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**30 Years of Being Wrong: A Systematic Review and Critical Test
of the Cox and Wohlgenant Approach
to Quality-Adjusted Prices in Demand Analysis**

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Abstract

Consumers respond to price rises by reducing quantity consumed, but also by cutting quality. Most demand studies in agricultural economics fail to estimate quality responses to price. Instead, following Cox and Wohlgenant (1986), quality choice is dealt with by adjusting unit values rather than by treating quality as a valid consumer response to model. Studying a two-choice problem in this manner cannot identify either the price elasticity of quantity or the price elasticity of quality, and instead will yield some unidentified hybrid of the quality and quantity responses. We review 150 papers that cite Cox and Wohlgenant (1986) to see how widespread is the neglect of quality responses to price in the literature. Almost 90 percent of studies wrongly mix quality responses to price in with their reported quantity demand elasticities, thus, overstating by how much price rises can be expected to moderate the quantity consumed. Our empirical test, for 32 food and drink groups in Vietnam, shows that the Cox and Wohlgenant method exaggerates quantity responses to price by a factor of three, on average, and hardly differs from what naïve approaches with unit values show. These results cast doubt on three decades of reported price elasticities of quantity demand estimated from household survey data.

Keywords

demand
household surveys
quality
price
unit values

JEL Classification

D12; I10

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I. Introduction

Consumers respond to price rises by reducing quantity consumed, but also by downgrading the quality of what they consume. For example, if beef prices rise there will be some switching from filet mignon to cheaper cuts, as well as a reduction in the overall quantity of beef consumed. If the response of quality to price is ignored, empirical estimates of the price elasticity of quantity demand will conflate responses on the quantity and quality margins and will overstate the effect of price on quantity. This exaggeration is especially likely in research that uses household survey data because, as first noted sixty years ago by Prais and Houthakker (1955, p.110), these survey data do not conform to the standard textbook demand model:

'An item of expenditure in a family-budget schedule is to be regarded as the sum of a number of varieties of the commodity each of different quality and sold at a different price.'

For example, where the lead author shops there are 27 various types of fresh beef on display, with the most expensive (filet) about five times the price of the cheapest. The carbonated soft drink category has even more variety; 160 different specifications, with the dearest 15 times the per liter price of the cheapest. Yet spatial price variation for beef, for soft drink, and for most food products is quite limited, with same-product prices in the most expensive areas perhaps 50 percent above the cheapest areas. Even in developing countries, where household surveys are especially relied upon to estimate price elasticities of demand, prices in costly areas may be just double those in cheap ones. Thus, there may be three to ten times more price variation within a survey group – which allows scope for consumers to alter their choice of quality as prices rise – as there is variation over space. It would be an unwise analysis that ignores this substantial within-group variation.

Yet that is just what agricultural economists have done. In decades of applied research on the price elasticity of quantity demand for food and drink using household surveys, few studies distinguish quality responses to price from quantity responses to price. Instead, quality choice is treated as something to adjust for prior to estimation rather than being a valid consumer response to model. The origin of this neglect is Cox and Wohlgenant (1986), who regress unit values (ratios of expenditures on a survey group to group quantity) on household characteristics and on temporal and spatial dummies, with regression-adjusted unit values then used as so-called 'quality-adjusted prices' when modelling demand.¹ This tactic is copied in many subsequent papers that report price elasticities of quantity demand but never report how within-group quality choice responds to price variation. These studies force

¹ In the agricultural economics literature other approaches to dealing with quality variation in household survey data include Nelson (1991) and Dong *et al.* (1998). We focus on Cox and Wohlgenant (1986) because it published earlier and is far more widely cited, with at least four times more citations than either of these other two studies.

a two-choice problem into a single equation framework that cannot be expected to identify either the price elasticity of quantity or the price elasticity of quality, and instead will yield some unidentified hybrid of these two types of responses.

In this study we review 150 published papers that cite Cox and Wohlgenant (1986), to see how widespread is the neglect of quality responses to price in the applied demand literature. We pay most attention to 43 empirical studies that estimate price elasticities of demand by using budget share data from household surveys. Almost 90 percent of these studies mix quality responses to price in with their reported quantity demand elasticities and, thus, overstate by how much price rises can be expected to moderate the quantity consumed. This exaggeration matters because of the growing interest by policy-makers in fiscal-food policies that use taxes and subsidies to alter food prices so as to induce a switch towards healthier diets. Proponents of such policies assume that quantity demand is fairly responsive to price and the estimated elasticities that applied economists have published over several decades undoubtedly contribute to this view.²

In addition to our systematic review, we provide a critical test of the Cox and Wohlgenant approach, using data on market prices, unit values, and budget shares from surveys in Vietnam that let us estimate demand models where both quantity and quality can respond to price. For the 32 food and drink groups we study, the mean (median) own-price elasticity of quantity demand is just -0.22 (-0.13), when we use the two-equation framework of McKelvey (2011) that allows both quantity and quality to respond to price.³ The Cox and Wohlgenant method gives a mean (median) own-price elasticity of quantity demand at least three times the magnitude, at -0.64 (-0.54). The difference between the two sets of elasticities is statistically significant (at $p < 0.05$) for 29 food and drink groups, and these significant differences all hold even after adjusting for multiple testing.

Yet, elasticities from the Cox and Wohlgenant method hardly differ from what the standard unit value method yields, where budget shares are directly regressed on unit values without any prior regression to purge unit values of variation due to household attributes. Under the standard unit value method, the mean (median) own-price elasticity amongst the 32 food and drink groups is -0.76 (-0.65). Apparently, the ‘quality adjustment’ from the initial regression achieves little, except perhaps to lull users into a false sense of security that they

² 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 percent, 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.

³ This framework is originally due to Deaton (1990) but Deaton did not have price data and so used a method based on weak separability (Deaton, 1988) that allows indirect estimates of the response of quality to price to be derived when a researcher just has budget shares and unit values. When price data are available, these weak separability restrictions are rejected in both Indonesia (McKelvey 2011) and in Vietnam (Gibson and Kim 2016).

have somehow dealt with quality responses to price. A similarity between results from the Cox and Wohlgenant method and the standard unit value method is also noted by Andalón and Gibson (2017), who study price elasticities of demand for soda in Mexico; both methods give an elasticity of -1.3 , while the unrestricted method that allows for consumer adjustment on the quality margin gives an own-price elasticity of quantity demand of just -0.3 . In other words, the Cox and Wohlgenant method overstates the response of quantity to price by a factor of more than four, which is slightly greater than the average degree of overstatement found with this method in the current setting.

It would be a mistake to see our results as showing that the main problem with the Cox and Wohlgenant method is its reliance on unit values. While these are prone to measurement error and are unavailable for non-purchasers, simply replacing unit values with market prices gives no gain if a single equation framework continues to be used to study a two-choice problem. Indeed, if market prices are used as covariates in the budget share equations, the mean own-price elasticity amongst the 32 food and drink groups is only slightly different to using unit values, at -0.82 . Previous work by McKelvey (2011) with market prices also notes that far more elastic responses of quantity to price are estimated when a single equation framework is used, which ignores the possibility of within-group quality adjustment as a way to cope with price rises, rather than having one equation for quality choice and another for quantity choice (or for budget shares).

Instead, the problem is that the Cox and Wohlgenant method obscures the need to estimate the response of quality to price if one wants unbiased estimates of how quantity responds to price. Relatedly, the need for data on both prices and on quality is not emphasized and research has been skewed into thinking of the unit value as a proxy for price rather than as an indicator of quality.⁴ Thus, one can argue that Cox and Wohlgenant (1986) has contributed to three decades of applied research on price elasticities of demand from household surveys that is almost certainly wrong, in the sense that it has systematically overstated the response of quantity to price.

In the next section we discuss methods of estimating price elasticities from household survey data, while Section III systematically reviews studies that cite Cox and Wohlgenant (1986). Our database that combines a price survey and a household survey is described in Section IV, while the results of our empirical tests are in Section V. The conclusions are in Section VI.

⁴ The quality mix within a survey group is unlikely to be constant over time and space, since the relative price of quality changes with storage and transport costs (also known as the Alchian-Allen effect or ‘shipping the good apples out’). This makes unit values ill-suited as a proxy for prices, over both time and space (Gibson and Kim 2015).

II. Methods of Estimating Quantity Demand Elasticities from Household Survey Data

While price elasticities of quantity demand can be estimated from several types of data, such as time series data for aggregate commodities, or finely disaggregated Universal Product Code (UPC) level scanner data for individual goods, household surveys are one of the most widely used sources. These surveys are available for almost all countries, since they are regularly fielded to provide expenditure weights for consumer price indexes. These surveys also allow distributional analyses (for example, Hasan 2017), and disaggregated elasticities for sub-populations like income quintiles. In this section we discuss four methods of using household survey data to estimate price elasticities, each of which is used in our empirical tests reported in Section V.

2.1 The Unrestricted Method

Price elasticities from household survey data are most commonly estimated by using budget share models such as the Linear-Approximate Almost Ideal Demand System (LA-AIDS). In these, 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 log total expenditure, $\ln x_i$, with the log of the price index for foods in group H (where θ_{GH} is for the cross-price effect of H on G and θ_{GG} is for the own-price effect), with conditioning variables, z_i , and with random noise, u :

$$w_{Gi} = \alpha_G^0 + \beta_G^0 \ln x_i + \sum_{H=1}^N \theta_{GH} \ln p_H + \gamma_G^0 \cdot z_i + u_{Gi}^0 \quad (1)$$

The budget share for food group G for one household may be lower than for a neighbor who faces the same prices, either because they buy a cheaper brand or because they buy less quantity. Thus, if the budget share is differentiated with respect to price there is no way to know whether the result is a quantity response, a quality response, or some hybrid of the two. This identification problem can be shown by noting that the unit value, v_{Gi} from the ratio of group expenditure, E_{Gi} to group quantity, Q_{Gi} shows where on the quality ladder the consumer locates (that is, it shows expensiveness conditional on the price structure). Thus, total expenditure on the group can be written as $v_{Gi}Q_{Gi}$, and any response of the budget share to price potentially involves both quantity adjustment (a change in Q_{Gi}) and quality adjustment (a change in v_{Gi}).

Therefore, and in contrast to most of the applied literature that neglects this point, a second equation is needed, to model quality choice. This can be indicated by household i 's unit value for group G , conditional upon the prices they face:

$$\ln v_{Gi} = \alpha_G^1 + \beta_G^1 \ln x_i + \sum_{H=1}^N \psi_{GH} \ln p_H + \gamma_G^1 \cdot z_i + u_{Gi}^1 \quad (2)$$

The variables in equation (2) are as defined for equation (1), with superscripts 0 and 1 used to distinguish parameters on the same variables in each equation. Log-differentiating yields:

$$\partial \ln w_G / \partial \ln x = \beta_G^0 / w_G = \varepsilon_G + \beta_G^1 - 1 \quad (3)$$

$$\partial \ln w_G / \partial \ln p_H = \theta_{GH} / w_G = \varepsilon_{GH} + \psi_{GH} \quad (4)$$

where ε_G is the elasticity of quantity demand with respect to total expenditure, β_G^1 is the elasticity of the unit value with respect to total expenditure, ε_{GH} is the elasticity of quantity demand with respect to the price of H , which is the key parameter for considering if health-related taxes can reduce intake of unhealthy items, and ψ_{GH} is the elasticity of the unit value with respect to the price of H . If equation (4) is rearranged, it becomes clear why one needs an equation like (2), for the household's choice of quality amongst the items within group G :

$$\varepsilon_{GH} = (\theta_{GH} / w_G) - \psi_{GH}. \quad (5)$$

The value of equation (5) is in showing that if one does not know how quality responds to price, which can be derived from the ψ_{GH} term, one cannot identify the elasticity ε_{GH} that shows how quantity responds to price. However, with data on budget shares, on prices, and on an indicator of quality, such as the unit value, equation (5) can be estimated, with input values from the estimates of equations (1) and (2). McKelvey (2011) calls this the 'unrestricted method' because the household's choice of quality is allowed to freely respond to price variation. Although this two equation framework was first developed almost 30 years ago by Deaton (1990), the only published examples of the unrestricted approach are McKelvey (2011) and Gibson and Kim (2013).

The paucity of studies using this unrestricted method is due to two factors; first, it requires household survey data with budget shares, unit values, and market prices and this combination is surprisingly rare (Gibson 2013). Second, many applied studies wrongly use a framework that is correct only for a standard, undifferentiated good, and as discussed below, some blame for this is due to Cox and Wohlgemant (1986) obscuring the main issues with price elasticity estimation from household survey data. This second reason also feeds back into the first because when economists use the wrong framework they do not realize that they need *both* market prices and unit values and so do not put enough pressure on statistical agencies to provide the right data.⁵

⁵ Gibson, Le and Kim (2017) provide another example where the development of 'no-price methods' (in this case, Engel curve methods to back-out cost-of-living differences over space) are counterproductive because they reduce the demand for the right data, while providing biased findings that distort understanding of key economic issues.

2.2 The Standard Price Method and Standard Unit Value Method

In contrast to equation (5), which needs a two equation system of budget shares and unit values to be estimated, many studies calculate the elasticity of quantity with respect to price from:

$$\varepsilon_{GH} = (\theta_{GH} / w_G) - \delta_{GH}, \quad (6)$$

where δ_{GH} equals 1 if $G=H$, and 0 otherwise. The parameters come from a budget share equation that is estimated in isolation. Gibson and Rozelle (2005) are an example of this, using a household survey with a linked community market price survey. However, equation (6) is the correct price elasticity formula only for a standardized item with no quality variation so that the numerator of the budget share is simply the product of price and quantity for good G . Under these conditions, if the budget share is differentiated with respect to price it unambiguously identifies the response of quantity to price. McKelvey (2011) calls the method that combines equations (1) and (6) the ‘standard price method’ and it is correct only for standardized goods.

A common variant sees budget shares regressed on unit values rather than on prices:

$$w_{Gi} = \alpha_G^* + \beta_G^* \ln x_i + \sum_{H=1}^N \theta_{GH}^* \ln \left(\frac{E_{Hi}}{Q_{Hi}} \right) + \gamma_G^* \cdot z_i + u_{Gi}^* \quad (7)$$

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 unit values as a proxy for prices. The elasticities that are derived from equation (7) will not be the same as those from equation (1), even with the same (and incorrect) equation (6) elasticity formula used. One reason is that the unit values introduce measurement errors (e.g., due to respondents misreporting expenditure or quantity) that would not be present in market prices. Another reason is that the unit values are only available for purchasing households, so some way of imputing missing unit values for non-purchasers has to be implemented; often the cluster or region means of unit values are used for this imputation.

A bigger problem for elasticities based on equation (7) is seen if equation (2) for unit values is rewritten in terms of $\ln p_H$ and then substituted into equation (1). This substitution shows that the coefficient for prices in equation (7) is $\psi_{GH}^{-1} \theta_{GH}$ rather than θ_{GH} from equation (1). The ψ_{GH} cannot be estimated without prices, so the elasticity from equation (7) is unidentified, unless ψ_{GH} is somehow indirectly derived. The typical approach is to assume, at least implicitly, that $\psi_{GG} = 1$ (and that $\psi_{GH} = 0$) so that $\psi_{GG}^{-1} \theta_{GG} = \theta_{GG}$. In other words, when the budget share equation is estimated with unit values used as a proxy for market prices, the only way that the coefficients can yield price elasticities is by ruling out any

within-group quality substitution in response to price variation (so that the unit values move one-for-one with prices). Thus, McKelvey (2011) calls the combination of equation (7) with the equation (6) elasticity formula the 'standard unit value method' since it mirrors the 'standard price method' in ruling out any response of quality to price, making it correct only for standardized goods.

2.3 The Cox and Wohlgenant Method

In contrast to the two-equation unrestricted model, Cox and Wohlgenant (1986, p.910) assert that quality is chosen first, and can thus be modeled independently of group-level quantity decisions. That is, consumers decide on quantity (if any) of a commodity aggregate whose quality has already been set by prior decisions about the component foods within the group. For example, a beef consumer might fix at the top of the quality ladder by only buying filet, and if prices rise they cut back on beef quantity but do not slide down the quality ladder to sirloin or rump. This assumption seems backwards, since a consumer is more likely to have a fixed quantity in mind (like a quarter pound of beef per dinner guest) and would find it easier to adjust quality by choosing a cheaper cut if prices are higher than expected. While Cox and Wohlgenant offer no evidence in support of their quality-decision-then-quantity-decision identifying structure, there is evidence for the opposite, of pre-committed quantities, in aggregate meat demand data (Marsh and Piggott 2013).

Putting aside the conceptual issue of whether quality or quantity is pre-committed, the Cox and Wohlgenant approach proceeds as follows: The unit value for survey group G for household h in region r and time period t is expressed as a deviation from the region/period mean to reflect 'quality' effects induced by household attributes and non-systematic supply-related factors. A regression is used to partition these deviations into two components; the error term for the non-systematic supply factors, and the deterministic part due to household attributes:

$$v_G^{htr} - \bar{v}_G^{tr} = \sum_j \gamma_{Gj} b_{Gj}^{htr} + e_G^{htr} \quad (8)$$

where \bar{v}_G^{tr} is the regional/period mean unit value, the b_{Gj}^{htr} are j household attributes to proxy for household preferences for unobserved quality characteristics, and e_G^{htr} is the regression residual. The regional and period effects are excluded from equation (8) because they potentially reflect systematic supply variations; however, their average effects are shown in the \bar{v}_G^{tr} . Based on this regression, the 'quality-adjusted price' for each purchasing household is set to:

$$p_G^{htr} = \tilde{p}_G = \bar{v}_G^{tr} + \hat{e}_G^{htr} \quad (9)$$

In other words, the regional/period mean unit value is augmented with the unexplained component of the household-specific deviation from that mean. For non-purchasing households, the regression cannot be estimated, since they have no unit value, so their

‘quality-adjusted price’ is based on the mean unit values, \bar{v}_G^{tr} . The ‘quality-adjusted prices’ (that is, mean or regression-adjusted unit values) are then used in equation (7) with elasticities calculated according to equation (6).

In some studies, the unit values (v_G^{htr}) are a dependent variable in the initial equation, with the period and regional dummies as covariates (for example, Gustavsen 2015). The ‘quality-adjusted price’ for survey group G , \hat{p}_G is then constructed as the sum of the intercept for each region/period and the residual. If the explanatory variables (b_{Gj}^{htr}) in equation (8) are standardized (or constrained to sum to zero), the two sets of ‘quality-adjusted prices’, \tilde{p}_G and \hat{p}_G , will be equivalent (with the non-purchasing households given the regional/period mean unit values in each case).

Irrespective of whether the original deviation from mean approach or the direct regression of unit values on regional and period dummies is used, there are three problems with the Cox and Wohlgenant method. First, ‘quality-adjusted prices’ include measurement errors in the unit values since these are a non-systematic component. In contrast, the procedure suggested by Deaton (1990) has a between-cluster, errors-in-variables model of regression-adjusted unit values and budget shares to deal with any measurement error. Second, equation (8) only strips out the variation due to household income and demographic factors but ignores community-wide responses of quality to price. In regions and periods with high prices, consumers will slide down the quality ladder as a coping mechanism, so the mean unit value will be lower. For example, in expensive cities in Mexico the mean unit value for soda is only 80% of the mean price, while it is 100% of the mean price in cheap cities, reflecting community-wide quality downgrading to cope with higher prices (Andalón and Gibson 2017). It was in order to deal with this issue that Deaton (1990) had to use the weak separability restrictions, so as to derive the effect of price on community-wide quality, in the absence of any price data to directly estimate ψ_{GH} .

Third, regression-adjusted unit values miss the point – even if they could be made like prices, in reflecting variation between areas due to spatial factors, and in being available for all households, there is still going to be a bias. It takes two equations to study adjustments that can occur on two margins, so irrespective of how unit values are processed so as to proxy for prices, a single equation framework like equation (7) will yield biased elasticities. Forcing a two-choice problem into a single equation framework cannot be expected to identify the price elasticity of quantity, and instead will yield some unidentified hybrid of the quality and quantity responses.

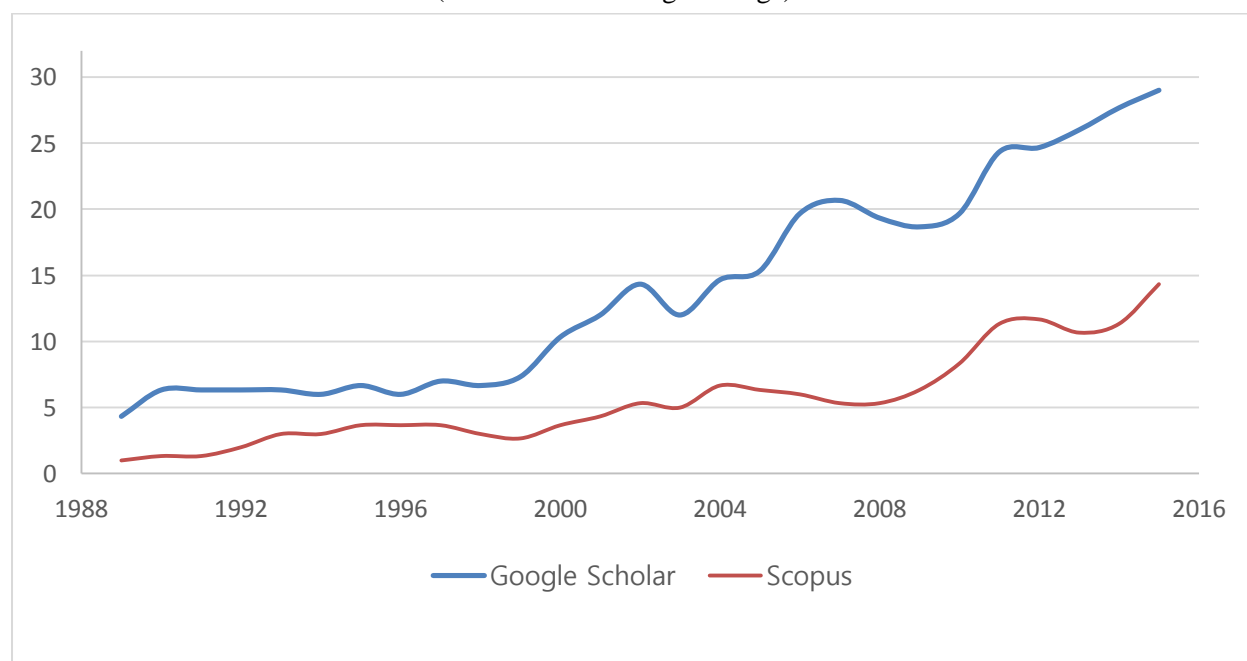
Cox and Wohlgenant (1986), and some related papers, also further obscure key issues for estimating price elasticities from household survey data by using censored demand approaches. While these may sometimes be needed, for many research questions the

unconditional expected value of demand, averaging over purchasers and non-purchasers alike, is more appropriate. For example, for a study assessing how taxes on unhealthy items might affect population health, like Grogger (2017), averaging over all households is the right thing to do and this breaks any direct link with utility theory (Deaton 1997, p.304). Moreover, if one needs the unconditional expected value, the coefficients from censored models like the Tobit have to be multiplied by the proportion of non-limit observations (which scales them down) and OLS applied to all observations is a good approximation (Greene 1981). Thus, in the estimates of equation (1) and its counterparts reported below, all observations are used and OLS is an appropriate estimator.

III. A Systematic Review of Studies Citing Cox and Wohlgenant (1986)

The citations to Cox and Wohlgenant (1986) have risen sharply in recent years (Figure 1). For the first 15 years after publication, this article had fewer than seven (three) citations per year in *Google Scholar* (*Scopus*). In contrast, since 2010 it has averaged 26 citations per year in *Google Scholar* and 12 citations per year in *Scopus*.⁶ This renewed attention likely reflects a rise in the number of applied demand studies, due to a focus on price elasticities for evaluating or advocating for tax policies that aim to nudge consumers towards healthier diets. For example, the World Bank analysis of Mexico's soda tax (Bonilla-Chacín *et al.* 2016) used the Cox and Wohlgenant method to estimate price elasticities so as to judge whether the tax was likely to cut soda intakes.

Figure 1: Citations Per Year to Cox and Wohlgenant (1986)
(Three Year Moving Average)



⁶ Since 2010 it has been the most cited article of all articles published in the *AJAE* in 1986, according to *Scopus*. Prior to then it was only the third-most cited article, with just two-thirds the citations of the most cited article.

To assess likely bias in existing estimates of price elasticities from household survey data we examined 151 published studies that *Scopus* records as citing Cox and Wohlgenant (1986). Of these studies, 120 are demand analyses (including some that are review or meta-analytical studies), and 81 of them use household survey data. Amongst these 81 studies we focus on those with budget shares as the dependent variable, since these vary with quantity, quality, and price (as noted in Section II) and so any failure to control for the response of quality to price would be most glaring. We were able to obtain full-text versions (in English) for 43 of these studies, and these provide the basis for our systematic review.

For each of these studies, one of the current authors and a research assistant independently judged whether the methods and data used gave any plausible way to estimate a quality response separate from the price elasticity of quantity, as opposed to estimating a conflated mixture of these two responses. The studies were also grouped according to the type of method used (amongst methods discussed in Section II), the type of journal where published (agricultural economics versus other applied economics), when published, and how highly cited the paper was.

For 37 of 43 studies (86 percent), the reported price elasticities of quantity demand include quality responses to price, and thus will exaggerate the response of quantity to price (Table 1). The papers that conflate the two responses use the standard price method ($n=3$), the standard unit value method ($n=8$) and especially the Cox and Wohlgenant method ($n=26$). The six studies that explicitly model quality choice rely on the weak separability restrictions of Deaton (1990) to indirectly derive price elasticities of quality from income elasticities of quality. In principle, this method allows quality responses to be separated from quantity responses to price but in practice it seems to understate quality responses (Gibson and Kim 2016). However, we would need prices and unit values from each study in order to establish the extent of the bias and since these data are unavailable (noting that Deaton's method was developed because he only had unit values and no prices) these studies receive the benefit of the doubt in how they are classified in Table 1.

Studies that conflate quality responses with quantity responses are slightly more prevalent in agricultural economics journals than in other applied economics journals (90% versus 81%). In part this may reflect lack of awareness of other approaches, especially the two-equation structure suggested by Deaton (1990), since just six out of the 19 papers in agricultural economics journals that conflate quality and quantity responses cite Deaton (1990) or his related papers. Studies that explicitly model quality choice have become less prevalent over time; two of eight studies did this in 1997-2006 but just two of 13 and two of 18 did so in the last two five-year periods. The studies that conflate quality and quantity responses to price are a rising share of the literature, so policy makers may be expected to become increasingly (over-)optimistic about how small taxes might yield big shifts in demand. The risk of skewed views is especially because all seven of the highly cited (≥ 20 citations) papers in Table 1 are ones that conflate quality and quantity responses.

Table 1: Summary of Published Journal Articles that are Empirical Demand Studies that Use Household Survey Data on Budget Shares and Cite Cox and Wohlgenant (1986)

	Method Used to Estimate Price Elasticity of Quantity Demand				TOTAL
	Cox and Wohlgenant Method	Standard Unit Value Method	Standard Price Method	Explicitly Model Quality Choice ¹	
<i>Journal Field</i>					
Agricultural economics	13	5	1	2	21
Other applied economics	13	3	2	4	22
<i>Publication Year</i>					
1987-1996	1	3	0	0	4
1997-2006	5	0	1	2	8
2007-2011	9	2	0	2	13
2011-2016	11	3	2	2	18
<i>Citations</i>					
High (≥ 20 cites)	5	2	0	0	7
Moderate (3-19 cites)	13	3	1	4	21
Low (≤ 2 cites)	8	3	2	2	15
Total	26	8	3	6	43

Notes:

The articles are identified using *Scopus* and citations are according to *Scopus*. ¹This category includes articles that use the Deaton (1990) method where quality responses to price are derived from weak separability restrictions.

The details on each of the 43 studies summarized in Table 1 are provided in Appendix Table 1. We also extracted from each paper their discussion of how ‘quality-adjusted prices’ are calculated if the Cox and Wohlgenant method is used, and how unit values are imputed for the non-purchasers. The text extracts indicate considerable sloppiness in terminology, with unit values often misnamed as ‘prices’. Thus, it is not surprising that the literature has been skewed away from thinking of the unit value as being more useful as a proxy for quality, and that so few studies report how within-group quality choice responds to price variation.

IV. Data Description

We link finely-grained price surveys to a consumption survey, to form the required database of budget shares, prices, and unit values. The prices are from a 2012 survey of 101 items (52 are foods) fielded by the Prices Department of Vietnam’s General Statistics Office (GSO) in 1,644 communes (one-fifth of all communes in Vietnam).⁷ Full details on the price survey, and the steps taken by surveyors to ensure consistency over space and to maximize the reliability of the estimates are provided in Gibson *et al.* (2017).

⁷ Vietnam’s communes are the lowest level administrative unit, averaging about 10,000 people or 2,500 households.

The food budget shares, unit values, and control variables are from the Vietnam Household Living Standards Survey (VHLSS). This survey uses a thirty-day recall of consumption from own-production, gifts and purchases for 56 food and drink groups, another recall of spending during festive periods on 24 of these food and drink groups, a thirty-day recall for 28 frequently purchased nonfood items and an annual recall for 36 other items. The VHLSS is lightly clustered, with three households per selected commune given the consumption recall. Merging the two surveys gives a database with $n=4380$ households, after allowing for observations with missing data (these may be missing for any of the 14 other covariates in our models, or for prices or unit values. Descriptive statistics for these other covariates are in Appendix Table 2).

Amongst the 56 food and drink groups in the VHLSS, there are 14 that do not have any quantities recorded, mainly due to their heterogeneous nature (e.g. 'other types of meat') which makes consistent quantities hard to define. Thus, we have no unit values for these groups and they are not considered further. Of the 42 food groups with unit values, ten do not have any item in the price survey, either because they are now of minor importance in the diet (e.g. cassava, kohlrabi) or because they are only available for sale in a subset of localities such as urban areas (e.g. fresh milk). This leaves 32 food and drink groups, which account for 66.4 % of food consumption (and 30.5 % of total consumption) that we consider.⁸

V. Results

In Table 2 we report four estimates of the own-price elasticity of quantity demand for each of the 32 groups, one from each method discussed in Section II. We also report the own-price elasticity of quality that comes from the unrestricted method, and the results for hypothesis tests comparing the Cox and Wohlgenant and unrestricted estimates of the own-price elasticity of quantity. A total of 160 equations are estimated to get the elasticities reported in Table 2; budget share and unit value equations for the unrestricted method, budget share equations for the standard unit value method, and unit value and budget share equations for the Cox and Wohlgenant method. These equations include 14 control variables other than prices or unit values: the logarithms of real total expenditure and household size, the share of the household who are young children, youths, elderly, and migrants (born in another province), the age, education and gender of the household head, dummy variables for whether the household head earns wages, farms, or is self-employed (these are not mutually exclusive), and the budget share for other groups of expenditures. Since there are too many regression results to report individually we give a brief overview of them before turning to a discussion of the elasticities.

⁸ When there are multiple price survey items that map to a consumption survey group, which is the case for ten of the 32 groups, the harmonic mean of the prices is used as a group-level price index.

Table 2: Estimates of the Own-Price Elasticities of Quantity Demand and Quality Demand

	Unrestricted Method		Standard	Standard	Cox and Wohlgengant	
	Quantity	Quality	Price method	Unit Value Method	Elasticity	Difference ^a
	(1)	(2)	(3)=(2)+(1)	(4)	(5)	(6)=(5)-(1)
Rice (all grades)	-0.165*** (0.007)	-0.530*** (0.023)	-0.695*** (0.015)	-0.338*** (0.001)	-0.334*** (0.001)	-0.169*** (0.007)
Sticky rice	-0.460*** (0.039)	-0.824*** (0.013)	-1.184*** (0.027)	-3.463*** (0.021)	-2.685*** (0.018)	-2.224*** (0.042)
Potato and sweet potato	-0.349*** (0.016)	-0.564*** (0.020)	-0.913*** (0.005)	-1.195*** (0.004)	-0.800*** (0.002)	-0.451*** (0.013)
Bread and wheat flour	0.009 (0.014)	-1.014*** (0.021)	-1.004*** (0.008)	-0.677*** (0.002)	-0.661*** (0.002)	-0.670*** (0.014)
Flour noodles and porridge	-0.213*** (0.063)	-0.612*** (0.118)	-0.825*** (0.054)	-0.581*** (0.000)	-0.534*** (0.000)	-0.321*** (0.062)
Fresh and dried rice noodles	-0.015 (0.017)	-0.503*** (0.030)	-0.518*** (0.035)	0.025*** (0.008)	-0.010 (0.008)	0.005 (0.017)
Pork of all types	-0.341*** (0.011)	-0.431*** (0.018)	-0.772*** (0.007)	-0.623*** (0.002)	-0.598*** (0.001)	-0.258*** (0.011)
Beef of all types	-0.087*** (0.010)	-0.792*** (0.019)	-0.879*** (0.012)	-0.927*** (0.006)	-0.438*** (0.003)	-0.351*** (0.011)
Chicken of all types	-0.118*** (0.004)	-0.511*** (0.018)	-0.629*** (0.014)	-0.369*** (0.002)	-0.227*** (0.001)	-0.110*** (0.005)
Duck and other poultry	-0.993*** (0.027)	-0.346*** (0.017)	-1.340*** (0.014)	-1.706*** (0.007)	-1.524*** (0.007)	-0.530*** (0.027)
Fats and cooking oil	0.002 (0.006)	-0.945*** (0.018)	-0.944*** (0.018)	-0.039*** (0.005)	-0.033*** (0.005)	-0.034*** (0.007)
Fresh fish and shrimp	-0.139*** (0.022)	-0.869*** (0.021)	-1.009*** (0.003)	-1.122*** (0.003)	-1.061*** (0.003)	-0.922*** (0.023)
Dried fish and shrimp	-0.009 (0.007)	-0.963*** (0.029)	-0.973*** (0.023)	-0.398*** (0.000)	-0.204*** (0.002)	-0.195*** (0.007)
Eggs (chicken and duck)	-0.088*** (0.004)	-0.442*** (0.022)	-0.530*** (0.018)	-0.174*** (0.002)	-0.157*** (0.002)	-0.068*** (0.004)
Tofu	-0.651*** (0.029)	-0.501*** (0.021)	-1.151*** (0.015)	-1.256*** (0.010)	-1.248*** (0.010)	-0.597*** (0.029)
Beans of various types	-0.378*** (0.025)	-0.482*** (0.034)	-0.860*** (0.009)	-0.804*** (0.001)	-0.727*** (0.000)	-0.349*** (0.024)
Peas of various types	-0.192*** (0.014)	-0.668*** (0.021)	-0.857*** (0.012)	-0.717*** (0.005)	-0.555*** (0.006)	-0.362*** (0.014)
Morning glory (water spinach)	-0.178*** (0.011)	-0.685*** (0.016)	-0.863*** (0.010)	-0.621*** (0.006)	-0.537*** (0.007)	-0.358*** (0.012)
Cabbage	-0.563*** (0.015)	-0.502*** (0.012)	-1.065*** (0.007)	-1.219*** (0.007)	-1.125*** (0.008)	-0.562*** (0.015)
Tomato	-0.445*** (0.014)	-0.530*** (0.013)	-0.975*** (0.007)	-0.993*** (0.007)	-0.932*** (0.008)	-0.488*** (0.014)
Orange	0.018*** (0.006)	-0.667*** (0.013)	-0.650*** (0.015)	-0.169*** (0.003)	0.057*** (0.003)	0.041*** (0.005)

Table 2: Continued

	Unrestricted Method		Standard Price	Standard Unit Value	Cox and Wohlgengant Method	
	Quantity	Quality	Method	Method	Elasticity	Difference ^a
	(1)	(2)	(3)=(2)+(1)	(4)	(5)	(6)=(5)-(1)
Banana	-0.177*** (0.009)	-0.678*** (0.018)	-0.855*** (0.009)	-0.699*** (0.001)	-0.537*** (0.002)	-0.361*** (0.009)
Mango	-0.217*** (0.018)	-0.687*** (0.007)	-0.904*** (0.012)	-0.963*** (0.005)	-0.675*** (0.007)	-0.459*** (0.018)
Cooking sauces	-0.028* (0.017)	-0.948*** (0.033)	-0.977*** (0.014)	-0.554*** (0.000)	-0.507*** (0.001)	-0.478*** (0.017)
Salt	-0.004 (0.005)	-0.982*** (0.019)	-0.985*** (0.016)	-0.263*** (0.000)	-0.265*** (0.001)	-0.261*** (0.005)
Sugar and molasses	-0.109*** (0.041)	-0.926*** (0.028)	-1.035*** (0.014)	-1.520*** (0.002)	-1.488*** (0.002)	-1.379*** (0.041)
Confectionery	-0.003 (0.013)	-0.989*** (0.026)	-0.992*** (0.013)	-0.586*** (0.000)	-0.497*** (0.001)	-0.494*** (0.013)
Condensed milk	-0.113** (0.051)	-0.173* (0.095)	-0.285*** (0.106)	-0.005 (0.009)	-0.018* (0.010)	0.095* (0.050)
Wine and spirits	-0.029*** (0.008)	-0.879*** (0.029)	-0.904*** (0.022)	-0.308*** (0.002)	-0.227*** (0.003)	-0.197*** (0.008)
Beer	-0.037 (0.030)	-0.957*** (0.035)	-0.995*** (0.017)	-0.830*** (0.007)	-0.749*** (0.007)	-0.711*** (0.031)
Water and soft drinks	-0.861*** (0.063)	-0.030 (0.069)	-0.892*** (0.018)	-0.874*** (0.004)	-0.880*** (0.003)	-0.019 (0.063)
Tea	0.022 (0.014)	-1.074*** (0.036)	-1.053*** (0.022)	-0.428*** (0.000)	-0.380*** (0.001)	-0.402*** (0.014)

Notes: ***, **, and * represent statistical significance at 1%, 5%, and 10% levels. Standard errors in (.). Regressions include the covariates described in Appendix Table 2, with equation summary statistics for the unrestricted models reported in Appendix Table 3.

^a The difference between own-price elasticities from the Cox and Wohlgengant method and the quantity demand elasticities from the unrestricted method.

For the benchmark unrestricted model based on equations (1) and (2), the budget share regressions vary in predictive power from an R^2 of 0.65 for rice to 0.02 for the bread and wheat flour group (Appendix Table 3 has details). For the unit value equations, the R^2 values range from 0.36 to 0.01, with rice again highest and the flour noodles and porridge group the lowest. The average R^2 is 0.13 for the budget share equations and 0.14 for the unit value equations. The degree of explanatory power varies with each group's importance, with a correlation of 0.84 between average budget shares and the R^2 values for the budget share regressions and a correlation of 0.50 between budget shares and the R^2 for the unit value regressions. When we summarize the elasticity results we also use budget share-weighted averages so that the results for some of the minor food and drink groups do not have an undue effect on our summary of the patterns.

The budget share equations for the standard price method are the same as those for the unrestricted method. For the standard unit value method the budget share equations have R^2 values that range from 0.02 to 0.67, with an average value of 0.15. In other words, using the unit value as a proxy for price gives a slight increase in explanatory power for budget shares

but this effect may be illusory since the unit value introduces a correlated measurement error (for example, if expenditure on group G is overstated both the budget share for G and the unit value for G will have a common error). For the Cox and Wohlgenant method, the initial regressions on deviations of unit values have R^2 values that range from 0.002 to 0.19, with an average value of 0.05. The fact that the explanatory power for the unit value equations is fairly low was also remarked upon by some of the papers reviewed for Section III.⁹ When the regression-adjusted unit values are used in the budget share equations, the R^2 values have a range from 0.02 to 0.68, with an average value of 0.15, and thus are almost the same as the R^2 values with the standard unit value method.

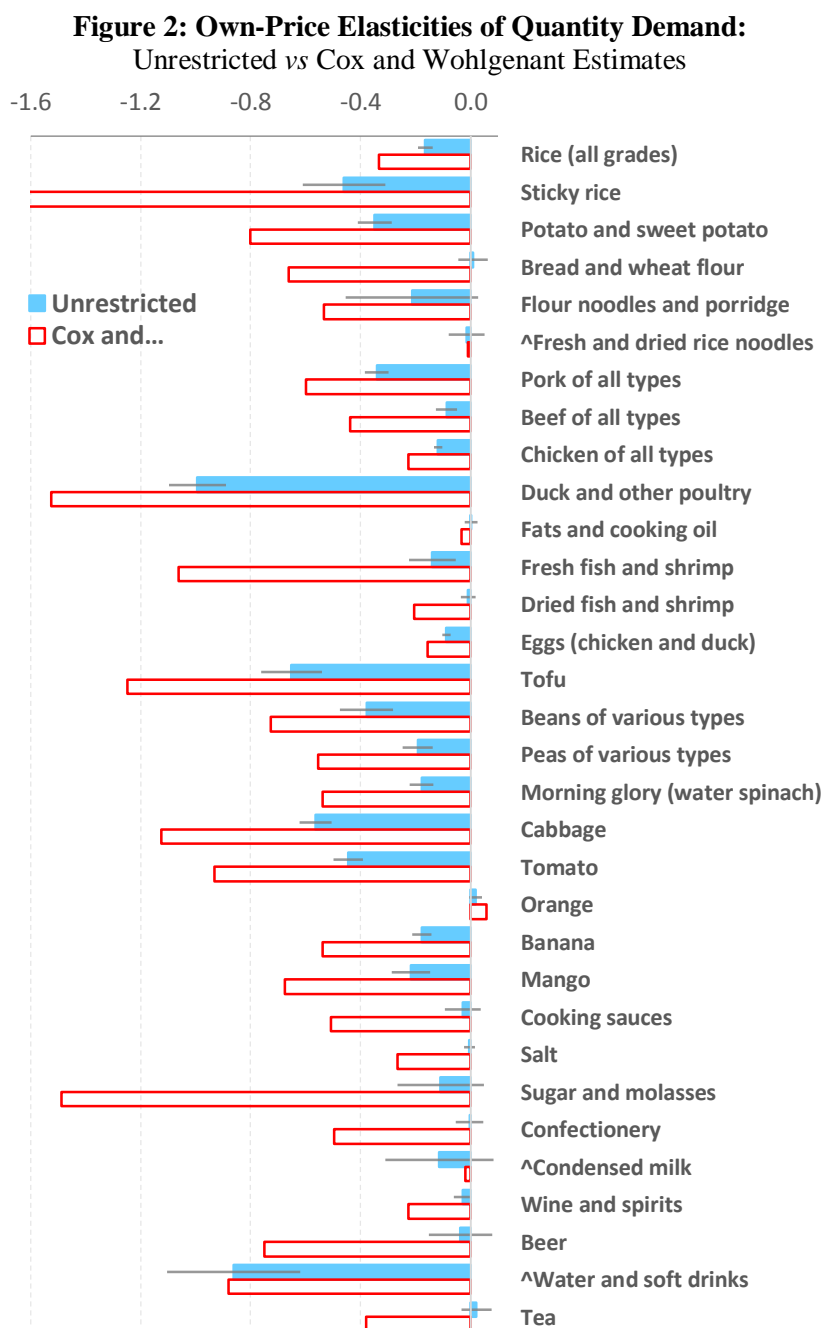
The unrestricted own-price elasticities of quantity and quality are reported in the first two columns of Table 2. On average, there is a 3:1 split in terms of responses on the quality margin versus the quantity margin; the average food and drink group has quantity demand go down two percent for every ten percent rise in price, while quality (as indicated by the unit value) goes down by six percent. The own-price elasticity of quality is calculated as $\psi_{GG} - 1$. Just four groups have a bigger response to own-prices on the quantity margin than on the quality margin. In other words, a dominant form of consumer adjustment to price variation in household survey data is to rearrange the composition of within-group demand, reflecting the fact that there are typically far bigger price differences within a group than across locations. Yet one would not know this from most of the literature using household survey data to estimate price elasticities, since the response of quality to price (which involves substitution amongst the items in a group) is hardly ever reported.

The standard price method that produces the results in column (3) of Table 2 conflates the responses on the quantity and quality margins, and so the apparent own-price elasticities from this method are four times larger, on average, than are the unrestricted own-price elasticities of quantity demand. Specifically, the budget share-weighted mean of the own-price elasticities is -0.20 (the unweighted mean is -0.22) if separate adjustments on the quality and quantity margins are allowed with the unrestricted method. In contrast, when the two effects are mixed together by the standard price method, the weighted mean elasticity is -0.82 and the unweighted one is -0.89 .

If ‘quality-adjusted prices’ from the Cox and Wohlgenant method are used, estimates of the response of quantity to own-price are also greatly exaggerated. For 30 of the 32 food and drink groups, the own-price elasticity of quantity demand from the Cox and Wohlgenant method is larger in magnitude than is the unrestricted estimate. These two sets of own-price elasticities of quantity demand are shown in Figure 2; while 19 of the Cox and Wohlgenant elasticities are more negative than -0.5 just four of the unrestricted ones are. For 29 of the

⁹ Likewise, in the original Cox and Wohlgenant study the R^2 for the unit value equations averaged just 0.04, despite having 22 explanatory variables to capture household and area characteristics and also restricting the sample to one particular region from the United States.

food groups the differences between the Cox and Wohlgenant elasticity estimates and the unrestricted estimates are statistically significant (at $p < 0.05$). The insignificant results are for the bottled water and soft drinks group, the condensed and powdered milk group, and the fresh and dried rice noodle group, and these minor items have a combined budget share of just 0.4 percent.¹⁰



Notes: Unrestricted estimates are all statistically significantly different from the Cox and Wohlgenant estimates at $p < 0.05$ except for three groups with ^. The 95% Confidence Interval for unrestricted estimates is shown by the grey bars.

¹⁰ These tests are reported in column (6) of Table 2. The same 29 groups with significant differences are identified if we use the Holm (1979) sequentially-rejective bonferroni method that adjusts the inferences for multiple testing.

In terms of averages, the Cox and Wohlgenant method gives mean own-price elasticities of quantity demand of -0.64 (unweighted) or -0.57 (weighted) and a median of -0.54 . These are three times larger than the values for the unrestricted method. In other words, using the so-called ‘quality-adjusted prices’ leads to a very exaggerated estimate of the rate that quantity responds to price. The wide use of this method shown in Section III, and the lack of consideration in the literature for reporting how within-group quality responds to price, makes it likely that the overstatement seen in Table 2 also occurs elsewhere.

In fact, the Cox and Wohlgenant method gives results that hardly differ from those under the standard unit value method (whose results are reported in column (4) of Table 2). The mean own-price elasticity if unit values are used without any prior regression for ‘quality-adjustment’ is -0.65 (weighted) or -0.76 (unweighted). If we compare the gap between the elasticities from the standard unit value method and from the unrestricted method, only one-fifth of this gap is closed by the Cox and Wohlgenant method, suggesting that the initial regression of unit value deviations from period and regional means does little to deal with the issue of within-group quality adjustment as prices vary. In other words, the Cox and Wohlgenant method is largely ineffective. However, this ineffectiveness is hardly benign, since it may have lulled many economists into thinking that their estimates identify a price elasticity of quantity demand, when in fact what they have estimated is some hybrid of quantity and quality responses to price that overstates the rate at which quantity adjusts. This econometric bias may have influenced views of policy makers about the efficacy of using small taxes on food and drink to induce big shifts towards healthier diets.

5.1 Sensitivity Analyses

The pattern of biases that we show in Figure 2 and Table 2 appear robust to various changes in our specifications. We undertook six sensitivity analyses, which are briefly described here, with full results available from the authors. First, we considered a different way of averaging the prices, for the ten groups that have multiple items whose prices were surveyed. If we use geometric means, rather than the harmonic means used in Table 2, the results hardly change. For example, the gap between the unrestricted quantity demand elasticity for rice and the Cox and Wohlgenant estimate grows slightly, from 0.169 to 0.175.

Our second sensitivity analysis was to consider cross-prices, which we have ignored until now so as to focus on the main issue of within-group quality substitution. Our justification for this is that price rises for a group like beef are likely to produce larger rearrangements within the beef group than switches between beef and other meats. The existing evidence from Mexico is that the gap between the Cox and Wohlgenant elasticities and the unrestricted ones gets slightly bigger when cross-prices are considered (Andalón and Gibson, 2017). For Vietnam, it appears that using the cross-prices makes almost no difference to the bias from any of the ‘standard’ methods (that is, the Cox and Wohlgenant method, standard price method, and standard unit value method). For example, if we consider the

‘beans of various types’ group when prices for peas, water spinach, cabbage, and tomato are also included, we get an unrestricted own-price elasticity of quantity demand for beans of -0.43 , compared with -0.38 when cross-prices were not included. There are even smaller changes in the elasticities for the other methods, and the gap between the unrestricted and the Cox and Wohlgemant estimates hardly changes, going from 0.31 to 0.35.

Our next sensitivity analyses consider variants of equations (8) and (9), where household attributes are stripped from the unit values. Rather than using regional/period means as in the main results, we re-estimated by using medians which should be more robust to outliers.¹¹ This change hardly made any difference; for example, for rice all of the own-price elasticities became slightly more negative (e.g. from -0.33 to -0.37 for the Cox and Wohlgemant method) and the gap between the different methods was hardly changed (compare the value in column (6) of Table 2, using medians sees a gap between unrestricted and Cox and Wohlgemant estimates of 0.185, up from 0.169). Likewise, when we use a Heckman procedure to estimate equation (8), as another way to deal with missing unit values (following the example of studies such as Park *et al.* (1996) and Park and Capps (1997)) the own-price elasticities hardly change from the values in Table 2; on average, the difference from the previous values is just over one percent.

Our final sensitivity analysis was to use quadratic log expenditure terms rather than the linear log expenditures from the main results. This hardly changed the price elasticities at all. For example, the unrestricted own-price elasticities of quantity demand for the rice, pork, and beef groups moved up or down by an average of four percent of their Table 2 values. The elasticities from the Cox and Wohlgemant method moved by about the same amount, and so the gap between the two sets of results closed slightly (by 0.004) for pork and beef, while for rice the gap increased somewhat (by 0.021).

The results of these sensitivity analyses suggest that it is a robust finding that the Cox and Wohlgemant method is largely ineffective. This method yields results similar to what the standard unit value method shows, with elasticities that grossly exaggerate the rate that quantity responds to own-price. This lack of effectiveness of the Cox and Wohlgemant method is also found by Andalón and Gibson (2017), in their study of soft drink demand in Mexico.

VI. Conclusions

In many countries, household surveys are the main source of data used to estimate price elasticities of demand. This may be because time series are too short, or have too much structural change, or because disaggregated elasticities for various sub-populations are

¹¹ A related sensitivity analysis was to trim observations that were more than 3 standard deviations from the mean for unit values. This also did little to alter the gap in the own-price elasticities coming from the various methods.

wanted. Scanner data are available in some countries, but even then analysts may aggregate UPC items, inducing the within-group quality variation that we study here. This variation is a key feature of household survey data, as was recognized 60 years ago by Prais and Houthakker (1955). For highly differentiated foods, such as carbonated soft drinks, there could be ten times more price variation within a survey group – which allows scope for consumers to downgrade quality as prices rise – than variation over space. Yet the typical approach to estimating price elasticities from household survey data is to leverage off the tiny degree of inter-regional (and sometimes inter-temporal) price variation while ignoring the much larger quality-related price variation within each survey group.

Consequently, what many studies report as a price elasticity of quantity demand is some unidentified hybrid of the price elasticity of quality and the price elasticity of quantity. About 90% of studies in our review mix quality responses to price in with quantity demand elasticities. This overstates the rate that quantity demand falls as prices rise, and overstates the likely efficacy of fiscal-food policies that tax and subsidize certain foods so as to induce a switch towards healthier diets. Our empirical example from Vietnam shows that standard approaches used with household survey data overstate the magnitude of quantity demand elasticities by a factor of three, on average. This gross exaggeration is irrespective of whether budget share equations use prices or unit values. A similar degree of overstatement by the standard methods is found in the few existing studies that also use the unrestricted method, where households can freely adjust quality in response to price changes (McKelvey 2011, Gibson and Kim 2016 and Andalón and Gibson 2017).

Notably, there are no studies in agricultural economics that use the unrestricted method, and few even cite the intellectual origins, in Deaton (1990). Instead, Cox and Wohlgenant (1986) is cited by agricultural economists to justify how household survey data are used to get elasticities. Our results show that this method is flawed, in the sense that it grossly overstates the response of quantity to price. Indeed, Cox and Wohlgenant elasticities hardly differ from those of the standard unit value method, where budget shares are directly regressed on unit values without any prior regression to get ‘quality-adjusted prices’. The flaws in the Cox and Wohlgenant method are not just an empirical matter – which would leave open the possibility that it might work somewhere else – they are inherent in the way that quality responses to price are treated. Rather than model a two-choice problem with an equation for quantity (or budget share) and one for quality, a dubious identifying assumption that quality is chosen first is made, and it is further assumed that quality effects can be purged by regressing unit values on household attributes. This method also ignores measurement error in unit values and ignores the community-wide response of quality to price.

Relying on Cox and Wohlgenant (1986) also contributes to the ongoing misuse of unit values as a proxy for price. Unit values should always be expected to be a bad price proxy, due to the Alchian-Allen effect; the relative price of quality will vary over time and space due to storage and shipping costs (Gibson and Kim 2015). With relative prices varying, the

composition of demand within a survey group will not be constant. Thus, unit values will not refer to the same quality mix over time and space and therefore cannot consistently indicate the group price level. However, if one has local price data, then, conditional on prices, the unit value can be informative about consumer quality choices. Yet the demand put on statistical agencies to provide local price data is diminished by so many studies opting to use unit values to measure price, and some responsibility for this again falls on Cox and Wohlgenant (1986). Looking backwards, 30 years of price elasticities estimated from household survey data are likely to be wrong because they have mixed together quality and quantity responses to price. Going forward, only once databases have *both* market prices and unit values are we likely to correctly estimate how price changes lead to demand responses on both the quantity and quality margins.

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Appendix

Appendix Table 2: Descriptive Statistics for Control Variables

	Mean	Std Dev	Min	Max
Log total expenditure	11.178	0.733	8.254	14.021
Log household size	1.252	0.456	0.000	2.485
Children share of household	0.088	0.142	0.000	0.667
Youth share of household	0.110	0.161	0.000	0.750
Elderly share of household	0.104	0.245	0.000	1.000
Migrant share of household	0.042	0.181	0.000	1.000
Dummy: Female head	0.262	0.440	0.000	1.000
Age of household head	50.266	14.316	18.000	89.000
Dummy: Head earns wages	0.406	0.491	0.000	1.000
Dummy: Head farms	0.521	0.500	0.000	1.000
Dummy: Head is self-employed	0.200	0.400	0.000	1.000
Dummy: Head is tertiary qualified	0.059	0.235	0.000	1.000
Dummy: Head is primary qualified	0.713	0.453	0.000	1.000
Budget share of other expenditures	0.695	0.142	0.076	0.964

Notes

There are N=4380 observations. Economic activity categories for the household head are not mutually exclusive, so add to more than 1.0.

**Appendix Table 3: Summary Statistics for Budget Share
and Unit Value Equations and for Prices**

	Budget Shares			Unit Values (log)			Prices (log)	
	Mean	Std Dev	Eq(1) R^2	Mean	Std Dev	Eq(2) R^2	Mean	Std Dev
Rice (all grades and varieties)	0.078	0.059	0.654	2.444	0.232	0.363	2.499	0.123
Sticky rice	0.005	0.024	0.096	2.900	0.244	0.134	2.884	0.222
Potato and sweet potato	0.001	0.003	0.018	2.176	0.394	0.197	2.394	0.255
Bread and wheat flour	0.001	0.003	0.016	3.190	0.450	0.015	3.338	0.258
Flour noodles and porridge	0.007	0.010	0.077	3.343	0.502	0.012	3.559	0.056
Fresh and dried rice noodles	0.002	0.004	0.038	2.511	0.424	0.099	2.199	0.162
Pork of all types	0.054	0.039	0.382	4.402	0.185	0.260	4.353	0.123
Beef of all types	0.010	0.015	0.107	5.112	0.211	0.070	5.066	0.132
Chicken of all types	0.023	0.024	0.254	4.440	0.259	0.196	4.406	0.179
Duck and other poultry	0.006	0.012	0.065	3.687	0.288	0.326	4.170	0.186
Fats and cooking oil	0.009	0.009	0.343	3.687	0.288	0.025	3.490	0.227
Fresh fish and shrimp	0.039	0.036	0.147	3.876	0.457	0.224	4.469	0.289
Dried fish and shrimp	0.004	0.009	0.096	0.986	0.256	0.170	4.349	0.222
Eggs (chicken and duck)	0.007	0.007	0.182	2.780	0.411	0.196	1.181	0.138
Tofu	0.005	0.006	0.148	3.365	0.380	0.133	2.720	0.254
Beans of various types	0.001	0.002	0.064	2.429	0.426	0.073	3.462	0.162
Peas of various types	0.001	0.003	0.041	1.784	0.482	0.137	2.584	0.245
Morning glory (water spinach)	0.004	0.005	0.087	2.002	0.501	0.173	1.930	0.384
Cabbage	0.002	0.004	0.057	2.388	0.360	0.335	1.962	0.474
Tomato	0.002	0.002	0.050	2.953	0.395	0.244	2.423	0.324
Orange	0.002	0.004	0.091	2.064	0.533	0.196	3.203	0.361
Banana	0.003	0.004	0.047	2.780	0.497	0.194	2.116	0.374
Mango	0.002	0.003	0.033	3.048	0.465	0.141	3.267	0.290
Cooking sauces	0.004	0.004	0.211	3.048	0.465	0.108	2.692	0.191
Salt	0.001	0.001	0.185	3.030	0.165	0.013	1.701	0.408
Sugar and molasses	0.004	0.004	0.115	3.847	0.500	0.014	3.076	0.080
Confectionery	0.005	0.005	0.113	4.830	0.929	0.068	1.705	0.260
Condensed milk	0.007	0.020	0.128	2.855	0.421	0.079	5.283	0.136
Wine and spirits	0.005	0.009	0.207	2.925	0.395	0.130	3.455	0.178
Beer	0.004	0.008	0.067	2.925	0.395	0.064	2.136	0.149
Water and soft drinks	0.002	0.005	0.023	2.449	0.973	0.074	2.153	0.167
Tea	0.005	0.007	0.139	2.444	0.232	0.031	4.833	0.263

Note

There are $N=4380$ observations.

Appendix Table 1: Bibliographic Details on the Studies Covered in Table 1

# Authors	Title	Year	Source title	Volume	Issue	Page
2	Abadie, L.M., Galarraga, I., Milford, A.B., Gustavsen, G.W.	2016	Journal of Cleaner Production	134	1	280
5	Bronnmann, J., Loy, J.-P., Schroeder, K.J.	2016	Marine Resource Economics	31	3	281
6	García-Enríquez, J., Echevarría, C.A.	2016	Journal of Agricultural Economics	67	2	324
11	Gustavsen, G.W., Rickertsen, K.	2014	Empirical Economics	46	2	427
12	Castellón, C.E., Boonsaeng, T., Carpio, C.E.	2015	Applied Economics	47	6	553
13	Cupák, A., Pokrivák, J., Rizov, M.	2015	Ekonomicky casopis	63	4	339
15	Selvaraj, S., Srivastava, S., Karan, A.	2015	BMJ Open	5	12	1
17	Majumder, A., Ray, R., Sinha, K.	2015	Review of Income and Wealth	61	2	302
20	Cardwell, R., Lawley, C., Xiang, D.	2015	Canadian Public Policy	41	1	1
21	Staudigel, M., Schröck, R.	2015	Journal of Agricultural Economics	66	3	615
25	Leifert, R.M., Lucinda, C.R.	2014	Applied Economic Perspectives and Policy	37	4	634
26	Gustavsen, G.W.	2015	European Review of Agricultural Economics	42	2	217
33	Basarir, A.	2013	Bulgarian Journal of Agricultural Science	19	1	32
41	Zheng, Z., Henneberry, S.R.	2012	China Economic Review	23	4	1090
44	Fourmouzi, V., Genius, M., Midmore, P.	2012	Journal of Agricultural Economics	63	3	677
50	Mergenthaler, M.	2012	Acta Horticulturae	930	1	13
52	Galdeano-Gómez, E., Pérez-Mesa, J.C.	2012	Journal of Food Products Marketing	18	2	139
56	Gibson, J., Rozelle, S.	2011	Applied Economics	43	27	4021
57	Hovhannisyan, V., Gould, B.W.	2011	Agricultural Economics	42	1	1
60	Lusk, J.L.	2011	Food Quality and Preference	22	5	452
61	Coffey, B.K., Schroeder, T.C., Marsh, T.L.	2011	Applied Economics	43	18	2343
66	Capacci, S., Mazzocchi, M.	2011	Journal of Health Economics	30	1	87
70	Dong, D., Kaiser, H.M.	2010	Agribusiness	26	3	389
72	Zheng, Z., Henneberry, S.R.	2010	Journal of Agricultural and Resource Economics	35	1	51
74	Zheng, Z., Henneberry, S.R.	2009	Review of Agricultural Economics	31	4	873
76	Mergenthaler, M., Weinberger, K., Qaim, M.	2009	Food Policy	34	5	426
79	Fleischer, A., Rivlin, J.	2009	Journal of Travel Research	47	3	285
82	Ul Haq, Z., Nazli, H., Meilke, K.	2008	Agricultural Economics	39	1	477
87	Akbay, C.	2007	Quality and Quantity	41	6	851
88	Dong, D., Kaiser, H.M., Myrland, O.	2007	Agricultural Economics	36	3	313
90	Angulo, A.M., Gil, J.M.	2006	Agricultural Economics	35	2	131
92	Alfonzo, L., Peterson, H.H.	2006	Agricultural Economics	34	3	243
100	Gibson, J., Rozelle, S.	2005	World Bank Economic Review	19	1	69
103	Kedir, A.M.	2005	Journal of African Economies	14	1	1
105	Lazaridis, P.	2004	Journal of Family and Economic Issues	25	3	411
122	Angulo, A.M., Gil, J.M., Gracia, A.	2001	Agricultural Economics	26	1	71
131	Gracia, A., Albisu, L.M.	1998	Agricultural Economics	19	3	359
136	Gao, X.M., Wailes, E.J., Cramer, G.L.	1997	American Journal of Agricultural Economics	79	2	573
140	Gao, X.M., Wailes, E.J., Cramer, G.L.	1996	American Journal of Agricultural Economics	78	3	604
142	Ramezani, C.A., Rose, D., Murphy, S.	1995	American Journal of Agricultural Economics	77	3	525
144	Chung, C.-F.	1994	American Journal of Agricultural Economics	76	3	513
157	Heien, D.M., Wessells, C.R.	1988	American Journal of Agricultural Economics	70	2	219
159	Widarjono, A.	2016	International Journal of Applied Business and Ecc	14	11	7775

Appendix Table 1 (continued)

Major method (Table 1 headings)	Sub-method details	List of studies in this category
Cox and Wohlgemant Method	No censored demand correction for households with zero budget shares	#2, #11, #13 (no zeros method), #17, #21, #26, #44 (computed uv by household characteristics for non-purchasers), #56, #57, #60, #66, #70, #72 (inverse mills

Appendix Table 1 (*continued*)

Major method (Table 1 headings)	Sub-method details	List of studies in this category
Cox and Wohlgemant Method	No censored demand correction for households with zero budget shares	#2, #11, #13 (no zeros method), #17, #21, #26, #44 (computed uv by household characteristics for non-purchasers), #56, #57, #60, #66, #70, #72 (inverse mills ratio in uv eq), #74, #87, #136 (no zeros method), #140
Cox and Wohlgemant Method	Censored demand correction for households with zero budget shares	#5, #20, #41, #50, #76 (Heckman inverse mills ratio), #90 (DH or IPM), #92, #105, #122 (Tobit)
Standard Unit Value Method	Covariates in budget share eqn claimed to control for quality effects	#142, #144, #157
Standard Unit Value Method	Covariates in budget share eqn claimed to control for quality effects	#25 (computed uv for missing uv), #33 (use CW regional/quarterly mean uv for missing uv only to get a cross-price elasticity), #61, #82 (similar to #33), #159
Standard Price Method		#6, #12 (household-level price indices), #100 (community prices)
Explicitly model quality choice (based on Deaton method)	Price elasticity of quality constrained by weak separability restrictions	#15, #52, #79, #88, #103, #131