Using contingent behaviour analysis to measure the price elasticity of demand for plastic bags

Abstract

Policymakers have little experience regarding designing the right levels of pricing for plastic bags. Prices for bags are generally set low; and are largely a symbolic reminder to consumers of the environmental concerns attributed to plastic bag use. The ineffectiveness of charging for bags in the long term, in countries such as South Africa, makes it imperative that the optimal price is set. Moreover, charging appropriate bag prices could alleviate the adverse effects associated with the use of substitute carrier bags. To address this issue, a survey was developed using the Contingent Behaviour (CB) approach to generate the stated preference (SP) data necessary to estimate the optimal price for bags that is likely to lead to a reduction in bag use over time. Thus, the aim of this study is to estimate the bag-use demand function for plastic shopping bags in South Africa. The current price of R0.40 (US$0.03) was found to be too low, and highly inelastic. Our analysis suggests that the price for plastic bags should be set at R6.40 (US$0.51). There is no danger of consumers shifting to substitutes in a manner that may be even more environmentally damaging to the environment.

Key words: Contingent behaviour, elasticity, levy, plastic bags, price, South Africa

1. Introduction

The rampant use of plastic bags around the world has led to growing concerns in recent years. The overuse of disposable plastic bags is a major environmental problem. Improperly discarded bags are a major source of plastic litter. For all these reasons, an increasing number of countries around the world have adopted various policies as part of their strategy to mitigate these environmental concerns. The mitigating strategies are primarily aimed at reducing plastic bag use levels. Because of the severity of the negative externalities associated with plastic bag litter, many governments are using market-based tools such as levies, taxes or subsidies to encourage consumers to internalise these negative externalities, as well as permitting the command and control of instruments such as setting norms and standards for the thickness of bags. This is sometimes accompanied by public awareness campaigns. At times, these approaches are used in combination. In contrast, some governments adopt a very tough stance, by banning use of plastic shopping bags altogether.

Previous studies suggest that the effectiveness of these instruments varies (Convery, McDonnell and Ferreira, 2007; Dikgang, Leiman and Visser, 2012a; Dikgang and Visser, 2012; Gupta, 2011; He, 2012; Poortinga, Whitmarsh and Suffolk, 2013; Rayne, 2008; Rivers, Shenstone-Harris and Young, 2017). For example, charging for bags has been effective in Ireland, Denmark, China and Botswana (Convery et al., 2007; Dikgang and Visser, 2012; He, 2012; Rayne, 2008), yet similar interventions have had limited success in South Africa, Canada and India (Dikgang et al., 2012a; Gupta, 2011; Rivers et al., 2017). This implies that the effectiveness of these interventions is context-specific and depends to a large extent on how they are implemented and what strategies are used.

In recent years, a significant number of countries (such as Ireland, Italy, South Africa, Botswana and the United Kingdom) have sought to curb disposable bag use by introducing a levy or charging at the point of purchase. However, these levies or prices tend to be set at low levels and are more symbolic Nonetheless, charging serves as a continuous reminder to consumers. By charging, governments are ‘nudging’ consumers towards reducing their use of plastic bags. It is hoped that this will change consumers’ purchasing decisions and/or curb plastic bag consumption. More drastic approaches – such as complete bans – have been pursued by some countries such as Bangladesh and Rwanda.

While existing studies suggest that where pricing does not work, it is largely due to small and symbolic price/levy levels, this study argues that none of these studies has determined what the optimal price/levy level of bags ought to be. In terms of welfare, it is not clear which fiscal policy would be optimal. To address this gap in the literature, our study aims to determine the

optimal bag price in South Africa by using a contingent behaviour (CB) analysis. This study investigates how the different price levels for bags are likely to affect plastic bag use. Survey information for consumers from the South African city of Johannesburg, ascertained by the contingent behaviour method, is used to assess the potential impact of price adjustments on plastic bag use. Consumer sensitivity to bag prices is not only essential information to enable plastic manufacturing companies to make choices, but also for environmental policies. Research findings highlight how setting bag price at an appropriate level can be useful in reducing bag usage levels. Using experimental data, and controlling for demographics and behavioural factors, this paper posits that for charging to be an effective nudging policy, it is critical that the price is set at a level that will remain a highly visible reminder of the negative outcomes associated with their excessive use.

This study estimates the demand function for plastic shopping bags in South Africa, to determine the scope for raising fees charged to consumers in order to reduce bag use in the long term. The argument here is that consumers are willing to pay a higher price for bags, as the current bag price constitutes a negligible fraction of their total shopping costs. While higher prices would presumably lead some customers to use alternative substitutes, the fact that the prices are a very small portion of overall shopping cost suggests that such substitution will be limited. Therefore, there is no danger of consumers shifting altogether or even significantly to substitutes that may be even more environmentally damaging.

These estimates are made using the contingent behaviour (CB) methodology. The bag use demand functions will be estimated using experimental data generated from the CB survey conducted on consumers. This is a valuation study; therefore, it asks consumers who do grocery shopping how they would respond to different hypothetical price levels. The management problems faced by South African policymakers are no different to those faced by other policymakers around the world. The common challenge around the world is that of excessive use of plastic shopping bags and the subsequent plastic litter. Thus, the solution presented in this study, of charging appropriate bag prices, could be a potential way to reduce bag use to sustainable levels. This article contributes to empirical work on optimal pricing by expanding on the scant literature available, which mostly concerns other subject areas, such as park pricing (see Alpízar, 2006; Chase, Lee, Schulze and Anderson, 1998; Dikgang and Muchapondwa, 2016; Dikgang, Muchapondwa and Stage, 2017). To the best of our knowledge, this is the first study to estimate the optimal price of plastic shopping bags.

2. Case study

It is argued that prior to the implementation of the plastic bag regulation, roughly eight million plastic bags were consumed annually in South Africa. As in various other developing countries, the use of plastic bags had grown in tandem with growing retail sectors Hasson et al. (2007). After a lengthy process of policy design and implementation, the South African government finally approached the problem of plastic bag use by adopting a policy mix combining a regulation-based prohibition and a consumer-based charge.

The legislation was fully implemented in May 2003. The minimum thickness requirement had consequences for the actual plastic bag sold and the price at which it was sold. The five-year leeway effectively led to plastic bag thickness settling at 24µm. The heavier gauge was intended to stimulate the reuse of plastic bags, avoiding immediate disposal following a single use. The nominal price for plastic bags was set at R0.46, including a levy initially launched at two cents, with proceeds channelled to the government. The law stipulated that consumers were obliged to purchase new bags at the stipulated price, reuse previously purchased and thicker plastic bags, or resort to other reusable alternatives.

The regulation initially targeted all retailers in the country, with a set charge for bags. However, following just three months of implementation and persistent protests from both industry and labour, the pricing and scope were changed. The charge was lowered to R0.32. Retailers further absorbed some of the cost, leaving consumers to pay R0.17 per bag (Hasson et al., 2007). Furthermore, some retailers had pushed back against the regulation, refusing to charge for plastic bags (Ngobese, 2003).

Using the funds directed at recycling received from government, a non-profit organisation was established called Buyisa-e-Bag. The company was responsible for "promoting efficiency in the use, reuse, collection, recycle and disposal of plastic bags, including setting up of buy-back centres" (Department of Environmental Affairs, 2010). Unfortunately, the company was dissolved in 2011 due to administrative issues and mismanagement. On the whole, the recycling of plastic bags proved a major challenge for South Africa, which was exaggerated by manufacturers using cheaper fillers in the production process that sabotaged recycling efforts (Knowler, 2017). The Department of Environmental Affairs (2017), recognising this, invested in addressing the recycling challenge largely by heavily financing standards-monitoring agencies. A paucity of data on the recycling of plastic bags in South Africa makes it difficult to assess how making the bags reusable has performed, from a consumer perspective.

Although plastic bag regulation has developed well in South Africa, recent studies suggest that consumers are becoming accustomed to paying for plastic bags. In order to maintain or improve

on the regulations' efficacy, consideration must be given to increasing the price, particularly if the current price of plastic bags continues to be low relative to income and goods purchased, as highlighted by Dikgang et al. (2012a, 2012b).

Considering the above, this study aims to aid policymakers in developing effective pricing strategies for plastic bags. Generally, there is very limited research directed at optimal pricing for plastic bags – an aspect that it could be argued is imperative in ensuring long-term effectiveness. By filling this gap, this study can advise policymakers on the demand effects of various plastic bag price increases. This may be useful for policymakers in South Africa, where plastic bag policy has been relatively ineffective, allowing them to tailor the plastic bag policy in a manner that ensures long-term efficacy in curbing bag consumption, in line with set objectives.

3. A review: mixed-bag policy responses to the plastic shopping bag legislation

Market-based instruments such as taxes and levies can lead to environmental enhancement in terms of waste reduction and littering. Convery et al. (2007) posited this argument when evaluating the performance of the €0.15[1] levy implemented in Ireland – that the levy was specifically tailored to changing consumer behaviour and increasing awareness of the policy. It was implemented at national level during 2002. As there was a 90 per cent reduction in plastic bag usage, and overall support for the levy, it is no surprise that the Ireland case is often deemed to be a major success story for plastic bag taxes.

In 2011, Wales became the first country in the United Kingdom to introduce a tax for plastic bags. Poortinga et al. (2013) evaluated the effectiveness and impact on plastic bag behaviour following the tax implementation by conducting a controlled field experiment using samples drawn from Wales and England. The latter served as the control group, and the former as the treatment group. The introduction of the tax resulted in a strong and significant change in own bag use (plastic bag reuse) within the treatment sample (Wales).

Gupta (2011) evaluated the effectiveness of various types of policies in India. Intriguingly, the study found that all three interventions – information provision, the cash-back scheme, and the provision of cloth bag substitutes – had a significant influence on encouraging consumers to use their own bags. The cash-back scheme was the most effective, although the differences were minimal.

[1] €1 (1 Euro) = R9.93 when the pricing started in Ireland in 2002.

In June 2008, China introduced a unique market-based instrument. Instead of a fixed tax or set amount, China implemented a national regulation banning the distribution of free plastic bags at point of sale, and compelling retailers to charge a price higher than the actual cost (He, 2012). Jakovcevic et al. (2014) found that market-based incentives or charges in this case were more effective at changing the way consumers behaved in Buenos Aires, Argentina. Interestingly, however, there was a slight increase in own bag use in the control and both treatment groups, which perhaps highlights the importance of awareness campaigns. Martinho et al. (2017) found that the Portuguese tax was largely effective, reducing the consumption of plastic bags by about 74% and concurrently increasing the use of reusable bags by about 61%. Another notable finding was that proximity to the ocean had no meaningful effect on consumer behaviour. However, the effectiveness of this tax was short-lived.

Taylor and Villas-Boas (2016) found that plastic bans paired with paper bag fees did significantly reduce the demand for disposable bags but led to an overall increase in the consumption of paper bags in the United States. Rivers et al. (2017) examined a nudging policy in Toronto, Canada. The study found that the policy nudge increased the use of reusable bags. Hasson et al. (2007) revealed that there was a large reduction in overall plastic bag sales – of approximately 80% shortly after charging started in South Africa. Dikgang et al. (2012a) found that bag usage reduction could not be achieved in South Africa in the long term. Dikgang and Visser (2012) found that bag use in Botswana was reduced significantly in Botswana following the implementation of charging.

The reviewed literature provides mixed results regarding regulation aimed at curbing plastic bag consumption. Much of the literature is directed at understanding the efficacy of the relevant intervention. Although the magnitude of the effects of market-based interventions varies, the overall theme is that they are effective at reducing plastic bag consumption. The variations may be attributed to various factors, but there is a strong case for the plastic bag price to be the underlying confounding variable. There is a very limited number of studies focused on understanding the influences of various pricing points. Some of the literature uses the contingent valuation framework to fill this gap. The CVM allows studies to identify willingness to pay (WTP) or willingness to accept (WTA) estimates over a set of hypothetical values. However, it has restricted capability to collect the data necessary for demand functions – most notably elasticities. An approach that addresses this issue is the Contingent Behaviour (CB) approach. Although CB is a powerful tool for estimating demand elasticities, it is very rarely applied. Consequently, this study utilises the CB approach to estimate plastic bag demand elasticities. The CB approach will be discussed further in the following section.

To the best of our knowledge, there are only a few studies on plastic bag pricing using experimental data. Therefore, this study makes an important contribution to the empirical work on bag pricing, by expanding on the limited literature. Most significantly, considering the ineffectiveness of the South African bag regulation, our study may aid policymakers regarding the development of effective pricing policies. This study bids to contribute to an interesting and policy-relevant question, not only in South Africa but globally. The findings of the analysis offer valuable inputs towards the process of establishing and reviewing plastic bag policies, particularly in countries where they have no impact on bag usage.

4. The Contingent Behaviour Method

The available historical plastic bag data in South Africa is not suitable for characterising plastic bag demand, as the price has remained about the same with very little variation over the years. Additionally, bag prices are similar and bag price changes are usually linearly related, meaning cross-price elasticities could not be estimated. This is a common situation with plastic bag pricing around the world. Therefore, non-market valuation methods ought to be used to better understand the prices that customers should be charged per bag. Given the objectives of this study, the CB approach is thought to be the most appropriate method, due to its ability to vary prices, as well as accounting for substitution effects when generating the experimental data necessary for estimating plastic bag demand functions. This study assumes the CB formulation by Chase et al. (1998) to estimate the optimal bag price within a South African plastic bag regulation framework.

This study employs the CB method to elicit stated preferences, as it permits collecting the necessary data to estimate an unobstructed system of demand equations that provides a platform for effectively designing differential pricing policies (Chase et al., 1998). The CB approach is commonly used in studies aimed at valuing recreational or environmental goods (see Chase et al., 1998; Dikgang and Muchapondwa, 2017; Manning et al., 2015). The CB approach is rarely applied to plastic bag price policy. Studies investigating various plastic bag prices have most often employed the Contingent Valuation Method (CVM) (Dunn, 2012; Madigele et al., 2017). CVMs generally aim to find values related to marginal change in terms of an environmental good (Zuo et al., 2016). Although the CVM is a very useful tool when estimating WTP, it has limited application in collecting the data required to estimate demand functions – specifically elasticities, which can be important when policymakers opt for market instruments and want to design effective pricing strategies (Chase et al., 1998).

In a CB setting, bag users are assumed to maximise a utility function $u = U(X, Q)$, subject to P_xX+$P_Q Q$=M where X is an n-vector of private goods, Q the number of plastic bags bought, P_x is an n-vector of market prices of private goods, P_Q is the vector of hypothetical prices of bags (i.e. plastic bag prices), and M being the individual's household income. In this expression, different bag prices are assumed to result in varying bag usage levels. Founded on earlier studies,[2] aggregate demand for bags is anticipated to be a function of bag prices, income and socio-economic characteristics.[3] The symmetrical demand functions for plastic bags can be written as follows:

$$Q_i = f(P_1, P_2, P_3, P_4; M; Z) \qquad \text{i=1,.....,4 Price levels} \qquad \textbf{(2)}$$

where Q_i is the total plastic bag consumption level (i.e. bags used per month) by all; P_i is the bag price; M is the consumers' household income; and Z captures the socio-economic characteristics.[4] The bag demand functions are estimated using experimental data generated through a CB survey experiment carried out on shoppers in Johannesburg (South Africa) shopping malls.

By employing CB, this study gathers data to do with consumer reactions to various non-market price levels for plastic bags, which forms the basis of this study's analysis. It is important to consider that there are some limitations to using this method. Firstly, there is the prospect of hypothetical bias (Manning et al., 2015). This is largely attributed to the fact that respondents may not answer honestly, as there is no actual trade-off required. To limit the effect of this, survey questions can be framed in such a way as to encourage respondents to consider the answers that they provide carefully. However, as Zuo et al. (2016) point out, many of the issues related to the CB approach often occur because the approach is commonly applied to recreational goods, where the respondent has limited information regarding the quality of the good. The case of plastic bags is somewhat different, as they are used in vast amounts – daily, by most consumers. Furthermore, consumers of plastic bags touch, feel and use plastic bags to carry groceries, which makes the quality easy to measure.

[2] The most common approach used for plastic bag demand estimations is the survey-based approach, as applied by Dunn (2012) and Madigele et al. (2017), who estimated WTP for bags in the US and Botswana respectively.
[3] However, given that plastic bag prices are a negligible portion of income, income is not expected to be a significant factor, as consumers already incur high grocery costs.
[4] Equation (2) represents a demand function that assumes individuals distribute their disposable income between plastic bags and other combined goods with a numeraire price.

5. Survey design

The survey design aimed to capture each respondent's behaviour with respect to the plastic bag regulation in South Africa. The survey was relatively short, consisting of seven pages encompassing two sections. Section one aimed to understand the respondents' plastic bag behaviour. It is in this section that the CB method is applied to elicit the stated preferences of individuals. The remaining questions in section one explored various policy options regarding plastic bags, in terms of alternatives, recycling, education and general opinion. Section two was designed simply to gather demographic and socio-economic data. In total, eight questions were asked, looking at gender, race, marital status, date of birth, household size, education level, employment status and income. It is worth mentioning that income had been captured as a categorical variable. The reasoning behind this considers considerations regarding the sensitivity of income-related questions. According to Fintel (2007), capturing income in surveys can be made more accurate using a categorical method, as respondents may inflate or deflate their salaries when using a continuous format.

Table 1 shows a chart like the one used to capture data regarding users' responses to actual and hypothetical own-price scenarios at the shopping malls. The respondents were asked how their bag use would be affected if retailers were to decide to increase bag prices. More specifically, they were asked to indicate how many bags in a month they would use at the bag prices shown in the chart below. Drastic increments were used to draw out behavioural changes (the increment at each price level was double the previous price). As shown, there were five prices (one actual price and four hypothetical prices) available to capture stated preferences. By developing five different pricing points, this study can determine a wide range of reactions to provide a spectrum of possible pricing strategies.

Table 1: Sample of contingent behaviour chart for plastic bag price-change questions posed to respondents

Item	**Actual**		**Hypothetical Increases**							
	Price	*Number of Bags*	*Price*	*Number of Bags*	*Price*	*Number of Bags*	*Price*	*Number of Bags*	*Price*	*Number of Bags*
Plastic Bag	R0.40		R0.80		R1.60		R3.20		R6.40	

The respondents were shown the table, with all but the first block of five columns covered using a blank paper. The respondents were asked, "Given the current bag prices, how many plastic bags do you buy per month on average at the current bag price of R0.40[5] per bag?" Following the completion of the first column with the appropriate number of 'bags bought', the interviewer explained that there would be a set of hypothetical questions next, in which the price would be raised. The first hypothetical question raises the bag price to R0.80. The interviewer would then ask, "If the price were increased to R0.80, how many bags would you purchase on average per month?"

The second hypothetical question raises the price to R1.60 per bag. The third hypothetical question raises the price to R3.20, followed by a fourth hypothetical question with a bag price hike to R6.40 per bag. Despite each respondent answering bag usage questions about five price levels (actual price, hypothetical price 1, hypothetical price 2, hypothetical price 3, hypothetical price 4), enough differences in the hypothetical price plans across respondents would be necessary to generate enough variability for demand functions to be estimated.

6. Data

A face-to-face questionnaire survey was conducted with randomly picked shoppers. The survey took place during the week and over weekends in the months of June and July in 2015. Surveys were conducted in two locations in Johannesburg, Gauteng Province. Johannesburg is the South African city with the largest economy. It is often recognised as the economic hub not only of South Africa but of the entire African continent. This study focuses on individuals who purchase goods from retail stores that offer plastic bags to carry groceries or other related products. Three designated interviewers were used. The role of the interviewers was largely to offer guidance and provide a background to the questionnaire. As the CB methodology may be susceptible to hypothetical bias, having an interviewer assists in increasing the overall validity of the respondents' answers.

Given the experimental nature of the study, as illustrated in Table 1 there were five observations per respondent. There were 421 respondents, resulting in a total of 2 105 observations. It should be noted that not all observations were used for the regression estimates, as some values were missing. We relied on random sampling to ensure we had a representative sample. Furthermore, we conducted surveys between 17 June and 3 July 2015. These dates provided access to higher volumes of shoppers, due to their proximity to the dates that salaries and wages are commonly

[5]1 US Dollar = R12.45, at the time the experiments were carried out in 2015.

received in South Africa. Table 2 presents the initial results of the respondents' plastic bag purchasing reactions to increasing prices.

Table 2: Characteristics of individual purchasing plastic bags (stated preference data)

Price (ZAR R/PB)	Buy (%)*	Mean*
0.4	63.9	14.95904
0.8	26.5	6.207229
1.6	7.3	1.73253
3.2	1.6	.3855422
6.4	0.7	.1686747

* Buy percentages were based on a total sample of 421 respondents.

The very small inconsistencies suggest that the overall performance of the experiment is a reliable format for ensuring suitable responses. Sensitivity tests were conducted by excluding the inconsistent respondents from the analysis. There were no differences in the results. Noting this, we re-included these respondents, to maximise the overall number of observations. Table 2 presents the preliminary results of respondents' reactions to the various price levels. Interestingly, around two thirds (63.9%) of the purchasing of plastic bags would occur at the actual price of R0.40, at a mean of approximately 15 plastic bags. Just over a quarter would occur at R0.80, at a mean of approximately six plastic bags. Substantial reactions occurred at the subsequent hypothetical price levels, with drastic reductions at each. Cumulatively, less than a tenth (9.6%) of hypothetical purchases would happen at prices R1.60, R3.20 and R6.40. Only 30 respondents were willing to purchase plastic bags at R3.20, and just 10 at R6.40. This is not that surprising, given the substantial difference between these prices and the actual price that respondents are accustomed to paying.

7. Estimation Approach

The nature of the CB experiment means that a large proportion of the quantity of plastic bags (the dependent variable) were zero or censored observations. Under such circumstances, conventional regression methods such as Ordinary Least Squares (OLS) are not recommended – for various reasons, but most notably that estimates would be biased (Chase et al., 1998). Furthermore, OLS fails to account for the qualitative variations between zero and non-zero observations (Zuo et al., 2016). To cope with the challenges presented by censored observations and still yield consistent estimates, we employed the technique proposed by Tobin (1958), the Tobit model, otherwise referred to as the censored regression model.

In a general censored regression model, dependent variables are either censored to the left, censored to the right, or censored to both right and left, in which case the lower or higher limit of the dependent variable taking any value (Henningsen, 2010):

$$Q_i \quad Q_i^* = x_i^1\beta + \varepsilon_i \quad \text{where i=1,…,N,} \tag{3}$$

$$Q_i = \begin{cases} a, if\ Q_i^* \leq a \\ Q_i^*\ if\ a < Q_i^* < b \\ b, if\ Q_i^* \leq b \end{cases} \tag{4}$$

where a and b are the lower and upper limits respectively of the independent variable, i is the observation, Q_i^* is the unobserved dependent variable, x_i refers to a vector of independent variables, β is a vector of unknown parameters, and ε_i is the error term.

One of the benefits of the CB approach is that we have five observations per respondent; making the random effects panel Tobit more appropriate for analysing the data, as it utilises all the available information (Greene, 2008). This paper uses random effects as opposed to fixed effects, owing to the problem of acquiring estimates of levels rather than changes (see Dikgang and Muchapondwa, 2017). Studies by Greene (1993) and Hsiao (1986) show that the random effects model allows certain deductions to be made regarding the demand preferences of the populace through the behaviour of the observed sample. Moreover, it permits the generation of more efficient coefficient estimates through estimating the correlation between multiple observations per respondent (Chase, 1998). It should be noted that an assumption is made that the unobserved respondent-specific effect does not correlate with the included independent variables.

The random effects Tobit model is employed to estimate plastic bag demand. It is worth mentioning that no *priori* expectation of the optimum functional form was made. To perform

a sensitivity analysis, this study opted to model different specifications. However, the nature of the data voids the taking of logarithms of the dependent variable, as a large proportion of the values are zero. Thus, we specify four equations, in Linear-Linear and Linear-Log functional forms, as follows:

$$Qi = \propto + \beta P + \varepsilon_1 \quad \textbf{(5)}$$

$$Q_i = \propto + \beta P + \beta Y + \varepsilon_1 \quad \textbf{(6)}$$

$$Q_i = \propto + \beta lnP + \varepsilon_1 \quad \textbf{(7)}$$

$$Q_i = \propto + \beta lnP + \beta lnY + \varepsilon_1 \quad \textbf{(8)}$$

where Q_i is the plastic bag demand, P is the hypothetical price level and Y represents various other independent variables, such as income, knowledge of the current price, awareness of the levy, reuse of plastic bags, age, household size, education, employment and gender. Although research estimating the demand for plastic bags with respect to various price levels is thin on the ground, the selected independent variables are typically indicated to influence plastic bag demand (Dunn, 2012; Madigele et al., 2017). To understand the impact this may have, equations (3) and (5) were run with just the independent variable price. In addition, price elasticity of demand for plastic bags was estimated from these equations. To encompass the entire price range and ensure the correct magnitude for the coefficients, equation (3) – the linear-linear model – was used to estimate elasticity at each price level. As a robustness check, we ran each model following a standard pooled Tobit.

8. Descriptive Statistics

The empirical findings presented in this chapter begin with a snapshot of the descriptive statistics following the CB experiment, presenting selected demographic and behavioural factors. This is followed by results from the random-effects Tobit model estimations for plastic bag demand, with the subsequent elasticity results and analysis. This study focuses on individuals at shopping malls, where retailers offer plastic bags at point of sale. Table 3 below provides the descriptive statistics of the sample. Note that price is the only dependent variable that varies by both respondent and panel. The remaining independent variables only vary between respondents. The first five rows are selected plastic bag consumer questions from section one of the survey.

Table 3: A selection of descriptive statistics of the 421 shoppers interviewed

Variable	Mean	Std Deviation	Min	Max
Quantity (at actual price)	14.95904	14.48773	0	140
Knowledge of current price	.7012048	.4578402	0	1
Aware	.3927711	.4884843	0	1
WTP	1.179663	1.229496	0	8
Reuse	.8795181	.3256027	0	1
Incomemid	102579.1	118870.5	5000	500001
Age	39.28916	14.53152	18	95
Household size	3.701205	2.020238	0	20
Education years	13.06988	1.908574	0	18
Low Education Dummy	0.4048193	0.4909754	0	1
Gender	.5084337	.5000494	0	1
Married dummy	.4698795	.4992122	0	1

The general image that emerges concerning plastic bag behaviour is that the respondents are not particularly sensitive about the topic. The average respondent purchases approximately 15 plastic bags at the current price level; has knowledge of the current price of plastic bags; is unaware that the plastic price includes a levy; is willing to pay (WTP) R1.17, almost three times the current price, before considering buying or using alternatives; and lastly (and more encouragingly) reuses his or her plastic bags – almost 88% of the respondents said that they reuse their bags. This speaks volumes about the gauge specification in South Africa, in that making bags stronger does have a benefit to the final consumer.

Regarding the socio-economic information from section two of the survey, the average respondent earns between R100 001 and R150 000 gross income; is approximately 39 years of age; has an average household size of 3.7 individuals; has 'high' education, which is classified as having completed high school and having an additional year of training or a certificate; is female; and is unmarried. The general image in this case is of a high-income household with

relatively mature respondents. A possible reason for this could be that surveys were conducted in shopping malls, which generally house retailers who target middle- to upper-income households. The descriptive statistics indicate that more needs to be done to raise awareness about the plastic bag price and what it entails. Furthermore, they indicate that the current price as per the survey, relative to average household income, seems rather low.

9. Estimation

Even though decisions about plastic bag charges made by policymakers are motivated largely by political considerations as opposed to economics, the aim of this paper is to provide decision-makers with enough information to warrant that plastic bag charge choices are evidence-informed and justified. The paucity of data on plastic bags makes accomplishing this particularly challenging. By generating and analysing relevant experimental data, this study can provide decision-makers with information around pricing structures for plastic bags that would otherwise not be possible. Thus, enabling decision makers to understand the influences of various socio-economic characteristics and decide on which prices best suit their goals in an evidence-informed manner. The results of the random effects (RE) Tobit models for plastic bag demand are illustrated in Tables 4 (linear-linear) and 5 (linear-log). The RE Tobit results are presented alongside the standard pooled Tobit results for robustness checks.

Table 4: Tobit estimation results for modelling plastic bag use (linear-linear)

Variable	**RE Tobit (Linear Linear)**		**Tobit (Linear Linear)**	
Equation	**(3)**	**(4)**	**(3)**	**(4)**
Price	-11.04014***	-11.04511***	-10.38799***	-10.49755***
Income		.0000189***		.0000205***
Awareness		-.6848776		-.9974187***
Reuse		-7.703163***		-8.225377***
Age		-.053012		-.0453265
Household Size		.6487717**		.7016968**
Education (Years)		-.4551376		-.5122531**
Employment Dummy		-1.678651		-1.843954*
Female Dummy		-.1081631		-.056969
Constant	13.2464***	25.26287***	12.34498***	25.26006***
Log likelihood	-3585.4398	-3565.9113	-3688.9564	-3648.0622
Wald Chi-2	659.94***	668.68***	-	-
Bayesian Information Criteria	7201.43	7223.475	7400.826	7380.139
LR test of panel variance component =0	207.03***	164.30***	-	-
Observations	2075	2075	2075	2075
Uncensored Observations	785	785	785	785

This study found that the RE Tobit model best fitted the data generated through the CB approach. To test whether the data is more suitably fit by a panel model as opposed to a pooled

model, a likelihood-ratio (LR) test for panel-level variance component = 0 was conducted, which was rejected at a 1% level of significance, reaffirming our approach of using a panel model as the appropriate treatment for our data. In each table two specifications are run using two methods, a RE Tobit and a standard Tobit, for robustness checks. In the first table, equations (3) and (5) are run using only the independent variable price. This represents the impact on demand only. This is followed by equations (4) and (6), which are run using price and other related independent variables for modelling demand.

Table 5: RE Tobit estimation results for modelling plastic bag use (linear-log)

Variable	**RE Tobit (Linear Log)**		**Tobit (Linear Log)**	
	(5)	**(6)**	**(5)**	**(6)**
ln_ Price	-17.00186***	-16.72819***	-10.38799***	-16.59309***
ln_Income		1.428982***		1.423794***
Awareness		-.4316591		-.7114169
Reuse		-5.983503***		-6.501772***
ln_Age		-2.13031		-1.687123
ln_Household Size		3.024742***		3.298547***
ln_Education (Years)		1.405571		1.284438
Employment Dummy		-2.8564**		-3.100736***
Female Dummy		-.2289312		-.0593111
Constant	-1.477775**	-8.64776	12.34498***	-9.527825
Log likelihood	-3420.0081	-3361.55	-3688.9564	-3490.3495
Wald Chi-2	1165.84***	1164.49***		
Bayesian Information Criteria	6870.567	6814.695	7400.826	7064.661
LR test of panel variance component =0	319.36***	257.60***	-	-

Observations	2075	2075	2075	2075
Uncensored Observations	785	785	785	785

At a glance, one can see that both the linear-linear model and the linear-log model have yielded the expected signs. Price, income, reuse and household size are significant in both models. The negative and significant coefficient estimates of price are robust in each of the equations estimated, suggesting that price does not correlate with other independent variables. Additionally, price coefficients suggest that as price increases, the number of plastic bags demanded would decrease. The relatively large and negative coefficients of price and of reuse suggest that they are very influential variables on plastic bag demand patterns. A possible explanation could be that the South African plastic bag policy regulation has two components: a market-based instrument (represented by price), and a reusability element (the banning of bags below a certain thickness, to ensure longer durability). Income has a positive and significant impact on the quantity of plastic bags demanded. This is expected, as higher-income earners would be more willing to pay a higher price to avoid the inconvenience of carrying re-usable bags – a similar finding to that of Dunn (2012). The income coefficients are quite small in comparison to the other coefficients. This can perhaps be explained by the bag price being low compared to an average overall shopping bill (see Dikgang et al., 2012b).

The positive and significant coefficient of household size is expected; larger households tend to use considerably more plastic bags, as they require higher volumes of goods to be purchased. Another important and interesting inference that can be drawn is that awareness that the bag price contains a levy – although negative, as expected – is not significant in all models. A possible reason for this finding could be that overall, current awareness of the levy is low. This could be attributed to poor awareness campaigns. Ireland, for example, invested some of the funds raised through the tax on awareness campaigns (see Convery et al., 2007). Directing more funding towards such campaigns might strengthen the influence of awareness on plastic bag consumption.

Regarding which functional form is more appropriate, it seems that both linear-linear and linear-log specifications indicate a good overall fit, considering that price coefficient estimates were highly significant in all models. The standard Tobit results provided for robustness show very little variation between results when comparing estimation strategies. The choice of the 'best' functional form was based on the Bayesian Information Criterion (BIC), which is a well-

documented approach (Posada and Buckley, 2004; Zuo et al., 2016). Through this process, we decided on the linear-log model for our demand model.

The coefficient estimates presented in Tables 4 and 5 represent the estimated demand coefficients. For any price level, elasticities can be calculated through the marginal coefficients associated with the estimated demand coefficients. As this study is interested in how the observed quantity of plastic bags demanded changes according to price, it may be of more importance to calculate elasticity estimates.

Table 6: Price elasticity for plastic bags

Price **ZAR R/PB**	**Linear-Linear**
0.4	-.1393259***[.006]
0.8	-.2718142***[0.011]
1.6	-.500673***[0.019]
3.2	-.7950397***[0.023]
6.4	-.9974753***[0.015]

Table 6 presents price elasticity estimates for each of our five price levels, as per the CB experiment. Elasticity estimates are calculated from the linear-linear functional form and equation (3). The reasons for this are twofold. Firstly, the price ranges in the survey begin from decimal numbers; thus, log transformations would make them negative, giving the elasticity estimates the wrong sign. Secondly, elasticity estimates provide marginal effects, by nature. By using the linear-linear model we get estimates with magnitudes that are more appropriate for direct interpretation.

The price elasticity estimates in Table 6 are all negative and significant, reflecting the inverse relationship between plastic bag price and quantity of plastic bags demanded. Unsurprisingly, at the current price of R0.40 the price elasticity of demand is inelastic. This does resonate with the findings of Dikgang et al. (2012b), who suggested that the current price was too low. An overall view of the elasticities suggests significant responses in terms of quantity demanded at each of the price levels. The price elasticity between the actual price as per the survey and the

first hypothetical price, R0.80, is almost double. At the last hypothetical price of R6.40, the elasticity estimate is almost unitary, suggesting that a percentage change in price at R6.40 would in turn lead to a percentage change in the quantity of plastic bags demanded. The range of elasticity estimates may provide policymakers with various options when considering a price that would be optimal. One key finding to be highlighted is that at the current price level of R0.40, slight increments and changes may not have the desired effect regarding plastic bag consumption.

Table 7: Estimates of purchase price elasticities aggregated by respondent characteristics

Subgroup elasticities at R1.60	
All	-.500673*** [0.019]
Income ≤ 125 000	-.5529263*** [0.024]
Income ≥ 125 001	-.4178322*** [0.032]
Aware = 1	-.5534575*** [0.033]
Aware = 0	-.4745969*** [0.023]
Reuse = 1	-.5698223*** [0.022]
Reuse = 0	-.3443807*** [0.038]
Age ≤ 39	-.542008*** [0.026]
Age ≥ 40	-.4516277*** [0.028]
Hhsize ≤ 4	-.5643912*** [0.0.25]
Hhsize ≥ 4	-.4480599*** [0.024]
Education Years ≤ 12	-.5774203*** [0.034]
Education Years ≥ 13	-.4677539*** [0.023]
Employment = 1	-.5018906*** [0.022]
Employment = 0	-.5123226*** [0.037]
Female = 1	-.5254999*** [0.028]
Female = 0	-.4881276*** [0.026]

In addition to the price elasticity estimates shown in Table 6, this paper reports elasticity estimates for various subgroups. Estimates are reported at the mean price level of R1.60 from our CB experiment. Lower price elasticity of demand is associated with the following individuals' characteristics: income greater than R175 001, unaware of the levy included in the price, does not reuse plastic bags, is older than the sample mean of 39, has a household size greater than four, has an education level beyond high school, is employed, and lastly, is female. Reusing plastic bags has the largest differential in elasticity estimates. This supports the earlier finding of the large coefficient from the RE Tobit of the demand equations. This is followed by income, which is to be anticipated, as South Africa suffers from large income disparities. Household size seems to have quite a substantial effect on elasticity estimates. What comes as something of a surprise is that people who are unemployed are less elastic to price changes than those who are employed. Employment can be associated with income; thus, the lack of consistency is a shock. A possible explanation is that it is due to the grouping done when creating the employment dummy. Students and retired individuals were considered unemployed in our dummy.

Overall, the RE Tobit demand and price elasticity of demand estimates provide interesting insights into consumer behaviour with respect to plastic bag demand. Depending on the policymaker's goals, decisions around the optimal price may vary. There are various political considerations that may have a large influence on decisions to do with the plastic bag tax. However, it's fair to say that the current pricing structure may fall short of encouraging the anticipated outcome. Gradually individuals seem to have become accustomed to the current charge, reducing its long-term efficacy; which is evident in our elasticity estimates, and further supports findings by Dikgang et al. (2012a). Addressing the plastic bag issue may require a long-term approach designed to alter consumer perceptions and attitudes towards plastic bags. In the short-term, price shocks are effective at curbing consumption; and in the case of South Africa, from our analysis, a higher price per plastic bag is required.

10. Conclusion

Plastic bag regulation has garnered much attention in recent times, one of the catalysts being that plastic bags are increasingly being recognised as a danger to the environment. In 2003, South Africa introduced a combination regulation that included a ban, to strengthen bags and make them reusable, and a compulsory charge, with the hope of curbing plastic bag consumption. The performance of the latter has been underwhelming over time, as many consumers have become used to paying for plastic bags. Arguments presented by Dikgang et

al. (2012a, 2012b) suggest that the current plastic bag price is too low, relative to both income and to the value of goods carried – an aspect that resonates with lower elasticity levels.

Against this backdrop of falling price elasticities of plastic bags, the primary aim of this study was to investigate elasticities related to various hypothetical prices. The objective was accomplished through first employing a Contingent Behaviour (CB) approach to gather demand information on five different price levels. This was followed by applying the RE Tobit analysis to estimate demand functions as well as elasticity estimates.

The approach followed by this study makes two key contributions to plastic bag literature. Firstly, it is the first to apply the CB approach to the plastic bag price in South Africa. This study finds that the CB approach can be a powerful tool to elicit consumption changes related to various pricing points, and to gather important information regarding plastic bag behaviour. Secondly, the methods used to analyse the data allowed for the formation of price elasticities at various hypothetical prices. This enabled understanding of the influences that price changes may have on the overall quantity of plastic bags demanded.

This studies' analysis, directed at South African shoppers, indicates that there is great variation in the elasticities of demand for plastic shopping bags. The CB method used is effective, as it allows for own-price elasticity. Overall, the results suggest that plastic bags are under-priced in South Africa, which implies scope for improvement in the policy of charging for bags. Increasing bag prices could maximise the effectiveness of the bag regulation. We are aware of the political and social opposition that increasing bag prices may incur, given the high level of poverty in South Africa. This suggests that optimal plastic bag prices are likely to impact on equity, inter alia. However, it should be noted that shoppers – including poorer consumers – do not ordinarily have to buy bags every month. In fact, the bag thickness means that they can start to reuse bags even more.

The rate of bag reuse is likely to remain unchanged until there is a significant increase in bag price. The relatively low price is a barrier to the reuse of bags. A higher price is more likely to 'nudge' all consumers – especially those who are price sensitive – towards re-using the bags than the existing price is currently doing, which is one of the objectives of plastic bag policymakers. Failure to implement an appropriate bag price would theoretically render bag regulation ineffective. Thus, we argue that if the current high bag purchases continue, and inadequate bag re-use and recycling remain, then bag users should be charged an optimal bag price of R6.40 per bag. Given that there is some opposition to charging optimal bag prices, particularly from the poor, regular gradual increments would be more palatable than large once-off increments.

This paper recommends that the current pricing framework be revisited. The current price is too low, and inelastic. We suggest the government substantially increase the plastic bag price, to around R6.40. At this price level, elasticity is unitary, strengthening the effectiveness of price changes in ensuring consumption responses. Awareness of the plastic bag levy is low; thus, this paper suggests directing some of the revenue created through the levy to awareness campaigns. This could strengthen the efficacy of the levy as well as encourage consumers to reuse bags more often.

Furthermore, there is a lack of viable substitutes, making incentivising bag reuse a worthwhile option to pursue, although further research needs to be done around the cost-effectiveness of such an approach. One of the challenges of bag reuse is the inconvenience of carrying your own bags when shopping. A possible solution to this could be providing bag renting stations that require a deposit at stores, which would keep bags in circulation and encourage reuse. Additionally, consumers would be more reluctant to throw the bags away, which would curb littering. Admittedly, the policy options suggested may require substantial resources and effort from various stakeholders; but plastic bag litter is a serious concern that needs to be addressed.

One of the main limitations of this study is that the CB approach as applied to generate experimental data for estimating bag demand functions did not consider substitution effects. In this formulation, different carrier bags, which may appeal to consumers differently, and bags that could be regarded as substitutes, were not considered. Based on previous studies, the aggregate demand for plastic bags should also be a function of prices of other substitute and complementary carrier bags, in addition to plastic bag own-price, income, and socio-economic characteristics. As a result, we were unable to make cross-price estimates. Despite these shortcomings, the determination of optimal plastic shopping bags prices by means of experimental data, contributes valuably to research on plastic bag policies as it can be devised to simulate the real market.

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