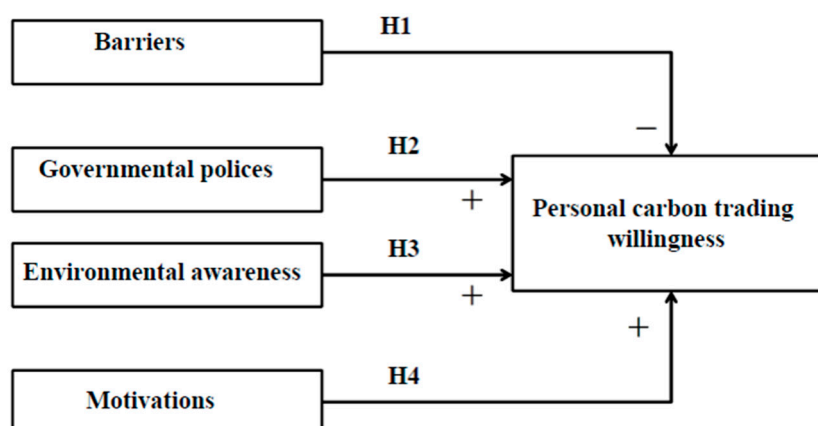

Figure 1. The structural model of the hypotheses cited.

According to the literature review, a large number of studies have focused on developed countries and analyzed residents' carbon trading behavior in such countries. However, few empirical studies have explored PCT willingness among Chinese residents and the factors that influence their willingness. Therefore, the author conducted a questionnaire survey to obtain insights in this respect.

3. Methods

To test the above-mentioned research hypotheses, the author first analyzed PCT willingness and its influencing factors and then designed an effective questionnaire. After the distribution of the questionnaires, empirical data were collected. Finally, according to the empirical data, a quantitative analysis model was established to test the research hypotheses.

3.1. Questionnaire Design

Questionnaires are frequently used in quantitative social research, which is a valuable method of collecting a wide range of information from a large number of individuals. When properly constructed and responsibly administered, questionnaires can provide valuable data about any given subject. Based on previous studies, the items in the questionnaire were designed to express the factors influencing PCT willingness.

First, barriers to residents' carbon trading may affect their PCT willingness, and such personal barriers were identified. One item pertained to residents' habits. Residents' lifestyle and habits are inconsistent with a low carbon life, which needs to be addressed. This need for a change in residents' habits may become a hindrance to the implementation of PCT [10–12]. Meanwhile, the size of individuals' personal carbon footprint will affect their enthusiasm regarding PCT. The greater an individual's carbon footprint, the more likely he/she will need to buy extra carbon emission units, which will increase his/her spending and potentially lead to opposition from high carbon footprint residents [13]. The cost of verifying one's self-reported personal carbon footprints is another barrier. Carbon emissions involve many aspects of residential life, and the collection and identification of such data will bear a cost, which may significantly reduce individuals' enthusiasm for participating in carbon trading, if they must bear a cost [14,15].

In addition, policy factors may affect residents' PCT willingness. The questionnaire items on governmental polices included the level certainty regarding the PCT policy [17,18], its fairness [14,15,19,22,23], and its effectiveness in solving environmental issues [8,16,25,27,37]. Thus, the questionnaire captures

the influence of three policy aspects on residents' PCT willingness: policy certainty, policy fairness, and policy effectiveness.

In addition, residents' environmental awareness may affect their PCT willingness. Based on the research on Capstick and Lewis [31], Nordlund and Garvill [32], and Wallace, Irvine, Wright, and Fleming [33], three items in the questionnaire were designed to capture environmental awareness: (1) awareness of the disastrous environmental consequences of massive greenhouse gas emissions from humans; (2) awareness of PCT (3); awareness of the effectiveness of a low carbon life in mitigating climate change.

Existing literature indicates that residents' motivation may affect their PCT willingness. The questionnaire items on motivations included fear of governmental punishment [34–36], social pressures [24], and economic motivations [8,33]. These dimensions capture the motivation of residents with respect to the mandatory government policy, such as the fear of fines and increased taxes, and with respect to pressure from friends and the community around them. Residents can gain a certain economic benefit from carbon trading, especially for those with a small carbon footprint, as they can sell excess carbon emissions and earn income, which may motivate them to support PCT.

After the collation of the above items, five-point Likert scales were employed as measurements. To determine any possible problems with the questionnaire, a prototype questionnaire was tested at Tianjin University by students and teachers. They were told about the nature of the interview and the reason for their selection for participation. The response rate for the pre-test was 71.43% (15 of 21). Problematic items (e.g., vague questions and questions that could be misunderstood) were identified and deleted. Finally, the questionnaire was completed. (see Table 1).

Table 1. Structure of the prototype questionnaire.

Items	
Demographic characteristics Gender; age; education level; income	
Personal carbon trading willingness (PCTW) There is an initial allocation of carbon permits to individuals based on carbon reduction targets, where individuals can buy and sell permits according to their desired carbon consumption and prevailing permit prices. Will you take part in the proposal (personal carbon trading (PCT))?	
Personal barriers (BA) BA1—I'm used to the status quo, and I won't change. BA2—I often drive private cars or travel by plane. BA3—I don't use energy-saving appliances in my house. BA4—The cost of verifying one's self-reported personal carbon footprints is high.	Sources Samuel and Zeckhauser (1988); North (1990); Aarts and Dijksterhuis (2000) Hou, Ma, Shabbir and Fu (2014) Hou, Ma, Shabbir and Fu (2014) Lockwood, 2010; Raymond and Cason, (2011)
Governmental polices (GV) GV1—Increasing the certainty related to the PCT policy will increase my willingness to participate. GV2—Increasing the fairness of the PCT policy will increase my willingness to participate. GV3—Increasing the effectiveness of the PCT policy in solving environmental issues will increase my willingness to participate.	De Groot and Steg (2006); Bristow et al. (2010) Bamberg and Rolle (2003); Ekins and Dresner (2004); Thumim and White (2008); Lockwood (2010) Ogden (1999); Schuitema and Steg (2008); Zanni, Bristow and Wardman (2013); Guzman and Clapp (2017)
Environmental awareness (EN) EN1—Massive emissions of greenhouse gases from humans can lead to disastrous consequences. EN2—I know about personal carbon trading. EN3—A low carbon life is an effective way to mitigate climate change. Motivations (MO) MO1—I will participate in PCT because I can gain economic benefits. MO2—I will participate in PCT because people around me are involved in carbon trading. MO3—I will participate in PCT because of the pressure from government rules.	Capstick and Lewis (2009) Capstick and Lewis (2010); Nordlund and Garvill (2003) Wallace et al. (2010); Zanni, Bristow and Wardman (2013) Schultz (1999) Cason and Gangadharan (2006); Murphy and Stranlund (2007); Eyre (2010)

The questionnaire generally includes three parts. The first part pertains to the basic information of the interviewees, such as gender, age, and education level. The second part is a direct inquiry into the willingness of the respondents to participate in PCT, for example, will you take part in the proposal (PCT)? The third part concerns the respondents' views on alternative factors including barriers, for example, BA1—I'm used to the status quo, and I won't change. BA4—The cost of verifying one's self-reported personal carbon footprints is high. The alternative factors also include government policies, such as GV1—Increasing the certainty related to the PCT policy will increase my willingness to participate. The other alternative factors are environmental awareness, and motivation.

3.2. Questionnaire Distribution

The city of Tianjin in China was selected as the research site. Tianjin is the carbon emission trading pilot city. According to the China Statistical Yearbook, the energy consumption structure in Tianjin is fossil fuel oriented. For example, in 2015, coal consumption was 4538.38 million tons, and crude oil consumption was 1616.72 million tons. Residents' energy consumption has resulted in rapidly increasing CO_2 emissions. For instance, in 2013, 2.10 million tons of CO_2 was emitted, which represents an increase of 0.6 times compared with 2007 [38]. These statistics show the urgent need to develop a low carbon economy in Tianjin. This survey only covered the metropolitan areas of Tianjin (Nankai, Heping, Hexi, Hedong, and Hebei). The total population is about 3.23 million (www.stats.gov.cn).

Moreover, Tianjin is a typical industrial city in northern China. Residents' habits and ways of travel are similar to those in northern China. In particular, given the central heating in the winter and an industry-dominated economic structure, the survey results for Tianjin are representative of those for northern China. Because of this situation, this study has focused on Tianjin, and the results can provide rich information for low carbon development in both Tianjin and other northern cities in China.

The questionnaires were randomly distributed using the Internet, Weixin and in interviews. Interviewees could answer the questionnaire online or by sending an email to our research team. The online platform used is called Wenjuanxing. It is the largest online questionnaire survey platform in China. Since it was established in 2006, lots of universities and scientific research institutes used the platform to distribute questionnaires in China. Some interviewees were contacted by email or telephone, and their feedbacks have been provided also by email or telephone conversation. Interviewees were told the full nature of the interview and the reason that they were selected. Some interviewees, such as without university degrees, refused to answer the questions. In all, 315 questionnaires were completed; however, some questionnaires were excluded because of missing answers. Ultimately, 304 questionnaires were valid. The characteristics of the samples are presented in Table 2. Overall, 52.96% of the respondents were men; more than half of them were under 40 years old. Half of them had university degrees, which meant the responded interviewees in this survey, 49.01% of them had university degrees. This did not indicate the overall level of education in Tianjin city.

Table 2. Characteristics of sample.

Demographic Characteristics		Percentage%
Gender	Male	47.04
	Female	52.96
Age	≤30	66.12
	31–40	23.68
	41–50	7.24
	≥51	2.96
Education level	High school and below	3.29
	College	49.01
	Postgraduate and above	47.7

3.3. Validity and Reliability

The reliability and validity of a questionnaire have a decisive impact on questionnaire data, as scientific conclusions can be drawn only from data collected from a questionnaire with high reliability and validity. While there is no universally accepted method for calculating validity and reliability, Cronbach's alpha (α) is commonly used to measure the internal consistency and reliability of a questionnaire. Cronbach's alpha is a function of the number of items in a questionnaire, the average covariance between item-pairs, and the variance of the total score of a questionnaire. The alpha can be viewed as the expected correlation of two tests that measure the same construct. Employing this definition, it is assumed the average correlation of a set of items is an accurate estimate of the average correlation of all items that pertain to a certain construct.

In addition, in this study, zero-order correlations among the global score, dimensional score, and items were employed to assess the questionnaire's validity. According to Table 3, all Cronbach's alpha values were over 0.70, which indicates acceptable internal reliability [39]. Moreover, the correlations including dimensional scores and global scores were significant at the 0.01 level (two-tailed), which also indicates good content validity.

Table 3. Results regarding validity and reliability.

	Correlation	Coefficients	A
	Global Score	Dimensional Score	
Personal barriers			0.72
BA1—I'm used to the status quo, and I won't change.	0.38 **	0.52 **	
BA2—I often drive private cars or travel by plane.	0.36 **	0.72 **	
BA3—I don't use energy-saving appliances in my house.	0.24 **	0.63 **	
BA4—The cost of verifying one's self-reported personal carbon footprints is high.	0.31 **	0.53 **	
Governmental polices			0.92
GV1—Increasing the certainty regarding the PCT policy will increase my willingness to participate.	0.59 **	0.91 **	
GV2—Increasing the fairness of the PCT policy will increase my willingness to participate.	0.62 **	0.94 **	
GV3—Increasing the effectiveness of the PCT policy in solving environmental issues will increase my willingness to participate.	0.60 **	0.94 **	
Environmental awareness			0.77
EN1—Massive emissions of greenhouse gases from humans can lead to disastrous consequences.	0.44 **	0.65 **	
EN2—I know about personal carbon trading.	0.47 **	0.69 **	
EN3—A low carbon life is an effective way to mitigate climate change.	0.41 **	0.76 **	
Motivations			0.77
MO1—I will participate in PCT because I can gain economic benefits.	0.50 **	0.79 **	
MO2—I will participate in PCT because people around me are involved in carbon trading.	0.48 **	0.87 **	
MO3—I will participate in PCT because of pressure from government rules.	0.47 **	0.83 **	

** Correlation is significant at the 0.01 level (two-tailed).

4. Results and Discussion

4.1. Descriptive Analysis of the Questionnaire Data

The interviewees indicated a high level of willingness to participate in PCT. The results of the survey indicated that most of the interviewees (74.92%) agreed or strongly agreed that they would participant in PCT. According to Figure 2, only 12.54% of the interviewees indicated that they were unwilling or very unwilling to participant in PCT. The remaining 12.54% of the interviewees were neutral about PCT.

Regarding the factors influencing PCT willingness from the questionnaires, the results showed that factors related to governmental policies and residents' motivation were the two most important influencing factors. Environmental awareness and barriers ranked third and fourth, respectively (See Table 4).
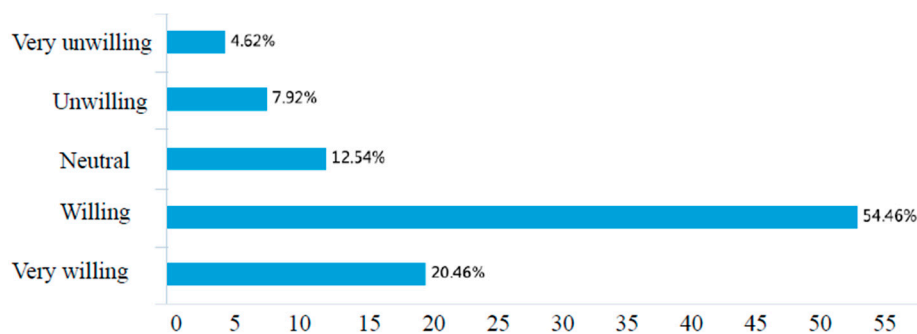
Figure 2. Results of residents' personal carbon trading willingness.

Table 4. Results for influencing factors from the questionnaires.

	Very Disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Very Agree (5)	Average Score
Barriers						2.73
BA1	4.28%	7.57%	34.87%	26.64%	26.64%	3.64
BA2	32.01%	15.84%	22.11%	20.79%	9.24%	2.59
BA3	18.42%	23.68%	36.18%	15.13%	6.58%	2.68
BA4	41.78%	30.26%	16.78%	7.24%	3.95%	2.01
Governmental policies						4.15
GV1	2.97%	1.65%	17.82%	40.59%	36.96%	4.07
GV2	1.99%	1.32%	15.56%	38.74%	42.38%	4.18
GV3	2.98%	2.65%	11.59%	37.75%	45.03%	4.19
Environmental awareness						3.77
EN1	2.96%	2.96%	9.21%	22.70%	62.17%	4.38
EN2	18.87%	18.21%	30.46%	19.87%	12.58%	2.89
EN3	3.97%	4.30%	15.89%	36.09%	39.74%	4.03
Motivations						4.15
MO1	2.97%	1.65%	17.82%	40.59%	36.96%	4.07
MO2	1.99%	1.32%	15.56%	38.74%	42.38%	4.18
MO3	2.98%	2.65%	11.59%	37.75%	45.03%	4.19

** Average score is arithmetic mean.

According to Table 4, most of interviewees agreed or substantially agreed that governmental policies (average score = 4.15) and their motivations (average score = 4.15) affected their PCT willingness. For example, the results for GV3 among the policy factors indicate that increasing the effectiveness of the PCT policy in solving environmental issues will increase residents' willingness to participate. Meanwhile, with respect to MO3 in motivational factors, residents will participate in PCT because of pressure from government rules. This is the main motivation for residents to participate in PCT. (two-tailed), which also indicates good content validity. The environmental factors considered were residents' environmental awareness (average score = 3.77). The results showed that residents' environmental awareness is not a main influencing factor. However, more than 80% of the respondents agreed or substantially agreed with EN1 (massive emissions of greenhouse gases from humans can lead to disastrous consequences). Barriers were found to be the least important influencing factor, with an average score of 2.73. It can be seen that although barriers directly impede residents' PCT willingness, it is not prominent among all the influencing factors.

4.2. Hypothesis Test Results

Multiple regression models were employed to analysis the relationships between the influencing factors and PCT willingness. To accurately explore the relationships, control variables were selected

based on their theoretically or empirically informed associations with PCT willingness, such as residents' income [15,19], education level [32], gender, and age. The expression has the following form:

$$PCTW_i = \beta_0 + \beta_1 BA_i + \beta_2 GV_i + \beta_3 EN_i + \beta_4 MO_i + \beta_5 IM_i + \beta_6 ED_i + \beta_7 GE_i + \beta_8 AG_i + \mu_i \quad (1)$$

PCTW: PCT willingness; *BA:* personal barriers; *GV:* governmental policies; *EN:* environmental awareness; *MO:* motivations; *IM:* income; *ED:* education level; *GE:* gender; and *AG:* age. The Mahalanobis distances of the predicted variables were employed to test for multivariate outliers [39], and the maximum absolute values of the skewness and kurtosis of the variables were below 2 and 8, respectively, which are acceptable [40]. Meanwhile, the Durbin–Wu–Hausman (DWH) test of endogeneity [41] indicated that the variables were not endogenous. Furthermore, variance inflation factors were employed to test for multicollinearity, and the results were below 7, which is acceptable [42]. All variables were initially included in model 1, and the insignificant variables then eliminated until a parsimonious model was obtained (model 2) (Table 5). The analysis shows that the hypotheses can be accepted. According to Table 5, governmental policies, environmental awareness, and motivations were positively and significantly related to residents' PCT willingness. (two-tailed), which also indicates good content validity.

Table 5. Multiple regression analysis results cited.

Independent Variable	Model 1	Model 2
BA: personal barriers	−0.279 (−5.128) *	−0.257 (−4.90) **
GV: governmental policies	0.149 (2.443) *	0.172 (2.873) **
EN: environmental awareness	0.250 (4.089) *	0.252 (4.193) **
MO: motivations	0.130 (2.438) *	0.118 (2.244) *
IM: income	0.111 (1.701)	
ED: education level	0.040 (0.732)	
GE: gender	0.021 (0.407)	
AG: age	−0.058 (−0.908)	
R	0.472	0.461
Standard error of regression	0.948	0.948
F	10.548 *	20.122 *
Variance inflation factors	<7	<7

* Indicates statistical significance at the 5% level; ** Indicates statistical significance at the 2.5% level; t-values in parentheses cited.

There is a significant positive correlation between government policy factors and residents' PCT willingness. Especially in China, the government has a strong appeal and organizational capacity. Residents' behavior is obviously affected by the government's behavior. Meanwhile, the quality of policies formulated by the government will also affect residents' PCT willingness. Governmental policies that lack certainty can positively affect residents' PCT willingness. For example, regarding the initial allocation of carbon permits, differences in the initial allocation directly affect the price and quantity of carbon trading units and then affect residents' carbon trading income, in line with the previous findings of Bristow et al. [18]. Moreover, considering the equity and distributional impacts of PCT [19,20], increased perceived fairness among residents positively affects residents' PCT willingness. This result is in line with previous research by Raymond and Cason [14]. Moreover, the effectiveness of a policy in solving environmental issues affects PCT willingness.

The main purpose of implementing carbon trading is to reduce greenhouse gas emissions. If the policy can effectively achieve such a purpose, it will enhance the willingness of residents to participate in the scheme, especially those with better environmental behavior and awareness. Many previous studies, including Schuitema and Steg [27], and Raux, Croissant, and Pons [16] support such findings.

Environmental awareness was positively and significantly related to residents' PCT willingness, as residents with better environmental awareness showed strong PCT willingness. Through PCT

transactions, residents will believe that they have contributed to environmental protection, and individual environmental awareness tends to affect PCT willingness partly because such residents believe that acting environmentally friendly is their moral duty. These results are in line with the previous findings of Capstick and Lewis [30].

Motivations can be classified into negative and positive motivations, such as costly punishments or economic benefits. The results showed motivations were positively and significantly related to residents' PCT willingness partly because of the fear of governmental punishments. In addition, residents feel social pressures to act in an environmentally friendly way or to act pro-environmentally. PCT can also create economic motivations, as individuals may desire to save household energy or earn money. Therefore, residents' motivators were positively related to PCT willingness.

However, barriers were negatively and significantly related to residents' PCT willingness. First, it is difficult for residents to change their existing habits in the short term, and residents' habits of high carbon use, such as driving a private car or traveling by air, affect their PCT willingness. Residents are reluctance to deviate from the status quo, and the size of their carbon footprint inversely correlates with their support for PCT. Furthermore, the cost of verifying one's personal carbon footprints is another important barrier. There is carbon footprint data on many aspects of residents' daily lives, and it is very difficult for them to collect such data by themselves. However, entrusting a professional to collect such data will increase the cost to residents, thereby impeding residents' PCT willingness. Finally, the control variables (income, education level, gender, and age) were not significantly related to residents' PCT willingness (Figure 3).
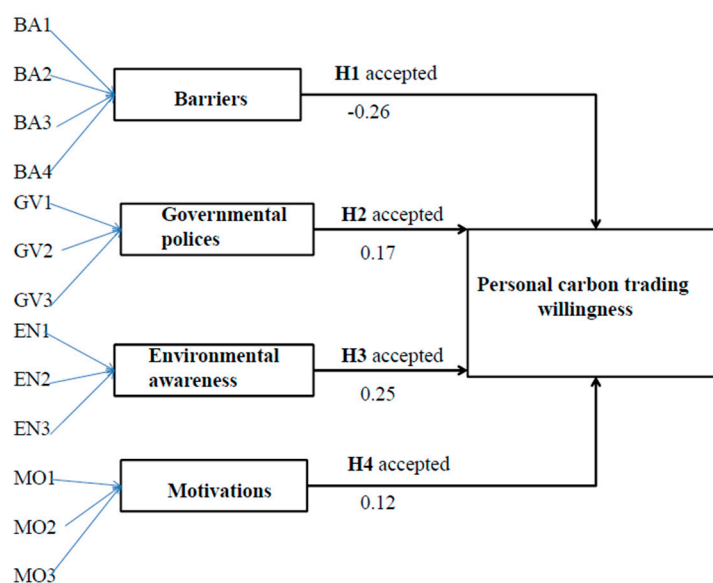

Figure 3. Results of the hypothesis test.

5. Conclusions and Policy Suggestions

5.1. Conclusions

Employing a questionnaire survey on residents in Tianjin China, the present research yielded interesting empirical findings. First, the interviewees showed high levels of willingness to participate in PCT. Moreover, in terms of factors affecting residents' PCT willingness, governmental policies and residents' motivations—particularly the effectiveness of the policy and pressure from government rules—obviously affected their willingness to participate. Residents' environmental awareness was the third most important factor, followed by personal barriers to PCT. Moreover, the multiple regression analysis indicated that governmental policies, environmental awareness, and motivations were positively related to residents' PCT willingness, whereas personal barriers, such as costs, were

negatively related to their PCT willingness. There was no significant statistical relationship between any of the demographic characteristics, such as educational background, and PCT willingness.

5.2. Policy Suggestions

Because the survey was conducted in the metropolitan areas of Tianjin. In addition, the majority of the responded interviewees were those with university degrees. Therefore, the policy suggestions put forward in this study have limitations. Nevertheless, the findings of the present research provide suggestions for policymaking. The policy suggestions can be piloted in the metropolitan areas of Tianjin, which can be considered as typical cases. The empirical results of these areas will establish PCT policy foundations for other areas in Tianjin. Moreover, considering the similarities between Tianjin and other cities in North China, Tianjin's policy practice also will provide a good example for other cities in North China.

First, an effective policy system is the foundation, and governmental policies related to PCT should be established. Although the Chinese government has implemented many policies to encourage low carbon development, policies related to PCT are scarce. For example, there is no policy to promote the collection of data on residents' carbon emissions, yet effective data collection is very important. The government should thus establish a professional department to collect carbon emission data. In addition, regular reporting of emission data should be included in the policy system. Initially, large fixed-point sources of carbon dioxide should be monitored. Then, allowances should be allocated to small sources. Nonetheless, the administrative costs, especially with regard to monitoring residents' emission and trading patterns, could be high. Such costs could be partly reduced by allocating allowances downstream based on the average fuel use per adult person in a reference year.

To increase the acceptance of PCT by residents, communication, such as emphasizing the effectiveness and fairness of the PCT policy, is important. Given that carbon emission trading is not mandatory for residents in China, and some residents may not be familiar with carbon emission transactions, which will decrease their enthusiasm for PCT. Therefore, the government should publicize individual carbon trading through social media and official websites. Such publicity could focus on the effectiveness of PCT, including the related reduction in greenhouse gas emissions and mitigation of climate change. Meanwhile, the fairness of the policy also plays a very important role. The government should thus emphasize that residents' efforts to reduce their carbon emissions and carbon footprint will be rewarded and that the policy is fair for every inhabitant: those who emit less, pay less.

Residents' acceptance of PCT can also be boosted by mitigating uncertainty regarding PCT. The implementation of an individual carbon trading policy will affect residents' existing lifestyle. It may even cost them money to reduce their carbon footprint, such as installing more energy-efficient household appliances. If the policy has lacks certainty and stability, residents will be less enthusiastic about participation in the scheme. Moreover, as the costs of their initial investment cannot be offset, they may oppose the policy. Therefore, the government should clearly and definitely indicate its determination to implement an individual carbon trading policy, which will enhance residents' willingness to participate.

In addition, an insurance policy can further reduce residents' concerns regarding the instability of the policy, where some insurance against high carbon prices can be provided for risk averse end-users to buy. The government could encourage insurance companies to set up related portfolio products for residents, and in the early stage of implementing PCT, the government can provide free or preferential insurance for residents to increase their willingness to participate in the scheme.

Finally, by enhancing the transparency and visualization of individual carbon trading, the government can improve residents' PCT willingness. Such transparency includes transparency regarding carbon data collection and carbon trading policies. In particular, data on the increase or decrease in residents' carbon emissions is directly related to residents' interests. Therefore, residents can be sent regular updates of their transactions and their allowance account, which increase the visibility regarding the reducing in energy consumption levels and the related benefits.

Some limitations of this research should be noted. This research focused only on some factors that influence residents' PCT willingness in China, and other possible influencing factors were not included, such as economic structure, consumption patterns, and intensity of climate change. Future studies should include relatively more influencing factors. Moreover, the representativeness of research conclusions was restricted by the specific sample characteristics from specific areas. However, this explorative research provides context and a starting point for further investigation and will support further studies on PCT.

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