Fiscal-Food Policies are Likely Misinformed by Biased Price Elasticities from Household Surveys: Evidence from Melanesia

John Gibson* and Alessandro Romeo

Abstract

Fiscal-food policies use taxes to alter relative food prices so as to change diets and are suggested for reducing non-communicable diseases in the Pacific. Price elasticity estimates used by advocates of fiscal-food policies are often biased and may make policy makers too optimistic about small taxes on unhealthy food and drink inducing big changes in diets. The bias is illustrated using the example of the demand for soft drinks in a household survey from the Solomon Islands, with further evidence from Papua New Guinea. About one-third of consumer response to soft drink price variation in the Solomon Islands is on the quantity margin, with two-thirds on the quality margin. If the quality response is wrongly treated as a quantity response to price—as in most studies—the price elasticity of soft drink demand is exaggerated by a factor of two in Papua New Guinea and three in the Solomon Islands.

Key words: demand, household surveys, quality, soft drink taxes, Melanesia

JEL Classification: D12, I10

1. Introduction

Non-communicable diseases (NCDs) are a growing problem in the Pacific, and various policies are suggested to reduce them. Fiscal-food policies that use taxes and subsidies to alter food prices so as to induce a change in diet are amongst the most commonly debated measures. Some discussion of such taxes, particularly by public health researchers, implies that countries in the Pacific can ‘have their cake and eat it too’ because it is claimed that these taxes are beneficial from both a health and a fiscal revenue standpoint. For example, in a discussion of soft drink taxes in four Pacific countries, Thow et al. (2010a) suggest that shaping the tax to suit the priorities of health and finance can facilitate uptake, and recommend that advocates highlight both the health and revenue implications of these taxes so as to gain political support. Similarly, Friel et al. (2015) review all-sector public policy making that seeks improved health impacts and conclude that soft drink taxes in Pacific Island countries are justified because they contribute both to health and to the Treasury.

This apparent ‘win–win’ situation differs from traditional understanding of commodity taxes, where there are trade-offs between fiscal objectives and reducing intake of the particular commodity. Traditionally, excise taxes have been viewed as relatively efficient taxes (even if somewhat inequitable) because they are often imposed on goods whose demand is own-price inelastic (Carnahan 2015). Items that may be efficient to tax from a revenue point of view are those with own-price inelastic
demand, because the pre-tax and post-tax equilibrium quantities are close together; thus, taxes on these items do not entail much distortion, in the sense of having smaller Harberger triangles than for price elastic items that have a large change in the post-tax equilibrium quantity. In other words, an unhealthy food is unlikely to be efficient to tax from both a health and a revenue standpoint, because one objective needs own-price elastic demand and the other needs inelastic demand.

The belief that demand for unhealthy food and drink will respond elastically to taxes pervades discussion of fiscal-food policies and is found even at the highest levels. For example, the World Health Organization advocates taxes on sugar-sweetened beverages at a rate high enough to raise retail price of these drinks by at least 20 per cent, and it is argued that this will lead to proportional reductions in consumption (WHO 2016), implying that the own-price elasticity of quantity demand is minus one for these drinks. Likewise, one of the first fiscal-food policy studies, by Marshall (2000), considered taxes on high cholesterol foods and based the analysis on an assumed own-price elasticity of demand of minus one for items such as whole milk, despite this being eight times more elastic than existing evidence suggested (Kennedy & Offutt 2000). Perhaps unfairly, one could characterize some of the advocacy for fiscal-food policies as the triumph of hope over experience.

The goal of this article is to explain why many elasticity estimates used in support of fiscal-food policies are exaggerated. This bias may make policy makers too optimistic about how small taxes on unhealthy food and drink can induce big changes in diets. The bias is illustrated using the example of the demand for soft drinks in a household survey from the Solomon Islands, with supplementary evidence from Papua New Guinea. The particular choice of commodity and countries is not because soft drink taxes are pressing policy concerns in these countries—in fact, across these two surveys, soft drinks account for an average of only about 1/200th of the total value of household consumption. Instead, the commodity choice reflects a focus in the literature on soft drink taxes, which comprise just under one-half of the studies of fiscal-food policies that Thow et al. (2010b) review. It is also important to present evidence from the Pacific, which is a region where policy-makers in health- and food-related areas have difficulty in accessing credible evidence (Waqa et al. 2017).

The source of the bias that misinforms fiscal-food policies is that most of the demand elasticities estimated with household survey data confuse two separate, but linked, responses that consumers can make as prices change. One response is to change the quantity of what is consumed, as in the standard textbook model of a demand curve, while the other is to change the quality of what is consumed. This quality response is largely ignored in the literature, even though both types of response are inherent features of household survey data, and even though both responses can occur for all types of food and drink rather than just for items subject to fiscal-food policies. For example, even a basic staple like rice has quality-related variation, and consumer downgrading of quality in response to higher rice prices seems to buffer nutrition of Vietnamese consumers against effects of price shocks (Gibson & Kim 2013); this coping would be missed if analysts only consider the standard textbook model of quantity responding to price with no quality response.

Rather than allow for this sort of quality response, most elasticity studies that are used to inform the advocacy for fiscal-food policies wrongly use calculations that are appropriate for a standard, undifferentiated good, as in the textbook model of a demand curve. This does not describe what household surveys provide, which is data on a mix of many different brands, varieties, package sizes, container types and so forth, as was first recognized over 60 years ago by Prais and Houthakker (1955). This feature was also emphasized in a series of papers written thirty years ago by Nobel-prize winner Angus Deaton (1987, 1988, 1989, 1990), but it remains largely ignored. A review of the applied demand literature using household survey data shows that over 80 per cent of studies ignore quality responses and wrongly attribute any adjustment on the quality margin to the (exaggerated) quantity response to price (Gibson & Kim 2016).
In the results reported below, approximately one-third of the consumer response to soft drink price variation in the Solomon Islands is on the quantity margin, while almost two-thirds is on the quality margin. In Papua New Guinea, consumer responses are split evenly between the quantity and quality margins. Thus, if the quality response is wrongly treated as a quantity response to price—as it is in most of the literature—the elasticity of soft drink demand with respect to own-price will be exaggerated by a factor of two in Papua New Guinea and three in the Solomon Islands. It is this elasticity that is the important one from a health point of view, because it is only by cutting the volume of soft drink consumed (and at the same time not triggering a switch into other unhealthy food and drink) that a fiscal-food policy can hope to achieve health objectives. Also, the inelastic quantity demand is unlikely to provide support for the argument that these taxes may be useful for fiscal reasons, because the elastic response of quality to price still implies a loss of consumer welfare (but in terms of quality, and consumers reveal a willingness to pay for this as well as for quantity).

The results for these two Melanesian countries may underestimate the bias in elasticities from household surveys in other countries, because quality variation for soft drinks in Papua New Guinea and the Solomon Islands is fairly modest. In settings with more quality variation, such as Mexico, the bias from ignoring consumer responses on the quality margin appears larger. For example, when the own-price elasticity of quantity demand for soft drinks in Mexico is estimated using a framework that allows responses on the quality margin, it shrinks from around $-1.2$ to just $-0.3$ (Andalón & Gibson 2017). Thus, ignoring quality responses may cause the quantity demand elasticity to be overstated by a factor of about four. In terms of health implications, such a large bias undermines the prediction by Grogger (2016) that the one peso per litre tax imposed on soft drinks in Mexico from January 2014 will reduce the weight of Mexicans by up to 2 kg, because this prediction uses the exaggerated elasticities. If the corrected elasticities are used, the expected weight loss due to higher priced soft drinks is less than 0.5 kg, which is too small to make much difference to population health. The effect of a soft drinks tax on population health in Melanesia would be even less, because consumption is much lower than in Mexico.

2. Data Sources for Estimating Price Elasticities of Demand

There are three main sources of data available for estimating price elasticities of quantity demand for food and drink. The first is time series data, which typically will be for an aggregate category of goods, such as all rice consumed in a country or all beer, where the original data will be either some combination of food balance sheets that account for production, trade and disappearances (e.g. animal feed, seed supply), or administrative data from excise statistics or other statistics that track production and consumption. There are two problems with time series data for developing countries, including those in the Pacific; often, there are not enough observations, with perhaps only 30 years for the time series, and the elasticities are likely to be time-varying with the changing structure of the economy. For example, income elasticities of demand for rice show a trend decline in Asia, and are much lower in urban than in rural areas (Timmer 2014) so on-going urbanization will see these elasticities fall further—it is doubtful that price elasticities will stay unchanged as income elasticities exhibit trend decline.

The second source of data is very finely disaggregated at the Universal Product Code (UPC) level. These are barcodes for tracking items within stores and for scanning at checkout and allow up to 100 billion different combinations and are found on all packaged food and drink products and increasingly on fresh produce as well. With bar-coded data, each individual specification is separately distinguished (e.g. a 600-ml bottle of Coke has a different UPC than a 600-ml bottle of Fanta or a 1-litre bottle of Coke). The UPC-level data are typically available from market research firms such as AC Nielsen, and enable detailed and precise measures of sales for defined geographic
markets. The UPC data may be combined with consumer level data, where a consumer panel is given barcode scanners so that all of their food and drink purchases are recorded in their home, and can be matched to the prices of those same items in local stores. These UPC data are mostly used in developed countries, where they show that previous estimates of price elasticities of demand based on less detailed data may be biased (e.g. Ruhm et al. 2012 show this for alcohol demand in the United States). While there are some market research consumer panels in middle income countries like Mexico, and these have been used for studying fiscal-food policies (e.g. Aguilar et al. 2016), the linkage to UPC level data from stores appears to be restricted to developed countries.

The third source of data, and the most widely used one in developing countries, is household surveys. These surveys cover a wide range of approaches to measuring the total consumption expenditures of households and include surveys described as household budget surveys, household income and expenditure surveys, living standards surveys and others. Most countries field surveys of this type every three to five years, making them a widely available data source. Moreover, price variation is potentially available for these surveys because prices differ over space in developing countries due to the weak infrastructure and the lack of national retail chains that might adopt a single-price strategy for a particular product. These surveys also allow distributional effects to be highlighted (e.g. Hasan 2017) because they have sufficient observations to disaggregate analyses by income or expenditure quintiles, by ethnic or caste groups, and so forth.

Although there is a wide variety of household survey approaches, a common feature of all types of these surveys is that the data for each category of consumption comprise several different types, varieties or packages of particular goods, each sold at a different price. For example, the Papua New Guinea Household Survey used here is a living standards survey where an individual respondent recalled the purchases, gifts, production and consumption of 36 categories of food and drink (out of about 100 categories across all types of consumption) for the whole household over a two-week period. One of these 36 categories of food and drink was ‘soft drink’, and so this covers a multitude of different brands, packages (cans or bottles) and sizes, each sold at a different price per litre. A different approach is used by the Solomon Islands Household Income and Expenditure Survey, where a diary was kept by respondents, with each transaction allocated to a nine-digit COICOP (Classification of Individual Consumption by Purpose) code, where there were different codes used for juice, for cordial and for each of the major brands of fizzy drink (e.g. Coke, Fanta, Szeba, etc). Although the Solomon Islands survey has more detail, even within a brand like Coke, there are cans and bottles of different sizes (which would each have a different UPC code) so restricting to, say, COICOP code 012207201 (for Coke products) would still see analyses based on a mix of different products. The same is true across all household surveys, and this matters because in most studies the elasticity estimates are incorrectly calculated from a framework that is only appropriate for standardized products for which there is no mix of different qualities.

3. Sources of Bias in Quantity Demand Elasticities from Household Survey Data

The typical elasticity study with household survey data uses budget share models, such as the Almost Ideal Demand System (Deaton & Muellbauer 1980), or the Linear-Approximate version (LA-AIDS), or the Quadratic Almost Ideal Demand System (QUAIDS) of Banks et al. (1997). In these models, the dependent variable is $w_{Gi}$, the share of the budget devoted to food group $G$ by household $i$. Budget shares are usually modeled as varying with indicators of the household’s income, such as a quadratic in the log of per capita expenditures, $\ln x_i$, with the log of the price index for foods in group $H$ (where $\theta_{GG}$ is for the own-price effect and $\theta_{GH}$ is for the cross-price effect), with conditioning variables, $z_i$, and with random noise, $\epsilon$: 

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\[ w_{Gi} = a_G + \beta_{1G} \ln x_i + \beta_{2G} [\ln x_i]^2 + \sum_{H=1}^{N} \theta_{GH} \ln p_H + \gamma_G \cdot z_i + u_{Gi} \]  

(1)

The usual calculation of the elasticity of quantity with respect to price is based on:

\[ \varepsilon_{GH} = \frac{\theta_{GH} / w_G}{\delta_{GH}} \]  

(2)

where \( \delta_{GH} \) equals 1 if \( G = H \), and 0 otherwise, and equation 2 is typically evaluated at the mean budget share. Thus, the own-price elasticity of quantity demand is treated as depending on the rate that budget shares vary as own-price varies, which is shown by \( \theta_{GG} \), and has a default value of \(-1\) (e.g. if \( \theta_{GG} = 0 \)). Mhurchu et al. (2013) is an example of this approach in a fiscal-food policy study, using 24 food and drink groups in the Household Economic Survey of New Zealand, with price data coming from the Food Price Index for each month and for six regions.

Equation 2 is the correct price elasticity formula only if the item is standardized and no quality variation is possible, or else is an aggregate good (as in a time series study) with the same quality composition over time. Under either of those two conditions, the numerator of the budget share is simply the product of price and quantity for good \( G \). Thus, when the budget share is differentiated with respect to price (which is what the regression in equation 1 does), the only possible thing that can be identified is the response of quantity to price.

However, household survey data are not for a standardized good (like a single UPC), and instead a food group is comprised of many different goods, each of different quality (as shown by a different price per unit weight). For example, Figure 1 shows some of the range in price per litre for fizzy soft drinks in the Waterfront-Foodworld supermarket in Port Moresby (as observed in December, 2016). Just within this store, there were 33 different specifications of fizzy drink, including local brands like Gold-Spot and Gogo Cola, imported brands like L&P and San Pellegrino, and locally bottled global brands like Coke and Pepsi. Across all of these different specifications, there was a 5:1 range in price from dearest to cheapest, and even if San Pellegrino is excluded there was a 4:1 ratio.\(^1\) Some of this variation is brand related, and some is related to presentation (size and type of container); for example, within the Coke brand, there is a 2:1 variation in price per litre depending on container size and type.

1. A similar range was seen at other supermarkets. The quality range is limited in the countries studied here (and so bias in the elasticities may be smaller than elsewhere); for example, the supermarket nearest the lead author has 160 different specifications with a 15:1 ratio of dearest to cheapest brand and presentation of fizzy drink.
When equations 1 and 2 are applied to household survey data, there is no way to know if budget shares are lower because the consumer buys a cheaper brand (e.g. a can of Gold-Spot at K5.45 per litre rather than Coke at K6.06 per litre) or because they buy less quantity. Thus, when the budget share is differentiated with respect to price, there is no way to know whether it is a quantity response, a quality response, or some hybrid of the two being identified. This lack of identification can be shown by noting that the unit value, \( v_{Gi} \), from the ratio of group expenditure to group quantity (\( Q_{Gi} \)) shows where on the quality ladder the consumer locates, because it shows expensiveness. Thus, total expenditure on the group can be written as \( v_{Gi} Q_{Gi} \) and any response of the budget share to price will, potentially, involve both quantity adjustment (a change in \( Q_{Gi} \)) and quality adjustment (a change in \( v_{Gi} \)).

Another way to make this point is to note that within a single store there is a 5:1 ratio of prices due to different brands and presentation (as in Figure 1) that is not controlled for in the analysis using equations 1 and 2. Meanwhile, the less substantial price variation over space (in the PNG survey the soft drink price index has a 2:1 ratio between the dearest and cheapest areas) is controlled for. Thus, the typical analysis attributes all the differences in budget shares to the inter-area price differences while leaving uncontrolled the much larger within-store differences that reflect quality variation. This research design seems incomplete and subject to bias, because it would be expected that in more expensive areas (or periods) consumers would slide down the quality ladder as one way to cope with the higher prices.

This same weakness in the analysis also affects another commonly used approach, where budget shares are regressed on unit values rather than on prices:

\[
\begin{align*}
\ln w_{Gi} &= \alpha_{G} + \beta_{1G} \ln x_{i} + \beta_{2G} \ln [\ln x_{i}]^2 \\
&+ \sum_{H=1}^{N} \theta_{GH} \ln p_{H} + \gamma_{G} \cdot z_{i} + \epsilon_{Gi} 
\end{align*}
\]

where the coefficients are given asterisks to distinguish them from equation 1. An example of this approach is Colchero et al. (2015) who report price elasticities for soft drinks in Mexico using the unit values from the household survey as a proxy for prices. Elasticities derived from equation 3 will not be the same as those from equation 1, even with the same equation 2 elasticity formula used, because the unit values introduce measurement errors (e.g. due to respondents misreporting expenditure or quantity) and because unit values are a poor proxy for price because the quality mix changes the further one moves in time or space from the point of production due to the effect of shipping and storage costs (Gibson 2016). Nevertheless, the same lack of identification occurs as when using prices because changes in budget shares could be due to adjustments that consumers make on either the quality margin or the quantity margin, and equation 3 gives no way to know which.

The only way to overcome this identification problem is to model consumer behavior using two equations; one for each margin of adjustment—quantity and quality. Based on Deaton (1990) and McKelvey (2011) but with a quadratic in the log of per capita expenditures (so equivalent to a QUAIDS), the appropriate framework is:

\[
\begin{align*}
\ln w_{Gi} &= \alpha_{G} + \beta_{1G} \ln x_{i} + \beta_{2G} \ln [\ln x_{i}]^2 \\
&+ \sum_{H=1}^{N} \theta_{GH} \ln p_{H} + \gamma_{G} \cdot z_{i} + \epsilon_{Gi} 
\end{align*}
\]

with quality choice indicated by household \( i \)'s unit value for group \( G \), \( v_{Gi} \) (conditional on price):

\[
\begin{align*}
\ln v_{Gi} &= \alpha_{G} + \beta_{1G} \ln x_{i} + \beta_{2G} \ln [\ln x_{i}]^2 \\
&+ \sum_{H=1}^{N} \psi_{GH} \ln p_{H} + \gamma_{G} \cdot z_{i} + \epsilon_{Gi}
\end{align*}
\]

Superscripts 0 and 1 distinguish between parameters on the same variables in each equation.

Differentiating the logarithm of equation 4 with respect to price gives:

\[
\frac{\partial \ln w_{Gi}}{\partial \ln p_{H}} = \theta_{GH}/w_{G} = \varepsilon_{GH} + \psi_{GH}
\]

where \( \varepsilon_{GH} \) is the elasticity of quantity demand with respect to the price of \( H \), which is the

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parameter of interest for considering fiscal-food policies, and $\psi_{GH}$ is the elasticity of the unit value with respect to the price of $H$. The own-price elasticity of quality is $\psi_{GG} - 1$. By rearranging equation 6, it becomes clear why one needs equation 5, for the household’s choice of quality amongst the items within group $G$:

$$\varepsilon_{GH} = (\theta_{GH}/w_G) - \psi_{GH}$$  \hspace{1cm} (7)

The importance of equation 7 is that it shows that without knowing how quality responds to prices, which can be derived from the $\psi_{GH}$ term, it is impossible to identify the elasticity $\varepsilon_{GH}$ that shows how quantity responds to prices.

Thus, one needs data on budget shares, on prices and on an indicator of quality, such as the unit value, to correctly estimate the elasticity $\varepsilon_{GH}$ that shows how quantity responds to prices.

4. Data Description

While the Solomon Islands survey has data on several types of soft drinks, based on the nine-digit COICOP codes, the price data are not as finely detailed. The only soft drink prices obtained were for a 300-ml bottle of $\text{Széba}$ and a 280-ml can of $\text{Coke}$ (data for the second specification were less frequently available), and these were for less than half of the areas with household survey data. While the price of a single, representative, specification can proxy for the spatial price index for a related group of foods, the analysis then has to be at group level rather than for individual nine-digit COICOP codes. The same applies to the Papua New Guinea (PNG) survey, which only has data available for the group described as ‘soft drinks’ when survey respondents recalled spending and consumption. In the PNG survey, the price index is based on the average of the prices for a can of $\text{Pepsi}$ and a bottle of $\text{Coke}$, which was obtained from the nearest trade-store to each Census Unit in the sample.

The descriptive statistics for the budget shares, unit values and prices are reported in Table 1. The values from the Solomon Islands survey are reported for the full sample and the sub-sample that was in the areas where the price survey was carried out. The average budget share for soft drink is the same in the full and sub-sample, at 0.2 per cent but the (log) unit value is slightly higher in the full sample (3.11 versus 2.89), suggesting that it may have been in the less densely populated, and more remote and expensive areas that surveyors did not do a price survey. The comments on the price survey sheet for the enumeration areas (EAs) with no data collected bear this out, with reasons like: ‘this canteen depends on trading vessel for cargo’ and ‘there is no main market in this EA. Only village street stalls, irregular—not every day’

In the PNG survey, the prices were more widely observed because if teams came back from the field with no price data, an individual was sent back to gather prices from the nearest store and market. In rural areas, these may sometimes be an hour walk or more away from the households in the survey (who also may be in scattered locations) so it does take strict discipline on survey teams to gather prices in Melanesia, particularly if the survey has a (misplaced) focus on collecting nominal

2. Full details on the logistics and cost of the PNG price survey are in Gibson and Rozelle (2005). Symptomatic of the neglect of price data, the 2009–10 HIES in PNG had interviewers live in villages for up to 3 weeks to complete the fortnight expenditure diary, but no price survey was carried out despite the survey teams needing to visit stores and markets to purchase their own supplies.
expenditures (which are hard to interpret in the absences of prices). The average budget share for soft drink in the PNG survey was 0.9 per cent. The prices and unit values had a similar mean but the unit values are more variable (because they differ between households rather than just between EAs).³

The price surveys are limited in commodity coverage, with only 12 items covering food and non-food in the survey for the Solomon Islands and 11 store-bought food items in the PNG survey, so data on possible substitutes and complements for including cross-prices in the budget share models are lacking. Moreover, one possible substitute—beer—has even less coverage in the price survey, with beer prices reported in just 46 per cent of the EAs with soft drink prices for the Solomon Islands survey and 60 per cent for PNG, reflecting the restrictions on outlets that can sell beer. Therefore, the models only consider own-price elasticities, which is a limitation that should be kept in mind, although the evidence from elsewhere is that the bias in estimates of the own-price elasticity of quantity demand due to ignoring responses on the quality margin is largely the same whether or not cross-prices are in the models (Gibson & Kim 2016; Andalón & Gibson 2017).

5. Results

The estimates of the own-price elasticity of quantity demand for soft drink that come from the three different methods discussed in Section 3 are reported in Table 2 for the Solomon Islands and in Table 3 for Papua New Guinea. The price survey for the Solomon Islands covered less than half of the areas, so when this is matched to the household survey, it reduces sample size from about 4300 to about 1700. It is partly for this reason that the Papua New Guinea results are also reported, because the inferences for the Solomon Islands are weakened by having only a partial price survey. To ensure that the results are robust to outliers, any observations with prices or unit values more than five standard deviations from the mean are trimmed.

Five equations are estimated to get the elasticities reported in Table 2 and four are used for Table 3 and these equations have up to 15 control variables other than prices or unit values; a quadratic in log per capita real expenditures; household size, three demographic ratios, up to six attributes of the household head (age, gender, education, ethnicity, migrant status and main livelihood), an area characteristic (urbanity) and three regional fixed effects.⁴ The full results for each equation are reported in Appendix Tables 1 and 2.

When responses on the quality margin are ignored, due to using either the standard unit value method, or the standard price method, the own-price elasticity of quantity demand for soft drink is estimated to be from −1.02 to −1.20 for the Solomon Islands (Table 2). The results for the reduced sample that matches

### Table 1 Summary Statistics for Soft Drink Budget Shares, Prices and Unit Values

<table>
<thead>
<tr>
<th></th>
<th>Solomon Islands 2012–13 Household</th>
<th>1996 PNG Household Survey</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Soft drink budget share</td>
<td>Log of unit value for soft drink</td>
</tr>
<tr>
<td>Full sample</td>
<td>0.002 (0.005)</td>
<td>3.113 (0.904)</td>
</tr>
<tr>
<td>Sub-sample with price survey</td>
<td>0.002 (0.005)</td>
<td>2.892 (0.769)</td>
</tr>
<tr>
<td>1996 PNG Household Survey</td>
<td>0.009 (0.018)</td>
<td>5.639 (0.202)</td>
</tr>
</tbody>
</table>

Notes: Unit values and prices are in the currency of each country at the time of the survey. The price survey for the Solomon Islands was only carried out for a sub-sample (N = 1730 households in these areas out of a total of N = 4357 households in the full survey). The PNG survey has N = 1025 observations. Standard deviations in ()..

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³ The correlation between prices and unit values was 0.25 in PNG and 0.29 in the Solomon Islands, which further shows that unit values are a fairly imperfect proxy for prices.

⁴ Area characteristics and fixed effects are included to provide a short-run interpretation for the elasticities; these are more appropriate than long-run ones for considering price reforms.
to the price survey (\(N = 1730\) households) are similar to the full sample (\(N = 4357\)) according to the standard unit value method, and so the need to rely on only a sub-sample should not bias the remaining comparisons. While the point estimates for the own-price elasticities are similar, the apparent precision of the estimates is much greater with the standard unit value method, but this is somewhat misleading; unit values vary across households who face the same prices (e.g. if a consumer buys a different bundle within the items covered by group \(G\) than that bought by their neighbour who shops at the same store) and so unit values give the impression of more price variability than their truly is, artificially improving the precision of the elasticity estimates.

When the unrestricted method is used, with a budget share equation and a unit value equation so as to study consumer responses on two margins, the own-price elasticity of quantity demand for soft drink is only \(-0.46\), while the price elasticity of quality is \(-0.74\). Effectively, the elasticity from the standard price method (\(-1.20\)), which shows how the budget share changes as prices vary, is being decomposed into two parts—changes in the budget share from quality change and changes in the budget share from quantity change. Thus, approximately one-third of the consumer response to soft drink price variation in the Solomon Islands is on the quantity margin, while almost two-thirds is on the quality margin. If researchers ignore the second margin of adjustment, by wrongly using a single-equation framework that attributes all of the adjustment to changes in quantity, they will overstate the response of quantity to own-price by a factor of up to three (based on results for the standard price method). This exaggeration is likely to make policy makers too optimistic about how small taxes on unhealthy items can cause big changes in diets.

Because the results for the Solomon Islands rely on only a partial price survey, it is helpful to corroborate them. While the PNG Household Survey is 20 years old and the structure of demand likely has changed since it was fielded, few other household surveys in the region have a linked price survey. This failure of statistical practice in low-income countries is in the very places with spatially varying prices and where nominal data are a poor guide to real welfare levels (Gibson 2013). In the PNG

| Table 2 | Own-Price Elasticity of Quantity Demand for Sugar-Sweetened Soft Drinks, Applying Various Methods to the 2012–13 Solomon Islands Household Income and Expenditure Survey |
|---|---|---|---|
| Elasticity | Standard error | 95% confidence interval |
| Own-price elasticity of quantity | | |
| Standard unit value method (\(N = 4357\)) | \(-1.05\) | (0.04) | \(-1.12\) to \(-0.98\) |
| Standard unit value method (\(N = 1730\)) | \(-1.02\) | (0.08) | \(-1.17\) to \(-0.87\) |
| Standard price method | \(-1.20\) | (0.50) | \(-2.18\) to \(-0.22\) |
| Unrestricted method | \(-0.46\) | (0.41) | \(-1.27\) to \(0.35\) |
| Own-price elasticity of quality | \(-0.74\) | (0.14) | \(-1.02\) to \(-0.46\) |

**Notes:** Based on regressions reported in Appendix Table 1. Standard errors are cluster adjusted.

| Table 3 | Own-Price Elasticity of Quantity Demand for Soft Drinks, Applying Various Methods to the 1996 Papua New Guinea Household Survey |
|---|---|---|---|
| Elasticity | Standard error | 95% confidence interval |
| Own-price elasticity of quantity | | |
| Standard unit value method | \(-0.97\) | (0.26) | \(-1.48\) to \(-0.47\) |
| Standard price method | \(-1.78\) | (0.47) | \(-2.72\) to \(-0.83\) |
| Unrestricted method | \(-0.86\) | (0.33) | \(-1.51\) to \(-0.21\) |
| Own-price elasticity of quality | \(-0.86\) | (0.03) | \(-0.93\) to \(-0.80\) |

**Notes:** Based on regressions reported in Appendix Table 2. \(N = 1025\). Standard errors are cluster adjusted.
results, the own-price elasticity of quantity demand for soft drinks is $-0.97$ with the standard unit value method, and it is $-1.78$ with the standard price method. This gap between the results for the two standard methods shows the possibility of equations 1 and 3 differing even when the same elasticity formula in equation 2 is used, partly due to potential measurement error in unit values.5

The remainder of Table 3 shows that the own-price elasticity from the standard price method splits evenly into an unrestricted elasticity of quantity of $-0.86$ and an own-price elasticity of quality of $-0.86$. In keeping with the results for the Solomon Islands, the elasticity of quality is more precisely estimated than is the elasticity of quantity. The even split between the two elasticities means that the variation in soft drink budget shares in the PNG survey in response to spatial price variation is made up on two equal responses—a cut in quantity and a cut in quality (e.g. sliding down quality ladders like those shown in Figure 1). Therefore, if the standard price method was used it would result in the estimated own-price elasticity of quantity demand for soft drink in PNG being overstated by a factor of two. This bias would be likely to cause policy makers to be too optimistic about the quantity reduction and consequent health benefits that might result from any tax on soft drinks.

6. Conclusions and Implications

Taxes on drinks with added sugar are being debated in several countries. These are an example of fiscal-food policies, which are motivated by concerns about non-communicable diseases like diabetes and obesity. Advocates for these taxes assume that quantity demand is fairly responsive to price. At the same time, some advocacy in the Pacific for these taxes has suggested that they also will be good for the Treasury, despite the usual trade-off between fiscal efficiency and reducing the intake of an unhealthy item. Some of the optimism about these taxes is likely to be misplaced and may reflect the exaggerated price elasticities that are coming from household survey data when researchers wrongly use the elasticity framework for a standard, undifferentiated, good.

This article provides an example of this bias for two Melanesian countries. The results suggest that about one-third of the consumer response to soft drink price variation in the Solomon Islands survey is on the quantity margin, while almost two-thirds is on the quality margin. In the Papua New Guinea survey, consumer responses are split evenly between the quantity and quality margins. As a consequence of these dual responses by consumers, if an analyst used the standard methods (whether with prices or with unit values on the right-hand side of the budget share equation), they would overstate the own-price elasticity of quantity demand for soft drink by a factor of between two and three.

The sort of biases illustrated here are inherent in elasticity estimates from household survey data when responses on the quality margin are ignored (Gibson & Kim 2016). Because the range of soft drink qualities found in stores in these two countries is more limited than in many countries, it is possible that the bias in the elasticity estimates would be larger elsewhere in places where consumers have a wider range of qualities to choose over. The empirical study of these biases requires household survey data with budget shares, with unit values and with market prices, and this combination of data is surprisingly rare. A recommendation for agencies interested in fiscal-food policy in the Pacific is to lend support to survey efforts that will create more comprehensive databases for studying the entirety of consumer responses, rather than let data limitations restrict analysts to using the inappropriate textbook model where only quantity adjusts as prices vary. In the absence of these comprehensive databases, and of more reliable elasticity estimates, policy makers should be cautious about the evidence produced by advocates in support of fiscal-food policies.

5. Previous analysis with the PNG survey also shows that results (for poverty) differ substantially when using the unit values compared to using the price survey (Gibson & Rozelle 2005).
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References


**SUPPORTING INFORMATION**

Additional Supporting Information may be found online in the supporting information tab for this article.

**Appendix Table 1** Regression Results for Solomon Islands 2012–13 Household Income and Expenditure Survey.

**Appendix Table 2** Regression Results for Papua New Guinea Household Survey.