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ENVIRONMENT AND NATURAL RESOURCE ECONOMICS 3 OPEN ACCESS

Influences of various pricing points: an experimental study of plastic bags in Johannesburg, South Africa

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ABSTRACT

Policymakers have little experience regarding designing the right levels of pricing for plastic bags. The ineffectiveness of charging for bags, in countries such as South Africa, makes it imperative that we map the demand curve. Getting the charge "right" depends on the size of the externality. Charging for bags is therefore an effective intervention to encourage consumers to carry their own bags to the stores. We employ a contingent behaviour (CB) dataset necessary to estimate the charge level that is likely to lead to a reduction in bag use over time. The results of the random effects Tobit model suggest that the current charge of US\$0.03 was found to be too low, and highly inelastic. A charge of US\$0.50 has potential to reduce unnecessary plastic use and is still lower than the price of alternatives; therefore, there is no danger of consumers shifting to alternatives that may cause more harm.

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1. Introduction

Previous studies suggest that the effectiveness of introducing charging at the point of purchase in reducing plastic bag use varies (see Dikgang, Leiman, & Visser, 2012a; Homonoff, Kao, Selman, & Seybolt, 2022; Nielsen, Holmberg, & Stripple, 2019; Poortinga, Whitmarsh, & Suffolk, 2013; Rivers, Shenstone-Harris, & Young, 2017; Taylor, 2019). For example, charging for bags has been effective in Ireland, Denmark, China and Botswana (Convery, McDonnell, & Ferreira, 2007; Dikgang & 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.

Moreover, regulation or taxation of products associated with negative externalities such as plastic bags is not always complete in its coverage. Leakage occurs when partial regulation directly results in increased consumption of these products in unregulated

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This is an Open Access article distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/ licenses/by/4.0/), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited. parts of the economy (see Fowlie, 2009). This was proven in California, where regulation of plastic carryout bags led to increases in the consumption of unregulated disposable bags (Taylor, 2019). Negative externalities "are secondary effects that produce inefficiencies in resource allocation. Some come from consumption (waste, which can cause littering and stormwater drain blockages), others from production (carbon dioxide emissions). They occur often when resource property rights are uncertain or non-existent, so negative externalities producers are not responsible for the external costs generated" (Lazăr, 2018).

These inefficiencies give rise to the environmental externalities associated with plastic bag production and disposal, exemplify a classic tragedy of the commons. Individual consumers benefit from the use of plastic bags because they can easily carry purchased goods without the burden of carrying around reusable bags, while the population as a whole bears the collective cost of the production and disposal of plastic bags (Akullian et al., 2006). The implication of negative externalities⁴ and leakage together is the need to get the correct charge.

To better understand Pigouvian taxation as a regulatory tool (see Salib, 2021; Vågsholm & Höjgård, 2010), consider that individual's activities often produce both benefits and costs. Imagine, for example, an individual's activities and choices that are both beneficial (e.g., planting trees in a garden) and harmful to the environment (e.g., littering, ocean contamination). However, excess use of plastic bags leads to pollution. The pollution that arises from plastic bag use is a negative externality or a cost that is not included in the price of plastic bags since it affects the public good of the three R's: reduce, reuse and recycle. The negative externality implies that use of plastic bag has become too high. Plastic bag consumption can be restricted by e.g., prohibiting the use plastic bags, or by using economic incentives, but banning plastic bag use could be offset by shifting consumption to other bags and repeat of negative externalities as a result of excess use of alternative bags. Crucially, absent regulation, an individual does not bear most of the cost of pollution. Instead, third parties suffer while an individual's costs remain artificially low as they use bags for which total social costs exceed total benefits. As argued by Pigou (1932), negative externalities may be internalised perfectly by levying a tax that equals the marginal external $\cos t - a Pigouvian tax - on consumption or$ production.

In either case, this tax would raise the price of plastic bags by an amount corresponding exactly to the cost of pollution caused by a marginal increase in use and force the individual to also consider that cost when deciding on consumption of plastic bags. Like a quantitative restriction (such as banning certain type of plastic bags), this would reduce the use of plastic bags and the rate of pollution. In addition, the proceeds from the tax could be used to subsidise plastic bag stakeholders (e.g., manufacturers and recycling firms) to develop new generation plastic bags as well as more innovative recycling initiatives, thereby compensating for the reduction in revenues caused by lower sales of plastic bags due to the tax. Thus, restricting plastic bag consumption by using a Pigouvian tax could preserve the benefits of plastic bags with smaller adverse effects on incentives to

⁴As correctly pointed out by an anonymous reviewer, getting the charge right" is not the only implication of leakage (alone). Getting the charge right" requires setting the bag fee equal to the marginal damage of bags at the socially optimal level of bags (i.e., a Pigouvian Tax). The problem for policymakers is that it is difficult to measure the socially optimal level of bags. The authors would like to thank an anonymous referee for this helpful input.

develop new generation plastic bags and recycling innovations than banning of plastic bags.

Of course, any tax that raises the price of plastic bags is likely to reduce consumption, thereby preserving benefits of plastic bags. However, current bag consumption levels imply that the current tax rate is too low, and hence the subsequent lower plastic bag price. This suggests that the price of the bag is set lower than the marginal cost of pollution, resulting in use of bags falling by too little. If the tax overshoots the cost caused by the marginal negative externality, the resulting welfare loss may be greater than the original one, which is also not desirable. Hence, it is important to get the price/charge right.

While existing studies suggest that, where pricing does not work, it is largely due to small and symbolic price levels, this study argues that none of these studies has determined what the appropriate price 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 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 by using a contingent behaviour (CB) analysis. CB generates state preference data on contingent demand under various hypothetical scenarios of interest (see Kipperberg et al., 2019). This approach is more desirable as it addresses the how the number of plastic bags would be affected by the hypothetical changes.

The argument here is that consumers can pay a higher price, as the current bag charge constitutes a negligible fraction of their total shopping costs. According to the Living Conditions Survey (LCS) 2014/15, South African households spend on average US\$1 112⁵ per annum on food, beverages and tobacco (Stats SA, 2017). This means that, at the current price and average consumption levels, plastic bag expenditure accounts for 0.005% of the total shopping trip. The proportion of plastic bag expenditure at the recommended charge of US\$0.50 would increase that share significantly, to 0.08% of total food expenditure. Unfortunately, there is no precise data globally on either the proportion of bag expenditure to total shopping trip or on per-capita consumption rate of bags; hence, we are unable to compare our estimates with those in other countries.

While higher charges would presumably lead some customers to use substitutes, the fact that the prices are a very small portion of overall shopping cost suggests that such substitution will be limited. In 2015, material bags⁶ were the only substitute to plastic bags in South Africa. Cotton and recycled polyethylene terephthalate (RPET) bags were the only two material bags that were available in the market, at a cost of US\$0.98 per bag, which is significantly higher than the current charge for a bag of US\$0.03. Other alternatives include paper bags, non-woven polypropylene bags, woven polypropylene bags, compostable bags and jute bags. Considering some of these alternatives are relatively more expensive, there is no danger of consumers shifting altogether or even significantly to substitutes such as paper bags and cotton, that may be even more environmentally damaging.

Survey information for consumers from the South African city of Johannesburg, ascertained by the CB method, is used to assess the potential impact of price adjustments

 $^{{}^{5}}$ US\$1 = R12.77, average exchange rate when experiments were carried out in 2015.

⁶Material bags refers to carrier bags made from recyclable materials.

on plastic bag use. 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 charge is set at a level that will remain a highly visible reminder of the negative outcomes associated with their excessive use. The management problems faced by South African policymakers are no different than those faced by other policymakers around the world. A 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.

2. Case study

The South African plastic bag legislation was fully implemented in May 2003, with a nominal price set at \$0.06 per reusable plastic bag. 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 24 μ m. The heavier gauge was intended to stimulate the reuse of plastic bags, avoiding immediate disposal following a single use. Hasson, Leiman, and Visser (2007) states that 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 alternatives. The regulation initially targeted all retailers in the country, with a set charge for bags. However, following just three months of implementation (May to July 2003) and persistent protests from both industry and labour, the pricing and scope were changed. The price was lowered to \$0.04. Retailers further absorbed some of the cost, leaving consumers to pay \$0.02 per bag.

In 2004, a plastic bag government levy at a rate of \$0.005 (R0.03)⁷ per bag was introduced,⁸ which increased to \$0.005 (R0.04) in April 2009, \$0.006 (R0.06) in 2013, \$0.005 (R0.08) in 2016 and \$0.01 (R0.12) in 2017. The increases represent inflation adjustments (see National Treasury, 2019). The levy is an environmental tax and is to be paid by plastic bag manufacturers or importers. It is passed on to consumers by manufacturers or plastic importers. 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 improve the regulations' efficacy, consideration must be given to increasing the charge, particularly if the current charge of plastic bags continues to be low relative to income and goods purchased, as highlighted by Dikgang et al. (2012a, 2012b).

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

⁷Because the South Africa currency is volatile (\$1 = R6.44 in 2004, \$1 = R8.42 in 2009, \$1 = R9.64 in 2013, \$1 = R14.71 in 2016, & \$1 = R13.3 in 2017), showing the changes in US dollars alone paints a picture where there are no levy increments, which is misleading, hence our decision to also show changes in levies in local currency.

⁸The charge for a bag in South Africa is made up of a price which goes to the retailer (which was \$0.06 at the time) and a levy (i.e., tax – \$0.005) which goes to the government. Therefore, a *charge* for a bag refers to retailer price plus the government levy, hence bag charge in 2004 was \$0.07.

argument when evaluating the performance of the $\notin 0.15^9$ levy implemented in Ireland – that the levy was specifically tailored to change consumer behaviour and increase awareness of the issue. There was a 90 per cent reduction in plastic bag usage, and overall support for the levy; it is no surprise that Ireland 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) found that the introduction of the tax resulted in a strong and significant change in own bag use (plastic bag reuse) within the treatment sample (Wales). In Portugal, Martinho, Balaia, and Pires (2017) found that a tax was largely effective, reducing the consumption of plastic bags by about 74% and concurrently increasing the use of reusable bags by about 61%. However, the effectiveness of this tax was short-lived.

Gupta (2011) 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 in India. The cash-back scheme was the most effective, although the differences were minimal. Bharadwaj, Baland and Nepa (2019) found that the effectiveness of the ban in Nepal essentially depended on enforcement and sanctioning system. Their results imply that the perceived sanction is a key driver of plastic bags use, as a doubling of the perceived sanction could reduce plastic bags use by two-thirds for retailers and by one-half for consumers.

In Buenos Aires, Argentina, Jakovcevic et al. (2014) found that market-based incentives or charges were more effective than an awareness campaign at changing the way consumers behaved. Interestingly, however, there was a slight increase in own bag use in both the control and treatment groups in Buenos Aires, which perhaps highlights the importance of awareness campaigns. 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.

In Chicago, plastic bag bans, the most common disposable bag policy in the US, led retailers to circumvent the regulation by providing free thicker plastic bags which fell outside the ban. The study concluded that narrowly-defined regulations (like plastic bag bans) may be less effective than policies that target a more comprehensive set of products, even in the case when the policy instrument itself (a tax rather than a ban) is not as strict (Homonoff et al., 2022). Rivers et al. (2017) examined a nudging policy in Toronto, Canada, and found that the nudge increased the use of reusable bags.

Dikgang and Visser (2012) found that bag use in Botswana was reduced significantly in Botswana following the implementation of charging. Turning to South Africa, Hasson et al. (2007) revealed that there was a large reduction in overall plastic bag sales – of approximately 80% shortly after charging started. However, Dikgang et al. (2012a) found that bag usage reduction could not be achieved in South Africa in the long term.

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

⁹€1 (1 Euro) = R9.93 when the pricing started in Ireland in 2002.

consumption. The variations may be attributed to numerous factors, but there is a strong case that the plastic bag price is the underlying variable.

Although significant empirical advances have been made in understanding the performance of plastic bag regulation, there is a very limited number of studies focused on understanding the influences of various pricing points. To help fill this gap, recent studies (see Dunn, Caplan, & Bosworth, 2014; Madigele, Mogomotsi, & Kolobe, 2017; O'Brien & Thondhlana, 2019) have explored stated preference approaches such as the contingent valuation framework. These studies have provided interesting insights into the possible effects that price may have on plastic bag consumption, which has motivated further exploration in this study. The CB approach is a state preference method that addresses limitation associated with recent contingent valuation method (CVM) studies. Relative to these recent studies, the use of contingent behavior questions adds a different dimension. The tradeoffs of using this rather than a more standard stated preference elicitation (i.e., CVM) is that it allows evaluating changes outside of the range observed today. Although CB is a powerful tool for estimating demand elasticities, it is very rarely applied.

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 currently 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 charge has remained about the same with very little variation over the years. Additionally, charges for bags are similar and changes in charges 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 such as revealed preference (RP) and stated preference (SP) approaches ought to be used to better understand the prices that customers should be charged per bag.

RP methods, such as the travel cost method, rely on observed individual behaviour mostly from surveys to infer values for environmental goods or services. Several surveybased SP techniques are used to assess the economic value of nonmarket environmental goods. These methods include CV and CB. In CV, respondents are asked to make statements about their willingness-to- pay (WTP), or to accept compensation for declines in environmental quality (Grijalva, Berrens, Bohara, & Shaw, 2002). According to Zuo, Ann Wheeler, Adamowicz, Boxall, and Hatton-Macdonald (2016) CVM generally aims to find values related to marginal change in terms of an environmental good.

CB is commonly used to assess quality or price changes at a recreational site. In the CB framework, respondents are asked to make statements about their intended behaviour (e.

g., visitation to site, purchase of plastic bags) given a proposed change (e.g., site quality, access or price). While CV elicits a value statement, CB is used to estimate changes in behaviour or levels of use for a nonmarket good. CB questions are restricted to consideration of hypothetical use levels, and thus measurement of use values. While potentially avoiding some of shortcomings (e.g., lack of familiarity with the good) concerning the application of CV methods and the measurement of non-use values, criticism of the CB method remains due to its inherent hypothetical nature. Nonetheless, given the restricted focus on use values, patterns of evidence concerning the validity of CV may not hold for CB data (Grijalva et al., 2002). Given the objectives of this study, the CB approach is the most appropriate method, due to its ability to vary charges, 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, Lee, Schulze, and Anderson (1998) to estimate the right price level for bags within a South African plastic bag regulation framework. In a CB setting, bag users are assumed to maximise a utility function u = U(X, Q), subject to $P_x X + P_Q Q = M$, where X is an n-vector of private goods, Q is 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 is the individual's household income. In this expression, different bag prices are assumed to result in varying bag usage levels. Founded on earlier studies,¹⁰ aggregate demand for bags is anticipated to be a function of bag prices, income and socio-economic characteristics.¹¹ The symmetrical demand functions for plastic bags can be written as follows:

$$Q_i = f(P_1, P_2, P_3, P_4; M; Z) \ i = 1, \dots, 4 \ Price \ levels$$
 (1)

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 consumer's household income; and Z captures the socio-economic characteristics.¹² The bag demand functions are estimated using experimental data generated through a CB survey experiment carried out with shoppers in Johannesburg (South Africa) shopping malls.

By employing CB, this study gathers data on consumer reactions to various nonmarket charges for plastic bags. 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 were framed in such a way as to encourage respondents to carefully consider the answers that they provide. Although we have pointed out internal consistency, we are aware that it is rather weak evidence of absence of hypothetical bias. Therefore, respondents were asked follow-up questions, with the aim of reducing the likelihood of hypothetical bias. We asked respondents to state at what charge (i.e., reservation charge) they would consider

¹⁰The most common approach used for plastic bag demand estimation is the survey-based approach, as applied by Dunn et al. (2014), Madigele et al. (2017) and O'Brian and Thondhlana (2019), who estimated WTP for bags in the US and Botswana respectively.

¹¹However, given that plastic bag prices are a negligible portion of income, income is not expected to be a significant factor, relative to the grocery costs that consumers already incur.

¹²Equation (2) represents a demand function that assumes individuals distribute their disposable income between plastic bags and other combined goods with a numeraire price.

switching to alternative carrier bags. That question helped us assess the effectiveness of how the experiment was framed.

Moreover, 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.

Secondly, anchoring is a concern, and it cannot be eliminated. Nonetheless, we have dealt with this ex-ante when designing the survey, by putting control measures such as limiting exposure to the full experiment and framing questions in a manner that encourages contemplated responses, which may reduce this effect. Both issues highlight the importance of structuring survey questions and conducting surveys in a manner that urges respondents to prudently deliberate on the hypothetical scenarios presented to them.

5. Survey design

Ideally, we would like to gather information pertaining to bag usage both pre- and postpolicy period, as done by Homonoff (2018). For purposes of our study, we would particularly like to gather data which captures bag price changes and bag usage over time. In the absence of such data, we designed this survey. The survey consisted of two sections. Section one elicited stated preferences of individuals, and explored various policy options regarding plastic bags, in terms of alternatives, recycling, education and general opinion. Our survey was developed to maximize the validity and reliability of the resulting value estimates as recommended in best practices for SP survey's (see Johnston et al., 2017).

Section two was designed simply to gather demographic and socio-economic data. It is worth mentioning that income had been captured as a categorical variable. The reasoning behind this considers 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). Participants were told why bag charges were increasing, and importantly what the revenue from the policy (assuming price increases are due to regulations) would be used for.

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

Actual									
Price	Number of Bags								
\$0.03		\$0.06	-	\$0.13		\$0.25	5	\$0.50	

Our study used one set of a CB question, and 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.

The respondents were shown the table, with all but the first block of five columns covered using a blank paper, to limit the effects of anchoring within the responses. 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 \$0.03 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 \$0.06. The interviewer would then ask, "If the price were increased to \$0.06, how many bags would you purchase on average per month?"

The second hypothetical question raises the price to \$0.13 per bag. The third hypothetical question raises the price to \$0.25, followed by a fourth hypothetical question with a bag price hike to \$0.50 per bag. The hypothetical bag prices used in the experiment are realistic and comparable to those in other countries, where the bag policies are more effective. For example, Ireland charged 5 Euro cent tax on reusable plastic bags in 2002 (see Convery et al., 2007), Washington DC in 2010 charged \$0.05 per reusable bag (see Homonoff, 2018), Wales charged £0.05 per single-use bag in 2011 (see Poortinga et al., 2013), while the California cities of El Cerrito, Richmond and San Pablo charged \$0.15 per reusable bag in 2014 (see Taylor and Villa-Boas, 2016). Despite each respondent answering bag usage questions about five price levels, 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 questionnaire survey was conducted, during the week and over weekends in the months of June and July in 2015. Surveys were conducted in Johannesburg, Gauteng Province. Johannesburg is the South African city with the largest economy. 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 background to the questionnaire. As the CB methodology may be susceptible to hypothetical bias and anchoring, having use of "cheap talk" by an enumerator assists in increasing the overall validity of the respondents' answers. A survey specifically designed to test whether various mitigation approaches discussed in the literature reduces hypothetical bias and anchoring bias requires use of several elicitation formats, and a large sample to obtain sufficient statistical accuracy. This would be expensive and our aim here is more modest (see Carlsson and Katariab, 2018; Champonnois, Chanel and Makhlouf, 2018).

One of the major features of shopping malls is the high concentration of retail space. A significant proportion of reusable plastic bags are distributed by major retail chains, and since the focus of our study is on reusable plastic bag consumption, we selected shopping malls as the ideal location to do our experiments. Since we required permission from the mall managing companies, surveys could only be undertaken at malls where permission

was granted. In our case, only 8 of the 11 malls that were approached granted us permission, and those are the places where surveys were carried out. Shoppers in Johannesburg tend to either live or work within proximity to the malls. The survey instrument is deliberately short. Our study is based on face-to-face sampling. Surveys were conducted at shopping mall parking areas. The parking areas were selected as this posed minimum interruption to consumers' shopping. The shoppers were approached before they began their shopping, as that is when they still had some time and did not have typical constraints encountered after shopping (such as carrying items or having paid for parking and therefore being under pressure to exit the mall before their parking tickets expired). Shoppers using public transport were also sampled.

In order to generalize our findings to some extent, it is vital to also study the consumption patterns of shoppers without private vehicles. Public transport users going to malls in South African are typically dropped in proximity to parking areas. The same applies to shoppers who walk or cycle to malls. Our sample therefore is representative of an average South African urban shopper. Urban shoppers in South Africa tend to either live or work within proximity to the malls. Excluding shoppers without cars would bias the results and make the findings invalid. The inclusion of all shoppers allows us to estimate a stated preference model for the full set of shoppers at shopping malls in Johannesburg.

We randomly approached shoppers and interviewed those who were willing to participate. Enumerators walked around parking areas and approached individuals they came across and asked them if they could interview them. The purpose of the survey was explained before the customer refused to answer. The rejection rate from those approached was understandably high.¹³ Hence, we excluded any self-selection bias. Given the experimental nature of the study (refer to Table 1), there were five observations per respondent. There were 421 respondents, resulting in a total of 2 105 observations. Table 2 presents the initial results of the respondents' plastic bag purchasing reactions to increasing charges.

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 \$0.03, at a mean of approximately 15 plastic bags. Just over a quarter would occur at \$0.06, 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 \$0.13, \$0.25 and \$0.50. Only 30 respondents were willing to purchase plastic bags at \$0.25, and just 10 at \$0.50. This is not that surprising, given the substantial difference between these prices and the actual price that respondents are accustomed to paying.

The very small inconsistencies suggest that the overall performance of the experiment is a reliable format for ensuring suitable responses. The inconsistency here is the nonmonotonic decrease in the number of plastic bags with bag prices. 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, since none of the

¹³We acknowledge that there could be selection bias.

Price	Buy (%) *	Mean Number of Bags Per Month*
\$0.03	63.9	14.96
\$0.06	26.5	6.21
\$0.13	7.3	1.73
\$0.25	1.6	0.39
\$0.50	0.7	0.17
* Buv percentad	nes were based on a total sa	imple of 421 respondents.

Table 2. Stated purchasing behaviour by price level.

respondents clearly showed inconsistencies that are not compatible with the underlying standard economic theory.

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):

$$Q_i Q_i^* =_i \beta + \varepsilon_i \quad \text{where} i = 1, \dots N, \tag{2}$$

$$Q_{i} = \begin{cases} a, if \ Q_{i}^{*} \leq a \\ Q_{i}^{*} if \ a < Q_{i}^{*} < b \\ b, if \ Q_{i}^{*} \leq b \end{cases}$$
(3)

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, 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. This paper uses random effects as opposed to fixed effects, owing to the problem of acquiring estimates of levels rather than changes. 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. 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 two equations, as follows:

$$Qi = \propto +\beta P + \varepsilon_1 \tag{4}$$

$$Q_i = \propto +\beta P + \beta Y + \varepsilon_1 \tag{5}$$

Where Q_i is the plastic bag demand, P is the hypothetical price level and Y represents various other independent variables, such as income, awareness of the levy, reuse, age, education 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 (see Dunn et al., 2014; Madigele et al., 2017). To understand the impact this may have, equations (4) and (5) were run with just the independent variable price. In addition, price elasticity of demand for plastic bags was estimated from these equations.

8. Descriptive statistics

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.

Regarding the socio-economic information from section two of the survey, the average respondent earns between \$7 831 and \$11 746 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 (>12 years education years) and having an additional year of training or a certificate; is female; and is unmarried (i.e., 53% are not married). Our sample had average incomes below the national averages of US\$10 819. There were substantial variations in the level of household income with a maximum of US\$39 154 while the minimum was US\$392, pointing to high inequality in South Africa (see Scotte, Zizzamia and Leibbrandt, 2018). Below average income of our sample is driven by the 21% earning on average \$392 per year. Removing that sub-sample gives us a mean (\$10 089) close to the average national household income levels. The descriptive statistics indicate that more needs to be done to raise awareness about the plastic bag

Variable	Mean	Std Deviation	Min	Max
Number of bags purchased (at actual price)	14.96	14.49	0	140
Know current bag price	0.7	0.46	0	1
Aware of bag prices	0.39	0.49	0	1
Reuse of bags	0.88	0.33	0	1
Household Income \$	8 033	9 309	392	39 154
Age	39.29	14.53	18	95
Household size	3.7	2.02	0	20
Education years	13.07	1.91	0	18
Low Education Dummy	0.4	0.49	0	1
Gender	0.51	0.5	0	1
Married dummy	0.47	0.5	0	1

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

price and what it entails. Furthermore, they indicate that the current price, relative to average household income, seems rather low.

9. Estimation

We ran the random effects (RE) Tobit models (linear-linear) for plastic bag demand, alongside the standard pooled Tobit results for robustness checks. We also ran the linear-log model; however, taking the logarithm of price when price is less than one (i.e., bag price ranges from below 1) is highly problematic. This is realized when we want to estimate elasticities, hence the log-liner results are not considered further.

We 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. Models 1 and 3 are run using only the independent variable price. This represents the impact on demand only.

HT Marginal effects on the dependent variable are more interesting to discuss than coefficients. Therefore, for the purpose of more straightforward interpretation of analysis, only marginal effects are reported. The results of estimation of the marginal effects for the random-effects Tobit model and standard pooled Tobit model are displayed in Table 4.

At a glance, the results have yielded the expected signs. The results above are overwhelmingly in support of the inverse relationship between price and quantity demanded. In all models, the estimated marginal effect price variable is negative and statistically significant at the 95% level of confidence or better. It follows, then, that any price increase will be accompanied by reductions in the number of plastic bags demanded. Considering we are running a linear model, a 1% increase in price will be accompanied by a 110.45% decrease in plastic bags demand. Estimates from standard pooled Tobit model show a reduction in bags of 104.98%. The estimated marginal effects on the remaining variables of the model provide additional insight into the relevant factors affecting plastic bag demand.

In particular, the results on the income variable indicate that, the income level of a consumer has a negligible positive impact on the quantity of plastic bags demanded. A 1% increase in income would lead to a 0.002% increase in bag consumption in both models. This positive effect 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 et al. (2014). Moreover, the negligible impact on bag demanded can perhaps be explained by the bag price being low compared to an average overall shopping bill (see Dikgang, Leiman, & Visser, 2012b).

Overall, the marginal effect results of the model in Table 4 demonstrate that, awareness, education level and gender are found to be insignificant in the Random Effects model. Additionally, household size has a positive and important effect on number of bags demanded. For every additional household member, bag demanded would increase by 65%. Larger households tend to use considerably more plastic bags, as they require higher volumes of goods to be purchased. In contrast, reuse, employment status and age of household head have a negative effect on bag consumption. The relatively large negative effect of reuse suggest that it is a very influential variable factor on plastic bag demand patterns. A possible explanation could be that the South African plastic bag

Variable	RE Tobit (Linear Linear)		Tobit (Linear Linear)	
Equation	ME1	ME2	ME3	ME4
Price	-11.04***(0.989)	-11.045***(0.967)	-1.77***(0.078)	-10.498***(1.010)
Income		0.00002***		0.00002***
		(3.09e-06)		(4.45e-06)
Awareness		-0.685 (0.712)		-0.997***(0.927)
Reuse		-7.70***(1.382)		-8.225***(1.954)
Age		-0.053*** (0.026)		-0.045 (0.036)
Household Size		0.65***(0.162)		0.702***(0.199)
Education (Years)		-0.46* (0.262)		-0.512**(0.380)
Employment Dummy		-1.68** (0.852)		-1.844(1.190)
Female Dummy		-0.108 (0.690)		-0.057 (0.919)
Constant	13.2***(0.942)	25.3***(4.197)	9.08***(0.372)	25.3***(6.073)
Sigma_u	9.64***(0.791)	8.88***(0.727)		
Sigma_e	11.9***(0.779)	11.9***(0.733)		
Var (e.Quantity)			80.3***	228.1***
Log likelihood	-3585.4	-3565.91	-3688.96	-3648.06
Chi-squared	124.7	176.8	510.4	145.3
Bayesian Information Criteria	7201.4	7223.5	15,011.7	7380.1
Observations	2075	2075	2075	2075

Та	bl	e 4	. 1	obit	with	Bootstrap	Std.	Err.	for	mod	lell	ing	plasti	ic I	bag	use
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Standard errors in parentheses.

M1= RE Tobit Reduced Marginal Effects M2= RE Tobit Marginal Effects M3= Pooled Tobit Reduced Marginal Effects M4= Pooled Tobit Marginal Effects.

*p<0.10, **p<0.05, ***p<0.01.

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). Taylor and Villas-Boas (2016) found that there were no differences in reusable bag use reductions between charging and banning.

The pooled standard Tobit model marginal effects results are very similar to those of the Random Effects model. Unlike in Random Effects, awareness has a negative effect, while age of household and employment status have no effect on demand for bags. 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 (see Posada and Buckley, 2004; Zuo et al., 2016).

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 the marginal effects for specific bag prices. Table 5 estimates price elasticity for price levels used in the experiment.

Table 5 presents price elasticity estimates for each of our five price levels, as per the CB experiment. Elasticity estimates are calculated from the random effects model. Unsurprisingly, at the current price of \$0.03, the price elasticity of demand is inelastic. This does resonate with the findings in a study by Dikgang et al. (2012b), which suggested that the current price was too low, hence policy became less effective over time. An overall view of the elasticities suggests significant relative 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, \$0.03, is almost double. At the last hypothetical price of \$0.50, the elasticity estimate is almost unitary, suggesting that a percentage change in price at \$0.50 would in turn lead to a percentage change in the quantity of plastic bags demanded.

	5 .
Price US\$/PB	Random Effects Tobit Model (Linear-Linear)
0.03	-0.139***[0.139]
0.06	-0.272***[0.022]
0.13	-0.501***[0.037]
0.25	-0.795***[0.043]
0.50	-0.997***[0.025]

Table 5. Plastic bag price elasticities.

Our findings are like those of the US study by Taylor and Villa-Boas (2016), which found that price-sensitive consumers reduce bag usage and increase reusable bag usage. Based on the elasticities above, South African households are sensitive to relatively higher bag prices and are therefore likely to reduce bag use and increase reuse of reusable bags, as well as use of alternative carrier bags. The range of elasticity estimates may provide policymakers with various options when considering an appropriate price level.

Determination of the plastic bag price does not only depend on the elasticity, but on many other things. Estimation of the bag price is also contingent upon the frequency at which bags are reused, the types of bags retailers choose to sell (see Taylor & Villas-Boas, 2016), the types of plastic bags that are subject to a bag levy, plastic bag leakage (i.e., the effect of plastic bag regulations on unregulated plastic bags; (see Taylor, 2019), availability of alternative carrying bags, costs of alternative bags, how recyclable the bags are, and the recycling infrastructure. Even though a host of other factors should be considered when estimating an appropriate price level, our results highlight that at the current price level of \$0.03, slight increments and changes may not have the desired effect of increasing the use of reusable bags and decreasing the use of plastic bags. 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).

The rate of bag reuse is likely to remain unchanged until there is a significant increase in bag prices. The relatively low price is a barrier to the reuse of bags. A higher price is more likely to encourage most 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 policymakers. Failure to establish and charge the right bag price theoretically renders bag regulation ineffective. Thus, we argue that considering the current high bag consumption levels, and the lack of evidence pointing to bag re-use and recycling, that a price of \$0.50 should be charged per bag. This is the price that is within the customer's reservation price: the price at which the users would consider alternative bags. Most importantly, there is still consumption of bags at this price level; however, it is at very low and desirable levels.

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. 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. This paper tackles an issue that is relevant for both developed and developing countries: reducing the use of plastic bags. The objective was accomplished through first employing a CB approach to gather demand information on five different price levels. This was followed by applying of the RE Tobit marginal effects analysis to estimate demand functions.

This studies' analysis, directed at South African shoppers, indicates that there is great variation in the elasticities of demand for plastic shopping bags. 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 setting the plastic bag prices at the right levels is 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.

This paper recommends that the current pricing framework be revisited. The current charge of US\$0.03 is too low. This price is lower than the bag tax in Ireland in 2002, and lower than both the 2010 and 2011 bag prices in Washington DC and Wales respectively. Elasticities suggests that consumers are still relatively unresponsive to charge increments to US\$0.06, US\$0.13 and US\$0.25 respectively. A charge of US\$0.50 shifts consumers from unresponsiveness (i.e., inelastic demand) to responsiveness (unit elastic demand). At this price, the response of plastic consumers to a price change is proportional to a change in price change. This price is higher than current plastic bag prices around the world, such as in California and Ireland. Thus, at this price level, we expect to see both reduced bags use and increase in usage of alternative bags.

There are various mechanisms in which government can ensure this price is set, one of which could be to simply increase the levy by the difference of current price and suggested price. This would require government, for example, to increase its levy from the current US\$0.01 to US\$0.48 per bag. To address equity, considering the high inequality and poverty in South Africa, government can, in turn, design programs that are aimed at exempting the poor from paying for a determined number of bags per year. This would require knowing the maximum of times bags can be reused, and the number required for a typical grocery shopping trip, conditional on the bags ending up at recycling plants at the end of their lifespan. Moreover, government can consider incentivizing the production of recyclable plastic bags, which could be accompanied by significant investments in recycling infrastructure.

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 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 the right price levels, by means of experimental data, contributes to research on plastic bag policies.

Our elicitation method may give rise to strategic responses that can lead to bias. It is generally problematic to ask people about multiple scenarios. The bias can be minimized by randomizing over the price scenarios, which serves to confound identification. Future research should consider random assignment of scenario ordering over the sample, in order to thoroughly check for the presence of anchoring. Moreover, a possible extension of our study would be to carry out field experiments involving for example actual incentives or plausible exogenous policy variation (i.e., policy experiments) to reveal more convincing evidence on how policies may affect the use of plastic bags.

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No potential conflict of interest was reported by the author(s).

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