frontiers in Environmental Science

ORIGINAL RESEARCH
published: 24 November 2021
doi: 10.3389/fenvs.2021.783486

Will Low-Carbon Purchasing Behavior Make Residents' Behaviors Greener? Research Based on Spillover Effects

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Specialty section:
This article was submitted to Environmental Economics and Management, a section of the journal Frontiers in Environmental Science

Received: *26 September 2021*
Accepted: *01 November 2021*
Published: *24 November 2021*

Citation:
Yue T, Zhang L, Long R, Chen H, Gao C and Li M (2021) Will Low-Carbon Purchasing Behavior Make Residents' Behaviors Greener? Research Based on Spillover Effects. Front. Environ. Sci. 9:783486. doi: 10.3389/fenvs.2021.783486

Low-carbon purchasing behavior is the core part of low-carbon consumption behavior. Its impact on low-carbon use behavior, recycling behavior, and garbage sorting behavior needs to be further clarified. Based on self-perception theory and cognitive dissonance theory, this paper constructs a theoretical model of the spillover effect of low-carbon purchasing behavior on low-carbon use behavior, recycling behavior and garbage sorting behavior through self-efficacy and environmental self-identity. This paper uses the Bootstrap method to analyze 494 valid questionnaires empirically. The results show that: low-carbon purchasing behavior has a significantly positive effect on low-carbon use behavior, recycling behavior, and garbage sorting behavior. Self-efficacy and environmental self-identity play partially parallel mediating roles in the spillover effect. The mediating effect of environmental self-efficacy is stronger than environmental self-identity between low-carbon purchasing behavior and low-carbon use behavior. The mediating effect of self-efficacy is weaker than environmental self-identity between low-carbon purchasing behavior and recycling behavior or garbage sorting behavior. The spillover effects are different in demographic variables. The spillover effect of men is more substantial than women. The spillover effect of residents in 18–44 years old is more significant than residents in other age groups. The spillover effect of married residents is the largest. Residents with a bachelor's degree have the most significant spillover effects on recycling behavior and garbage sorting behavior than residents with other educational levels. Professional and technical personnel have the most considerable spillover effect than other occupation types. The spillover effect is the largest when the family have three members. The spillover effect of residents with a monthly household income of 6,000–8,000 yuan is the largest between low-carbon purchasing behavior and low-carbon use behavior.

Keywords: low-carbon purchasing behavior, self-efficacy, environmental self-identity, low-carbon use behavior, recycling behavior, garbage sorting behavior

1 INTRODUCTION

The IPCC fifth climate change assessment report strengthens the conclusion that global warming is caused by human activities (IPCC, 2015). The main cause of climate warming is the increasing concentration of greenhouse gases. Residents' behavior is an important factor affecting emissions of greenhouse gas (Wang, 2018). It not only directly affects energy consumption and domestic carbon emissions but also is the main driving factor of energy consumption and industrial carbon emissions (Pachauri and Spreng, 2002). And residents' consumption behavior has a direct impact on the low-carbon economy (Jin and Zhao, 2018).

This paper is concerned with several components of low-carbon consumption behavior: low-carbon purchasing behavior, low-carbon use behavior, recycling behavior and garbage sorting behavior. Low-carbon purchasing behavior is when residents consider factors such as resource utilization, resource efficiency and carbon dioxide emissions in their purchasing decisions, and in particular when residents prioritize the purchase of low-carbon products (Zhang, 2010). Low carbon use behavior is when residents manage and control the use of energy-consuming products in terms of clothing, food, housing, transportation, etc. (Mi et al., 2016). Recycling and garbage sorting behaviors are two closely related types of behavior which consider the way households separate the different types of waste (organic vs. plastic vs. paper vs. residual) and the way some parts of it are recycled (either through curbside collection or through bringing to centers). Similarly to low-carbon purchasing behavior, these types of behavior have the potential to reduce substantially carbon emissions (Liu et al., 2019).

The objective of this paper is to estimate the spillover effect of low-carbon purchasing behavior on low-carbon use behavior, recycling behavior and garbage sorting behavior. To this end, we surveyed randomly selected individuals on a variety of questions related to low-carbon purchasing behavior. The questions were stated in such a way, that they were clearly attributable to one of the studied dimensions (purchasing vs. use vs. sorting vs. recycling behaviors). Moreover, our questions included a time/causal dimension that allows us to identify the specific order of those behaviors. As an example, we ask the surveyed individuals whether they identify with the statement "After implementing low-carbon purchasing behavior, I think I am a low-carbon consumer." The richness of the questions in the data and the embedded causal dimension allows us to evaluate the effect of low-purchasing behavior on all other types of studied behaviors. Moreover, we observe a large number of sociodemographic variables which allows us to study the heterogeneity of this effect.

We find that low-carbon purchasing behavior has a positive effect on low-carbon use behavior, recycling behavior, and garbage sorting behavior. We interpret our positive findings in light of the so-called cognitive dissonance theory. This theory states that individuals pursue actions that help to maintain their goals in a consistent way (Festinger, 1958). Thus, the start of one pro-environmental behavior (such as purchasing behavior) can potentially trigger spillovers in other behaviors. This process is facilitated by individuals relating subsequent behaviors to past similar past behaviors (this is the so-called self-perception theory, see e.g., Bem, 1972). Our paper contributes to the literature in several ways. First, most of the studies have focused on the factors of low-carbon purchasing behavior such as sociodemographic, psychological, and contextual factors (Rahnama and Rajabpour, 2017; Zahan et al., 2020; Zhao et al., 2020). Our study contributes to that literature by focusing instead on the effect of low-carbon purchasing behavior on other pro-environmental behaviors. Thus, our paper is also related to the literature on pro-environmental behavioral spillovers, see e.g., Alacevich, Bonev and Söderberg JEEM 2021 for a recent study as well as "Maki, A., Carrico, A. R., Raimi, K. T., Truelove, H. B., Araujo, B., Yeung, K. L., 2019. Meta-analysis of pro-environmental behavior spillover. Nat. Sustain. 2 (4), 307–315" for a comprehensive review of this literature. Most commonly, the literature has studied spillover effects of behaviors at different times, spillover effects between different and unrelated environmental protection behaviors, spillover effects between behaviors with similar costs and spillover effects in different fields (Margetts and Kashima, 2017; Xu et al., 2018; Fanghella et al., 2019; Nash et al., 2019; Penz et al., 2019; Henn et al., 2020; Alacevich et al., 2021; Truelove et al., 2021; Yang et al., 2021). To the best of our knowledge, the relationship between different low-carbon consumption behavior has not been studied yet.

2 LITERATURE REVIEW

2.1 Spillover Effect

Behavior spillover effects refer to the observable causal impacts of one behavior on another, including positive spillover effect and negative spillover effect. Positive spillover effect refers to specific behavior that enhancing other behavior, and negative spillover effect refers to certain behaviors that weakening or inhibiting other behaviors (Truelove et al., 2014). In order to have spillover effect, firstly, behaviors are different, meaning it is not a related component of a single behavior. Low-carbon purchasing behavior, low-carbon use behavior, recycling behavior, and garbage sorting behavior are different behaviors. Secondly, behaviors are continuous. The behavioral variables in this paper are dynamic and coherent. Thirdly, there are a common motivation for implementing behaviors. The behavioral motivation in this paper is to reduce carbon dioxide emissions. Finally, a common link is involved. The behavioral variables in this paper all satisfy the above conditions. In general, the precondition for the spillover effect is established.

Low-carbon consumption behavior refers to the behavior of consumers to reduce carbon emissions by implementing low energy consumption, low pollution and low emission as much as possible during the consumption process, including the whole process of purchasing, using and disposing (Wang and He, 2011). Disposal behavior includes recycling behaviors and garbage sorting behavior. Recycling behavior refers to the behavior of residents who pay attention to product (or material) reduction and recycling after purchasing behavior (Wang, 2010). Garbage sorting behavior refers to the behavior of residents sorting and

collecting garbage at the source of production and placing it in designated locations (Liao, 2020).

Current research results on the spillover effect of low-carbon purchasing behavior are not consistent. For example, the study of (Thøgersen and Olander, 2003) showed that purchasing organic products had a negative spillover effect on subsequent recycling behavior, while the study of Catlin and Wang (2012) showed that purchasing organic products promoted sustainable behavior in other fields. The research of Mazar and Zhong (2010) found that behaviors after purchasing green products were more altruistic, and the research confirmed that residents' low-carbon consumption behavior had a positive effect on residents' environmental-friendly behavior from the perspective of goal commitment.

Accordingly, this paper proposes the following research hypotheses:

H1: Low-carbon purchasing behavior has a significantly positive effect on low-carbon use behavior;

H2: Low-carbon purchasing behavior has a significantly positive effect on recycling behavior;

H3: Low-carbon purchasing behavior has a significantly positive effect on garbage sorting behavior.

2.2 Self-Efficacy

Self-efficacy refers to the inference and judgment of an individual's ability to implement a specific behavior to achieve the desired effect in an organization (Bem, 1972). It is an essential factor that influences low-carbon behavior (Delgado and Aguayo, 2013). The research (Steinhorst et al., 2015) shows that when residents implement environmental protection behaviors, they can acquire the corresponding knowledge and skills, then increase the possibility of further environmental protection behaviors. According to the self-perception theory, self-efficacy is derived from people's past behavioral experiences. Individuals recall their behaviors related to this kind of thing firstly and then infer their attitudes based on past behaviors. Combined with the theory of planned behavior, attitudes have an indirect influence on behavior (Ajzen and Fishbein, 1997), so past behavior will affect the subsequent behavior of residents. People decide their future behaviors through perceived self-efficacy and past behaviors. Participating in low-carbon behaviors can increase relevant knowledge, skills and experience, thereby promoting other low-carbon behaviors (Nash et al., 2019).

Self-efficacy could stimulate behavioral participation and influences behavioral choices (Bandura 1986). Studies have shown that self-efficacy promotes residents to implement environmental protection behaviors, such as recycling behavior and using repeatable shopping bags (Muniandy et al., 2019). When residents feel a stronger sense of self-efficacy in environmental protection behaviors, they will make more outstanding efforts to engage in environmental protection behaviors. Adolescents with higher self-efficacy report more environmental behaviors than others. People with higher self-efficacy engage in more ecological behaviors (Delgado and Aguayo, 2013). Therefore, self-efficacy is an essential driving force for adaptation and behavior change (Lauren et al., 2016). Residents' sense of self-efficacy is related to household electricity consumption (Thøgersen and Grønhøj, 2010), so improving personal self-efficacy can promote individual behavior change.

Accordingly, this paper proposes the following research hypotheses:

H4: Self-efficacy plays a mediating role in spillover effect between low-carbon purchasing behavior and low-carbon use behavior;

H5: Self-efficacy plays a mediating role in spillover effect between low-carbon purchasing behavior and recycling behavior;

H6: Self-efficacy plays a mediating role in spillover effect between low-carbon purchasing behavior and garbage sorting behavior.

2.3 Environmental Self-Identity

Environmental self-identity refers to the degree to which individuals regard themselves as environmentalists (Liu and Wu, 2018). It is an important predictor of environmental behavior, and helps individuals distinguish themselves from others, and conforms to social groups' values, beliefs and behavior (Whitmarsh and O'Neill, 2010). We understand ourselves by observing our past behaviors (Lacasse, 2016), and infer what type of person we are through our past behaviors, thereby affecting the intensity of environmental self-identity. Residents who participate in more environmentally friendly behaviors report a stronger sense of environmental self-identity. Residents' environmental self-identity is stronger especially when past green behavior signal function is strong (Van der Werff et al., 2014). Therefore, residents' low-carbon purchasing behavior will make residents see themselves as low-carbon consumers, and their environmental self-identity will be stronger, thereby promoting subsequent low-carbon behaviors.

Environmental self-identity is a significant predictor of low-carbon behavior and a vital driving force for residents to implement low-carbon behavior. Residents with stronger environmental self-identity show greater attention to the environment, then increasing the possibility of participating in pro-environmental behaviors (Sorensen et al., 2015; Hansmann et al., 2020). Studies have shown that environmental self-identity is significantly related to personal environmental behavior (Dresner et al., 2015), and the frequency of past behaviors may ease the relationship between environmental self-identity and behavior. Environmental self-identity affects behavioral intentions, and people who call themselves "green consumers" are more likely to buy organic food (Whitmarsh and O'Neill, 2010). When residents realize that they have a stronger sense of environmental self-identity by implementing pro-environmental behaviors, they maintain a more positive attitude towards environmental policies (Delgado and Aguayo, 2013), then promoting residents to implement other low-carbon behaviors (Lalot et al., 2019).

Accordingly, this paper proposes the following research hypotheses:

H7: Environmental self-identity plays a mediating role in spillover effect between low-carbon purchasing behavior and low-carbon use behavior;

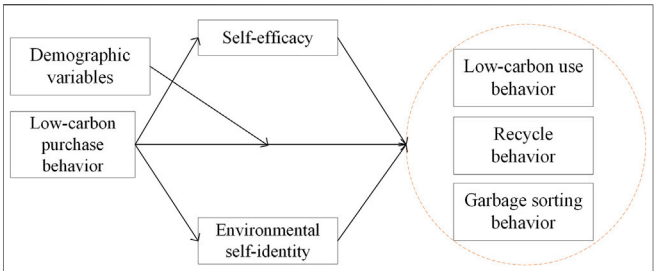

FIGURE 1 | Conceptual model construction.

H8: Environmental self-identity plays a mediating role in spillover effect between low-carbon purchasing behavior and recycling behavior;

H9: Environmental self-identity plays a mediating role in spillover effect between low-carbon purchasing behavior and garbage sorting behavior.

In summary, the theoretical framework constructed in this paper is shown in **Figure 1**.

3 METHODS

3.1 Data Collection

This paper uses an online questionnaire survey to collect data. From December 2020 to February 2021, 612 questionnaires were collected, of which 494 were valid, and the data efficiency was 80.72%. Among the valid samples, males accounted for 43.9% and females accounted for 56.1%. The age of the survey respondents was younger, of which 18–28 years old accounted for 53.2% and 29–44 years old accounted for 33.4%. The distribution of marital status was relatively even. The proportion of married people was 47.2% and unmarried accounted for 51.6%. Divorced and remarried families accounted for 1.2%. The educational level of the survey respondents was mainly at the college and undergraduate level, accounting for 68.0%. The survey respondents were distributed in various fields, party and government agencies, business units, state-owned enterprise staff accounted for 12.6%. Education, scientific research, and health personnel accounted for 14.6%. Professional and technical personnel accounted for 13.2%. Business, service industries and sales personnel accounted for 10.5%. Production, transportation equipment operators and related personnel accounted for 8.7%. Freelancers accounted for 7.5%. Students accounted for 27.7%. Homemakers, retirees and other professionals accounted for 5.2%. Residents' families mainly were three or four people, accounting for up to 71.1%. The monthly income level of households is relatively evenly distributed. The monthly income level of 4,000 yuan or less accounted for 14.8%. The monthly income level of 4,000–6,000 yuan accounted for 21.9%. The monthly income level of 6,000–8,000 yuan accounted for 21.3%. The monthly income level of 8,000–10,000 yuan accounted for 18.6%, and 10,000–30,000 yuan accounted for 19.8%.

3.2 Measuring Tools

All scales in this paper refer to domestic and foreign literature, and all items are scored by Likert 5 points, 1–5 respectively indicate "very inconsistent-very consistent". Low-carbon purchasing behavior refers to the research of Wang et al. (2020) (Wang 2016; Long and Yue, 2017) including four items, such as "I don't buy unnecessary clothes", "I don't buy over-packaged products". Self-efficacy refers to the study of Huang et al. (2016) including four items, such as "I believe that my low-carbon purchasing behavior can reduce carbon dioxide emissions", "After implementing low-carbon purchasing behavior, I believe I can take actions to reduce carbon dioxide emissions". Environmental self-identity refers to the research of Whitmarsh and O'Neill (2010), including three items, such as "After implementing low-carbon purchasing behavior, I think I am a low-carbon consumer", "After implementing low-carbon purchasing behavior, I even think that I am a person who cares about carbon emissions". Low-carbon use behavior refers to the study of Long and Yue (2017), Mi et al. (2019) including six items, such as "When I use the air conditioner, the temperature setting in summer is not lower than 26°C, and the temperature setting in winter is not higher than 20°C to save electricity", "When the home appliance is not in use, I will actively turn off the power (turn off the switch)"; Recycling behavior refers to the study of Darby and Obara (2005), Wang (2007) including five items, such as "I will recycle products as long as possible until they are completely discarded". Garbage sorting behavior refers to the study of Liao (2020), including three items, such as "I separate recyclable waste such as waste paper and plastic bottles and put them out separately when I throw out the garbage." The reliability coefficients of the scales are shown in **Table 1**. The reliability coefficient of low-carbon purchasing behavior and environmental self-identity are above 0.6. The reliability coefficient of low-carbon use behavior is above 0.7. The reliability coefficients of self-efficacy, recycling behavior, and garbage sorting behavior are above 0.8, indicating that the scales have good reliability.

4 RESULTS

4.1 Common Method Deviation and Discriminative Validity Test

This paper uses Harman's single factor test to verify the homology error problem. The results show that the first factor without rotation explains 12.32% of the variation of all measurement items of each variable, which is less than 40%, indicating that the data in this paper does not have a serious homology deviation problem.

Confirmatory factor analysis was conducted to test the validity of all variables. The results are shown in **Table 2**,and a six-factor model χ^2/df is below 3, CFI is above 0.9, IFI is above 0.9, TLI is

TABLE 1 | Cronbach's α.

Variables	Low-carbon purchasing behavior	Self-efficacy	Environmental self-identity	Low-carbon use behavior	Recycling behavior	Garbage sorting behavior
Cronbach's α	0.682	0.826	0.669	0.780	0.828	0.834

TABLE 2 | Confirmatory factor analysis.

Model	χ^2	df	χ^2/df	CFI	IFI	TLI	RMSEA
Six-factor model	632.253	237	2.668	0.917	0.918	0.904	0.058
Five-factor model	772.367	242	3.192	0.889	0.890	0.873	0.067
Four-factor model	854.720	246	3.474	0.872	0.873	0.857	0.071
Three-factor model	1,139.867	249	4.578	0.813	0.814	0.793	0.085
Two-factor model	1,493.212	251	5.949	0.740	0.741	0.714	0.100
One-factor model	1,760.760	252	6.987	0.684	0.685	0.654	0.110

TABLE 3 | Descriptive statistical analysis.

Behavior	Mean	SD	Low-carbon purchasing behavior	Self-efficacy	Environmental self-identity	Low-carbon use behavior	Recycling behavior	Garbage sorting behavior
Low-carbon purchasing behavior	3.995	0.679	1					
Self-efficacy	4.139	0.633	0.433**	1				
Environmental self-identity	4.093	0.617	0.388**	0.570**	1			
Low-carbon use behavior	4.103	0.631	0.436**	0.494**	0.502**	1		
Recycling behavior	3.916	0.781	0.395**	0.405**	0.447**	0.602**	1	
Garbage sorting behavior	3.871	0.947	0.297**	0.365**	0.384**	0.556**	0.558**	1

** *Indicates significance level of 1%.*

above 0.9, RMSEA is below 0.8, all meet the standard requirements, and the fitting effect is the best, indicating that the six variables in this paper have good discrimination validity.

4.2 Descriptive Statistical Analysis

Table 3 shows the mean values, standard deviations, and Pearson's correlation coefficients of the variables. It can be seen that the average value of low-carbon use behavior is larger than low-carbon purchasing behavior. The average value of recycling behavior and garbage sorting behavior is less than low-carbon purchasing behavior. This is because residents with low-carbon purchasing behavior scores larger than three points are selected to be valid questionnaires to ensure that residents implement low-carbon purchasing behavior regularly to make the data results more convincing. From the perspective of correlation analysis, low-carbon purchasing behavior and self-efficacy, environmental self-identity, low-carbon use behavior, recycling behavior, and garbage sorting behavior are all significantly positively correlated. Self-efficacy, environmental self-identity and low-carbon use behavior, recycling behavior, and garbage sorting behavior are all significantly positively correlated.

4.3 Hypotheses Test

4.3.1 Main Effects

We estimate a regression of the form $Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8$+ epsilon, where the dependent variable Y is the score obtained on question. Variables Y are low-carbon use behavior, recycling behavior, and garbage sorting behavior respectively. The main explanatory variable X_1 is the score obtained on the low-carbon purchasing behavior. Other variables X_2 to X_8 are the score obtained on the socio-demographic variables, including sex, age, marital status, education level, occupation type, number of family members, and family monthly income level. Epsilon is the error term which we assume to be independent of the covariates. The results are displayed in **Table 4**.

According to this result, an increase of one unit of low-carbon purchasing behavior corresponds to an increase of 0.407 (β = 0.407, p = 0.000 < 0.001) of low-carbon use behavior under the control of covariates, so the hypothesis H1 is verified. An increase of one unit of low-carbon purchasing behavior corresponds to an increase of 0.359 (β = 0.359, p = 0.000 < 0.001) of recycling behavior under the control of covariates, so the hypothesis H2 is verified. An increase of one unit of low-carbon purchasing

TABLE 4 | Direct effect analysis.

Variables	Low-carbon use behavior	Recycling behavior	Garbage sorting behavior
Sex	–0.045	0.014	–0.039
Age	0.099	0.108*	0.009
Marital status	–0.069	–0.045	–0.077
Education level	–0.054	–0.006	–0.062
Occupation type	0.003	–0.101*	–0.087
Number of family members	–0.004	–0.035	–0.037
Family monthly income level	0.055	0.004	0.011
Low-carbon purchasing behavior	0.407**	0.359**	0.266**
R^2	0.212	0.176	0.099
ΔR^2	0.160	0.123	0.067
F	43.949	36.193	19.033

*Note: ** and * indicate significance levels of 1 and 5%, respectively.*

TABLE 5 | The mediating effect of self-efficacy and environmental self-identity.

Behavior	Effect	β	Boot SE	Boot LLCI	Boot ULCI	Relative effect size (%)
Low-carbon use behavior	Total indirect effect	0.206	0.031	0.149	0.269	52.59
	Self-efficacy	0.111	0.027	0.062	0.169	28.30
	Environmental self-identity	0.095	0.024	0.053	0.144	24.29
Recycling behavior	Total indirect effect	0.184	0.036	0.118	0.258	44.97
	Self-efficacy	0.071	0.031	0.014	0.135	17.25
	Environmental self-identity	0.113	0.029	0.061	0.175	27.72
Garbage sorting behavior	Total indirect effect	0.220	0.044	0.141	0.311	59.91
	Self-efficacy	0.103	0.039	0.033	0.185	27.98
	Environmental self-identity	0.117	0.034	0.056	0.187	31.93

behavior corresponds to an increase of garbage sorting behavior corresponds to an increase of 0.266 ($\beta = 0.266$, $p = 0.000 < 0.001$) of garbage sorting behavior under the control of covariates, so the hypothesis H3 is verified. And the effect is economically significant, not only statistically.

4.3.2 The Mediation Test of Spillover Effect

The Bootstrapping method was used to analyze the mediating effect of self-efficacy and environmental self-identity between low-carbon purchasing behavior and low-carbon use behavior, recycling behavior, or garbage sorting behavior in the control of gender, age, marital status, educational background, occupation type, number of family members, and family monthly income level. The Bootstrapping method takes 5,000 samples and tested the mediating effect of self-efficacy and environmental self-identity against 95% confidence interval. If the confidence interval does not include 0, the effect is significant. If the confidence interval includes 0, the effect is not significant.

Table 5 shows the parallel mediating effect analysis. It can be seen that self-efficacy and environmental self-identity play a parallel mediating role between low-carbon purchasing behavior and low-carbon use behavior, recycling behavior, and garbage sorting behavior. For the spillover effect of low-carbon purchasing behavior on low-carbon use behavior, the mediating effect of self-efficacy is stronger than environmental self-identity. When it targets the spillover of recycling behavior and garbage sorting behavior, the mediating effect of self-efficacy is weaker than environmental self-identity.

4.3.3 The Mediating Role of Self-Efficacy

To analyze the mediating effect of self-efficacy, the Bootstrapping method was used. The spillover effect of low-carbon purchasing behavior on low-carbon use behavior is significant ($\beta = 0.409$, $t = 9.874$, $p < 0.05$). And when placed in self-efficacy after the variables, the spillover effect of low-carbon purchasing behavior on low-carbon use behavior is still significant ($\beta = 0.252$, $t = 5.986$, $p < 0.05$). The positive predictive effect of low-carbon purchasing behavior on self-efficacy is significant ($\beta = 0.415$, $t = 9.970$, $p < 0.05$). Self-efficacy has a significant positive predictive effect on low-carbon use behavior ($\beta = 0.379$, $t = 9.041$, $p < 0.05$). In addition, the upper and lower bounds of the Bootstrap 95% confidence interval of the direct effect of low-carbon purchasing behavior on low-carbon use behavior and the mediating effect of self-efficacy do not contain 0, so the hypothesis H4 is verified. The spillover effect of low-carbon purchasing behavior on recycling behavior is significant ($\beta = 0.356$, $t = 8.388$, $p < 0.05$). When the self-efficacy is put into it, the spillover effect of low-carbon purchasing behavior on recycling behavior is still significant ($\beta = 0.242$, $t = 5.386$, $p < 0.05$). Self-efficacy has a significant positive predictive effect on recycling behavior ($\beta = 0.275$, $t = 6.164$, $p < 0.05$). So the hypothesis of H5 is

TABLE 6 | The direct and mediating effects of self-efficacy.

Behavior	Effect	β	Boot SE	Boot LLCI	Boot ULCI	Relative effect size (%)
Low-carbon use behavior	Total effect	0.398	0.040	0.319	0.477	
	Direct effect	0.245	0.041	0.165	0.326	61.56
	Indirect effect	0.153	0.028	0.102	0.213	38.44
Recycling behavior	Total effect	0.409	0.049	0.313	0.504	
	Direct effect	0.278	0.052	0.176	0.379	67.97
	Indirect effect	0.131	0.033	0.072	0.202	32.03
Garbage sorting behavior	Total effect	0.368	0.062	0.246	0.489	
	Direct effect	0.202	0.065	0.074	0.330	54.89
	Indirect effect	0.166	0.038	0.095	0.243	45.11

verified. The spillover effect of low-carbon purchasing behavior on garbage sorting behavior is significant (β = 0.264, t = 5.958, $p < 0.05$). When the self-efficacy is put into it, the spillover effect of low-carbon purchasing behavior on garbage sorting behavior is still significant (β= 0.145, t = 3.094, $p < 0.05$). The positive predictive effect of self-efficacy on garbage sorting behavior is also significant (β = 0.286, t = 6.147, $p < 0.05$). So the hypothesis H6 is verified. It can be seen that low-carbon purchasing behavior not only has a positive spillover effect on low-carbon use behavior, recycling behavior, and garbage sorting behavior, but also can influence the spillover process through the mediation effect of self-efficacy. Among them, low-carbon purchasing behavior has a positive impact on low-carbon use behavior. The direct spillover effect of behavior accounted for 61.56% of the total effect, the direct spillover effect of low-carbon purchasing behavior on recycling behavior accounted for 67.97% of the total effect, and the direct spillover effect of low-carbon purchasing behavior on garbage sorting behavior accounted for 54.89% of the total effect. The results are shown in **Table 6**.

4.3.4 The Mediating Role of Environmental Self-Identity

To analyze the mediating effect of environmental self-identity, the Bootstrapping method was used. The spillover effect of low-carbon purchasing behavior on low-carbon use behavior is significant (β = 0.409, t = 9.874, $p < 0.05$). When placed in environmental self-identity after the variables, the spillover effect of low-carbon purchasing behavior on low-carbon use behavior is still significant (β = 0.263, t = 6.445, $p < 0.05$). Low-carbon purchasing behavior has a positive effect on environmental self-identity (β = 0.369, t = 8.719, $p < 0.05$). The positive predictive effect of environmental self-identity on low-carbon use behavior is significant (β = 0.396, t = 9.739, $p < 0.05$). In addition, the upper and lower bounds of the Bootstrap 95% confidence interval for the direct effect of low-carbon purchasing behavior on low-carbon use behavior and the mediating effect of environmental self-identity do not contain 0, so the hypothesis H7 is verified. The spillover effect of low-carbon purchasing behavior on recycling behavior is significant (β = 0.356, t = 8.388, $p < 0.05$). When the environmental self-identity is put into it, the spillover effect of low-carbon purchasing behavior on recycling behavior is still significant (β= 0.232, t = 5.393, $p < 0.05$). The positive predictive effect of environmental self-identity on recycling behavior is also significant (β = 0.335, t = 7.811, $p < 0.05$). So the hypothesis H8 is verified. The spillover effect of low-carbon purchasing behavior on garbage sorting behavior is significant (β = 0.264, t = 5.958, $p < 0.05$). When environmental self-identity is put into it, the spillover effect of low-carbon purchasing behavior on garbage sorting behavior is still significant (β= 0.149, t = 3.282, $p < 0.05$). The positive predictive effect of environmental self-identity on garbage sorting behavior is also significant (β = 0.310, t = 6.824, $p < 0.05$). So the hypothesis H9 is verified. It can be seen that low-carbon purchasing behavior not only has a positive spillover effect on low-carbon use behavior, recycling behavior, and garbage sorting behavior, but also can affect the spillover process through the mediating effect of environmental self-identity. Among them, low-carbon purchasing behavior has a positive impact on low-carbon use behavior. The direct spillover effect of behavior accounted for 64.32% of the total effect, the direct spillover effect of low-carbon purchasing behavior on recycling behavior accounted for 65.28% of the total effect, and the direct spillover effect of low-carbon purchasing behavior on garbage sorting behavior accounted for 56.52% of the total effect. The results are shown in **Table 7**.

4.3.5 Analysis of the Difference of Spillover Effect on Demographic Variables

Using regression analysis to calculate the regression coefficients of low-carbon purchasing behavior on low-carbon use behavior, recycling behavior and garbage sorting behavior on different demographic variables, and analyze the difference in spillover effects by analyzing the regression coefficients. The calculation result is shown in **Table 8**. It shows that from the perspective of gender, the spillover effect of low-carbon purchasing behavior of men is stronger than women, especially in the spillover effect on recycling behavior and garbage sorting behavior. The common point is that the spillover effect of low-carbon purchasing behavior on low-carbon use behavior is the largest, followed by recycling behavior and garbage sorting behavior. From the perspective of age, 18–28 years old and 29–44 years old have a more significant spillover effect than other age groups. For all age groups, 29–44 years old residents' low-carbon purchasing behavior has the largest spillover effect on low-carbon use

TABLE 7 | Direct and mediating effects of environmental self-identification.

Behavior	Effect	β	Boot SE	Boot LLCI	Boot ULCI	Relative effect size (%)
Low-carbon use behavior	Total effect	0.398	0.040	0.319	0.477	
	Direct effect	0.256	0.040	0.178	0.334	64.32
	Indirect effect	0.142	0.026	0.096	0.197	35.68
Recycling behavior	Total effect	0.409	0.049	0.313	0.504	
	Direct effect	0.267	0.049	0.169	0.364	65.28
	Indirect effect	0.142	0.030	0.087	0.203	34.72
Garbage sorting behavior	Total effect	0.368	0.062	0.246	0.489	
	Direct effect	0.208	0.064	0.084	0.333	56.52
	Indirect effect	0.159	0.035	0.098	0.235	43.21

TABLE 8 | Difference analysis of spillover effects of demographic variables.

Profile		Low-carbon use behavior	Recycling behavior	Garbage sorting behavior
Sex	Male	0.456**	0.444**	0.352**
	Female	0.415**	0.354**	0.246**
Age	17 years old and below	0.480	0.369	0.540*
	18–28 years old	0.331**	0.330**	0.234**
	29–44 years old	0.612**	0.502**	0.390**
	45–59 years old	0.190	0.314*	0.114
	60 years old and above	0.225	0	0.393
Marital status	Married	0.499**	0.444**	0.320**
	Unmarried	0.357**	0.328**	0.246**
	Divorced	0.073	0.707	0.076
Education level	Junior high school and below	0.439*	0.498*	0.191
	High school or technical secondary school	0.477**	0.278*	0.222
	Junior college	0.463**	0.237*	0.143
	Undergraduate	0.492**	0.503**	0.388**
	Master's degree and above	0.244*	0.207	0.237*
Occupation type	Party and government agencies, business units, state-owned enterprises staff	0.374**	0.452**	0.172
	Personnel in the fields of education, scientific research and health	0.285*	0.202	0.233*
	Professional and technical worker	0.67**	0.518**	0.477**
	Business, service industries and sales personnel	0.406**	0.375	0.224
	Production and transportation equipment operators and related personnel	0.592**	0.523**	0.258
	Freelancer	0.461**	0.326*	0.296
	School student	0.370**	0.323**	0.275**
	Homemaker	0.776*	0.696	0.607
	Retired personnel	−0.932	−0.393	−0.010
	Other	0.087	0.089	−0.281
Number of family members	1–2 people	0.319	0.198	0.083
	3 people	0.599**	0.582**	0.448**
	4 people	0.459**	0.353**	0.308**
	5 people and above	0.265**	0.287**	0.161
Family monthly income level	below 4,000 yuan	0.273*	0.204	0.108
	4,000–6,000 yuan	0.356**	0.365**	0.336**
	6,000–8,000 yuan	0.587**	0.461**	0.462**
	8,000–10,000 yuan	0.479**	0.364**	0.338**
	10,000–30,000	0.467**	0.481**	0.224*
	30,000–100,000	0.468	0.401	0.229
	More than 100,000 yuan	0.778*	0.731	0.245

*Note: ** and * indicate significance levels of 1 and 5%, respectively.*

behavior and recycling behavior. The low-carbon purchasing behavior of residents aged 17 and under has the largest spillover effect on garbage sorting behavior. The spillover effect of low-carbon purchasing behavior on recycling behavior of residents aged 45–59 years old is significant. In contrast, the spillover effect on low-carbon use behavior and garbage sorting behavior is not significant. Besides, the spillover effect of low-carbon purchasing behavior of residents aged 60 and

above is not significant. As for the spillover effect on recycling behavior, the regression coefficient of is 0, indicating that for residents of this age, there is no linear relationship between the implementation of recycling behavior and the implementation of low-carbon purchasing behavior. From the perspective of marital status, the spillover effect of low-carbon purchasing behavior of married residents is the largest. With unmarried residents, the common point of spillover effects is that low-carbon purchasing behavior has the largest spillover effect on low-carbon use behavior, then followed by recycling behavior, and finally garbage sorting behavior. The spillover effect of divorced residents is not significant. For education level, low-carbon purchasing behaviors of undergraduate residents have the largest spillover effect on recycling behavior and garbage sorting behavior. Low-carbon purchasing behaviors of residents with a master's degree or above have no significant spillover effects on recycling behavior. The spillover effect coefficients of recycling behavior and garbage sorting behavior are respectively 0.244 and 0.295, and they are significant at the level of 5%. From the perspective of occupation type, the spillover effect of professional and technical personnel is the largest compared with other occupation types, and the spillover effect of school students is smaller. The low-carbon purchasing behavior of homemakers has the largest spillover effect on low-carbon use behavior, while the spillover effect on recycling behavior and garbage sorting behavior is not significant. The spillover effect of low-carbon purchasing behavior of retired people on low-carbon use behavior and recycling behavior is not significant. However, the regression coefficient is negative. This may be due to the moral permission effect of such residents after they have implemented low-carbon purchasing behavior. They allow themselves to do nothing in other low-carbon behaviors. From the perspective of the number of family members, the spillover effect of households with one or two members is not significant, the spillover effect with three members is the largest, and the low-carbon purchasing behavior of residents with four members has the largest spillover effect on the low-carbon use behavior then followed by recycling behavior, and finally garbage sorting behavior. From the perspective of household monthly income level, households with a monthly household income level of 6,000–8,000 yuan have the largest spillover effect on low-carbon use behavior. The second is garbage sorting behavior, and then is recycling behavior. Residents with a monthly household income level of 8,000–10,000 yuan have the largest spillover effect on low-carbon use behavior, followed by recycling behavior and garbage sorting behavior. Residents with a monthly household income level of 10,000–30,000 yuan has the largest spillover effect on recycling behavior, then followed by low-carbon use behavior, and finally garbage sorting behavior. The spillover effect of households with a monthly household income of 30,000 to 100,000 yuan is not significant. Residents with a monthly household income more than 10,000 yuan have the largest spillover effect on low-carbon use behavior. The spillover effect on recycling behavior and garbage sorting behavior is not significant.

5 DISCUSSION

This paper discusses the dynamic relationship between low-carbon purchasing behavior and low-carbon use behavior, recycling behavior, and garbage sorting behavior. Firstly, it takes residents with good practices in low-carbon purchasing behavior as the research object. It finds that low-carbon purchasing behavior has a positive spillover effect on behavior in the low-carbon consumption field, which supplements the evidence for the positive spillover effect of low-carbon purchasing behavior. Secondly, based on the self-perception theory and cognitive dissonance theory, this paper reveals the mediating role of self-efficacy and environmental self-identity, and explores the spillover path of low-carbon purchasing behavior, and expands the applying scope of the theory of self-perception and cognitive dissonance.

Firstly, relevant policymakers should pay attention to the positive spillover effects of low-carbon purchasing behavior, and formulate relevant policies to promote residents' low-carbon purchasing behavior, such as reducing the purchasing cost of low-carbon products and giving relevant preferential treatment or rewards to residents who implement low-carbon purchasing behavior. Giving full support to the positive spillover effects of low-carbon purchasing behavior through the invisible infiltration of relevant policies. Secondly, the government should be aware of the importance of residents' self-efficacy and environmental self-identity to low-carbon behavior. The government can improve residents' self-efficacy and environmental self-identity through corresponding measures, such as holding relevant lectures and organizing corresponding low-carbon behaviors activities to allow residents to participate. Besides, the government should combine with corresponding institutional regulations to guide residents to transform their sense of self-efficacy and environmental self-identity into more low-carbon behaviors. Thirdly, producers of low-carbon products can give consumers relevant feedback in time on the product packaging, such as attaching corresponding thank-you words on the packaging, "Thank you for your contribution to a low-carbon society" and so on to strengthen residents' low-carbon self-efficacy and environmental self-identity after purchasing behaviors to promote positive spillover of residents' low-carbon purchasing behaviors. Finally, low-carbon product marketers could design different marketing programs for different people, such as designing different publicity programs for men and women to promote their low-carbon purchasing behavior.

6 CONCLUSION

Based on self-perception theory and cognitive dissonance theory, this paper constructs a theoretical model of the spillover effects of low-carbon purchasing behavior on low-carbon use behavior,

recycling behavior, and garbage sorting behavior through self-efficacy, environmental self-identity, and draws the following conclusions:

Firstly, low-carbon purchasing behavior has a significant positive impact on low-carbon use behavior, recycling behavior, and garbage sorting behavior, confirming that low-carbon purchasing behavior has a positive spillover effect on low-carbon use behavior, recycling behavior, and garbage sorting behavior, so it will make residents' behaviors greener.

Secondly, self-efficacy and environmental self-identity play a parallel mediating role between low-carbon purchasing behavior and low-carbon use behavior, recycling behavior, and garbage sorting behavior. The mediating effect of environmental self-identity is stronger than environmental self-identity between low-carbon purchasing behavior and low-carbon use behavior. The mediating effect of self-efficacy is weaker than environmental self-identity between low-carbon purchasing behavior and recycling behavior or garbage sorting behavior.

Finally, the spillover effects of low-carbon purchasing behavior are different in different demographic variables. The spillover effect of male residents is stronger than that of female residents. The spillover effect of residents aged 29–44 is stronger than that of residents aged 18–28. Residents with a degree of undergraduate education have a stronger spillover effect than those with a college degree or below, and the spillover effects vary by occupation types. The spillover effect is the strongest for residents with three family members, and the spillover effect of households with a monthly household income of 6,000–8,000 is significantly stronger than other residents.

However, there are some limitations. Firstly, there is no investigation on the residents' self-efficacy and environment before implementing low-carbon purchasing behavior. This paper only measured residents' self-efficacy and environment after low-carbon purchasing behavior. Therefore, future research can explore these two aspects and observe the psychological changes in the spillover effect. Although the data the researchers have are theoretically-aligned, they are cross-sectional, future research could use experimental designs to causally demonstrate spillover effect. Besides, the measurement of the intermediary variables in this article is to ask residents how the various psychological variables feel after implementing low-carbon purchasing behavior, which may invisibly remind residents to recall their low-carbon purchasing behavior. Therefore, future research can consider exploring the mediating roles of residents' self-reflection and low-carbon labels.

DATA AVAILABILITY STATEMENT

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

AUTHOR CONTRIBUTIONS

Guiding in the experiment and revising the manuscript: TY. Conducting the experiment and writing the original draft: LZ. Project administration: RL. Supervision: HC. Assisting in the experiment: CG. Data collection: ML.

FUNDING

This study was financially supported by grants from the National Natural Science Foundation of China (grant numbers 72074211, 71603257, 71874188, and 71904187). Major Projects of the National Social Science Foundation (grant number 19ZDA107); Key Projects of the National Social Science Foundation (grant number 18AZD014); Major Projects of Philosophy and Social Science Research in Jiangsu Universities (grant number 2018SJZDA008), we also received funding from the General Financial Grant project from the China Postdoctoral Science Foundation (Grant No.2016M601920).

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