



## Original Research

## Consumer perceptions and behaviors toward take-out food plastic packaging reduction: A case study of college students in China

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## ABSTRACT

With the prevalence of online take-out food, the increasingly generated single-use plastic packaging waste has aroused public concern in the context of combating plastic pollution globally. The majority of present studies have focused on product design and policy design to influence the corporate behaviors in packaging waste management. Few attentions have been concentrated on consumer perceptions, a neglected vital factor in commercial practices, which determines whether the proposed measures can be effectively applied. This study takes college students, the main consumer group of take-out who are most likely to receive new environmental protection concepts, as a case study and employs the contingent valuation method to investigate their perceptions and behaviors toward emerging plastic packaging reduction approaches and taxation mechanisms. It was found that packaging circulation was preferred mostly with a proportion of 73.20% of the respondents, while taxation mechanism was more favored by those who have higher daily expenditure on meals. Gender, living costs and ordering frequency could significantly influence the acceptance levels. Therefore, a circulation mechanism using cabinet near take-out food hot spots and third-party cleaning services could target students and officers as pioneers. Regarding the taxation approach, it was suggested that the payment that most of the respondents could accept is 1.5 CNY. This study serves as a reference for the reduction of plastic waste from take-out packaging on campus, and provides a possible model that could reduce the environmental impacts of take-out food packaging through both taxation and circulation measures. The findings are expected to bring primary insights for take-out food plastic packaging reduction in China. For future studies, the methodology of this study was also well-prepared to investigate a larger scale of consumers and develop a more universal policy.

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## 1. Introduction

With the popularity and development of the Internet, the Online-to-Offline (O2O) business mode, which combines offline services and Internet platforms, has emerged (Liu, 2017a). The online take-out food platform is an O2O e-commerce mode that effectively combines the traditional restaurant industry with logistics and delivery services (Lu & Li, 2013). China's take-out food industry has developed rapidly since 2009 (Li & Jiang, 2017). It was indicated by the Data Center of the China Internet (DCCI, 2019) that 85.6% of Internet users in China use online take-out food services, and Meituan Take-out Food occupies the largest

market share among these platforms, reaching 64.6%. As of April 2019, the amount of take-out orders on Meituan exceeded 25 million units per day (Wen, 2019). However, at the same time, the plastic waste generated by take-out food packaging and tableware has become a heated issue, especially at a time when both the international community and China have made plastic pollution control a high priority in environmental management. It is suggested that the large quantities of plastic packaging waste from take-out food lead to negative environmental externalities (Xie & Song, 2018). It has been estimated that each single take-out food order consumes an average of 3.27 disposable plastic meal boxes/cups, 1 set of take-out tableware and 1 take-out bag (Kou & Feng, 2017). In 2018, the consumption of single-use plastic (SUP) containers for take-out food was estimated to be 1.76 million metric tons — a stunning amount (Tu, 2020). These SUP wastes could contaminate soil, water and

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farms, and reducing consumption of SUP is urgently needed (Chen et al., 2021).

The materials composing take-out food packaging vary, but the majority are plastic. Polypropylene (PP) plastic has stable physical and chemical properties, enabling it to be reused (Thong Guan Industries Berhad, 2020). Sixty percent of take-out meal boxes are made of PP plastic, with the percentage reaching 90% in some cities, dominating the market with an absolute advantage. For take-out food packaging bags, high density polyethylene (HDPE) plastic dominates the market with over a 95% share (Wen et al., 2019). Polyethylene glycol terephthalate (PET) plastics are also often used for beverage bottles (Center for Food Safety, 2012). Recently, degradable plastics (usually polylactic acid, PLA) have also been used to improve the environmental performance of take-out food packaging (Kong et al., 2021). Nevertheless, it is worth mentioning that the largest quantity of plastics is causing persistent pollution and damaging both marine and terrestrial ecosystems (UNEP, 2021). As several studies have shown, the production process of plastic take-out packaging consumes large amounts of resources such as oil and wood, and it also produces water pollutants and air pollutants that cause eutrophication, lead to global warming, induce acid precipitation and emit inhalable inorganic substances that are toxic to human health (Luo, 2021; Wen et al., 2019).

The Chinese government has made it a priority to tackle the plastic pollution problem and improve the environment. On January 19, 2020, the government issued *Opinions on Further Strengthening the Control of Plastic Pollution* (hereinafter referred to as “*The Opinions*”), according to which the restriction on single-use plastic consumption and re-utilization of waste plastic are two of the key measures. Online take-out food is regarded as a critical sector, since food packaging consumes vast amounts of single-use plastics (NDRC, 2020). *The Opinions* reveals the determination of China to solve plastic-related pollution, and provides a solid foundation for solving the take-out food-packaging waste problem. Acknowledging this reality, circulation of take-out food packaging is one way of reducing the amount of waste and thereby the environmental impacts. Research has found that the environmental impacts could be reduced up to 38% for every 10% increase in the reuse rate of PP containers (Gallego-Schmid et al., 2019). From another perspective, most consumers believe plastic bags are necessary (Kasznik & Łapniewska, 2023), therefore they will have psychological identity and make practical efforts. However, the development of reusable meal boxes in China is still in its infancy, with neither a perfect reusable alternative to existing materials, nor a corresponding mandatory policy to support the reuse of meal boxes (Zhu et al., 2020).

Considering this situation, a substantial number of studies have focused on both packaging designs and circulation schemes. Regarding the meal box, studies had proposed reusable take-out meal boxes as one of the solutions (Liu, 2017b; Zhu et al., 2019), while the circulation systems have also been studied, including online applications and onsite cabinets, to reduce the amount of take-out food packaging (Song et al., 2018; Wang et al., 2018). Reverse logistic systems have been considered for this problem, with clear regulations of entity responsibilities (Tian & Xie, 2018). The sharing of tableware has also been studied and found to have significant effects in reducing take-out food waste generation (Zhou et al., 2020). A nod-and-network-based circulation system has been researched, using simulation modelling to analyze the interactions among entities (Yu, 2018). Although implementing reusable take-out food packaging and circulation schemes could be difficult enough, consumers' perceptions and behaviors—especially their acceptance of any circulation scheme—are even more serious problems that research has rarely studied. It has been shown that people's decisions about whether they are willing to reuse such

packaging are largely driven by the properties of the packaging itself (Greenwood et al., 2021). Scholars have also discussed how to increase the return rates, and found that a cash reward is one of the most effective choices (Numata, 2016). It has been shown, however, that when a small group of people rent reusable meal boxes, others will follow this example (Dorn & Stöckli, 2018). In addition, it has also been proposed to combine promotion, both online and offline, to subconsciously make the public more willing to recycle take-out food packaging (Xue et al., 2020). Consumer perceptions on food packaging have as well been investigated by a recent study (Macht et al., 2023). Notably, in the context of China, the escalation of e-commerce has led to a substantial augmentation in food packaging waste generated by online take-out food services. Consequently, a noteworthy study void persists pertaining to the explicit apprehensions and conduct exhibited by consumers with respect to the life cycle of take-out food packaging. Of particular interest are consumer attitudes towards the feasibility and hygienic aspects associated with packaging reuse.

As 84.8% of college students order take-out food frequently (Zhang et al., 2022) and more than half of the take-out food orders are made by college students, including postgraduates (The Prospective Economist, 2021), to simplify the methodology, this study was designed to explore direct concerns and reactions of college students toward the circulation of take-out food packaging. In addition, to diversify the results, this study put forward a second choice for consumers—a taxation scheme, where the revenue raised would be used to collect marine plastic litter. The aim was to compare the perception and preference of consumers toward these two mechanisms, as research shows most people would like to donate for plastic waste management (Nguyen et al., 2023). It should be noted that take-out food packaging consists of a packing bag and meal boxes, as take-out tableware in China is usually disposable chopsticks, which are hard to reuse or recycle. The circulation mechanism put forth in this study includes the collection, cleaning and reuse phases for reusable food packaging in a useable condition, as well as the collection and recycling phases for non-reusable or damaged food packaging.

By investigating the consumer perceptions and behaviors of college students, this study found substantial conclusions and quantitative mental accounts for reducing take-out food plastic packaging. Based on the results, this study promoted a possible business model that could reduce take-out food plastic packaging practically, in accordance with consumers' perceptions and behaviors. In addition, the results could bring adequate insights to policy designing and the methodology could also contribute to further studies for a larger scale of investigation.

## 2. Methods

A college in Beijing was selected as the case study area while the students were set as the target population. In order to evaluate the perceptions that consumers may have and the behaviors that they would engage in, precisely and directly, this study used the contingent valuation method (CVM) as its major approach. CVM is mainly used to price public goods and other non-marketable goods or services by means of a questionnaire survey (Zhang, 2006). In this case, consumers' willingness to pay (WTP) of remaining the positive externality or removing the negative externality could be appropriately evaluated. For this research, consumers' WTP of reducing the take-out food plastic packaging waste could be derived directly through an investigation under the CVM, while WTPs under different scenarios could also be found and further discussed. In addition, behaviors they may engage in, in response to the promoted policies, could be predicted and evaluated further as well.

## 2.1. Questionnaire design and sampling

The survey was conducted through an online questionnaire to investigate both the students' subjective attitudes toward the circulation of reusable plastic take-out food packaging, under the circulation mechanism, and their willingness to pay (WTP) under the taxation mechanism as an alternative. Before the formal survey, a pilot survey was conducted, and a total of 33 responses were collected during this period. Based on these responses, we adjusted the structure, wording and expected results of the questionnaire, and finally another 97 responses were formally collected.

The questionnaire used in the formal survey consisted of five sections: (1) respondents' basic information on take-out food ordering behavior; (2) respondents' cognition of the environmental impact of the take-out food packaging; (3) respondents' take-out food consumption behavior and preferences; (4) respondents' expected behavior and preferences in the given contexts; and (5) respondents' personal characteristics. The survey aims, questionnaire sections and indicators are shown in Fig. 1. The overall aims of this study were three. First, we investigated the current behaviors of take-out food ordering. Then the core part of this study—consumer preferences, perceptions and expected behaviors—were studied. Finally, the personal characteristics of the sampled students were collected. In addition, to better inform the sampled students with the purpose of this survey, tests of cognitive levels were posed in Section 2.

The questionnaire adopted a variety of questions to conduct effective inquiries. Single-choice questions were used to collect basic information, such as personal information and consumer behaviors and perceptions. Multiple-choice questions were also

used when revealing the incentives or concerns of consumers. In addition, blank boxes were included for some questions, to give the respondents the opportunity to express answers in their own words or offer their own thoughts. When investigating the preferences, sorting questions were adopted to get better results. Furthermore, the Likert 5 scale (Likert, 1932) with the form of matrix questions was applied, to evaluate the acceptance level and its changes, which were core parts of this study.

In Section 2, five scientific questions were asked, to evaluate the consumers' environmental knowledge levels: "How many plastic bags are produced in the whole of China for take-out food packaging?" (Q6), "What is the degradation time for plastic?" (Q7), "What is the degradation time for biodegradable plastic meal boxes?" (Q8), "How do you compare the environmental impacts of single-use plastic and multiple-use metal meal boxes?" (Q9), and "How do you compare the environmental impacts of single-use plastic and multiple-use plastic meal boxes?" (Q10).

In Section 3, we proposed the two mechanisms: circulation and taxation. For the circulation mechanism, we explored the acceptance level for reusing plastic meal boxes ( $Acc_p$ ) and metal meal boxes ( $Acc_m$ ). Distinguishing the material is necessary, as repeating metal meal boxes could lead to even lower environmental impacts than biodegradable ones (Wei et al., 2022). Then, the maximum acceptable tax was solicited, to measure the acceptance level of the taxation mechanism ( $Acc_t$ ). Finally, we put forward several changes of background conditions, such as "sufficient compensation when packaging is unsanitary," "higher taxes coupled with stronger supervision," and "including electronic tags and real-name registration." The consumers were then asked how their acceptance level would change based on these revisions ( $\Delta Acc_b$ ).

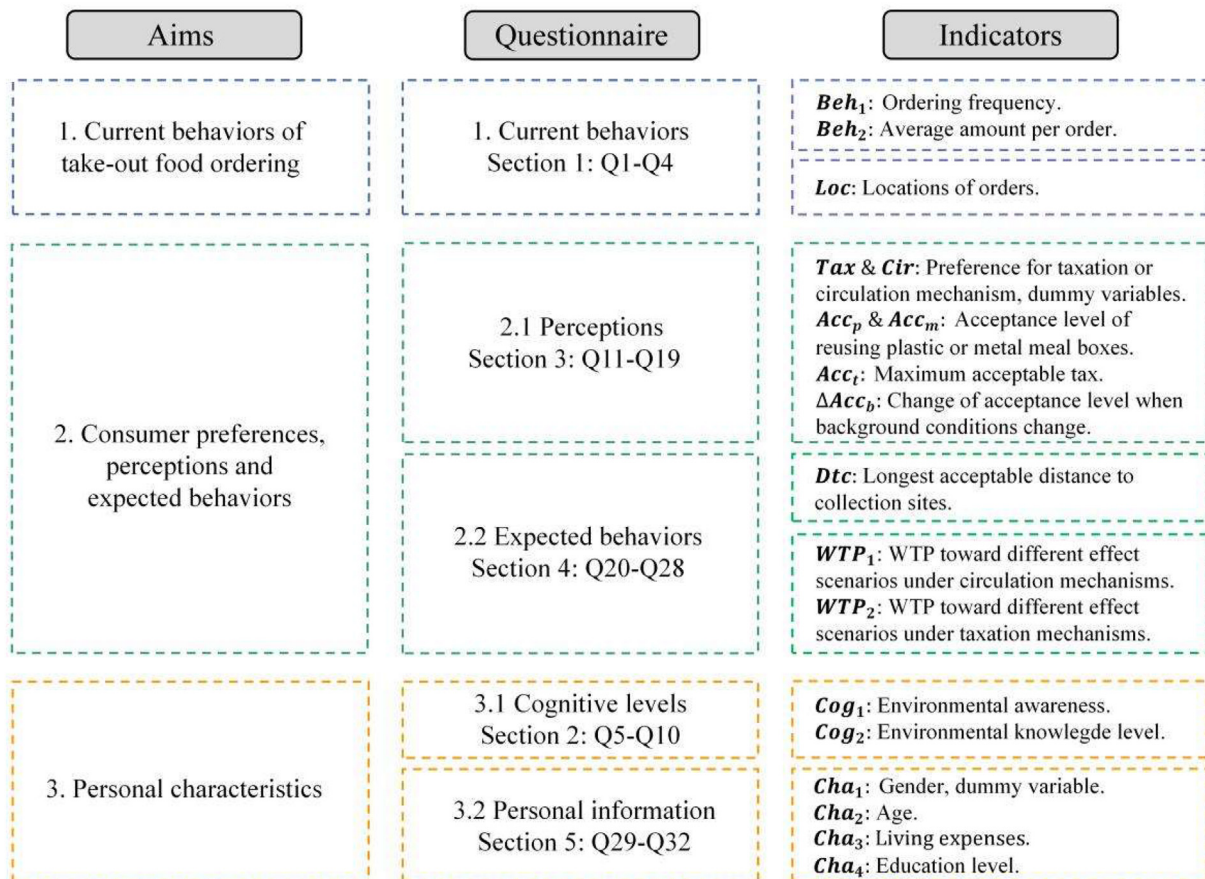


Fig. 1. Survey aims, questionnaire sections, and indicators.



In Section 4, to quantify consumers' willingness to pay for the taxation and circulation mechanisms, this study used a three-stage enquiry, first asking for responses to conditions resulting in a lower environmental effect, and then increasing the effect of their unit endeavors, twice. For the taxation mechanism, consumers were asked how much tax they would be willing to pay, assuming that every 1 CNY paid in tax can clean up 20 g (low effect)/50 g (medium effect)/100 g (high effect) of marine plastic waste, which were estimated through a recent research (Burt et al., 2020). For the circulation mechanism, consumers were asked whether they were willing to accept the circulation mechanism, assuming that the function of improving the environment is achieved after reusing meal boxes 20 times (high effect)/50 times (medium effect)/100 times (low effect), as estimated (Gallego-Schmid et al., 2021). The exact questionnaire used in the formal survey can be found in Appendix A, which is in the Electronic Supplementary Material (ESM) in the online version of this paper.

The questionnaire was randomly distributed to different categories of college students, while maximum effort was made to include a realistic distribution of educational level, gender and other similar data. Taking the COVID-19 regulation policies and operation costs into consideration, online questionnaires were used in the formal survey. Online survey was also used by other research on relevant issues (Asselt et al., 2022), thus the rationality could be promised.

## 2.2. Data processing

As an online questionnaire cannot promise targeting accuracy, there is a possibility of survey misdistribution and thus sample deviation. In order to minimize the effect of such deviation, once response sheets were collected, data cleaning was carried out to remove the influence of respondents outside the expected sample range. Age and educational level were collectively used to sort out inappropriate respondents, so that it could be ensured that all the data used in the analysis period were from college students.

We extracted two major dimensions of the cognition of respondents: environmental awareness, which reflects the willingness of the respondent to protect the environment, and environmental knowledge, which represents the level of knowledge about the scientific facts on relevant issues. Awareness was directly defined by the self-ranking score in the question "How well do you feel you understand the environmental impacts of take-out food packaging waste?", while the knowledge level was calculated by aggregation of scores of answers to the five scientific questions (see Q6–Q10 in Appendix A in ESM).

As for the value assignments of different behaviors or personal characteristics, we widely adopted dummy variables and hierarchical variables. For instance, we used two dummy variables, *Cir* and *Tax*, to express the respondents' preference. If the respondent prefers circulation, then *Cir* = 1 and *Tax* = 0, while if the respondent prefers taxation, then *Tax* = 1 and *Cir* = 0. Besides, both *Cir* and *Tax* equal 0 when the respondent chose "others" in the questionnaire, indicating he/she does not prefer either of the two options. Another example is the environmental awareness. We used the Likert 5-scale investigating form to categorize this variable into 5 classes, in expression of the level of environmental awareness from low to high, respectively. After data process, empirical analysis was implemented to realize our research goals.

## 2.3. Empirical analysis

For determining the overall mechanism preference, although taxation saves time which conforms to the take-out food consumers' psychology (Jiang et al., 2020), it is more rational to assume

they would be more willing to choose circulation rather than taxation mechanisms, for two reasons. First, a taxation mechanism takes consumers' money directly, affecting their disposable incomes. Consumers would be less likely to accept this effect, as they will perceive that they are losing money they might spend on something else. Secondly, although a circulation mechanism would increase the labor cost of take-out food, thereby increasing its price, this effect is indirect and would be less visible (Varian, 2014). Moreover, returning packaging is a behavior that could bring positive externalities, demonstrating an individual's concern for protecting the environment, both to himself/herself and to other people (Brick et al., 2017). Hence, we chose H.1 as our test.

### H.1. Consumers prefer circulation to taxation, of the take-out food packaging.

Since personal characteristics could influence an individual's environmental behavior and preferences (Brick & Lai, 2018), Hypothesis H.2 was put forward. For plastic pollution issues, WTP could be impacted by age, education, cognitive levels, and so forth (Thinh et al., 2022). In this study, it could be divided into three parts. First, different consumers would have different mechanism preferences (H.2a). People with higher environmental awareness and knowledge levels would engage in better environmental behaviors (Friedrich, 2022), and education would enhance such knowledge (Guerra-Carrillo et al., 2017). Second, the acceptance level of the proposed mechanisms would be different depending on personal characteristics (H.2b). For instance, female consumers might be more motivated by their self-identity as "green" consumers (Tung et al., 2017) and have more awareness of the environmental performance and usage efficiency of the goods they purchase (Tu et al., 2021). Education might have similar effects (Walker et al., 2021). Third, the degree of reaction to changes in background conditions would likely also differ with various personal characteristics, and thus hypothesis H.2c was added.

### H.2. Personal characteristics influence consumers' behaviors and preferences within the scale of this study.

#### H.2a. Personal characteristics influence consumers' overall mechanism preferences.

#### H.2b. Personal characteristics influence consumers' acceptance level for circulation and taxation mechanisms.

#### H.2c. Personal characteristics influence the degree of reaction when background conditions change.

Consumers' perceptions are also consistent with their behaviors under given scenarios. It is found that when people are well informed about the effectiveness of a policy, especially the usage of money, they will be more supportive of the policy (Muhammad et al., 2021). Hence, different possible effect scenarios of the unit endeavor made by the consumers could also lead to different expected behaviors. Therefore, Hypothesis 3 (H.3) was put forward as below.

### H.3. Consumers will put forth more effort when the effect of a unit endeavor is higher.

Hypothesis H.1 could be easily examined from the results, and a series of regressions were made to test Hypothesis H.2. Regressions between the overall mechanism preference variables (*Tax* and *Cir*) and personal characteristic variables (*Beh*<sub>1,2</sub>, *Cog*<sub>1,2</sub>, and *Cha*<sub>1–4</sub>) were conducted to test Hypothesis H.2a. To test Hypothesis H.2b, a series of regressions between the acceptance variables (*Acc*<sub>p</sub>, *Acc*<sub>m</sub>, and *Acc*<sub>c</sub>) and personal characteristic variables (*Beh*<sub>1,2</sub>, *Cog*<sub>1,2</sub>, and *Cha*<sub>1–4</sub>) were made. For Hypothesis H.2c, the change degree of acceptance level  $\Delta Acc_b$  was regressed with the personal characteristic variables (*Beh*<sub>1,2</sub>, *Cog*<sub>1,2</sub>, and *Cha*<sub>1–4</sub>). As for Hypothesis H.3, a matched samples *t*-test was rendered to assess whether the

consumer behaviors would be likely to change in the given contexts. The concrete models and formulas used are given in [Appendix B](#) in ESM.

### 3. Results

A total of 98 responses were collected, and 97 of which were valid. The 33 responses of the pilot survey were not included, as the questions and formats of the questionnaire were fundamentally adjusted between the pilot survey and the final one. As the aimed area is concentrated on campus, the targeted group shall be a bit homogeneous, thus a relatively small sample size could meet our research goals. To promise the accuracy and precision of answers, the scope of respondents was carefully selected, as the questions in the survey were somehow complicated. From the perspective of results, these samples we collected were already able to statistically prove some conclusions, thus our research aims were met. Therefore, we have adequate evidence to believe the results shall be reasonable and qualified to answer our proposed questions. The socio-demographic characteristics and consumer behaviors of the sample are shown in [Appendix C](#) in ESM. The original responses and indicators used for empirical analysis are provided in the Electronic Supplementary Dataset (ESD) in the online version of this paper.

#### 3.1. General consumer perceptions and behaviors

##### 3.1.1. Overall mechanism preference

Of all the valid responses, 73.2% of them preferred a reliable take-out food packaging circulation mechanism regardless of the material of packaging compared to paying more, while 14.4% of

them preferred a taxation mechanism that would go to a green fund to improve the environment. To statistically test H.1, we adopted single sample *t*-test to judge whether the population prefers circulation. It was found that, the *t*-statistic is about 5.13, which is larger than 2.36. Therefore, H.1 is proved at the significance level  $\alpha = 0.01$ , thus we have reasons to believe the population of consumers prefers circulation of take-out food packaging to taxation.

##### 3.1.2. Impacts of personal characteristics

As shown in [Table 1](#), the only result at the significance level  $\alpha = 0.01$  was that consumers who on average spend more on a single order have a 0.8% higher possibility of preferring a taxation mechanism to a circulation one ( $p = 0.099$ ). A possible explanation could be that the marginal cost of 1–2 CNY (the tax) is negligible to the consumer ([Varian, 2014](#)). Thus, Hypothesis H.2a could only be proved at a small scale, indicating that the mechanism preference could be influenced by certain personal characteristics, but there were too few influential factors to make a determination.

The regression outcome of acceptance levels and personal characteristics are shown in [Table 2](#). It appeared that the consumers who are more receptive to reusing take-out plastic meal boxes are females ( $p = 0.012$ ) and those who have lower monthly living costs ( $p = 0.072$ ). No significant distinctions were observed in these two groups, however, for reusing metal meal boxes versus reusing plastic ones. Therefore, Hypothesis H.2b could also only be proved at a small scale, indicating that the acceptance levels could indeed be influenced by certain personal characteristics, but that the effect of these characteristics was small.

As for Hypothesis H.2c, it was observed that consumers who order take-out food frequently would have a higher probability of

**Table 1**  
Regression outcome of overall mechanism preference and personal characteristics.

Variable	Explanation	Cir		Tax	
		Mean	Std. Err.	Mean	Std. Err.
<i>Beh</i> <sub>1</sub>	Ordering frequency (times per week)	−0.243	(0.183)	0.0003	(0.015)
<i>Beh</i> <sub>2</sub>	Average amount per order (CNY)	−0.006	(0.006)	0.008*	(0.005)
<i>Cog</i> <sub>1</sub>	Environmental awareness (scores)	0.043	(0.046)	0.023	(0.037)
<i>Cog</i> <sub>2</sub>	Environmental knowledge level (scores)	−0.007	(0.043)	0.026	(0.035)
<i>Cha</i> <sub>1</sub>	Gender (dummy variable, female = 1)	0.155	(0.099)	−0.028	(0.080)
<i>Cha</i> <sub>2</sub>	Age (years old)	0.016	(0.023)	−0.009	(0.019)
<i>Cha</i> <sub>3</sub>	Living expenses (CNY per month)	−0.00003	(0.00006)	0.00004	(0.00005)
<i>Cha</i> <sub>4</sub>	Education (BD = 0, MD = 1, PhD = 2)	0.068	(0.099)	−0.101	(0.081)
Con.	Constant	0.383	(0.431)	−0.296	(0.351)

Note: 1. Standard errors in parentheses: \* $p < 0.1$ , \*\* $p < 0.05$ , \*\*\* $p < 0.01$ .

2. Tax is a dummy variable, equal to 1 when a consumer preferred the taxation mechanism. Cir is a dummy variable, equal to 1 when a consumer preferred the circulation mechanism.

**Table 2**  
Regression outcome of acceptance level and personal characteristics.

Variable	Explanation	<i>Acc</i> <sub>p</sub>		<i>Acc</i> <sub>m</sub>		<i>Acc</i> <sub>t</sub>		$\Delta Acc_b$	
		Mean	Std. Err.	Mean	Std. Err.	Mean	Std. Err.	Mean	Std. Err.
<i>Beh</i> <sub>1</sub>	Ordering frequency (times per week)	−0.079	(0.216)	−0.169	(0.256)	0.039	(0.053)	−0.683***	(0.231)
<i>Beh</i> <sub>2</sub>	Average amount per order (CNY)	0.012	(0.070)	−0.013	(0.083)	0.013	(0.017)	−0.010	(0.075)
<i>Cog</i> <sub>1</sub>	Environmental awareness (scores)	0.564	(0.543)	0.693	(0.641)	0.192	(0.133)	0.782	(0.580)
<i>Cog</i> <sub>2</sub>	Environmental knowledge level (scores)	0.512	(0.509)	0.428	(0.601)	0.029	(0.125)	0.473	(0.544)
<i>Cha</i> <sub>1</sub>	Gender (dummy variable, female = 1)	3.009**	(1.167)	2.047	(1.379)	0.091	(0.286)	1.162	(1.248)
<i>Cha</i> <sub>2</sub>	Age (years old)	−0.027	(0.273)	−0.117	(0.322)	0.002	(0.067)	0.218	(0.292)
<i>Cha</i> <sub>3</sub>	Living expenses (CNY per month)	−0.001*	(0.0007)	−0.0007	(0.0008)	−0.0002	(0.0002)	0.001	(0.0008)
<i>Cha</i> <sub>4</sub>	Education (BD = 0, MD = 1, PhD = 2)	0.530	(1.183)	1.047	(1.398)	0.361	(0.290)	−0.795	(1.264)
Con.	Constant	11.027**	(5.105)	12.880**	(6.032)	0.756	(1.251)	11.197***	(5.456)

Note: 1. Standard errors in parentheses: \* $p < 0.1$ , \*\* $p < 0.05$ , \*\*\* $p < 0.01$ .

2. *Acc*<sub>p</sub> denotes for the acceptance level for reusing plastic meal boxes, *Acc*<sub>m</sub> denotes for the acceptance level for reusing metal meal boxes, *Acc*<sub>t</sub> denotes for the acceptance level for the taxation mechanism, and  $\Delta Acc_b$  denotes the degree of acceptance-level change when background conditions change.

changing their acceptance level when the background conditions change ( $p = 0.004$ ). Therefore, only under this circumstance could Hypothesis H.2c be proved, and compared to internal characteristics like cognition level, external behavior like take-out food ordering frequency would have more significant influence for changing the degree of acceptance level.

To conclude, it was found that Hypothesis H.2 could be proved for only some of the factors, and the above-mentioned gender effect on acceptance level was supported by this study, while the education effect was not. Therefore, specific personal characteristics could indeed influence acceptance level, but the overall effects were inconclusive.

### 3.1.3. Reactions to the change effects of unit endeavor

The outcomes of the matched sample  $t$ -tests are shown in Table 3. It was found that all the  $p$ -values were less than 0.05, indicating that an increase in the effects of unit endeavor, that a consumer made, would have a positive impact on their choices, whether the choice was a taxation or circulation mechanism. Hence, Hypothesis H.3 was proved on the  $\alpha = 0.05$  level. In other words, when consumers were informed of the higher effects of their unit endeavor on protecting the environment, they would engage in better environmental behavior, such as paying a higher tax or reusing products more times.

### 3.2. Acceptance rate of the circulation mechanism and its changes

As a matter of fact, although the acceptance level was heterogeneous among different individuals, consumers always shared similar concerns in regard to the circulation mechanism, which was the choice of the majority of the sample. As shown in Fig. 2, for cleaning the packaging, 83.67% of consumers said that a reliable third-party

organization would be acceptable. For returning packaging, 53.06% of consumers were receptive to giving it directly to the delivery worker while 66.32% of consumers preferred to put it directly on the collection site, eliminating the need to clean it themselves.

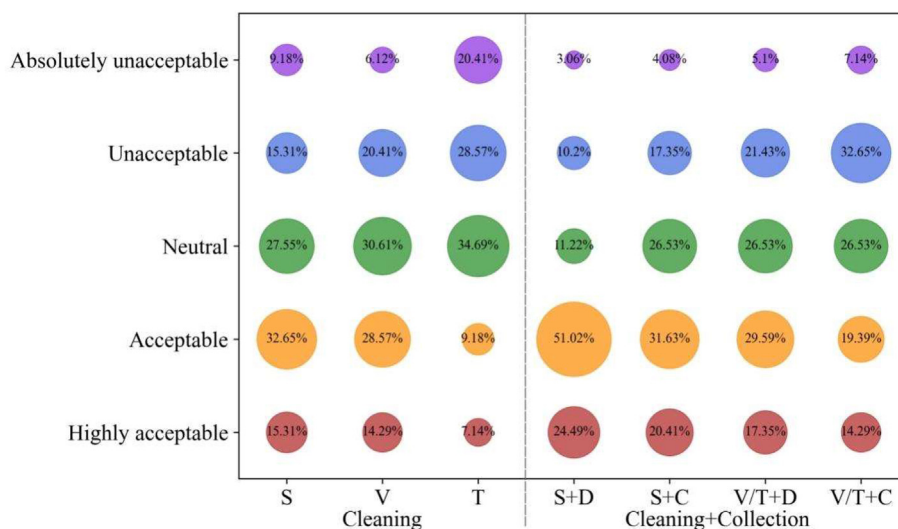
The results of a change in consumers' acceptance levels based on a change in background conditions are shown in Fig. 3. Calculating the average score using the Likert 5 scale (Likert, 1932), it was found that the material of which the meal boxes were composed had no influence on the acceptance levels (plastic: 2.86, metal: 3.09, biodegradable plastic: 3.32; all within the range of 2.5–3.5). More influential factors were effective government regulation (3.75), a logical and reasonable system (3.53) and high average social awareness (3.53), as these average scores were larger than 3.50. More specifically, 54.08% of the consumers believed that those factors could slightly increase their acceptance level of the circulation mechanism, while 15.31% of them believed that this could significantly increase their acceptance level. This was followed by the use of biodegradable meal boxes and compensation for unhygienic incidents, with 44.89% and 60.20% of the population, respectively, believing that these circumstances would increase their acceptance levels. Lastly, only 41.83% of consumers believed that worsening environmental pollution would increase their acceptance levels. The average score for this parameter was 3.16, still within the 2.5–3.5 range. In other words, consumers were more concerned about governmental actions, the logic and reasonableness of the system and the level of detail of the mechanism, than with the pollution situation on the earth.

It was also interesting to see that some changes were opposite to what was expected. For meal box material changes, the lower acceptance level could be due simply to resistance to a change in habitual use patterns. Results for other background condition changes, though, were sometimes puzzling. It's possible that in

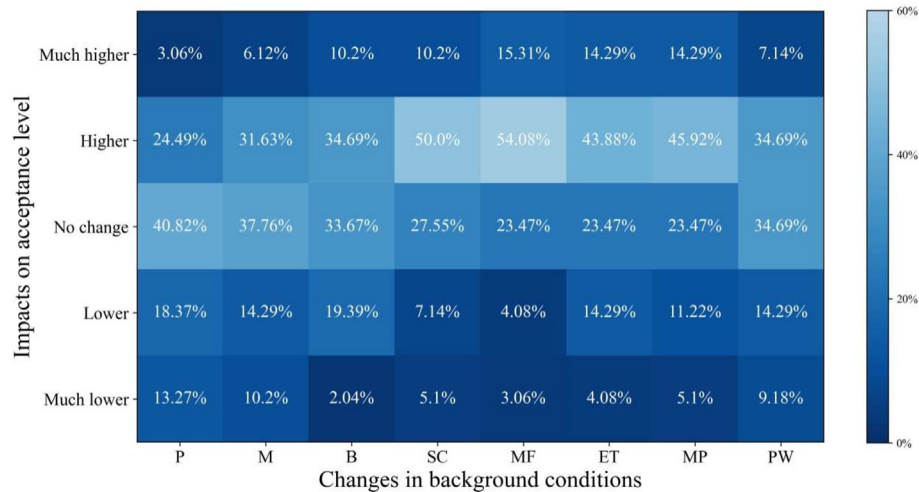
**Table 3**  
Testing the outcomes of Hypothesis H.3

Null hypothesis	Mean	Std. Err.
Consumers will pay a higher tax when moving from a low- to a medium-effect scenario	0.1340***	(0.0377)
Consumers will pay a higher tax when moving from a medium- to a high-effect scenario	0.0928**	(0.0417)
Consumers are more willing to reuse packaging, when moving from a low- to a medium-effect scenario	0.1649***	(0.0456)
Consumers are more willing to reuse packaging, when moving from a medium- to a high-effect scenario	0.0825**	(0.0378)

Note: Standard errors in parentheses: \* $p < 0.1$ , \*\* $p < 0.05$ , \*\*\* $p < 0.01$ .



**Fig. 2.** Acceptance rate of different cleaning and collection patterns (S stands for 'consumer himself cleans', V stands for 'vendor cleans', T stands for 'reliable third party cleans', D stands for 'deliveryman collects', and C stands for 'takes to collection sites').



**Fig. 3.** Impacts of changes in background conditions, on acceptance levels (P stands for 'reuse plastic meal boxes', M stands for 'reuse metal meal boxes', B stands for 'use biodegradable meal boxes with higher price', SC stands for 'Sufficient compensation when unsanitary incidents occur', MF stands for 'More funds and stronger supervision', ET stands for 'insert electronic tags and real-name registration', MP stands for 'most people clean them well', and PW stands for 'pollution on the earth worsens').

some cases the respondents didn't understand the exact meanings of the statements or the question, although omitting these questions would have made the experiment much less meaningful. From another perspective, options that appeared to be more expensive could have aroused concerns about higher fees, and real-name registration could lead to credit score problems. Hence, the behavior that might be expected of some consumers, in response to controversial changes, should also be taken into consideration, to improve the design of future research into this area.

### 3.3. Willingness to pay under different effect scenarios

This study provided a rough estimate of the overall willingness to pay of the respondents, and the results are shown in Table 4. The outcomes were within expectations. Consumers would be significantly more willing to pay a higher tax if a 1 CNY tax would reduce the environmental impacts by more (from 20 g of marine litter reduction to 50 g of marine litter reduction). If spending less effort on circulation would reduce the environmental impacts by an equal amount (from 50 recycling trips to 20 recycling trips), consumers would be more willing to choose a circulation mechanism.

## 4. Discussion

### 4.1. Business strategies of take-out food platforms

Reusable take-out food packaging designs and circulation mechanisms have already been piloted commercially. Taking Meituan again as an example, in August 2017, Meituan launched the first social responsibility program in the industry, the Blue Mountain Project, with the aim of reducing the environmental impacts of take-out food packaging (UN DESA, 2021). It added a "no disposable cutlery" option on its food ordering page to encourage users to use less disposable cutlery, and then put in place a set of reward mechanisms to arouse consumer incentives for choosing the

option. At the same time, Meituan released the "Green Packaging Recommendation List," which includes 46 types of biodegradable plastic take-out packaging products from 31 companies and 41 types of paper take-out packaging products from 30 companies (Meituan, 2018). It also explored the path of large-scale recycling and reuse of lunch boxes and carried out more than 350 plastic lunch box reuse pilot projects. What's more, Meituan also has experience in green funds and door-to-door collection mechanisms (Meituan, 2020). Besides online take-out food platforms, Shuangti, a company dedicated to intelligent dining houses, has already completed more than 30 million non-contact orders (Shuangti, 2017). Its main business mode—the take-out food cabinet and its operation system—could also contribute to the establishment of collection sites.

Based on the existing commercial applications and the results from this study, a business model that could reduce the environmental impacts of take-out food packaging was put forward, as shown in Fig. 4. When registering on a take-out food platform, consumers would provide some basic information, which could be used to draw a portrait of his/her personal characteristics. The platform could then offer consumers the options they would be most likely to choose, using sophisticated technology. Options could include paying a tax, returning the packaging to the delivery workers or taking them to collection sites—actions supported by Hypothesis H.2. The used meal boxes could then be delivered to a cleaning agency, which should be supervised by the government. Finally, the catering vendors could reuse these meal boxes for future orders. What's more, the online take-out food platforms could also provide information on reusable packaging, for vendors, and the green funds established and operated by the platform could give financial support to the cleaning agency or to other enterprises and activities beneficial to the environment. With the research results of this study, it is reasonable to believe this kind of business model could reduce the environmental impacts of take-out food packaging, at least to some extent.

**Table 4**  
Willingness to pay for taxation mechanisms and circulation mechanisms.

Mechanism	Indicator	Low effect	Medium effect	High effect
Taxation	Willingness to pay (CNY)	1.14	1.31	1.43
Circulation	Acceptance rate (%)	39.18	47.42	63.92



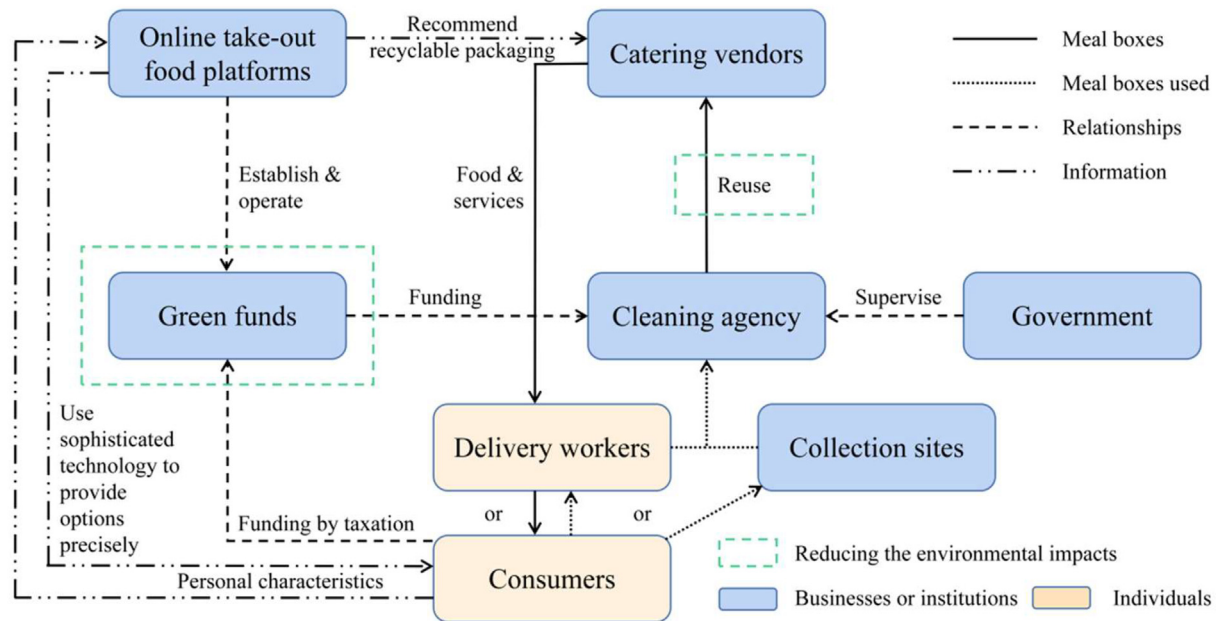


Fig. 4. Business model that could reduce the environmental impacts of take-out food packaging.

#### 4.2. Establishment of the circulation system

As, in this study, no statistically significant difference was observed in consumer attitudes toward plastic versus metal meal boxes, simply changing the packaging materials would have little to no effect on consumer behavior. Therefore, aside from instituting a complete ban on plastic, the most effective action the government could take, to improve the plastic waste situation, would be to support the circulation of plastic wastes, especially those generated by the take-out food industry.

First of all, it is suggested that the government openly enable third-party institutions to establish collection, cleaning and utilization mechanisms for take-out plastic meal boxes. The process should be open and transparent, because, since take-out tableware comes into direct contact with food, the importance of its safety cannot be overemphasized. In the day-to-day operations of these institutions, it is also necessary for the government to play a supervisory role, to ensure that the institution is functioning properly and, if necessary, opens a window for public monitoring so that the public can be convinced and reassured.

Secondly, the government can work to improve consumer acceptance of circulation mechanisms. According to the results of this study's questionnaire, consumers' concerns were about the standardization of "cleanliness" (88.8%), the consequences of not returning the boxes on time (63.8%), the increased cost of packaging (57.2%), the penalties for not washing the boxes (53.8%), and who is responsible for damage to the boxes (52.6%). Hence strategies such as strengthening monitoring functions, making reasonable and consistent standards, and establishing appropriate financial systems such as insurance, could be applied.

When setting up collection sites, consumers' acceptance of the distance to the collection site should be taken into account. It was found that the majority of consumers would accept a short distance (63.27%), generally on the ground floor of a building; while a distance of 50–200 m from the use site could also achieve good results (44.9%). Therefore, the appropriate distance for setting up a collection site should be 50–100 m from a use site, which is roughly equivalent to the average distance between two buildings, and the capacity can be calculated, at a ratio of one collection site covering

two buildings. It was also found that the locations where college students often order take-out are dormitories (63%) and workplaces (26%). Hence, when setting up collection stations on campuses, setting them up in such areas would be most effective.

Finally, the government can improve the effectiveness of unit financial resources; for instance, increasing the utilization rate of funds, improving staff efficiency, introducing more advanced equipment or mechanisms, and so forth. It can also enhance propaganda to let consumers understand how many grams of plastic waste can be effectively reduced or how much the environmental level can be improved by the unit of plastic take-out food meal boxes they reuse or the unit amount they invest in. This could influence consumers' willingness to pay, as stated in Hypothesis H.3.

#### 4.3. Limitations and future directions

In this study, two rounds of research were conducted, with the second round achieving a higher validity. The main limitation is that the sample size of the research was not sufficient enough. Also, the questionnaire distribution was affected by COVID-19, with the necessity of using online methods, and the sample may have been biased by the interpersonal relationships of the researchers. Future research could look at the construction of collection sites in study or office locations, i.e., starting with students and office workers. Further segmented demographic profiles based on more in-depth research could also be conducted, to obtain a more precise cost-benefit analysis for the circulation mechanism and site construction.

#### 5. Conclusions

Responding to the initiative of combating plastic pollution, this study puts emphasis on the single-use plastic packaging waste from the take-out food sector, and evaluates college students' perception and behavior toward reducing packaging waste. It was found that 73.2% consumers favored the circulation mechanism of take-out food packaging over taxation. For acceptance levels, personal characteristics have influences at a small scale. In terms of consumers' willingness to pay, this study quantified the tax at



around 1.5 CNY, close to which most of the respondents chose an amount. It was also found that consumers had higher willingness to pay if the effect of a unit endeavor was high.

From a practical perspective, the government could reconsider the circulation of take-out food packaging, as it can cause around 73% of consumers to react. Also, it needs to play a third-party monitoring role, unifying standards, strictly enforcing them and imposing severe penalties in the event of unhygienic incidents, so that over 50% consumers can rest assured and feel at ease with the practice. It is also important to improve the efficiency and effectiveness of the process, or to strengthen propaganda to promote better environmental behavior. Online take-out food platforms could use sophisticated technology to deliver corresponding mechanisms to each consumer based on their personal characteristics. They could also set up green funds and provide lists of reusable packaging sources for catering vendors, to incentivize their cooperation. We envision that adopting the circulation of take-out food packaging and the business models this study promotes can greatly reduce the environmental impacts of take-out food packaging waste.

### Electronic Supplementary Material

Electronic Supplementary Material (ESM) and Electronic Supplementary Dataset (ESD): supplementary material is available in the online version of this article <https://doi.org/10.1016/j.cec.2023.100052>.

### Author contributions

Quanyin Tan, Yusheng Guan, Fan Wei and Sijie Liu conceived the study. Sijie Liu provided majority of the background information and literature review. Yusheng Guan developed the methods, collected data, analyzed the data and drafted the manuscript. Fan Wei, Quanyin Tan and Jinhui Li reviewed several drafts, made substantial revisions, and provided additions.

### Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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