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When the Ledger is Visible: Scheme Transparency, Perceived Consumer Effectiveness, and Low-Carbon behavior in China's Personal Carbon Accounts

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ABSTRACT

China has built municipal personal carbon accounts to reward citizens for low-carbon actions. Yet many registered users stay passive, and the schemes face doubts about how points are counted and verified. Drawing on social cognitive theory, this study examines whether citizens' perceived transparency of a carbon account scheme raises their perceived consumer effectiveness, the belief that their own actions make a difference, and whether this belief carries over to two outcomes: continued participation intention within the scheme and everyday low-carbon behavior outside it. Survey data from 287 registered users of government-run personal carbon accounts in four Chinese cities supported the model. Perceived transparency was positively related to perceived consumer effectiveness. Perceived consumer effectiveness, in turn, was positively related to both outcomes. It fully transmitted the effect of transparency to continued participation intention. For everyday low-carbon behavior it carried a smaller share, and transparency kept a direct association with the behavior. The indirect effect was larger for continued participation than for everyday behavior. The findings suggest that clear rules for counting, verifying, and redeeming carbon points matter beyond fairness. They shape whether citizens see their small actions as consequential, and transparency is also linked to behaviors the scheme does not reward. Policymakers can raise the return on carbon inclusion schemes by making the ledger legible to the people it records.

Keywords: Carbon Generalized System of Preferences, Personal Carbon Account, Policy Transparencym, Perceived Consumer Effectiveness, Behavioral Spillover
JEL Classifications: D12, Q35, Q56

1. INTRODUCTION

Household consumption is now a central target of climate policy. Daily choices about energy, travel, and goods add up to a large share of emissions, and they are hard to govern with instruments built for factories and power plants. China has responded with demand-side tools that reward rather than tax. Its carbon generalized system of preferences (CGSP), often called carbon inclusion, records individuals' low-carbon actions and converts them into points that can be redeemed for benefits (Tan et al., 2019). Evaluations suggest that the CGSP has strengthened residents' willingness to practice low-carbon living over time (Chen et al., 2023). Survey work also confirms that Chinese citizens report a wide range of such behaviors, from energy-saving habits at home to low-carbon purchases (Wang et al., 2024).

Personal carbon accounts are the main vehicle of this policy. Guangzhou launched the earliest government scheme in 2015, and the number of systems grew to more than 60 by 2022 (Rick, 2025). Local governments continue to extend them, and Xizang reported in 2025 that its personal carbon account service covered all of its cities and its prefecture (Xinhua, 2025). We focus on one feature of these schemes that citizens experience directly: perceived scheme transparency, defined as the extent to which citizens understand how the scheme decides which actions count, how points are calculated and verified, how they can be redeemed, and how

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personal data are used. This definition follows the three objects of government transparency, namely decision processes, policy content, and policy outcomes (Grimmelikhuijsen and Meijer, 2014), and the stakeholder view of transparency as disclosure that is clear, complete, and useful (Rawlins, 2009). Transparency carries clear benefits. Disclosure can raise the perceived competence and benevolence of public bodies (Grimmelikhuijsen and Meijer, 2014), and well-designed feedback about one's own consumption reduces energy use (Karlin et al., 2015).

However, transparency is not a guaranteed asset for carbon accounts. Its effects on citizens depend on what they already know and believe about government (Grimmelikhuijsen and Meijer, 2014). Carbon accounts also suffer from a credibility problem. No national standard governs how points are calculated, so the same bike ride can earn different credit in different cities, and regulators have kept personal carbon credits out of China's voluntary carbon market over concerns about baselines and additionality (Rick, 2025). A scheme that hides its rules may leave citizens unsure whether their recorded actions mean anything. A scheme that shows them may do the opposite.

Research on CGSP participation has mostly explained adoption through technology acceptance and planned behavior models, which put perceived usefulness, incentives, and attitudes at the center (Li and Liu, 2024; Tan et al., 2019). Spillover scholars, for their part, have asked for tests of the psychological mechanisms that carry a targeted behavior into untargeted ones, with efficacy beliefs as a leading candidate (Lauren et al., 2016; Truelove et al., 2014).

Addressing this call is important for two reasons. First, it moves the explanation of carbon account outcomes from what a scheme offers (rewards and convenience) to what a scheme communicates about the meaning of individual action. This matters because voluntary schemes cannot rely on mandates, and their rewards are small. Second, it speaks to a practical question that policymakers face. If carbon accounts change only the behaviors they pay for, their value rests on point tallies that regulators already doubt (Rick, 2025). If they also shift behaviors they do not pay for, their policy value is larger than their ledgers show.

The present study responds to this need by developing and testing a model of how perceived scheme transparency shapes continued participation intention and everyday low-carbon behavior. Using social cognitive theory (Bandura, 1986), we propose that transparency works as a source of efficacy information. Social cognitive theory holds that people act when they believe their actions can produce valued outcomes, and that these beliefs grow from clear evidence about the link between action and result (Bandura, 1977; 1997). A transparent ledger supplies that evidence. It shows citizens which actions count and how much each one adds.

The mechanism we test is perceived consumer effectiveness (PCE), the belief that one's own efforts can make a difference in solving an environmental problem (Ellen et al., 1991). PCE is distinct from environmental concern. People can care about the climate yet doubt that their actions matter (Ellen et al., 1991). PCE is also close to the domain-specific self-efficacy that predicts sustainable consumption choices (Hanss and Böhm, 2010). We expect PCE to support two outcomes. The first is continued participation intention, a user's intention to keep using the carbon account rather than abandon it (Bhattacherjee, 2001). The second is everyday low-carbon behavior, such as saving energy and avoiding waste, which the schemes do not record directly (Wang et al., 2024). The second outcome lets us test whether a policy-induced efficacy belief spills over beyond the targeted domain (Lauren et al., 2016).

This study makes three contributions. First, it extends research on China's carbon inclusion policy. Prior studies have modeled participation willingness through perceived usefulness, incentives, and risk (Tan et al., 2019), through information and protection motivation appraisals (Li and Liu, 2024), and at the aggregate level through policy evaluations of residents' low-carbon willingness (Chen et al., 2023). Studies of the Ant Forest platform have likewise traced continued use to persuasive design and satisfaction (Yang et al., 2018; Zhang et al., 2020). We add a policy design attribute that governments control, transparency, and show how it works through citizens' beliefs about their own impact. Second, it extends the PCE literature. This work has shown that PCE predicts green purchasing and sustainable consumption (Hanss et al., 2016; Kim and Choi, 2005) and that it is separate from environmental concern (Ellen et al., 1991). Much less is known about how public policy shapes PCE. We position a policy feature as an antecedent of PCE. Third, it extends research on behavioral spillover. Earlier studies have found mixed evidence for spillover (Truelove et al., 2014), identified self-efficacy as one carrier of spillover from easy to harder behaviors (Lauren et al., 2016), and shown that organizational green practices can reach employees' environmental behavior outside work (Usman et al., 2023; 2025). We show that a public incentive scheme can generate spillover through PCE, and we compare the strength of this pathway for targeted and untargeted outcomes. Together, these contributions frame carbon accounts as information systems that teach citizens whether their actions count, not only as reward systems.

2. THEORETICAL BACKGROUND AND HYPOTHESES

2.1. Personal Carbon Accounts as a Policy Instrument

The CGSP is a voluntary mechanism. Citizens register an account, usually through a municipal app or a partner platform, and the scheme records actions such as green travel or reduced electricity use. Points can then be exchanged for discounts, services, or financial benefits (Tan et al., 2019). The model is attractive to governments because it avoids the political cost of mandatory personal carbon trading. It also has a weakness. Its outcomes depend on citizens choosing to stay active. Studies of Guangzhou residents found that the institutional and technical environment of the scheme shaped their willingness to take part (Tan et al., 2019). Studies of public support for the CGSP found that information about the scheme raised support partly through efficacy appraisals (Li and Liu, 2024). Both lines of evidence point to the same insight. How citizens understand the scheme shapes how they respond to it.

2.2. Social Cognitive Theory

Social cognitive theory explains behavior through the interplay of personal beliefs, behavior, and environment (Bandura, 1986). Two beliefs matter most. Efficacy expectations concern whether one can perform an action, and outcome expectations concern whether that action will produce results (Bandura, 1977). People build these beliefs from four sources: mastery experiences, vicarious experiences, persuasion, and physiological states (Bandura, 1997). Mastery experiences are the strongest source. They work best when people can see a clear link between what they did and what followed.

Personal carbon accounts are designed to create such experiences. Each logged action is a small mastery episode. Whether citizens learn from it depends on whether they can interpret the record. If the rules are opaque, the episode is ambiguous. A citizen cannot tell whether the points reflect genuine reductions, an arbitrary formula, or a marketing device. If the rules are visible, the episode becomes informative. The citizen sees that a specific action led to a specific, verified reduction. From a social cognitive view, we expect that transparency shapes behavior mainly by changing citizens' beliefs about their own effectiveness.

2.3. Perceived Scheme Transparency and Perceived Consumer Effectiveness

PCE reflects a person's estimate that individual action can contribute to an environmental outcome (Ellen et al., 1991). It is fragile in the climate domain. Emissions are invisible, and one person's share of the problem is tiny. Citizens can easily conclude that their efforts are pointless. Carbon accounts offer a remedy by translating invisible reductions into a visible ledger. Transparency determines whether that translation persuades.

We expect transparency to raise PCE through three routes, one for each object of transparency (Grimmelikhuijsen and Meijer, 2014). Process transparency shows which actions count and why. It tells citizens that the scheme rests on a defensible logic rather than an arbitrary list. Content transparency shows how points are calculated and redeemed. It turns each action into a quantity that citizens can compare and accumulate. Outcome transparency shows how reductions are verified and aggregated. It links a single action to a collective result, which is the core of PCE. Research on energy feedback supports this reasoning. Feedback reduces consumption, and its effects are stronger when it is engaging and tied to goals (Karlin et al., 2015). Research on the CGSP adds that information about the scheme raises citizens' response efficacy and self-efficacy (Li and Liu, 2024).

Hypothesis 1 (H_1): Perceived scheme transparency is positively related to perceived consumer effectiveness.

2.4. Perceived Consumer Effectiveness and the Two Outcomes

Social cognitive theory predicts that people persist in actions they believe will work (Bandura, 1997). Within the scheme, this persistence takes the form of continued participation. Continuance is a distinct decision from initial adoption, and it depends on users' judgment that ongoing use delivers value (Bhattacherjee, 2001). For a carbon account, the main value is not the reward, which is modest. It is the sense of contributing. Users who believe their logged actions reduce emissions have a reason to keep logging. Users who doubt it have little reason to continue once the novelty fades. Evidence from Ant Forest shows that users' continued use rests on satisfaction and on a sense of achievement from their green contributions (Yang et al., 2018; Zhang et al., 2020).

Hypothesis 2a (H_{2a}). Perceived consumer effectiveness is positively related to continued participation intention.

PCE should also guide behavior that the scheme does not record. Efficacy beliefs are not tied to one action. They generalize to related actions in the same domain (Bandura, 1997). Spillover research supports this view. People who perform easy pro-environmental behaviors gain self-efficacy, and this efficacy then predicts intentions and actions toward harder behaviors (Lauren et al., 2016). Positive spillover is more likely when people attribute their initial behavior to internal motives rather than external rewards (Truelove et al., 2014). PCE is such an internal motive. It frames low-carbon action as effective, not merely paid. Organizational research points the same way. Green practices at work have been linked to employees' eco-friendly behaviors and green activism beyond the workplace (Usman et al., 2023; 2025). We expect a citizen who believes that small actions matter to save energy, reuse items, and avoid waste even when no points are on offer.

Hypothesis 2b (H_{2b}). Perceived consumer effectiveness is positively related to everyday low-carbon behavior.

2.5. The Mediating Role of Perceived Consumer Effectiveness

Taken together, these arguments describe an indirect process. Transparency does not make citizens act by itself. It supplies interpretable evidence about the link between action and outcome. This evidence builds PCE, and PCE motivates both continued use of the scheme and low-carbon behavior beyond it. Social cognitive theory places efficacy beliefs at the center of this chain (Bandura, 1986). We propose that PCE transmits the effect of transparency to both outcomes.

Hypothesis 3a (H_{3a}): Perceived consumer effectiveness mediates the positive relationship between perceived scheme transparency and continued participation intention.
Hypothesis 3b (H_{3b}): Perceived consumer effectiveness mediates the positive relationship between perceived scheme transparency and everyday low-carbon behavior.

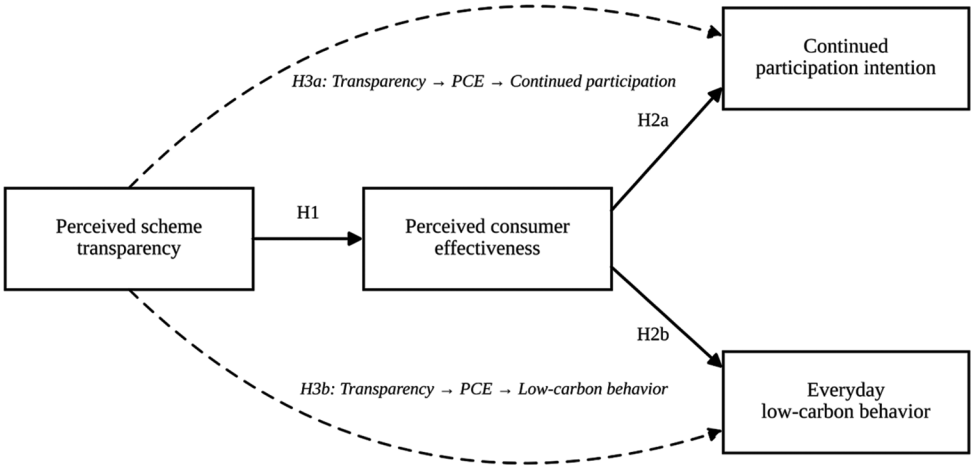
Figure 1 presents the research model.

3. METHODS

3.1. Context, Sample, and Procedure

The study took place in four Chinese cities that operate government-run personal carbon account schemes: Beijing, Shanghai, Guangzhou, and Wuhan. We recruited adult residents through an online survey panel. A screening question admitted only respondents who had registered an account with a municipal

Figure 1: Research model



or government-endorsed carbon inclusion scheme and had used it at least once in the past 3 months. Respondents who used only commercial platforms were excluded. The questionnaire was developed in English and translated into Chinese using back-translation (Brislin, 1970). Ten account users pretested the Chinese version for clarity. Participation was voluntary and anonymous. Respondents gave informed consent and received a small panel incentive.

Initially, we contacted 400 people. We received 301 responses. We screened the data before analysis. Respondents who failed instructed-response attention checks, finished in implausibly short time, or gave identical answers across all substantive items were excluded. The final sample comprised 287 respondents. Age was collected in five bands; the largest groups were 26-35 years (35.5%) and 36-45 years (28.9%), and 53.3% of respondents were female. Respondents had used their carbon account for 17.10 months on average (SD=10.11). Table 1 presents the sample profile.

Table 1: Sample profile (n=287)

Characteristic	n	Percentage
Gender		
Male	134	46.7
Female	153	53.3
Age (years)		
18-25	52	18.1
26-35	102	35.5
36-45	83	28.9
46-55	35	12.2
56 and above	15	5.2
Education		
High school or below	39	13.6
Junior college	63	22.0
Bachelor's degree	138	48.1
Postgraduate degree	47	16.4
Monthly income (RMB)		
Below 5,000	31	10.8
5,000-9,999	65	22.6
10,000-14,999	86	30.0
15,000-19,999	62	21.6
20,000 and above	43	15.0

Account tenure: M=17.10 months, SD=10.11, range 1-46

3.2. Measures

All items appear in Appendix A. Unless stated otherwise, items used a five-point scale (1 = strongly disagree, 5 = strongly agree).

Perceived scheme transparency was measured with five items adapted from Rawlins (2009). We wrote the items to cover the three objects of transparency identified by Grimmelikhuijsen and Meijer (2014): which actions count (process), how points are calculated and redeemed (content), and how reductions are verified and data are used (outcomes). A sample item is "I understand how my carbon points are calculated."

Perceived consumer effectiveness was measured with four items adapted from Ellen et al. (1991) and Kim and Choi (2005). A sample item is "What I do through my carbon account makes a difference to carbon emissions."

Continued participation intention was measured with three items adapted from Bhattacherjee (2001). A sample item is "I intend to continue using my personal carbon account rather than stop using it."

Everyday low-carbon behavior was measured with six items that capture energy saving, reuse, and waste avoidance at home. The items draw on the behavior domains in Wang et al. (2024) and Usman et al. (2023). We chose behaviors that the sampled schemes do not record, so that the measure captures conduct outside the scheme. Respondents reported how often they had performed each behavior in the past month (1 = never, 5 = always).

Controls. We controlled for gender (1 = female), age, education, monthly income, and account tenure in months, because each may shape both environmental beliefs and app use.

3.3. Analytic Strategy

We first assessed the measurement model with confirmatory factor analysis (CFA) using maximum likelihood estimation. We judged fit with the comparative fit index (CFI), the Tucker-Lewis index (TLI), and the root mean square error of approximation (RMSEA), using common cutoffs (Hu and Bentler, 1999). We assessed convergent validity through loadings, composite

Table 2: Comparison of measurement models

Model	χ^2	df	χ^2/df	CFI	TLI	RMSEA
Four-factor model (hypothesized)	174.14	129	1.35	0.980	0.976	0.035
Three-factor model (TRN+PCE combined)	487.32	132	3.69	0.841	0.815	0.097
Three-factor model (CPI+LCB combined)	415.41	132	3.15	0.873	0.853	0.087
Two-factor model (PCE+CPI+LCB combined)	715.83	134	5.34	0.739	0.702	0.123
Single-factor model	1081.94	135	8.01	0.575	0.519	0.157

TRN: Perceived scheme transparency, PCE: Perceived consumer effectiveness, CPI: Continued participation intention, LCB: Everyday low-carbon behavior

reliability (CR), and average variance extracted (AVE), and discriminant validity through the Fornell and Larcker (1981) criterion and the heterotrait-monotrait ratio (HTMT; Henseler et al., 2015). We then tested the hypotheses with a path model on standardized scale scores, estimating the mediator equation and both outcome equations with all controls. We tested indirect effects with 5,000 percentile bootstrap samples (Hayes, 2022). This approach is equivalent to PROCESS Model 4 run for each outcome. We also tested whether the two indirect effects differed. As a robustness check, we re-estimated the model as a latent structural equation model.

4. RESULTS

4.1. Measurement Model

The hypothesized four-factor model fit the data well, χ^2 (129) = 174.14, χ^2/df = 1.35, CFI = 0.980, TLI = 0.976, RMSEA = 0.035. As Table 2 shows, it fit better than all alternative models, including a model that merged transparency and PCE and a model that merged the two outcomes. All standardized loadings were significant and ranged from 0.681 to 0.831. Cronbach's alpha ranged from 0.754 to 0.889, CR from 0.754 to 0.889, and AVE from 0.506 to 0.573 (Table 3). These values support convergent validity. The square root of each construct's AVE exceeded its correlations with the other constructs (Table 4), and the largest HTMT ratio was 0.575 (PCE and continued participation intention), well below 0.85. These results support discriminant validity.

4.2. Common Method Variance

Because all data came from one source at one time, we took procedural and statistical steps against common method variance (Podsakoff et al., 2003). Procedurally, we assured anonymity, placed the predictor and outcome measures in separate blocks, and used different response formats for the behavior measure. Statistically, the first unrotated factor in Harman's single-factor test explained 33.90% of the variance, well below half, and the single-factor CFA fit poorly (Table 2). These checks suggest that common method variance is unlikely to explain the results, although they cannot rule it out.

4.3. Descriptive Statistics

Table 4 reports means, standard deviations, and correlations. Perceived scheme transparency was positively correlated with PCE (r = 0.37, P < 0.01). PCE was positively correlated with continued participation intention (r = 0.45, P < 0.01) and everyday low-carbon behavior (r = 0.31, P < 0.01). Transparency was also correlated with both outcomes (continued participation intention: r = 0.19; everyday low-carbon behavior: r = 0.46; both P < 0.01).

Table 3: Standardized loadings, reliability, and convergent validity

Construct and item	Loading	α	CR	AVE
Perceived scheme transparency		0.866	0.867	0.566
TRN1	0.831			
TRN2	0.754			
TRN3	0.720			
TRN4	0.718			
TRN5	0.735			
Perceived consumer effectiveness		0.811	0.812	0.519
PCE1	0.750			
PCE2	0.690			
PCE3	0.736			
PCE4	0.705			
Continued participation intention		0.754	0.754	0.506
CPI1	0.681			
CPI2	0.729			
CPI3	0.723			
Everyday low-carbon behavior		0.889	0.889	0.573
LCB1	0.718			
LCB2	0.777			
LCB3	0.766			
LCB4	0.757			
LCB5	0.775			
LCB6	0.746			

Item wording appears in Appendix A. All loadings are significant at P<0.001.
CR: Composite reliability, AVE: Average variance extracted

The two outcomes were only modestly correlated (r = 0.17, P < 0.01), which supports treating them as distinct.

4.4. Hypothesis Testing

Table 5 presents the path estimates. After controls, perceived scheme transparency was positively related to PCE (β = 0.370, SE = 0.056, P < 0.001). H_1 was supported. PCE was positively related to continued participation intention (β = 0.438, SE = 0.057, P < 0.001) and to everyday low-carbon behavior (β = 0.165, SE = 0.056, P = 0.004). H_{2a} and H_{2b} were supported. The model explained 14.2% of the variance in PCE, 21.1% in continued participation intention, and 24.3% in everyday low-carbon behavior. All variance inflation factors were below 1.2, so multicollinearity was not a concern.

Table 6 reports the indirect effects. The indirect effect of transparency on continued participation intention through PCE was positive and significant (effect = 0.162, boot SE = 0.032, 95% CI [0.103, 0.229]). H_{3a} was supported. The direct effect was not significant (β = 0.033, P = 000.566), which indicates that PCE fully carried the relationship. The indirect effect on everyday low-carbon behavior was also positive and significant (effect = 0.061, boot SE = 0.025, 95% CI [0.020, 0.116]). H_{3b} was supported. Here the direct effect remained large and significant (β = 0.398,

Table 4: Means, standard deviations, and correlations

Variable	M	SD	1	2	3	4	5	6	7	8	9
1. Gender	1.53	0.50									
2. Age	2.51	1.08	−0.13*								
3. Education	2.67	0.91	0.06	−0.06							
4. Income	3.07	1.21	0.09	−0.14*	0.01						
5. Tenure	17.10	10.11	0.01	−0.03	−0.05	−0.06					
6. Transparency	3.37	0.79	−0.03	−0.05	0.06	−0.03	−0.05	(0.75)			
7. PCE	3.32	0.74	−0.07	0.01	0.00	−0.03	0.05	0.37**	(0.72)		
8. Participation intention	3.38	0.74	−0.02	0.08	0.01	0.03	0.04	0.19**	0.45**	(0.71)	
9. Low−0carbon behavior	3.47	0.77	0.00	−0.02	0.01	−0.10	0.02	0.46**	0.31**	0.17**	(0.76)

n=287. Gender: 1: Male, 2: Female. Values in parentheses on the diagonal are square roots of AVE. *P<0.05. **P<0.01

Table 5: Path model results (standardized coefficients)

Predictor	PCE β	SE	CPI β	SE	LCB β	SE
Transparency	0.370**	0.056	0.033	0.058	0.398**	0.056
PCE			0.438**	0.057	0.165**	0.056
Female	−0.106	0.112	0.038	0.108	0.051	0.106
Age	0.021	0.057	0.084	0.054	−0.009	0.053
Education	−0.016	0.056	0.009	0.054	−0.017	0.052
Income	−0.003	0.056	0.052	0.054	−0.087	0.053
Account tenure	0.066	0.056	0.022	0.054	0.030	0.052
R^2	0.142		0.211		0.243	

PCE: Perceived consumer effectiveness, CPI: Continued participation intention, LCB: Everyday low-carbon behavior. Continuous variables were standardized. Female is a dummy variable (1=female). *P<0.05. **P<0.01

Table 6: Total, direct, and indirect effects of perceived scheme transparency

Effect	Estimate	SE	95% CI
Outcome: Continued participation intention			
Total effect	0.195**	0.059	
Direct effect	0.033	0.058	
Indirect effect via PCE (H_{3a})	0.162	0.032	(0.103, 0.229)
Outcome: everyday low-carbon behavior			
Total effect	0.459**	0.053	
Direct effect	0.398**	0.056	
Indirect effect via PCE (H_{3b})	0.061	0.025	(0.020, 0.116)
Contrast (H_{3a} minus H_{3b})	0.101		(0.040, 0.163)

Indirect effects were tested with 5,000 percentile bootstrap samples. Standard errors for indirect effects are bootstrap standard errors. All controls in Table 5 were included. *P<0.05. **P<0.01

P < 0.001), indicating partial mediation. The difference between the two indirect effects was significant (difference = 0.101, 95% CI [0.040, 0.163]). In this sample, PCE carried the effect of transparency more fully to participation within the scheme than to behavior outside it.

4.5. Robustness Checks

We ran two checks. First, we re-estimated the model without control variables. The indirect effects were virtually unchanged (0.161 for continued participation intention and 0.061 for everyday low-carbon behavior). Second, we estimated a latent structural equation model, which fit well, χ^2 (130) = 174.29, CFI = 0.980, TLI = 0.977, RMSEA = 0.035. The hypothesized paths remained significant (transparency to PCE: β = 0.438; PCE to continued participation intention: β = 0.584; PCE to everyday low-carbon behavior: β = 0.172; all P < 0.05). In this model, the direct path from transparency to continued participation intention was not significant (β = −0.033, P = 0.664), whereas the direct path to everyday low-carbon behavior was significant (β = 0.439, P < 0.001). This pattern matches the main analysis.

5. DISCUSSION

This study asked whether the transparency of China's personal carbon account schemes matters for citizens' behavior, and why. The answer, in this sample, is yes, and largely through belief. Citizens who understood how the scheme counted, verified, and redeemed their actions were more convinced that their actions made a difference. That conviction was linked both to their intention to keep using the account and to low-carbon behaviors the account does not record. The belief fully accounted for the link between transparency and continued use. It accounted for a smaller share of the link between transparency and outside behavior, which also had a direct component.

5.1. Theoretical Implications

Our findings carry three implications. First, they add a design perspective to research on carbon inclusion. Earlier studies explained CGSP participation through perceived usefulness, incentives, and risk (Tan et al., 2019), or through threat and coping appraisals triggered by information (Li and Liu, 2024). Our results suggest that a feature of the scheme itself, the legibility of its rules, shapes the beliefs that drive participation. This shifts attention from the generosity of rewards to the quality of the information that accompanies them. It also gives a micro-level account of the aggregate gains in low-carbon willingness reported for CGSP cities (Chen et al., 2023).

Second, the study identifies a policy antecedent of PCE. PCE research has treated the belief largely as a stable consumer trait that predicts green purchases and sustainable consumption (Hanss et al., 2016; Kim and Choi, 2005). Our results suggest that PCE can be built by public institutions. When a scheme makes the contribution of each action visible, citizens appear to revise their estimate of their own impact. In social cognitive terms, the

ledger turns routine actions into interpretable mastery experiences (Bandura, 1997).

Third, the findings speak to the debate on behavioral spillover. Reviews have documented both positive and negative spillover and called for attention to its mechanisms (Truelove et al., 2014). Self-efficacy has emerged as one carrier (Lauren et al., 2016), and organizational practices have been shown to reach employees' green behavior outside work (Usman et al., 2023; 2025). We extend this evidence to a public incentive scheme. A reward-based program might have been expected to crowd out intrinsic motivation and limit spillover, because spillover is weaker when people attribute their behavior to external rewards (Truelove et al., 2014). Our results suggest that transparency may counter this risk, at least in part. By framing rewarded actions as effective rather than merely paid, it supports a belief that travels into unrewarded domains. That belief explained only a modest share of the association with unrewarded behavior, however, so transparency probably works through other routes as well.

5.2. Policy Implications

The results offer four lessons for policymakers. First, transparency should be treated as a core design element, not a compliance task. Municipal schemes can show users, action by action, how points are calculated and what reduction each point represents. Second, outcome transparency deserves special attention. Showing citizens how their reductions are verified and how they add up across the city links individual action to a collective result. This is the belief our findings place at the center of the process. Third, the lack of a national standard for carbon points (Rick, 2025) is not only a technical problem for carbon markets. It may also weaken citizens' belief that their actions count. A common national methodology, explained in plain language, would serve both goals. Fourth, evaluations of carbon account schemes should look beyond logged actions. If schemes also shape unrecorded behavior, evaluations that count only points will understate their benefits.

6. CONCLUSION

Carbon accounts ask citizens to believe that small actions matter. This study suggests that the belief depends on whether citizens can see how their actions are counted. Transparent schemes strengthened perceived consumer effectiveness, which in turn supported both continued participation and low-carbon behavior beyond the scheme. For China's carbon inclusion policy, making the ledger legible may be as important as making it rewarding.

This study has limitations. First, the cross-sectional, single-source design does not allow causal claims. Although our tests suggest that common method variance did not drive the results, reverse causality remains possible. Citizens who already feel effective may pay closer attention to scheme rules. Field experiments that vary the information shown in carbon account apps would provide stronger evidence. Second, everyday low-carbon behavior was self-reported. Future studies could link survey responses to app records for continued participation and to utility data for household energy use. Third, we sampled registered users in four large cities. Non-users and residents of smaller cities may respond differently, and future work could compare schemes with different rule designs. Fourth, we examined one mechanism, and the direct link between transparency and everyday low-carbon behavior shows that PCE is not the whole story. Future research could test whether trust in the scheme or reward value offers competing explanations, and whether factors such as environmental identity strengthen or weaken the pathway we found.

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APPENDIX

Appendix A: Measurement items

Construct and item
Perceived scheme transparency
Adapted from Rawlins (2009), covering the transparency objects in Grimmelikhuijsen and Meijer (2014). 1=strongly disagree, 5=strongly agree
TRN1. The carbon account clearly explains which of my actions earn carbon points.
TRN2. I understand how my carbon points are calculated.
TRN3. The account shows how my recorded emission reductions are verified.
TRN4. The rules for redeeming carbon points are clearly disclosed.
TRN5. The scheme explains how my personal data are used.
Perceived consumer effectiveness
Adapted from Ellen et al. (1991) and Kim and Choi (2005). 1=strongly disagree, 5=strongly agree
PCE1. What I do through my carbon account makes a difference to carbon emissions.
PCE2. My low-carbon actions add up to a meaningful contribution to China's carbon goals.
PCE3. By changing my daily habits, I can help reduce carbon emissions.
PCE4. Each person's low-carbon behavior can have a positive effect on the environment.
Continued participation intention
Adapted from Bhattacherjee (2001). 1=strongly disagree, 5=strongly agree.
CPI1. I intend to continue using my personal carbon account rather than stop using it.
CPI2. I intend to keep recording my low-carbon actions in the account.
CPI3. I plan to keep using the account in the coming months.
Everyday low-carbon behavior
Drawn from the behavior domains in Wang et al. (2024) and Usman et al. (2023). Stem: "In the past month, how often have you." 1=never, 5=always
LCB1. Turned off lights and appliances when they were not in use.
LCB2. Set the air conditioner to an energy-saving temperature.
LCB3. Reused bags, containers, or other items instead of discarding them.
LCB4. Avoided buying products I did not really need.
LCB5. Saved water when washing, cooking, or cleaning.
LCB6. Avoided wasting food at home.

Attention checks (placed in the transparency and behavior blocks): "To show you are reading carefully, please select "agree" for this item" and "Please select "disagree" for this item"