



UNIVERSITY OF GOTHENBURG  
SCHOOL OF BUSINESS, ECONOMICS AND LAW

**WORKING PAPERS IN ECONOMICS**

**No. 453**

**The Effects of an Environmental Policy on  
Consumers:  
Lessons from the Chinese Plastic Bag Regulation**

**Haoran He**

**June 2010**

**ISSN 1403-2473 (print)  
ISSN 1403-2465 (online)**

# **The Effects of an Environmental Policy on Consumers**

## **- Lessons from the Chinese Plastic Bag Regulation**

Haoran He<sup>†</sup>

*University of Gothenburg and Beijing Normal University*

This version June 2, 2010

### **Abstract:**

To reduce plastic bag litter, China introduced a nationwide regulation requiring all retailers to charge for plastic shopping bags on June 1, 2008. By using the policy implementation as a natural experiment and collecting individual-level data before and after the implementation, we investigate the impacts of the regulation on consumers' bag use. We find that the regulation implementation caused a 49% reduction in the use of new bags. Besides regulation enforcement, consumers' attitude toward the regulation and some consumers' socioeconomic characteristics also affected bag consumption. However, the regulation effects differ largely among consumer groups and among regions and shopping occasions.

**Key word:** China; litter; market-based policy; natural experiment; plastic bag

**JEL codes:** Q53, Q58

---

<sup>†</sup> Department of Economics, University of Gothenburg, and School of Economics and Business Administration, Beijing Normal University. Postal address: Box 640, 405 30 Gothenburg, Sweden; Tel: +46 31 786 47 28, Fax: +46 31 773 10 43; E-mail: haoran.he@economics.gu.se. I would like to thank Peter Berck, Fredrik Carlsson, Mitesh Kataria, Peter Martinsson, Thomas Sterner, Jiegen Wei, Qian Weng, and seminar participants at Peking University, Chinese Academy of Sciences and the University of Gothenburg for extremely helpful discussions and comments on this paper. I am also grateful to the field work support team from Guizhou University and Peking University. All errors and omissions remain the sole responsibility of the author. Financial support from Sida to the Environmental Economics Unit at the University of Gothenburg is gratefully acknowledged.

## 1. Introduction

Plastic bag litter has become a common problem across continents and countries, waterways and oceans. Many countries and cities around the globe are now taking actions against the use of plastic bags in an attempt to reduce litter and pollution. However, previous experience has taught that unless the correct instruments are chosen and enforced effectively and persistently, plastic bag litter control will not be successful. China, the largest consumer of plastic bags in the world, has joined the list of countries that are taking action against the use of plastic bags by banning thin, free plastic shopping bags. In June 2008, a market-based regulation that forces shops to charge for the use of these bags was implemented. Accordingly, it is of interest to analyze to what extent the market-based environmental policy, intended to influence all citizens who use plastic bags, actually affects people's behavior and to analyze the factors affecting the influence of the policy. This paper focuses on these issues by relying on individual-level data from surveys conducted with consumers both before and after the implementation of the regulation. In addition, we try to understand in more detail the impacts of the regulation on different groups of people and at different locations and shopping occasions. Since the regulation has failed to be perfectly enforced, i.e., some shops still provide the bags for free, it is also of interest to investigate the influence of enforcement variation on people's bag consumption behavior. The resulting information is intended to help policy-makers better understand the role of the regulation for short-term plastic shopping bag<sup>1</sup> reduction and to suggest possible ways to further improve the regulation.

A number of studies have analyzed the effects of various market-based environmental policy instruments such as charge systems, tradable permits, market friction reductions, and government subsidy reductions (see, e.g., OECD, 2001; Stavins, 2002; and Sterner, 2003<sup>2</sup>). Although policy impacts can be more adequately analyzed with detailed – both *ex-ante* and *ex-post* –

---

<sup>1</sup> In the remainder of this paper, “plastic shopping bag” is abbreviated as “plastic bags” or “bags” in most places.

<sup>2</sup> For detailed information about each policy instrument and its effects, see the specific chapters of the books.

socioeconomic and environmental data (Briassoulis, 2001), the impacts of environmental policy instruments have rarely been assessed by using detailed information from both before and after a policy change. In the present paper, we use this regulation implementation as a naturally occurring opportunity to make a detailed analysis of the impacts of the regulation by conducting surveys both before and after the regulation implementation.

The *ex-ante* survey was conducted one month before the implementation date, when most citizens were well aware of the news of the forthcoming regulation.<sup>3</sup> Hence, the questions in our questionnaire could be easily understood by the respondents.<sup>4</sup> In the *ex-ante* survey, we collected information about consumer characteristics and plastic bag use situations. The *ex-post* survey was conducted about four months after the regulation was implemented so that citizens had time to adjust to the regulation. Both surveys were conducted in the same shops at the same time of day and with the same questionnaire, but some complementary questions about the enforcement of the regulation in the respondent's home community were asked in the *ex-post* survey. During the period in which the two surveys were conducted, there was no other major economic change or any relevant action or campaign with respect to the use of plastic bags<sup>5</sup> in China. It is therefore reasonable to assume that any change in behavior regarding plastic bag use was clearly due to the implementation of the regulation.<sup>6</sup> Furthermore, the same two surveys were conducted in different regions in order to identify possible regional differences in the behavior change due to the regulation. By analyzing and comparing the results from the surveys, we are able to analyze

---

<sup>3</sup> At the time of the pre-policy survey, more than 80% of the respondents in the survey reported that they already knew about the regulation.

<sup>4</sup> We interviewed both consumers and shop managers about whether they had noticed any changes in plastic bag use behavior that could be linked to the news of the forthcoming regulation. No change was reported, which is consistent with evidence from supermarkets' formal records that bag consumption did not change until the regulation had been implemented (see, e.g., Figure 1 in Section 5).

<sup>5</sup> Promotion of reduced plastic bag use occurred before June 2008 when the regulation had not yet been implemented.

<sup>6</sup> This can be seen in Figure 1 in Section 5 that the monthly consumption of regulation-targeted bags remained constant during the two periods before and after the regulation implementation, respectively. A drastic drop in the monthly consumption of the targeted bags can only be seen in connection with the implementation of the regulation.

whether there were any clear effects of the regulation.

Regarding litter control, consumers' environmental-friendly intentions and behaviors are affected by individual demographics as well as by internal and external motivators. The primary incentive for individuals to use plastic bags is simply that they are the cheapest alternative for carrying goods home from stores. Market-based policies have the potential to provide incentives for consumers to adopt better technologies into their daily lives since, by using product-charging instruments (also called "advanced disposal fees") such as charging for plastic bags, it always pays off for consumers to use a bit less if another sufficiently low-cost method of doing so is available.<sup>7</sup> Moreover, along with the policy implementation, a clear signal that plastic bag litter is environmentally harmful was sent out via information campaigns with the charging of the bags (Convery *et al.*, 2007). This signal and the bag pricing *per se* could shift consumers' external environments and reference points of plastic bag consumption. Therefore, the information together with a small price added to the bags has the potential to generate a considerable reduction of bag consumption.

The remainder of the paper proceeds as follows: Section 2 presents the background of the regulation and Section 3 introduces the survey design. Section 4 discusses the methodology used and Section 5 describes the data. The results are reported in Section 6 and Section 7 concludes the paper.

## **2. Background of international actions and China's regulation**

### ***2.1. International actions against the use of plastic bags***

Many countries and cities around the globe are taking actions and/or are implementing policies against the use of plastic bags with the motivation of reducing litter and pollution (e.g.,

---

<sup>7</sup> Taylor (2000) summarizes policy incentives that can be used to minimize waste. For other examples, see Geller *et al.*, 1973; Downing and White, 1986; Pearce and Turner, 1993; Carr-Harris, 1996; Ackerman, 1997; and Manuel *et al.*, 2007.

Bangladesh, China, California, Denmark, Hong Kong, Kenya, Ireland, South Africa, Rwanda, Tanzania, and the UK). For example, the Bangladesh government banned the use of plastic bags in its capital Dhaka in 2002 and Rwanda prohibited the use of plastic bags by shoppers in 2006. Denmark imposed a tax of 22 DKK per kilogram of plastic bags on retailers in 1994, which has since cut plastic bag usage by 66% (Danish EPA, 1999). In contrast to imposing a tax on retailers as in the case of Denmark, in March 2002 Ireland introduced a product tax of €0.15 per plastic bag levied on consumers, which has led to a 90% reduction in bag use. In July 2007, the Irish government further increased the environmental levy on plastic bags to €0.22 per bag in order to maintain its impact<sup>8</sup> (Irish Department of the Environment, Heritage & Local Government, 2007). The success in terms of substantially reducing the use and the associated gains in the form of reduced litter and a more attractive landscape in Ireland has attracted considerable international interest (Convery *et al.*, 2007). However, the seemingly similar legislation implemented in South Africa in 2003 witnessed a gradual rebound in plastic bag consumption after showing an initially significant reduction (Hasson *et al.*, 2007).

## ***2.2. China's regulation of plastic bags***

Plastic bags, with the advantages of being lightweight, strong, waterproof, and seemingly free of charge, have been ubiquitous for several decades in China ever since they were introduced as a way of promoting sales in the early 1980s. Although plastic bags have been provided for free, they have not been without costs. Before the regulation, retailers in China spent more than 24 billion Chinese yuan per year on plastic bags (Zhang, 2008). This was passed on to consumers through higher prices of other goods. While supermarkets have consumed 25% of all plastic bags, department stores, roadside stores, open markets and all other retailers have consumed the

---

<sup>8</sup> Surveys provided by the Irish Central Statistics Office indicate that the levy caused yearly plastic bag per capita usage to decrease overnight from an estimated 328 bags to only 21 in 2002. More than 90% of the reduction remained in 2003. However, survey data indicate that plastic bag usage rose to 30 bags per capita during 2006.

remaining 75% (Wang, 2008). As a result of mass usage, plastic litter composed of plastic bags constitutes 3-5% of the weight of the total landfill solid waste (Chinese National Development and Reform Commission, 2008b). These buried plastic bags may last for 500-1,000 years in landfills (Friends of the Earth Scotland, 2005).

Since the late 1990s, local governments in a few cities and provinces have introduced policies with the intention of limiting or even eradicating the use of plastic bags. However, most regional policies aimed at reducing plastic bag use have become useless paperwork after implementation or have not even reached practical enforcement. It was not until early 2008 that, as an effort to host a “Green” Olympic Games, the Ministry of Commerce, the National Development and Reform Commission, and the State Administration for Industry and Commerce jointly published the nationwide byelaw *The Administrative Byelaw for Non-free Use of Plastic Shopping Bags in Retailer Situations*. The administrative byelaw (the regulation) has been in effect since June 1, 2008. The key feature of the regulation is that free provision of plastic bags is prohibited in all supermarkets, stores and all other retailers across the country (excluding plastic bags used for separating foods and other products for hygiene and food safety purposes). All shops are instructed to mark the price of the plastic bags clearly and to not attach the cost to that of other items. The price of the plastic bags can be set by individual shops, yet at a level no less than the acquisition cost (Chinese Ministry of Commerce *et al.*, 2008; Chinese National Development and Reform Commission, 2008a).

Consumption of a bag has two costs: the first is the cost of acquisition including production and transportation costs and the second is the negative external effect on the environment due to disposal of the bag. The regulation, however, only requires charging for the acquisition cost but excludes the social cost. This is partially because, before enacting the formal regulation, a draft was announced in early 2008 for the purpose of collecting public opinions and comments. A considerable number of complaints were made that charging for plastic bags was a disguised form of price markup, increasing shopping costs and therefore hurting all citizens. Therefore, a

compromise from the original environment-protection purpose of the regulation had to be made while still leaving space for its further adjustment. It is also noteworthy that due to the fiercely competitive Chinese retail trade environment, a substantial fraction of shops have enforced the regulation incompletely, i.e., only charging for some of all the provided bags, or even none. Therefore, consumers still obtain a considerable proportion of the total number of bags for free.

### **3. Survey design**

The policy change on June 1, 2008 is used in order to compare plastic bag use behaviors obtained by the two surveys *ex-ante* and *ex-post*. The *ex-ante* survey was conducted from late April to early May of 2008, and the *ex-post* survey was conducted from October to November of 2008. For both surveys, the two most frequently visited types of shops were chosen since these shops account for a considerable fraction of citizens' daily plastic bag consumption (Wang, 2008). Intercept surveys were conducted when consumers exited the shops and a between-subject design was used. The advantage of using an intercept survey with a between-subjects design is that it avoids the "recall effect" that would follow from using the same subjects in both surveys. Therefore, both surveys needed to be conducted *ex-ante* and *ex-post* in the same shops at the same time of day in order to receive responses from comparable respondents from the same sample pool. The two surveys investigated individual consumers' current plastic bag use behaviors before and after the implementation, respectively. Since the regulation was not perfectly enforced, the *ex-post* survey also collected information about the percentage of individual consumers' paid-for bags out of their total bags as an index of regulation enforcement in their community after the implementation.

Since we are interested in analyzing the impacts of the regulation on the use of plastic bags, we designed a series of questions to capture the different aspects of the use.<sup>9</sup> In order to obtain

---

<sup>9</sup> All surveys were answered by individual respondents based on their personal situation; yet, an individual's bag use behavior could be somehow related to the situations of his/her family.



measures of the consumption of new plastic bags<sup>10</sup> at the individual level, we investigated the number of new bags used in a one week period since it is expected to be relatively stable across weeks, and we also recorded the number of new bags used during the surveyed shopping trip since it is easily observed. We further investigated three other aspects of bag use that could also be affected by the regulation: new bag use, bag reuse, and use of substitutes. Regarding the general bag reuse situation, we recorded respondents' average proportion of bags being reused and their average number of reuse times. Moreover, we designed a systematic way to find out the information about how consumers use new plastic bags and substitutes used during the surveyed shopping trip. First, we collected information about the number of new plastic bags used and the weight of the goods in the new plastic bags during the current shopping trip. We then calculated each respondent's average weight of goods per new bag as a measure of new bag use efficiency. Second, we recorded each respondent's total expenditure for all goods and the expenditure for goods carried in containers other than plastic bags during the same shopping trip. Substitute use is then quantified by the ratio of the two expenditures<sup>11</sup>. In this study, we are also interested in the factors, excluding the regulation *per se*, that could affect the use of plastic bags and the impacts of the regulation on different groups of people. The first group of factors includes what people think about the regulation and how difficult it is for them to reduce or to dispose of their use of the plastic bags. The second group of factors concerns respondents' socioeconomic characteristics since bag use behavior might be influenced by respondents' lifestyles and other specific conditions. Last but not least, in order to obtain a representative sample and to detect potential differences in bag consumption behavior, we conducted the surveys at different times of day, on different shopping occasions, and in different regions.

We conducted two parallel surveys in the two cities Beijing and Guiyang in order to detect

---

<sup>10</sup> The term "new plastic bags" means the first time the plastic bags are used. After the first time, the bags are not "new."

<sup>11</sup> The proportion of expenditure is a more neutral measurement of substitute use level than the proportion of weight. This is because the expenditure for goods is much less correlated with the means of carrying them than the weight of goods is.

any possible regional discrepancy. Beijing is the capital and one of the most developed metropolitan areas in China, and Guiyang is a medium-sized city located in one of the most undeveloped provinces. We conducted surveys in the two most frequently visited types of shops, namely supermarkets and open markets, in order to see whether there are differences between people shopping in different types of shops. Consumers who shop in supermarkets are generally considered to have higher income and a higher standard of living than those who shop in open markets. We chose three main residential areas in each city and included one large supermarket and one large open market from each of these areas. Furthermore, since shopping behavior may differ depending on the day of the week and on the time of day,<sup>12</sup> our surveys cover both regular weekdays and weekends/public holidays as well as the three main shopping rush hours, namely early morning, noon/early afternoon, and late afternoon/early evening. As presented in Table 1, we attempted to distribute our samples evenly in each of the dimensions so that we could detect possible behavioral effects among these situations and obtain a sample representing urban consumers in China.

*<Table 1 to be here>*

The sampling procedure of interviews was exactly the same: Every third shopper who exited the shop<sup>13</sup> was approached by the enumerators and asked if s/he would like to participate in a survey that would last a few minutes. If the selected customer refused to participate, the enumerator approached the very next shopper. If this person agreed to participate, then the enumerator would complete the survey and proceed to the next third shopper. We ended up with 3,074 interviewed respondents<sup>14</sup>. The most commonly stated reason for refusing to participate

---

<sup>12</sup> The potential differences in bag use depending on time of day could be generated by unobserved factors such as the differences in the complex characteristics of consumers, the differences in goods purchased, etc.

<sup>13</sup> If more than one shopper exited at the same time, the enumerators always counted them from left to right in order to select the “third” subject.

<sup>14</sup> In total, we asked about 4,000 in order to obtain the 3,074 respondents. We discard 18 observations considered as outliers since these respondents consumed an extremely high number of new plastic bags and lack representativeness of the bag use behavior for normal citizens.

was lack of time.

#### 4. Methodology

In order to analyze the impact of the regulation on the use of plastic bags for different groups of people, we use econometric models. The dependent variable in the first model is the individual consumer's number of new bags used per week, while the independent variable vector  $X$  has several components, i.e.,  $X = (X_0, X_i, X_j, X_m, X_n, X_r)$ .  $X_i$  is the key variable "implementation of regulation," while all the other variables take the role of controls in this study:  $X_j$  denotes consumers' self-reported percentage of paid-for plastic bags out of their total bag consumption<sup>15</sup>, which captures the enforcement of the regulation;  $X_m$  expresses the variables regarding consumers' knowledge of the policy and inconvenience of not using plastic bags provided by shops, etc.;  $X_n$  denotes the socioeconomic variables of the respondents and their families;  $X_r$  denotes variables controlling for bag use behavior shifts due to regional discrepancy, market type difference, weekday or weekend, and time of day. We take the first element  $X_0$  as a constant. We will explain all variables in detail in the next sub-section.

The dependent variable number of new plastic bags used has a count data structure, i.e., taking only nonnegative integral values. Therefore, we apply Negative Binomial regression models (Cameron and Trivedi, 1986 and Greene, 2003) to deal with the structure.<sup>16</sup> The present study mainly focuses on the results from Negative Binomial regression models but still reports the results from OLS and Tobit regression models in the appendix for comparison.<sup>17</sup> In the second

---

<sup>15</sup> The percentage of paid-for bags is set to be zero for all observations from the *ex-ante* survey since no shops charged for plastic bags then.

<sup>16</sup> Since the Poisson variance assumption does not hold for the dependent variable due to over-dispersion, i.e., the variance exceeds the mean, the Poisson regression model is not an appropriate method.

<sup>17</sup> OLS models are used to analyze the data as a benchmark. In addition, since a fraction of respondents do not use new plastic bags in our sample, Tobit models (Wooldridge, 2002) can also be applied to deal with the censored structure of the data. However, since zero-bag users accounts for only 6% of the sample, using a Tobit model does not offer any significant benefits as compared to an OLS model while suffers strict assumptions. In addition, the comparisons of the

model, we take the number of new bags used during the surveyed shopping trip instead of the number of new bags used per week as dependent variable and estimate using the same model specifications and the same independent variables as in the first model.<sup>18</sup>

Since the regulation increased the cost of using plastic bags, it is expected to have decreased bag consumption. Experiences from other countries show that whether the regulation can, and if so how it will, succeed in ensuring a reduction in plastic bag consumption depends on (1) people's environmental protection consciousness which maintains their positive attitude toward the reduction and (2) the support of its enforcement from all relevant administrative departments (Convery *et al.*, 2007). That is to say, the reduction in plastic bag use is likely to be positively correlated with positive attitudes toward the regulation and with regulation enforcement. As for the socioeconomic variables, it is possible that more educated people with a relatively high degree of concern for the environment use relatively few bags and that males consume more bags than females since they are less likely than females to bring other bags with them. It is also possible that higher income and having a larger family is linked to using more bags. Regarding the regional and shop type dummies, since various factors associated with the dummies could affect people's plastic bag use behavior in different ways, the net effect is not straightforward.

We note that the effects of some influencing variables on plastic bag use could differ between before and after the regulation implementation. For example, older people may be more sensitive to the price change thereby reducing their plastic bags more than younger ones following regulation implementation. Therefore, in some of our models, we add interaction variables, i.e., variables interacted with the regulation implementation dummy. The coefficients of

---

distributions between the true value of the dependent variable and its predicted values from OLS, Tobit and Negative Binomial models respectively suggest that the Negative Binomial model fits the data best.

<sup>18</sup> The variable of bag price at the current surveyed shops is not included in the main models since the purpose of this research is to investigate the overall effects of the regulation unconditional on the prices set by individual shops. Yet, it is also interesting to explain the bag consumption during the surveyed shopping trip with further incorporating the bag price variable.

the interaction variables enable us to analyze the differences in impacts of the regulation on different groups of people with different characteristics as well as in different locations and different shopping occasions.

Moreover, since we are interested in understanding the extra effects of the regulation on bag consumption reduction if enforced perfectly, we make comparisons between the true value of bag consumption under imperfect regulation enforcement and the predicted values of bag consumption from a Negative Binomial model under perfect enforcement. The comparisons were conducted in the following steps: First, we estimated a Negative Binomial regression model of weekly bag consumption using only the *ex-post* survey data. Hence, we did not include the dummy variable “implementation of regulation” and its interaction variables in this model. Second, based on the estimation results, we calculated the predicted value of the dependent variable using parameters estimated from the model yet conditional on the regulation being enforced perfectly, i.e., the enforcement variable “percentage of paid-for bags” for every observation is equal to 100%. Third, we performed non-parametric tests to compare the predicted value of the number of new bags used per week under perfect enforcement with the true value of number of new bags used under imperfect enforcement. If the test results suggest that the predicted value of bag consumption is larger than the true value, then tighter enforcement will reduce more bag consumption.

## **5. The data**

### ***5.1. Reduction in plastic bag consumption***

As previously discussed, we included several measures of the use of plastic bags in order to capture different aspects of the response to the regulation. Table 2 summarizes the situation both *ex-ante* and *ex-post* the implementation.

Regarding the general use of plastic bags, it can be observed that before the regulation was implemented, respondents, on average, used 21 plastic bags per week with each bag being reused

about 0.7 times. After the regulation, nearly half of all new bags were saved with the sizeable increase in reuse by 0.6 times to 1.3 times. As for the bag use behavior during the surveyed shopping trip, the probability that respondents used at least one new plastic bag when shopping decreases dramatically from 99% to 56%. The average number of new bags used decreases by 64%, from 3.0 to 1.1 bags. The average weight of goods per new plastic bag increases by about 50%, from 1.3 to 1.9 kilograms. The proportion of total goods (measured in terms of expenditure) not held in plastic bags increases from less than 7% to more than 41%. The values of all these variables differ largely between the *ex-ante* survey and the *ex-post* survey, and the differences in the mean of all variables are highly significant in terms of the t-test or the proportional test<sup>19</sup> as the corresponding p-values show in Table 2. A clear tendency of a reduction in the consumption of new plastic bags due to implementation is seen. In addition, the regulation also affects the way consumers use plastic bags: first, the new bags are used to hold more goods than before; second, the bags are reused more frequently than before; third, more substitutes are used, meaning that more goods are placed in containers other than plastic bags.

*<Table 2 to be here>*

Furthermore, we collected information about shops' monthly sales income and consumption of two types of plastic bags<sup>20</sup> in 2007 and 2008 from all surveyed supermarkets in Guiyang. The results are shown in Figure 1. No seasonal effects can be detected from the trends of free plastic bags and paid-for plastic bags, although the trend of sales income reflects weak seasonal variation.<sup>21</sup> Across the two-year period, the trend of sales income remains nearly flat, although apparent variances appear with sales income peaks occurring in the months that include main

---

<sup>19</sup> The variable with proportion data is tested by a proportional test; the remaining variables are tested by t-tests.

<sup>20</sup> One type of plastic bag is that sold right after the regulation implementation; the other type is the one still provided for free even after regulation implementation, i.e., the one used to separate foods and other products for hygiene and food safety purposes.

<sup>21</sup> The sales income seems to be higher in the winter than in the summer and nearly the same in the spring and the autumn. We conducted the two surveys in the spring and in the autumn, respectively.

festivals.<sup>22</sup> The consumption trend of the free plastic bags also kept stable across the 24 months, although with some variation. Nevertheless, paid-for plastic bag consumption experienced a drastic decrease directly after the regulation implementation in June 2008. The average number of paid-for bags consumed monthly fell from around one million to 0.2 million, while it stayed stable during the separate periods of both before and after the implementation. Compared to the bag consumption in April 2008, bag use decreased by 79% in the Guiyang supermarkets in November and December 2008. It is worth noting that the counterpart data from our survey reflects that the reduction in use of new plastic bags equals 75%, which corresponds well with the percentage reduction indicated by the sales records of the surveyed supermarkets in Guiyang.

*<Figure 1 to be here>*

## ***5.2. Descriptive statistics***

Factors other than the implementation of the regulation may also influence plastic bag use. These potential influential factors are presented in Table 3.

The first set of variables reflects individuals' support of the regulation and the inconvenience of not using plastic bags provided by shops. In the survey, we measured the first two variables on a 5-level scale from "low" to "high." As shown in Table 3, more than 80% of the respondents present a positive attitude toward the regulation although the supportive attitude generally went down after experiencing the impacts of the implementation. The stated actual inconvenience caused by no longer using plastic bags provided by shops is greater than the respondents thought beforehand. Four months after the regulation was implemented, the percentage of new plastic bags consumed that were actually paid for, rather than obtained for free, is only 42% on average, reflecting that the enforcement effort is far from satisfying. After the regulation, the average bag price weighted by the surveyed subjects is 0.21 yuan in all surveyed shops and 0.33 yuan if only

---

<sup>22</sup> For example, a sales explosion occurred in January 2008 simply because, due to tradition, people bought lots of food to prepare for the celebration of China's most important festival, the Chinese Spring Festival.

the surveyed shops that charged for bags are included. The subject-weighted average bag price is 0.37 and 0.30 yuan in the Beijing and Guiyang surveyed shops that charged for bags, respectively.

The socioeconomic characteristics of the respondents and their families constitute the second set of variables that affect the use of plastic bags. Considering the pooled data of both surveys, the mean age of all respondents is 41, and about 45% are male. A “businessman” dummy is created to control for the effect of this particular profession on weekly bag use: respondents running their own business, such as a restaurant or a grocery store, may shop not only for themselves or their own families but also for all their customers, thereby consuming many more plastic bags than the average. About 10% of respondents belong to this profession, nearly 20% are registered as rural residents, and one-fifth are members of the Communist Party<sup>23</sup>. The average years of schooling and the average monthly income of the sample are 12.7 years and 2,200 Chinese yuan, respectively, while the average family size is nearly three persons. It is worth noting that the differences in mean of these characteristics between the sample from the *ex-ante* survey and from the *ex-post* survey are small in a quantitative sense. However, the differences in the mean or the distribution of some of the characteristics are significant in terms of the t-test, the proportional test or the Wilcoxon-Mann-Whitney test<sup>24</sup> partially due to the large sample.

<Table 3 to be here>

## 6. Econometric results

Econometric analysis is applied to estimate the effects of the aforementioned factors on the number of new plastic bags used per week and during the surveyed shopping trip, especially the effects of the regulation implementation. As mentioned before, interaction variables are included

---

<sup>23</sup> At the end of 2008, nearly 70% of the party members were urban residents (Organization Department of the Central Committee of the Communist Party of China, 2009) and in China, the urban population is smaller than the rural population. Our data therefore shows a larger fraction of party members in urban populations than the gross fraction of party members in the whole population.

<sup>24</sup> Variables with ranked data are tested by Wilcoxon-Mann-Whitney tests.



in some of the models. Table 4 reports regression results from two different specifications of Negative Binomial regression models, with and without interaction variables, concentrating on the effects on the number of the bags used per week. In both models, the dummies are included to control for weekdays and weekends/holidays and the time of day the survey was conducted. We begin by looking at the models without interaction variables.

*<Table 4 to be here>*

The results of the first Negative Binomial model are presented in Column [2]. Only the main variables *per se* are included in this model. The results shows that, controlling for other socioeconomic characteristics, regulation implementation has a strong impact on the use of new plastic bags: people on average use 12.5 fewer new bags per week following the regulation implementation. The results from this model also suggest that several control variables significantly influence the number of new plastic bags consumed per week. Nevertheless, the regulation has a quantitatively much larger influence than any other single factor.

Since the impacts of several influencing variables on bag consumption could differ from before to after the regulation implementation, our analysis mainly focuses on the results of the second Negative Binomial model in Column [3]. This model further incorporates interaction variables that are the regulation implementation dummy interacted with all the variables of interest<sup>25</sup> respectively, in order to capture the impacts of the regulation on different groups of people and on different places and shopping occasions.

Before the implementation, respondents with a one level higher feeling of inconvenience on average consume 0.4 more new plastic bags per week. Males on average consume 1.2 more new bags per week, while people with one more year of education use 0.5 fewer new bags weekly. One additional family member increases 0.7 new bags consumed weekly. As for the bag

---

<sup>25</sup> The only exception is the variable “percentage of paid-for bags.” Since the “percentage of paid-for bags” is set to be zero for all the observations from the *ex-ante* survey, its interaction variable is equivalent to itself, thereby turning out to be perfect collinear.

consumption of shoppers surveyed in different types of shops and in different regions, the shoppers surveyed in supermarkets use three fewer new plastic bags per week than those in open markets. Respondents from the less developed regional city Guiyang consume 2.7 more new bags weekly than respondents from the most developed capital Beijing.

After the implementation, for every 10 percentage point more paid-for plastic bags out of their total bag consumption, respondents use 0.2 fewer new bags weekly. It can be seen that the interaction variables interacting with attitude, age, supermarket dummy, and Guiyang dummy are significant, which indicates different reactions to the regulation. Specifically, respondents with a one level higher supportive attitude toward the regulation and those with a one year increase in age consume 1.2 and 0.1 fewer new bags per week, respectively, after regulation implementation, although neither of these factors plays a role in bag consumption before implementation. In addition to the three fewer bags used by people surveyed in supermarkets than by those surveyed in open markets before the regulation implementation, the former group use 2.2 fewer new bags per week than the latter group after implementation. Moreover, people in Guiyang consume 2.6 more new bags than those in Beijing *ex-ante*, while this consumption difference increases to 13.3 new bags *ex-post*. All of the above mentioned marginal effects are significant at the 5% level or better. From the models shown above, the sizes of the marginal effects reflect that the regulation exerts a large impact on reduction of weekly plastic bag use.<sup>26</sup>

As for the effects of the regulation implementation and other factors on the number of new bags used during the surveyed shopping trip, Table 5 reports the results from Negative Binomial regression models. The same independent variables as before are included in the models. The results demonstrate that the regulation has similar effects on per shopping trip bag consumption

---

<sup>26</sup> The marginal effects from OLS and Tobit models are reported in Table A1 in the appendix. Comparing the regression results between OLS and Negative Binomial models and between the Tobit and Negative Binomial models, the significant variables are almost the same. The marginal effects of all the significant variables maintain the same sign, and their magnitude differences are small across various models. The small variations in the marginal effect estimates of most variables suggest robustness of our results.

as compared to the effects on weekly bag consumption.<sup>27</sup> Consumers on average use 2.3 fewer new bags during one shopping trip following the regulation implementation. Many interaction variables are significant, indicating that the effects of the regulation on per shopping trip bag consumption differ among different groups of people. Consumers with a stronger supportive attitude, older consumers, party members, and people surveyed in supermarkets are more affected by the regulation, while consumers with a stronger inconvenience feeling, males, consumers registered as rural residents, and consumers in Guiyang are more likely to stick to their previous bag use habit.

*<Table 5 to be here>*

Using the comparison approach introduced at the end of Section 4, Table 6 displays the descriptive statistics of the true and the predicted values of the number of new bags used per week after regulation implementation, under imperfect and perfect regulation enforcement, respectively. It can be seen that consumers would further reduce their consumption by more than one new bag per week if the regulation was enforced perfectly, and this further reduction is highly significant in terms of t-test and Wilcoxon-Mann-Whitney test results.<sup>28</sup> The comparison above confirms that the regulation would be even more effective on bag use reduction if the regulation enforcement was more effective.

*<Table 6 to be here>*

## **7. Conclusions and lessons**

In recent years, an increasing number of countries have enacted various regulations to limit the

---

<sup>27</sup> The estimation results from OLS and Tobit model are reported in Table A2, which tells the similar story as shown by the Negative Binomial model. Moreover, the results of the regression models further incorporating the variable of bag prices are shown in Table A3. Unsurprisingly, the marginal effects of the price variables demonstrate that bag consumption during a certain shopping trip decreases with the bag price increase in the shops.

<sup>28</sup> The regression results of the corresponding Negative Binomial model are presented in Table A4. The statistical test results are shown in Table A5.

use of plastic bags. Similar plastic bag control policies that appear successful in some countries, e.g., Denmark and Ireland, have turned out to be far from successful in others, e.g., South Africa and Kenya (Hasson *et al.*, 2007; Clean Up the World, 2008). Hence, when China implemented a regulation requiring shops to charge consumers for plastic bags, we took the opportunity to conduct surveys both *ex-ante* and *ex-post* regulation implementation. Our findings show that Chinese consumers in the two surveyed cities reduced their overall plastic bag consumption by 49% and their bag consumption during the surveyed single shopping trip in supermarkets or open markets by 64% from the first to the second survey. This indicates that a potential success in plastic bag litter control measure is occurring in China – the country with the largest consumption of plastic bags in the world. Apart from bag consumption, the plastic bag regulation also shifted various other aspects of bag use behavior in the direction of more efficient use, more reuse of plastic bags, and more use of substitutes. The influence of the regulation differs substantially across different groups of people and different locations. This information can be used to further improve the regulation.

Citizens' attitudes toward the policy indeed play a significant role in reducing the number of bags used after regulation implementation, which is consistent with the experience from Ireland (Convery *et al.*, 2007). Since plastic bags are still easily affordable following the new regulation, it is important to strengthen and maintain people's supportive attitudes toward the regulation in order to keep the degree of reduction in bag use. People surveyed in open markets and people in Guiyang consumed more bags than those in supermarkets and those in Beijing before the regulation implementation, and the differences were further enlarged after the regulation. Apart from the fact that people shopping in supermarkets and living in Beijing could be more environmentally conscious, the better dissemination of information and enforcement of the regulation in these places could be the main driving forces behind the differences. Our results further show that the regulation would reduce bag consumption to an even higher degree if it were enforced more effectively. Generally speaking, the improvements such as better

enforcement and nationwide information dissemination would be more easily achieved if the government were to take over the charging duty from the shops by levying a plastic bag tax directly on consumers and requiring the shops to collect the levy.

It is noteworthy that the results of the paper reveal only the short-term effects of the regulation and cannot simply be generalized to conclude anything about the long-term effects. Using monetary incentive tools alone to achieve a long-run impact on pollution control could be unreliable: The effects of increases in shopping costs at the margin become weaker for consumers as time passes. After the first feelings of resistance, which are provoked by the additional expenditure, consumers become accustomed to what they were initially upset about (East and Hogg, 2000). This may be found to be particularly true with goods, such as plastic bags, that can be classified as daily consumption commodities and add only marginally to the total shopping bill. The changed pattern of consumption following plastic bag legislation in South Africa shows that the initially significant consumption reduction in plastic bags gradually rebounded (Hasson *et al.*, 2007). Therefore, the current success in terms of bag use reduction should only be considered a trigger; any future reduction depends on the long-run enforcement efforts of the regulation. Further adjustments, such as adding the negative environmental cost of the bags into the price, persistent information campaigns to maintain people's environmental concerns, and enhancing enforcement at various locations and shopping occasions, may need to be adopted.

## **References**

- Ackerman, Frank (1997), "Why Do We Recycle: Markets, Values, and Public Policy", Washington, DC, USA: Island Press.
- Briassoulis, Helen (2001), "Policy-Oriented Integrated Analysis of Land-Use Change: An Analysis of Data Needs", *Environmental Management* 27 (1): 1–11.
- Cameron, A. C., and P. K. Trivedi (1986), "Econometric Models Based on Count Data: Comparisons and Applications of Some Estimators and Tests", *Journal of Applied Econometrics* 1(1): 29–53.
- Carr-Harris, H. (1996), "Instruments Available to Waste Managers to Encourage Waste minimization", In: *Washington Waste Minimization Workshop, Vol. II, Which Policies, Which Tools?* Paris, France: Organization for Economic Cooperation and Development: 145- 197.
- Chinese Ministry of Commerce, Chinese National Development and Reform Commission, Chinese State Administration for Industry and Commerce (2008), "*The Administrative Byelaw for Non-free Use of Plastic Shopping Bags in Retailer Occasions*", No.8, 2008. (In Chinese)
- Chinese National Development and Reform Commission (2008a), "*The 33<sup>rd</sup> Pronunciamento of National Development and Reform Commission in 2008*", No. 33, 2008. (In Chinese)
- Chinese National Development and Reform Commission (2008b), "*FAQ of National Development and Reform Commission*", [http://www.gov.cn/fwxx/sh/2008-01/11/content\\_855746.htm](http://www.gov.cn/fwxx/sh/2008-01/11/content_855746.htm). Accessed on June 5, 2008. (In Chinese)
- Clean Up the World (2008), "Plastic Bags - World Report", *The website of Clean Up the World*. [http://www.cleantuptheworld.org/PDF/en/plastic-bags-\\_e.pdf](http://www.cleantuptheworld.org/PDF/en/plastic-bags-_e.pdf). Accessed on February 15, 2009.
- Convery, Frank, McDonnell, Simon and Ferreira, Susana (2007), "The Most Popular Tax in Europe? Lessons from the Irish Plastic Bags Levy", *Environmental and Resource Economics* 38 (1): 1-11.

- Danish Environmental Protection Agency (1999), “Waste in Denmark”, *Ministry of Environment and Energy*, Copenhagen, Denmark.
- Downing, P.B. and J. White (1986), “Innovation in Pollution Control”, *Journal of Environmental Economics and Management* 13 (1): 18-29.
- East, Robert and Hogg, Annik (2000), “Advertising for Economic Change”, *Journal of Economic Psychology* 21 (5): 577-590.
- Friends of the Earth Scotland (2005), “Evidence to the Environment Committee on Environmental Levy on Plastic Bags (Scotland) Bill”, *the website of Friends of the Earth Scotland*. [http://www.foe-scotland.org.uk/publications/plastic\\_bag\\_bill\\_evidence.pdf](http://www.foe-scotland.org.uk/publications/plastic_bag_bill_evidence.pdf). Accessed on June 5, 2008.
- Geller, E. Scott, John C. Farris and David S. Post (1973), “Prompting a Consumer Behavior for Pollution Control”, *Journal of Applied Behavior Analysis* 6 (3): 367-376.
- Greene, William H. (2003), *Econometric Analysis (Fifth Edition)*. New Jersey: *Pearson Education, Inc.*
- Hasson, R., Leiman, A. and Visser M. (2007), “The Economics of Plastic Bag Legislation in South Africa”, *South African Journal of Economics* 75 (1): 66-83.
- Irish Department of the Environment, Heritage & Local Government (2007), “Announcement of the Minister for the Environment, Heritage & Local Government Mr. Dick Roche”, <http://www.environ.ie/en/Environment/Waste/PlasticBags/News/MainBody,3199,en.htm>. Accessed on April 28, 2009.
- Manuel, Jennifer C, Mary Anne Sunseri, Ryan Olson and and Miranda Scolari (2007), “A Diagnostic Approach to Increase Reusable Dinnerware Selection in a Cafeteria”, *Journal Applied Behavior Analysis* 40(2): 301–310.
- OECD (2001), “Environmentally Related Taxes in OECD Countries: Issues and Strategies”, *OECD*, Paris.
- Organization Department of the Central Committee of the Communist Party of China (2009),

- “The Inner-Party Statistic Communique of the Communist Party of China: 2008”, *CPC Central Committee Party's publishing house*. (In Chinese)
- Pearce, David W. and R. Kerry Turner (1993), “Market-based Approaches to Solid Waste Management”, *Resources, Conservation and Recycling* 8 (2): 63-90.
- Stavins, R.N. (2002), “Experience with Market-Based Environmental Policy Instruments”, *FEEM Working Paper No. 52.2002; KSG Working Paper No. 00-004*.
- Sterner, Thomas (2003), “Policy Instruments for Environmental and Natural Resource Management”, *Resources for the future*, Washington DC, USA.
- Taylor, Donald C. (2000), “Policy Incentives to Minimize Generation of Municipal Solid Waste”, *Waste Management & Research* 18 (5): 406-419.
- Wang Youling (2008), “Exclusive Interview of the Deputy Director Li Jing, the Department of Resource Conservation and Environmental Protection, Chinese National Development and Reform Commission” Xinhua News Agency. <http://news.sdinfo.net/itxw/426489.shtml>. Accessed on June 5, 2008. (In Chinese)
- Wooldridge, J. M. (2002), *Econometric Analysis of Cross Section and Panel Data*. Cambridge: MIT Press.
- Zhang, Jianxun (2008), “China Gets Ready to Reduce Its Plastic Bag Overuse”, *the website of China Trade News*. <http://www.chinatradenews.com.cn/Article.asp?NewsID=105162>. Accessed on July 3, 2008. (In Chinese)
- Zhang, Jinfeng (2000), “Discussion of Some Questions Related to Selection and Resource of Municipal Solid Waste treatment and disposal”, *Environmental Sanitation Engineering* 8 (3): 122–125. (In Chinese)



**Table 1: The time and spatial distribution of the observations in both surveys**

Survey period	Beijing		Guiyang		All regions and shops
	supermarket	open market	supermarket	open market	
07:30-11:00	227	202	276	285	990
12:00-15:00	195	194	349	272	1010
17:30-20:00	202	190	276	406	1074
All periods	624	586	901	963	3074

Note: The three periods are the main shopping hours of the shops

**Table 2: Descriptive statistics of variables defining the relevant plastic bag use behaviors**

Bag use behavior variables	Description	Before policy			After policy			P-value
		Obs.	Mean	Std. Dev.	Obs.	Mean	Std. Dev.	
<b>Self-reported behavior of plastic bag use in general</b>								
Number of new plastic bags per week	= number of new plastic bags respondent uses per week (bag)	1039	20.923	18.221	2035	10.678	14.501	0.000 <sup>a</sup>
Bag actual reuse time	= product of the average reuse proportion and average reuse time (time)	1039	0.746	0.642	2035	1.275	1.289	0.000 <sup>a</sup>
<b>Measurable behavior of plastic bag use during the surveyed shopping trip</b>								
Use new bags or not	= 1 if respondent used new plastic bag during the surveyed shopping trip; =0 otherwise	1039	0.987	0.111	2035	0.564	0.496	0.000 <sup>b</sup>
Number of new plastic bags used	= number of new plastic bags respondent uses during the surveyed shopping trip (bag)	1039	3.013	1.996	2035	1.079	2.159	0.000 <sup>a</sup>
Average weight per new bag <sup>c</sup>	= respondent's average weight of goods in one new plastic bag during the surveyed shopping trip (Kg/bag)	1026	1.284	1.197	1148	1.877	2.101	0.000 <sup>a</sup>
Expenditure percentage of goods not held in plastic bags	= respondent's percentage of total expenditure not held in plastic bag during the surveyed shopping trip (%)	1039	6.683	19.643	2035	41.260	45.305	0.000 <sup>a</sup>

Notes: 1. <sup>a</sup> indicates it is from a t-test; <sup>b</sup> indicates it is from a proportional test; <sup>c</sup> This variable is only for the respondents who use new plastic bags at the time of shopping.

2. At the times of the surveys, 6.98 Chinese Yuan Renminbi = 1 USD (May 2008) and 6.85 Chinese Yuan Renminbi = 1 USD (November 2008).

**Table 3: Definitions and descriptive statistics of variables used in econometric analyses**

Description	Before policy			After policy			P-value	Before & after policy		
	Obs.	Mean	Std. Dev.	Obs.	Mean	Std. Dev.		Obs.	Mean	Std. Dev.
Supportive attitude	1039	4.459	0.930	2035	4.069	1.067	0.000 <sup>c</sup>	3074	4.201	1.039
Inconvenience of not using plastic bags	1039	2.740	1.375	2035	3.000	1.221	0.000 <sup>c</sup>	3074	2.912	1.281
Percentage of paid-for bags	1039	0.000	0.000	2035	42.251	32.924	0.000 <sup>a</sup>	3074	27.970	33.422
Bag price in the current shop	1039	0.000	0.000	2035	0.206	0.168	0.000 <sup>b</sup>	3074	0.136	0.168
Age	1039	42.858	16.535	2035	40.620	16.894	0.001 <sup>a</sup>	3074	41.376	16.804
Male	1039	0.417	0.493	2035	0.460	0.499	0.021 <sup>b</sup>	3074	0.446	0.497
Businessman	1039	0.090	0.287	2035	0.099	0.298	0.460 <sup>b</sup>	3074	0.096	0.295
Rural register	1039	0.180	0.384	2035	0.201	0.401	0.154 <sup>b</sup>	3074	0.194	0.396
Education years	1039	12.398	3.242	2035	12.815	3.269	0.001 <sup>a</sup>	3074	12.674	3.266
Monthly income	1039	2.178	1.674	2035	2.215	1.688	0.559 <sup>a</sup>	3074	2.203	1.683
Party member	1039	0.226	0.419	2035	0.188	0.391	0.012 <sup>b</sup>	3074	0.201	0.401
Family size	1039	2.876	1.311	2035	2.975	1.457	0.065 <sup>a</sup>	3074	2.941	1.410

Notes: 1. <sup>a</sup> indicates it is from a t-test; <sup>b</sup> indicates it is from a proportional test; <sup>c</sup> indicates it is from a Wilcoxon-Mann-Whitney test.

2. At the time of the surveys, 6.98 Chinese Yuan Renminbi = 1 USD (May 2008) and 6.85 Chinese Yuan Renminbi = 1 USD (November 2008).

**Table 4: Regression results from negative binomial models regarding weekly bag consumption**

Model specification	[1] Negative binomial model 1 without interaction variables	[2] Negative binomial model 2 with interaction variables
Dependent variable	Number of new plastic bags per week	
	Mar. Eff.	Mar. Eff.
After policy implementation	-12.495 (14.88)***	-7.528 (1.68)*
Supportive attitude	-1.277 (6.37)***	-0.197 (0.56)
Inconvenience of not using plastic bags	0.420 (2.54)**	0.432 (1.68)*
Percentage of paid-for bags	-0.034 (4.18)***	-0.018 (2.28)***
Age	-0.002 (0.14)	0.040 (1.61)
Male	1.681 (4.08)***	1.239 (1.91)*
Businessman	2.463 (2.99)***	2.061 (1.57)
Rural register	0.704 (1.19)	0.476 (0.49)
Education years	-0.499 (6.53)***	-0.453 (3.75)***
Monthly income	0.582 (4.30)***	0.347 (1.55)
Party member	-0.614 (1.23)	-0.206 (0.26)
Family size	0.492 (3.41)***	0.733 (2.75)***
Supermarket	-4.559 (10.94)***	-2.990 (4.75)***
Guiyang	8.076 (18.44)***	2.681 (4.03)***
Attitude*After policy imple.		-1.204 (2.89)***
Inconvenience*After policy imple.		0.418 (1.29)
Age*After policy imple.		-0.068 (2.30)**
Male*After policy imple.		0.459 (0.56)
Businessman*After policy imple.		0.895 (0.60)
Rural register*After policy imple.		0.997 (0.81)
Eduyear*After policy imple.		-0.051 (0.34)
Income*After policy imple.		0.065 (0.23)
Party member*After policy imple.		-0.234 (0.24)
Family size*After policy imple.		-0.506 (1.62)
Supermarket*After policy imple.		-2.238 (3.00)***
Guiyang*After policy imple.		10.694 (9.83)***
Dummies for weekdays and weekends/holidays	Yes	Yes
Dummies for time of day conducting survey	Yes	Yes
No. of Obs.	3074	3074
Pseudo R-square	0.051	0.060
Prob > chi2	0.000	0.000

Notes: 1. Absolute value of t or z statistics in parentheses.

2. \* significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%.

**Table 5: Regression results from negative binomial models regarding bag consumption during the surveyed shopping trip**

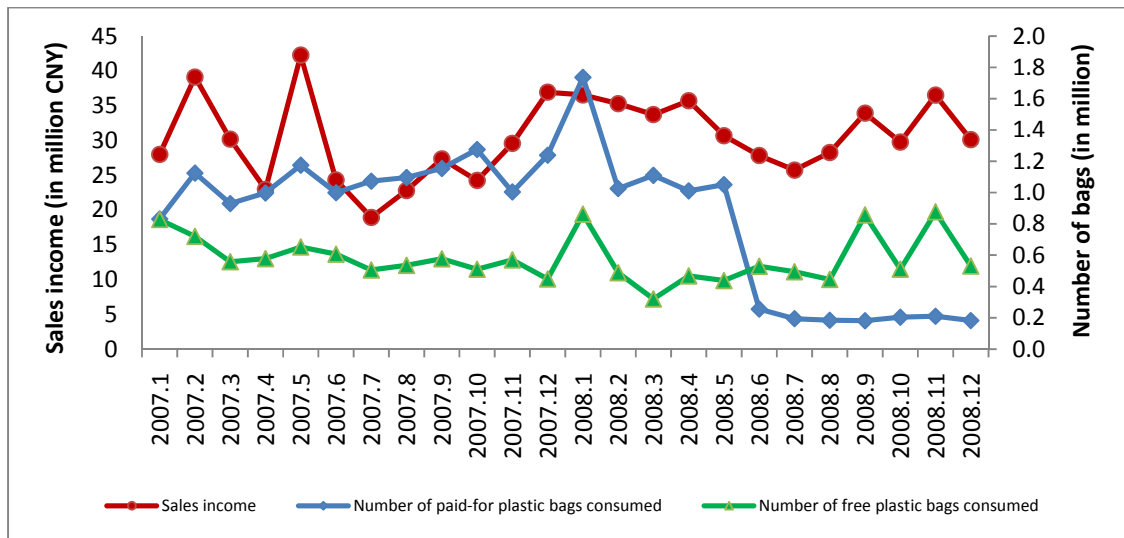
Model specification	[1] Negative binomial model 1 without interaction variables	[2] Negative binomial model 2 with interaction variables
Dependent variable	Number of new plastic bags during the surveyed shopping trip	
	Mar. Eff.	Mar. Eff.
After policy implementation	-2.315 (19.49)***	-1.036 (2.03)**
Supportive attitude	-0.105 (4.26)***	0.038 (1.14)
Inconvenience of not using plastic bags	0.049 (2.45)***	0.020 (0.86)
Percentage of paid-for bags	0.003 (2.38)***	0.004 (3.73)***
Age	-0.007 (3.73)***	0.001 (0.26)
Male	0.140 (2.76)***	-0.051 (0.86)
Businessman	0.004 (0.05)	0.034 (0.31)
Rural register	-0.009 (0.13)	-0.239 (3.01)***
Education years	0.009 (1.00)***	0.007 (0.59)
Monthly income	0.056 (3.64)***	0.016 (0.80)
Party member	-0.165 (2.72)***	-0.017 (0.24)
Family size	0.027 (1.55)	0.035 (1.60)
Supermarket	-1.014 (18.94)***	-0.397 (6.75)***
Guiyang	0.231 (4.40)***	-0.091 (1.44)
Attitude*After policy imple.		-0.192 (4.4)***
Inconvenience*After policy imple.		0.104 (2.92)***
Age*After policy imple.		-0.017 (5.1)***
Male*After policy imple.		0.320 (3.33)***
Businessman*After policy imple.		-0.021 (0.14)
Rural register*After policy imple.		0.555 (3.43)***
Eduyear*After policy imple.		0.020 (1.22)
Income*After policy imple.		0.026 (0.96)
Party member*After policy imple.		-0.262 (2.65)***
Family size*After policy imple.		-0.033 (1.08)
Supermarket*After policy imple.		-1.004 (13.83)***
Guiyang*After policy imple.		0.746 (6.84)***
Dummies for weekdays and weekends/holidays	Yes	Yes
Dummies for time of day conducting survey	Yes	Yes
No. of Obs.	3074	3074
Adjusted/pseudo R-square	0.118	0.151
Prob > chi2	0.000	0.000

Notes: 1. Absolute value of t or z statistics in parentheses.

2. \* significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%.

**Table 6. Descriptive statistics of the true value and predicted value of the number of new plastic bags per week after regulation implementation**

	No. of Obs.	Mean	Std. Dev.
True weekly bag consumption under imperfect enforcement ( $Q_{imperf}^T$ )	2035	10.678	14.501
Predicted weekly bag consumption by NB model under perfect enforcement ( $Q_{perf}^{P\_NB}$ )	2035	9.644	6.461



**Figure 1. The sales income and the number of consumed plastic bags at the sampled supermarkets in Guiyang**

**Appendix**

**Table A1: Regression results from OLS and Tobit models regarding weekly bag consumption**

Model specification	[1] OLS model 1 without interaction variable	[2] OLS model 2 with interaction variables	[3] Tobit model 1 without interaction variable	[4] Tobit model 2 with interaction variables
Dependent variable	Number of new plastic bags per week			
	M.E./Coef.	M.E./Coef.	Mar. Eff.	Mar. Eff.
After policy implementation	-10.716 (-14.75)***	-6.907 (-1.33)	-10.207 (-15.48)***	-6.724 (-1.47)
Supportive attitude	-1.168 (-4.25)***	-0.238 (-0.46)	-1.123 (-4.81)***	-0.190 (-0.43)
Inconvenience of not using plastic bags	0.475 (2.12)**	0.703 (1.87)*	0.456 (2.40)**	0.582 (1.84)*
Percentage of paid-for bags	-0.026 (-2.47)**	-0.027 (-2.52)**	-0.019 (-2.17)**	-0.019 (-2.07)**
Age	-0.015 (-0.73)	0.041 (1.17)	-0.028 (-1.64)	0.036 (1.20)
Male	1.519 (2.74)***	2.354 (2.48)**	1.518 (3.21)***	1.900 (2.36)**
Businessman	4.131 (4.23)***	4.235 (2.47)**	3.309 (3.76)***	3.481 (2.25)**
Rural register	0.836 (1.10)	0.917 (0.67)	0.858 (1.31)	0.794 (0.68)
Education years	-0.647 (-6.49)***	-0.929 (-5.28)***	-0.505 (-5.92)***	-0.755 (-5.10)***
Monthly income	0.567 (3.21)***	0.416 (1.30)	0.498 (3.31)***	0.351 (1.31)
Party member	0.196 (0.28)	0.635 (0.54)	0.080 (0.13)	0.467 (0.47)
Family size	0.485 (2.54)**	0.881 (2.41)**	0.380 (2.34)**	0.725 (2.36)**
Supermarket	-5.008 (-9.13)***	-5.331 (-5.76)***	-4.487 (-9.63)***	-4.328 (-5.58)***
Guiyang	7.473 (12.63)***	5.216 (5.15)***	6.972 (14.51)***	4.214 (5.10)***
Attitude*After policy imple.		-1.231 (-2.01)**		-1.212 (-2.34)**
Inconvenience*After policy imple.		-0.082 (-0.17)		0.137 (0.34)
Age*After policy imple.		-0.086 (-2.03)**		-0.100 (-2.78)***
Male*After policy imple.		-1.300 (-1.11)		-0.669 (-0.68)
Businiessman*After policy imple.		0.035 (0.02)		0.040 (0.02)
Rural register*After policy imple.		0.229 (0.14)		0.460 (0.33)
Eduyear*After policy imple.		0.423 (1.98)**		0.385 (2.13)**
Income*After policy imple.		0.195 (0.51)		0.162 (0.50)
Party member*After policy imple.		-0.587 (-0.40)		-0.488 (-0.40)
Family size*After policy imple.		-0.596 (-1.39)		-0.543 (-1.50)
Supermarket*After policy imple.		0.509 (0.44)		-0.256 (-0.26)
Guiyang*After policy imple.		3.244 (2.59)***		4.440 (4.12)***
Dummies for weekdays and weekends/holidays	Yes	Yes	Yes	Yes
Dummies for time of day conducting survey	Yes	Yes	Yes	Yes
No. of Obs.	3074	3074	3074	3074
Adjusted/Pseudo R-square	0.220	0.226	0.034	0.037
Prob > chi2	0.000	0.000	0.000	0.000

Notes: 1. Absolute value of t or z statistics in parentheses.

2. \* significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%.



**Table A2: Regression results from OLS and Tobit models regarding bag consumption during the surveyed shopping trip**

Model specification	[1] OLS model 1 without interaction variables	[2] OLS model 2 with interaction variables	[3] Tobit model 1 without interaction variables	[4] Tobit model 2 with interaction variables
<b>Dependent variable</b>	<b>Number of new plastic bags during the surveyed shopping trip</b>			
	M.E./Coef.	M.E./Coef.	Mar. Eff.	Mar. Eff.
After policy implementation	-2.132 (21.26)***	-1.109 (1.56)	-2.472 (23.53)***	-1.123 (1.68)*
Supportive attitude	-0.092 (2.43)**	0.083 (1.17)	-0.113 (3.38)***	0.056 (0.97)
Inconvenience of not using plastic bags	0.052 (1.67)***	0.048 (0.94)	0.061 (2.22)**	0.034 (0.80)
Percentage of paid-for bags	0.002 (1.51)	0.003 (1.76)*	0.004 (3.25)***	0.006 (4.05)***
Age	-0.007 (2.44)***	-0.000 (0.04)	-0.012 (4.65)***	0.001 (0.24)
Male	0.126 (1.64)	-0.112 (0.86)	0.147 (2.17)***	-0.089 (0.83)
Businessman	0.038 (0.28)	0.073 (0.31)	-0.040 (0.34)	0.050 (0.26)
Rural register	-0.090 (0.86)	-0.548 (2.92)***	0.019 (0.20)	-0.351 (2.47)**
Education years	0.014 (1.04)	0.019 (0.79)	0.016 (1.29)	0.014 (0.71)
Monthly income	0.058 (2.38)***	0.036 (0.83)	0.069 (3.23)***	0.023 (0.65)
Party member	-0.173 (1.77)*	-0.022 (0.13)	-0.198 (2.36)***	-0.025 (0.19)
Family size	0.042 (1.59)	0.089 (1.78)*	0.027 (1.15)	0.060 (1.46)
Supermarket	-1.081 (14.28)***	-0.930 (7.33)	-1.142 (16.99)***	-0.612 (5.88)***
Guiyang	0.216 (2.64)***	-0.223 (1.61)	0.374 (5.26)***	-0.129 (1.13)
Attitude*After policy imple.		-0.224 (2.67)***		-0.223 (3.16)***
Inconvenience*After policy imple.		0.049 (0.76)		0.105 (1.91)*
Age*After policy imple.		-0.010 (1.72)*		-0.022 (4.43)***
Male*After policy imple.		0.320 (1.99)**		0.338 (2.38)***
Businiessman*After policy imple.		0.023 (0.08)		-0.067 (0.29)
Rural register*After policy imple.		0.692 (3.06)***		0.660 (3.04)***
Eduyear*After policy imple.		-0.005 (0.18)		0.013 (0.52)
Income*After policy imple.		0.010 (0.20)		0.040 (0.92)
Party member*After policy imple.		-0.230 (1.15)		-0.274 (1.71)*
Family size*After policy imple.		-0.082 (1.39)		-0.067 (1.35)
Supermarket*After policy imple.		-0.194 (1.23)		-0.846 (6.98)***
Guiyang*After policy imple.		0.672 (3.90)***		0.898 (5.87)***
Dummies for weekdays and weekends/holidays	Yes	Yes	Yes	Yes
Dummies for time of day conducting survey	Yes	Yes	Yes	Yes
No. of Obs.	3074	3074	3074	3074
Adjusted/pseudo R-square	0.225	0.240	0.088	0.104
Prob > chi2	0.000	0.000	0.000	0.000

Notes: 1. Absolute value of t or z statistics in parentheses.

2. \* significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%.

**Table A3: Regression results from negative binomial, OLS and Tobit models regarding bag consumption during the surveyed shopping trip with price information**

Model specification	[1] Negative binomial model 1 without interaction variables	[2] Negative binomial model 2 with interaction variables	[3] OLS model 1 without interaction variables	[4] OLS model 2 with interaction variables	[5] Tobit model 1 without interaction variables	[6] Tobit model 2 with interaction variables
	Dependent variable					
	Number of new plastic bags during the surveyed shopping trip					
	Mar. Eff.	Mar. Eff.	M.E./Coef.	M.E./Coef.	Mar. Eff.	Mar. Eff.
After policy implementation	-1.489 (14.02)***	-0.826 (1.71)***	-1.789 (14.76)***	-0.899 (1.26)	-1.872 (15.45)***	-0.873 (1.33)
Bag price in the current shop	-3.305 (14.02)***	-1.557 (4.83)***	-1.760 (5.00)***	-1.582 (3.66)***	-2.913 (9.13)***	-1.882 (4.58)***
Supportive attitude	-0.084 (3.64)***	0.037 (1.13)	-0.084 (2.21)***	0.083 (1.16)	-0.099 (2.97)***	0.056 (0.96)
Inconvenience of not using plastic bags	0.049 (2.62)***	0.020 (0.85)	0.055 (1.78)***	0.048 (0.93)	0.066 (2.43)***	0.033 (0.79)
Percentage of paid-for bags	0.006 (5.36)***	0.005 (4.4)	0.003 (2.21)***	0.003 (2.06)***	0.006 (4.79)***	0.006 (4.44)***
Age	-0.006 (3.35)***	0.001 (0.26)	-0.006 (2.25)***	-0.000 (0.03)	-0.011 (4.43)***	0.001 (0.25)
Male	0.120 (2.55)***	-0.051 (0.87)	0.124 (1.63)	-0.112 (0.86)	0.140 (2.08)***	-0.090 (0.84)
Businessman	-0.004 (0.05)	0.035 (0.32)	0.027 (0.20)	0.074 (0.32)	-0.056 (0.49)	0.052 (0.27)
Rural register	-0.004 (0.06)	-0.238 (3.01)***	-0.083 (0.79)	-0.548 (2.92)***	0.036 (0.38)	-0.350 (2.47)***
Education years	0.014 (1.65)	0.007 (0.59)	0.017 (1.21)	0.019 (0.79)	0.020 (1.64)	0.014 (0.72)
Monthly income	0.037 (2.60)	0.015 (0.80)	0.050 (2.04)***	0.036 (0.82)	0.056 (2.64)***	0.023 (0.64)
Party member	-0.141 (2.49)***	-0.018 (0.25)	-0.167 (1.71)***	-0.022 (0.14)	-0.187 (2.24)***	-0.025 (0.20)
Family size	0.040 (2.41)***	0.035 (1.61)	0.050 (1.90)***	0.090 (1.79)***	0.040 (1.70)***	0.060 (1.47)
Supermarket	-0.581 (10.33)***	-0.396 (6.75)***	-0.825 (9.05)***	-0.930 (7.34)***	-0.733 (9.08)***	-0.611 (5.89)***
Guiyang	0.010 (0.19)	-0.091 (1.44)	0.055 (0.63)	-0.223 (1.61)	0.134 (1.75)***	-0.130 (1.13)
Attitude*After policy imple.		-0.193 (4.44)***		-0.223 (2.65)***		-0.221 (3.13)***
Inconvenience*After policy imple.		0.106 (2.98)***		0.050 (0.78)		0.107 (1.94)***
Age*After policy imple.		-0.016 (4.85)***		-0.009 (1.62)		-0.022 (4.29)***
Male*After policy imple.		0.329 (3.42)***		0.332 (2.07)***		0.346 (2.43)***
Businiessman*After policy imple.		-0.028 (0.20)		0.005 (0.02)		-0.083 (0.35)
Rural register*After policy imple.		0.564 (3.47)***		0.703 (3.11)***		0.677 (3.11)***
Eduyear*After policy imple.		0.023 (1.45)		-0.004 (0.12)		0.016 (0.62)
Income*After policy imple.		0.022 (0.81)		0.005 (0.09)		0.036 (0.81)
Party member*After policy imple.		-0.262 (2.64)***		-0.226 (1.13)		-0.269 (1.67)***
Family size*After policy imple.		-0.027 (0.87)		-0.075 (1.28)		-0.060 (1.21)
Supermarket*After policy imple.		-0.679 (6.55)***		0.160 (0.86)		-0.434 (2.74)***
Guiyang*After policy imple.		0.469 (4.04)***		0.441 (2.41)***		0.607 (3.70)***
Dummies for weekdays and weekends/holidays	Yes	Yes	Yes	Yes	Yes	Yes
Dummies for time of day conducting survey	Yes	Yes	Yes	Yes	Yes	Yes
No. of Obs.	3074	3074	3074	3074	3074	3074
Adjusted/pseudo R-square	0.135	0.153	0.231	0.243	0.095	0.105
Prob > chi2	0.000	0.000	0.000	0.000	0.000	0.000

Notes: 1. Absolute value of t or z statistics in parentheses.

2. \* significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%.

**Table A4: Regression results from the negative binomial model regarding weekly bag consumption after regulation implementation**

Model specification	Negative binomial model
Dependent variable	Number of new plastic bags per week
	Mar. Eff.
Supportive attitude	-1.044 (5.76) <sup>***</sup>
Inconvenience of not using plastic bags	0.626 (3.88) <sup>***</sup>
Percentage of paid-for bags	-0.015 (2.31) <sup>**</sup>
Age	-0.023 (1.7) <sup>*</sup>
Male	1.234 (3.13) <sup>***</sup>
Businessman	2.412 (2.96) <sup>***</sup>
Rural register	1.180 (2.02) <sup>**</sup>
Education years	-0.360 (4.94) <sup>***</sup>
Monthly income	0.315 (2.43) <sup>**</sup>
Party member	-0.282 (0.57)
Family size	0.169 (1.30)
Holiday or weekend	-1.312 (3.44) <sup>***</sup>
Noon	-1.949 (4.42) <sup>***</sup>
Afternoon	-0.825 (1.77) <sup>*</sup>
Supermarket	-4.069 (9.74) <sup>***</sup>
Guiyang	8.314 (20.97) <sup>***</sup>
Dummies for weekdays and weekends/holidays	Yes
Dummies for time of day conducting survey	Yes
No. of Obs.	2035
Adjusted/pseudo R-square	0.057
Prob > chi2	0.000

Notes: 1. Absolute value of z statistics in parentheses.

2. \* significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%.

**Table A5. The results of statistical tests of the further reduction**

Null hypothesis	$Q_{imperf}^T = Q_{perf}^{P\_NB}$
Differences in mean consumption	1.034
t-test (p-value)	0.000
Rank-sum test (p-value)	0.000
No. of Obs: $Q^A / Q^P$	2035/2035

Note:  $Q_{imperf}^T$  denotes the true weekly bag consumption under imperfect enforcement;  $Q_{perf}^{P\_NB}$  denotes the predicted weekly bag consumption by the NB model under perfect enforcement