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Quality, Quantity and Spatial Variation of Price: Back to the Bog

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Abstract

Demand studies increasingly use household survey data on budget shares, which vary with quantity, price, and quality. If quality response to price is ignored, estimated price elasticities of quantity demand will conflate responses on the quantity and quality margins. Deaton (1988) developed a method of estimating price elasticities from survey data, using separability restrictions to derive the quality responses to price changes. We use unique survey data with prices and qualities observed over space to test these separability restrictions, which are overwhelmingly rejected. Many reported price elasticities of quantity demand will greatly exaggerate quantity responses to price changes.

Keywords

demand
household surveys
quality
price
unit values
weak separability

JEL Classification

C81; D12

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I. Introduction

Sixty years ago, Sigbert Prais and Hendrik Houthakker (1955) resisted a temptation that hundreds of economists since then could not. That temptation is to divide survey estimates of household expenditures on a food group like rice or soft drink by the reported quantity bought, call the ratio a 'price' and use it to estimate the elasticity of quantity demand. Prais and Houthakker (1955 p.110) correctly noted that this ratio – which is a unit value – is not a price at all because survey data do not adhere to the 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.'

There are many different varieties, brands, package sizes and so forth within survey groups – even narrowly defined ones like 'carbonated soft drinks' – so a consumer faces two choices rather than just choosing quantity as in the textbook model. They also choose *quality*. If demand models are estimated without allowing for both choices, quality responses to price changes get conflated with quantity responses, and the effect of price on quantity demand is overstated. Some price rises may be mandated by policy makers so as to lower intake of unhealthy items like sugar-sweetened soft drinks, so a failure to correctly disentangle quality and quantity responses may result in disappointed policy makers and poorer societies.

These issues were recognized, and potentially solved, almost thirty years ago in a set of papers by Angus Deaton (1987, 1988 and 1990). Deaton derived the response of quality to price so as to isolate quantity demand elasticities, without needing price data. The method assumed weakly separable preferences so that the unobserved effects of price on quality could be derived from income elasticities of quality and quantity. Intuitively, by forcing the effect of price on quality to operate as an income effect, Deaton leveraged off what household surveys are good at – measuring incomes or expenditures – to get at what they are bad at or never do, which is measuring local prices.[1] If one had a household survey with good measures of local prices, and with the usual data on food group expenditures and quantities, one could directly estimate the effect of price on quality by using unit values to indicate consumer quality choice (since unit values are the product of price and quality). Indeed, Deaton (1990 p.302) concluded that it 'would be extremely desirable to have direct measures of market prices against which this method could be tested.'

[1] To this day, very few household surveys are linked to spatially disaggregated price surveys, especially in poor countries where food prices vary most widely over space (Gibson 2013).

In this paper we do just that. Especially collected data on market prices and unit values are used to directly estimate quality responses to price for 45 types of food and drink in Vietnam. These estimates show much larger responses of quality to price than do the indirect estimates from Deaton's approach, which relies on separability restrictions. The differences are highly significant for 41 items. Our study is just the third to test these restrictions and covers many more items than McKelvey (2011) and Gibson and Kim (2013), who test the separability restrictions on six and eight food groups. All three studies find Deaton's method understates the response of quality to price and so overstates price elasticities of quantity demand. Since the current study uses quite narrowly defined food and drink groups, these large quality responses are not an artifact of using broad, heterogeneous groups. Instead the response of quality to price seems to be an inherent feature of demand data from household surveys, which economists ignore at their peril.

That the weakly separable preference structure does not fit the data should give no solace to economists who estimate demand models from household survey data and ignore the problems raised by Deaton, and earlier by Prais and Houthhaker. Scores of studies use survey data and force the joint choice of quality and quantity into a single budget share equation framework whose estimated parameters logically cannot identify a quantity response to spatial price variation unless all quality adjustment is *a priori* ruled out.[2] Studies that force the joint quantity-quality choice problem into the wrong single equation budget share framework include some with market prices as right-hand side variables; even without using unit values there is a bias because the response of budget shares to prices involves both quantity and quality adjustments (McKelvey 2011).

That so many studies ignore quality response to price may not just be from thoughtlessness. Analysts may hope they dealt with quality, by using regressions to purge unit values of variation due to observed household characteristics, based on Cox and Wohlgenant (1986).[3] This tactic is misguided. Even if regression-adjusted unit values are like prices in varying between localities due to transport costs and other spatial factors, but not varying with buyer characteristics within localities, there is still a bias. This bias is seen in studies with market prices giving different price elasticities of quantity demand when ignoring *versus* when allowing

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[2] Our on-line appendix examines 71 empirical demand studies in 37 journals that use household survey data, and that cite Cox and Wohlgenant (1986). Over 75% wrongly mix quality responses with their reported quantity demand elasticities.

[3] This method misses community-wide responses of unit values to price. While it may deal with measurement error, so too does Deaton's method. Results from recent studies with market prices as a benchmark suggest that bias from ignoring quality responses matters more than bias from measurement error. The contrary view of Deaton (1989 p.198) that measurement error matters more in practice may have been coloured by the separability restrictions he used; these cause quality responses to be understated compared to what direct estimates have subsequently shown.

quality responses (McKelvey 2011). Consider fizzy soft drinks, whose demand response to actual or potential taxes receives much attention (Zhen *et al.* 2014); where the lead author shops there is a 10:1 price range within this group, from $5.83 per liter (a 4 pack of 330ml bottles of *Coke*) to $0.60 per liter (a 1.25 liter bottle of store-branded cola). Hence there is great scope to maintain quantity as prices rise, by sliding down the quality scale from expensive *Coke* in small bottles to cheap store-brand cola in large bottles. The budget share reflects where on this quality scale a consumer locates, the quantity they buy, and the prevailing prices; to model consumers as adjusting to higher prices by reducing just quantity but not moving down the quality scale seems arbitrary and is unlikely to be true.

Our main title deliberately copies Deaton (1988) because in our view unidentified quality responses are still biasing price elasticities of quantity demand estimated from survey data. Our sub-title is from Gordon Tullock (1985 p.262) describing his role in an intellectual debate:

> '…my role in this controversy is to watch people trying to get out of the swamp and then push them back in. Clearly, my role is not a constructive one, but nevertheless, I feel it necessary.'

Our contribution may be viewed similarly; before Deaton, economists used unit values as if they were prices when estimating elasticities of quantity demand. They were in a bog where quality and quantity effects could not be distinguished. Deaton provided a way out, pulling himself up just by the bootstraps of separability restrictions, with no firm ground (good price data) in sight.[4] Standing on firm ground now, armed with good data on local prices and on consumer's choice of quality, we are pushing people back into the bog by showing that Deaton's restrictions do not hold. The necessary role we play, even if not a constructive one, is to point out that we are still bogged down; many estimates of the effect of price on quantity are instead some murky mixture of quality and quantity responses. Our defence for our role is that it is only once we realize that we are still bogged that the value of firm ground (good data on local prices and on quality) becomes clear. In our opinion, there will be little headway in using household survey data to accurately estimate quantity responses to price variation until better data on local prices and qualities are collected, so that responses on both the quantity and quality margins can be directly estimated.

In the next section we present a model of consumer choice over quantity and quality, along with Deaton's separability restrictions. The data used to test these are described in Section III. The results are in Section IV, followed by a discussion of the implications for demand modelling.

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[4] While Cox and Wohlgenant (1986) published before Deaton, their tactic of regressing unit values on household characteristics gave no way out of the bog since it does not identify the response of quality to price. Indeed, the many citations to Cox and Wohlgenant and the papers that copy their tactic show how widespread is the misunderstanding by applied economists of the quality response issues raised by Prais, Houthakker, and Deaton.

II. Quantity and Quality Choice with Separability Restrictions

Since the seminal work of Deaton and Muellbauer (1980), applied demand studies mostly estimate budget share models. These models are used even if the ultimate aim of the study is to measure how quantity demand responds to price changes.[5] Hence, the dependent variable for a demand study using household survey data is w_{Gi}, the share of the budget devoted to food group G by household i. These budget shares are typically modeled as varying with the logarithm of the household's total expenditure, $\ln x_i$, the logarithm of the price for foods in group H, $\ln p_H$, a set of household characteristics and conditioning variables (e.g. demographics, labor market status and spending on non-food goods) that are captured in the vector z_i, and random noise, u:

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

A food group covers many varieties so expenditure on group G represents price, quantity, *and* quality. One proxy for quality is the unit value (v_G, average expenditure per unit). The total expenditure on the group is then $v_G Q_G$, where Q_G is group quantity. The budget share (dropping household subscripts) is $w_G = v_G Q_G / x$, so any response of the budget share to prices involves both quantity and quality adjustments. Thus, log differentiating equation (1) with respect to $\ln x$ and $\ln p_H$ does not allow one to obtain the usual expenditure and price elasticities of quantity demand; for example, the movement in the budget share with respect to price could come from adjustment on either the quantity or quality margins. Therefore, a second equation is needed to model quality choice, which is indicated by household i's unit value for group G, v_{Gi}:

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

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. If the logarithm of equation (1) is differentiated to provide budget share elasticities, it gives:

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

$$\partial \ln w_G / \partial \ln p_H = \theta_{GH} / w_G = \varepsilon_{GH} + \psi_{GH} \qquad (3b)$$

[5] Switching to (log) quantity as the dependent variable does not solve the problem of uncontrolled quality responses because household survey data beg the question: 'quantity of what?' The survey data on a food group – even a narrowly defined one – aggregate over the quantities of many different varieties, which each sell at a different price due to the within-group quality gradient. Indeed, the first estimator developed by Deaton to deal with the quality choice problem (Deaton 1987), was for the double-log demand specification.

where ε_G is the elasticity of quantity demand with respect to total expenditure (the 'income elasticity of demand'), ε_{GH} is the elasticity of quantity demand with respect to the price of *H*, β_G^1 is the elasticity of the unit value with respect to total expenditure and ψ_{GH} is the elasticity of the unit value with respect to the price of *H*.

Three implications emerge from equations (3a) and (3b). First, observed changes in budget shares as prices or incomes change are not directly informative about quantity responses. Quality responses (the β_G^1 and the ψ_{GH}) also alter the budget share. Second, in order to isolate the elasticity of quantity with respect to price – the key parameter for evaluating tax interventions that aim to cut intakes of unhealthy food and drink – one also must estimate the elasticity of the unit value with respect to price. Hence, surveys would ideally collect market prices and also unit values (to show consumer choices over quality, rather than serving as a proxy for price). The need to have both is apparent if equation (3b) is expressed as: $\varepsilon_{GH} = (\theta_{GH}/w_G) - \psi_{GH}$. The budget share responses to price changes, θ_{GH} need to have quality response to price, ψ_{GH} subtracted so that the quantity response, ε_{GH} can be isolated. The ψ_{GH} quality responses to price could be estimated directly from equation (2) if a survey has both prices and unit values available. However, this direct approach is almost never possible because of lack of suitable data; McKelvey (2011) and Gibson and Kim (2013) are the only published examples of this direct approach.

The third implication of ignoring quality is that responses on the quality margin wrongly get treated as a quantity response, exaggerating quantity demand elasticities. The typical applied demand study just estimates equation (1) and uses elasticity formula: $\varepsilon_{GH} = (\theta_{GH}/w_G) - \delta_{GH}$, where δ_{GH} equals one for own-price and zero otherwise. In other words, an untested restriction of a 1:1 movement of unit values with respect to own-prices $(\psi_{GG} = 1)$ is imposed. If consumers, in fact, respond to higher own-prices by sliding down the quality scale, $\psi_{GG} < 1$ and quantity responds less elastically to price than what is suggested from using $\varepsilon_{GH} = (\theta_{GH}/w_G) - \delta_{GH}$.

The estimators developed by Deaton (1987, 1988 and 1990) enable one to indirectly derive an estimate of ψ_{GH} when direct estimation of equation (2) is rendered impossible because a survey does not have data on prices. Deaton's method first purges household-specific demographic and income effects from budget shares and unit values by estimating variants of equations (1) and (2), with dummy variables for each survey cluster in place of the unobserved prices. The households in the same cluster are assumed to face the same local prices so residuals from these regressions indicate the extent of measurement errors in unit values (and in budget shares). These errors are dealt with by using a between-cluster, errors-in-variables regression of purged budget shares on purged unit values. These corrected regression coefficients still reflect the effect of price on cluster-wide quality (with only household-specific quality effects previously being purged). So a final step in deriving ψ_{GH} is needed, which relies on two key assumptions: fixed price relativities within a commodity group, and weak separability of commodity groups.

The fixed price relativities assumption is that when the price vector for the individual items within a group, *G* is decomposed into (i) a scalar term that raises or lowers the price level of all items in the group across clusters (say, due to transport costs), and (ii) a reference price vector of the relative price of each item within the group, the scalar term dominates. In fact, any method of using unit values to measure prices requires this Hicksian separability to hold since otherwise, if within-group relative prices vary over space, the composition of what is bought within the group will shift toward items with locally lower within-group relative prices. If group composition varies, the unit values will not refer to the same quality mix in all areas, and will not be a consistent indicator of the price level across space (Gibson and Kim 2015).

The second assumption uses the fact that quality depends on the composition of demand within the group. If preferences are weakly separable, group demand will depend only on the ratio of group expenditure to group price. Thus the unobserved effect of group price on quality can be derived from the price elasticity of quantity and the income elasticities of quality and quantity:

$$\frac{\partial \ln v_{Gc}}{\partial \ln p_{Hc}} = \psi_{GH} = \delta_{GH} + \beta_G^1 \frac{\varepsilon_{GH}}{\varepsilon_G} \tag{4}$$

A price rise reduces the demand for a food group according to the price elasticity, ε_{GH} . When less is bought, the quality effect under separable preferences depends only on the elasticity of quality with respect to expenditures on the group, given by the ratio of β_G^1 and ε_G. Substituting expressions for ε_{GH} and ε_G from equations (3a) and (3b) into equation (4) gives:

$$\begin{aligned} \psi_{GH} &= \delta_{GH} + \frac{\beta_G^1(\theta_{GH}/w_G - \psi_{GH})}{(1-\beta_G^1) + \beta_G^0/w_G} \\ &= \delta_{GH} + \frac{\beta_G^1}{1+\beta_G^0/w_G}(\theta_{GH}/w_G - \delta_{GH}) \end{aligned} \tag{5}$$

After substitution to eliminate ψ_{GH} from the right-hand side of the first row of equation (5), the unknown quality response to price depends only on coefficients estimated from the variants of equations (1) and (2) that use cluster dummy variables. Thus, subject to the separability restrictions in equation (4), Deaton's method has all the parameters needed to calculate a price elasticity of quantity demand that allows for quality substitution:

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

If one has data on local prices and unit values, equation (2) can be used to directly estimate ψ_{GH} with no need for the weak separability restrictions. The directly estimated ψ_{GH} could then be subtracted from the budget share elasticity (as in equation (3b)) to isolate the elasticity of quantity demand with respect to price. This direct approach places no restriction on how consumer's choice of quality responds to price. Comparing direct estimates of ψ_{GH} with indirect estimates derived from weak separability restrictions can help to establish the plausibility of those restrictions. More generally, the magnitude of the direct estimates of ψ_{GH} can show if there are important quality responses to price in household survey data, whose omission from standard analyses would be expected to lead to biased estimates of the quantity elasticities of demand.[6]

III. Data Description

We use atypical data, with finely-grained price surveys linked to a consumption survey, to estimate equations (1) and (2). In 2012, the Prices Department of the General Statistics Office (GSO) of Vietnam surveyed prices of 101 items (52 were foods) in 1,644 communes (one-fifth of all communes in Vietnam); half in March and the rest in September.[7] These communes match the sample for two of the four rounds of the Vietnam Household Living Standards Survey (VHLSS), fielded at the same time, and for which each round is nationally representative.

To ensure consistency over space, enumerators were given photographs of each of the 101 goods or services to be priced. Figure 1 shows examples for two items in the pork group: rump and belly. The instructions required surveyors to find examples in the market that were of similar size and quality to what was pictured (with a matchbox used as a scale indicator), and to weigh them and record prices per metric unit (unless the item was in standard packaging of known

[6] McKelvey (2011) and Gibson and Kim (2013) do not directly test the restrictions on the preference structure and instead compare direct estimates of ψ_{GH} with indirect estimates based on all steps of the Deaton (1990) estimator, including the errors-in-variables correction. In the current study equations (1) and (2) are estimated using market prices (rather than using cluster dummy variables) so as to get the parameters needed for equation (5). Thus, differences between direct and indirect estimates of ψ_{GH} reported here should inform us about the plausibility of the restrictions on the preference structure and not on other aspects of Deaton's three-step estimation procedure.

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

weight). The sampled prices were to be obtained from three different vendors in each locality.[8]

The food budget shares, unit values, and the covariates other than prices in equations (1) and (2) come from the VHLSS. The consumption module of this survey uses a thirty-day recall of purchases and consumption from own-production and gifts 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 only lightly clustered, with three households per selected commune given the consumption recall (a larger sample from the same communes are given an income-only questionnaire). Thus we have over 4000 households, spread over all of Vietnam, available for estimating equations (1) and (2) in order to see if the restrictions asserted in equation (4) hold.

While there are 52 food (and drink) items in the price survey, and 56 food and drink groups in the VHLSS consumption recall, only 45 price survey items are suitable candidates for testing the separability restrictions.[9] Concordances between these 45 items and the consumption survey groups are in Appendix Table 1. Ten of the consumption survey groups have more than one item in the price survey; specifically, 23 of the 45 prices are for those ten consumption groups.[10] However, regardless of whether we count consumption groups (n=32) or price survey items (n=45), the current test of the weak separability restrictions covers far more items than any previous study. This comprehensive coverage lets us rule out a possible threat to the findings, which is that the separability restrictions on the preference structure may not fit the data for broad, heterogeneous groups. Our food groups are quite specific, and include some items that are often considered for possible health-related taxes (e.g., lard, cooking oil, vodka, beer, soft drinks, and fruit juice).

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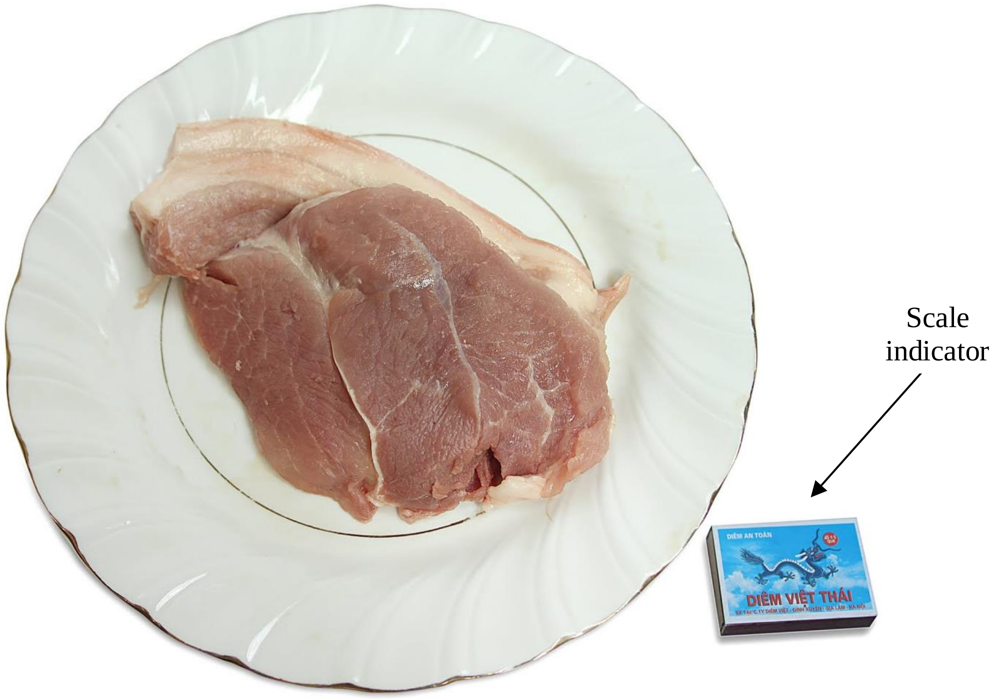
8 The repeated observations enable reliability ratios to be calculated for the average price of each item in each commune. The evidence from an earlier version of the same survey, fielded in 2010 but in fewer communes and with only 64 items, is that reliability ratios for the prices range from 0.97 to 0.99 (Gibson and Kim 2015).

9 No quantities were reported (so no unit value can be calculated) for 16 ‘catch-all’ groups of heterogeneous items. Five minor food groups in the consumption recall have no matching price survey items.

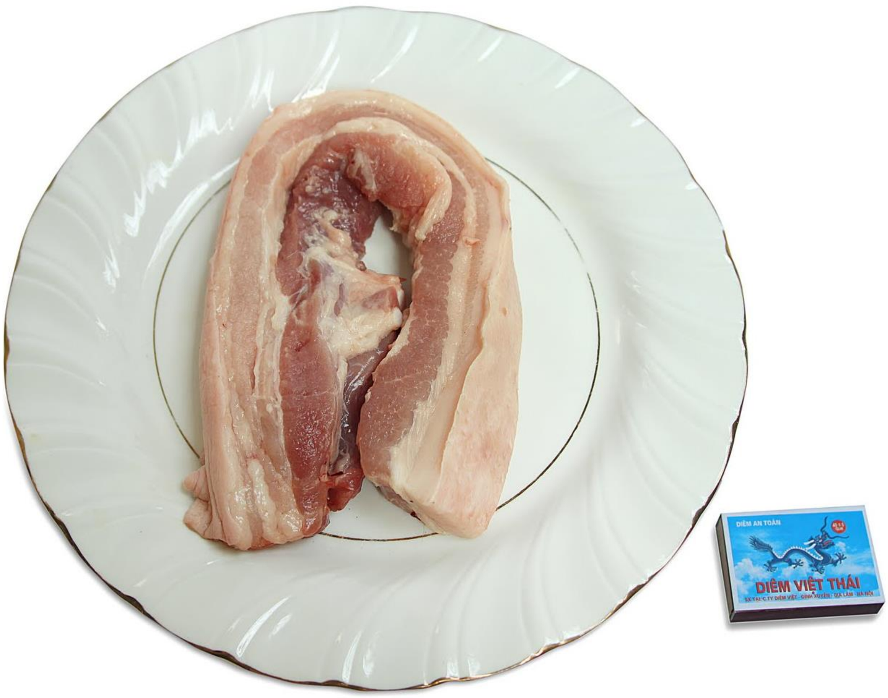
10 The cases of multiple prices from within the same consumption group allow us to test the second assumption made by Deaton (which is needed by all unit value methods), that price relativities within each group are fixed.

Figure 1: Examples of Photographs used to Ensure Consistent Price Collection for Items

Panel A
Pork Rump, Loose, Not pre-packaged



Panel B
Pork Belly, Loose, Not pre-packaged



The descriptive statistics for budget shares, prices, and unit values for each of the 45 items are reported in Appendix Table 2. Our estimates of equations (1) and (2) also include 14 control variables: 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 expenditures. The descriptive statistics for these control variables are reported in Appendix Table 3.

IV. Results

The budget share and unit value equations for the 45 items provide too many details to feasibly report each regression result. So we give a brief overview of the regressions and then provide details for one exemplar item (pork) to show how the tests of the separability restrictions are done. We then compare direct and indirect estimates of quality and quantity elasticities for all 45 items.

The budget share regressions vary in predictive power from an R^2 of 0.60 for rice to 0.01 for potato (see Appendix Table 2 for details). For the unit value equations, the R^2 values range from 0.36 to 0.01, with rice again highest and white bread lowest. The explanatory power varies with the importance of the consumption groups, with correlations between average budget shares and R^2 values of 0.7. When we summarize the elasticity results, budget share-weighted averages are reported along with simple averages. Thus, impressions about how elasticities change if quality substitution is directly estimated, is derived from separability restrictions, or is not allowed at all, may be less likely to be skewed by the results for some minor items.

The key parts of the regression for the budget shares for the pork consumption group (with standard errors given in ( ) and using rump as the price survey item), are as follows:

$$w_i^{pork} = 0.037 - \underset{(0.001)}{0.012} \ln x_i + \underset{(0.001)}{0.016} \ln P_i^{pork} + controls \qquad R^2 = 0.19$$

The average budget share for the pork group is 5.4% so the combined effect of the elasticities of pork quantity and quality with respect to household total expenditure at that mean is calculated as [(-0.012/0.054)+1]=0.78.[11] Many applied demand studies use this same simple approach, of dividing the regression coefficient by the average budget share (but subtracting one rather than adding one as in the expenditure elasticity), as a way to estimate the elasticity of quantity

[11] The unit value equation shows that the quality elasticity with respect to total expenditure is 0.06, so the remaining 0.72 is the response of pork quantity to a one percent increase in household total expenditure.

demand with respect to own-price. McKelvey (2011) calls this the 'standard price method' because it ignores any within-group quality substitution in response to price differences and would be appropriate in the case of a standard, undifferentiated good where quality substitution is impossible. Using this approach, the own-price elasticity of quantity demand for pork appears to be -0.71.[12]

The results of the unit value equation provide a challenge to the standard price method. There appears to be considerable within-group quality substitution, with the elasticity of the unit value with respect to own-price significantly less than one ($\psi_{GG} = 0.55$):

$$\ln v_i^{pork} = -2.406 + \underset{(0.005)}{0.059} \ln x_i + \underset{(0.017)}{0.550} \ln P_i^{pork} + controls \qquad R^2 = 0.26$$

In communes with higher pork prices the unit value for pork does not increase one-for-one. This sluggishness implies that households respond to higher prices by substituting toward lower quality, cheaper, items within the pork group. This type of response is summarized by the elasticity of quality substitution ($\psi_{GG} - 1$). Given this degree of within-group quality substitution, we can estimate an elasticity of pork quantity demand with respect to own-price of -0.26. Notably, this quantity elasticity is purged of any quality response to own-price and shows much less quantity adjustment than what is (wrongly) suggested by the standard price method.

How well do the weak separability restrictions proposed by Deaton work? Recall that these let one derive an estimate of ψ_{GG} using the standard price elasticity of quantity (-0.71) and the income elasticities of quality (0.06) and quantity (0.72). This indirect approach, following equation (4), gives an elasticity of quality substitution with respect to price ($\psi_{GG} - 1$) that is almost zero (-0.05). Thus, the weak separability restrictions wrongly make it seem that higher pork prices pass almost one-for-one into higher unit values for pork and that there is little quality downgrading. Accordingly, the own-price elasticity of quantity demand that is derived using the separability restrictions (-0.66) is not very different from the elasticity coming from the standard price method (-0.71) that completely rules out any quality substitution.

The separability restrictions make it seem that allowing for quality response to price has almost no effect on the estimated quantity responses to price. In contrast, the unrestricted estimates show a statistically significant gap of 0.45 between the elasticity of quantity demand that allows for quality substitution (-0.26) and the one that rules out quality substitution (-0.71). The estimates differ so markedly from those based on separability restrictions (the gap of 0.40 between the two sets of elasticities has a standard error of 0.02) because the equation (4)

[12] The own-price elasticity is -0.75 if the pork belly price is used and -0.70 if using a group price index.

restrictions are inconsistent with the patterns of how consumers adjust quality in response to own-price in Vietnam.[13]

These patterns across the various elasticities appear to be widespread. In Table 1 we report results for all 45 items. The first columns of the table are used for the two approaches to estimating the quality substitution elasticities (which are assumed to be zero by the standard price method). For 41 out of the 45 items the unrestricted estimates of quality substitution are significantly larger in magnitude than are the indirect estimates that come from the weak separability restrictions. The only insignificant results are for four minor items (sticky rice, condensed milk, *Coca Cola*, and orange juice) that have a combined budget share of just one percent. For three of these four items, the quality substitution elasticities indirectly derived from the separability restrictions are large and positive, implying that consumers choose higher quality if prices are higher. These unlikely results further suggest that the separability restrictions used by Deaton's method fail to fit with the observed patterns of quality responses to spatial price differences in Vietnam.

The patterns of the quality substitution elasticities are illustrated in Figure 2. For most items, the values derived from Deaton's assumptions are close to zero, while four-fifths of the directly estimated quality substitution elasticities lie between -0.40 and -0.95. Another way to make this contrast is to consider the average food and drink item, for whom the elasticity of quality substitution is -0.60 when directly estimated but just -0.20 when indirectly derived from Deaton's weak separability restrictions (where this average is weighted by budget shares). If we use an unweighted average the gaps are even larger; the mean (median) of the direct estimates is -0.68 (-0.66) but is just -0.05 (-0.06) for estimates based on the separability restrictions. In other words, the separability restrictions cause one to greatly understate the degree of within-group quality substitution as prices change. The same pattern was found by McKelvey (2011) and by Gibson and Kim (2013) when working with fewer (six and eight) and broader food groups.

The final three columns of Table 1 report the quantity demand elasticities and the comparison between the unrestricted estimates and those derived from the separability restrictions is also shown in Figure 3. The standard price method forces quality substitution to be zero, while the separability restrictions allow it but greatly understate it. Consequently, quantity demand elasticities are greatly overstated by these two methods. Using the unrestricted method, the 25th and 75th percentiles of the own-price elasticities of quantity demand are -0.10 and -0.26. In contrast, elasticities are much larger under the weak separability restrictions, with 25th and 75th percentiles of -0.23 and -0.74, although they are not as large as for the standard price method (-0.61 and -1.01) that rules out any quality substitution.

[13] This gap would be 0.48 rather than 0.40 if prices for pork belly were used instead of rump. In general, the groups with multiple items priced reveal the same pattern of results regardless of which price survey item is used.

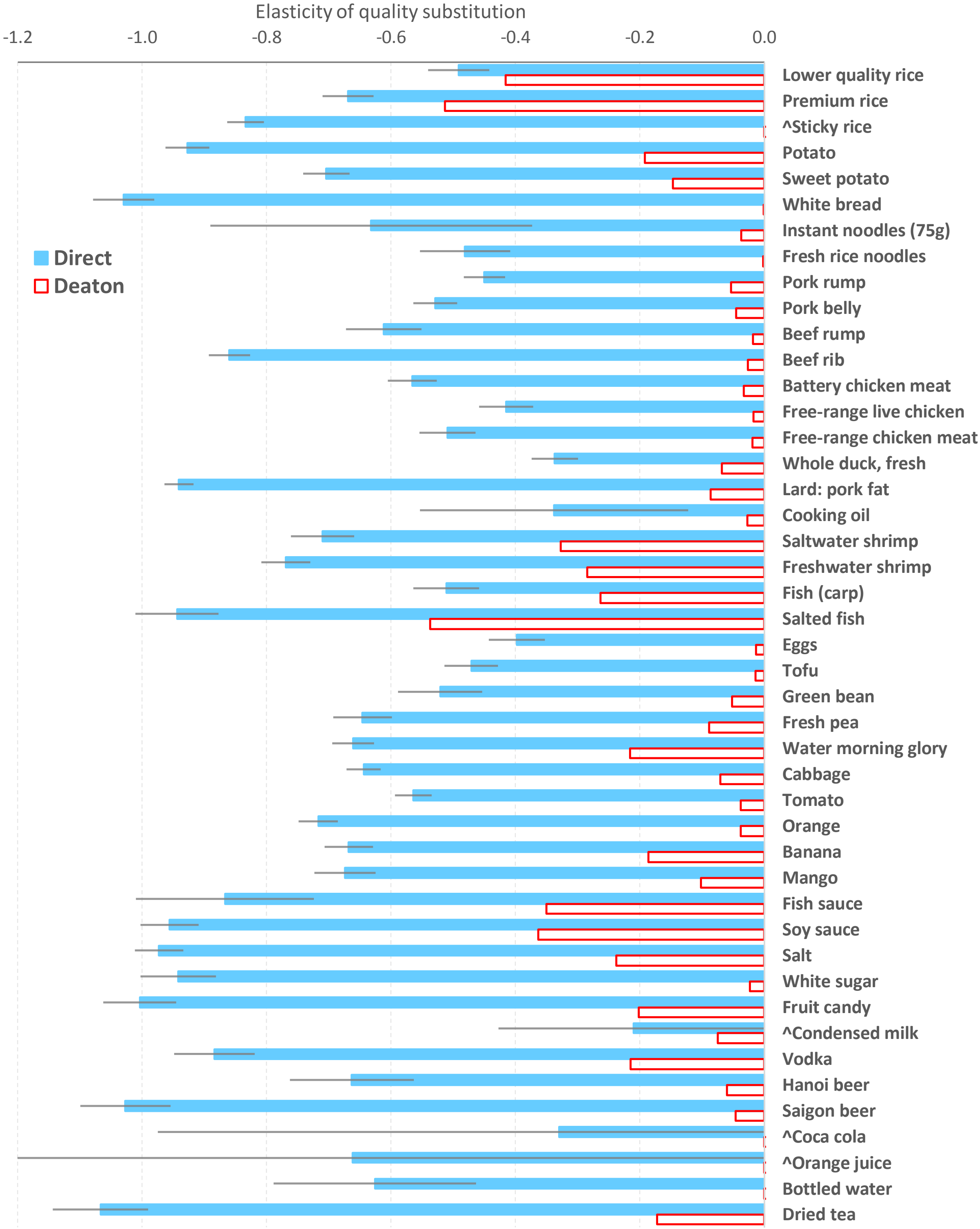
Table 1: Item-level Estimates of the Own-Price Elasticities of Quality Substitution and Quantity demand

Price Survey Item	Elasticity of Quality Substitution			Own-Price Elasticity of Quantity Demand		
	Unrestricted Method (Direct)	Deaton Method (Indirect)	Test of separability restrictions	Unrestricted Method (Direct)	Deaton Method (Indirect)	Standard Price Method
	(1)	(2)	(3)=(2)-(1)	(4)	(5)	(6)=(1)+(4)
Lower quality rice	-0.491***	-0.416***	0.075***	-0.106***	-0.181***	-0.597***
	(0.025)	(0.036)	(0.035)	(0.006)	(0.033)	(0.018)
Premium rice	-0.669***	-0.513***	0.155***	-0.078***	-0.234***	-0.747***
	(0.021)	(0.042)	(0.042)	(0.005)	(0.041)	(0.016)
Sticky rice	-0.834***	1.153	1.988	-0.371***	-2.360	-1.206***
	(0.015)	(2.162)	(2.162)	(0.041)	(2.162)	(0.029)
Potato	-0.927***	-0.192***	0.735***	-0.081***	-0.816***	-1.008***
	(0.018)	(0.033)	(0.038)	(0.021)	(0.034)	(0.005)
Sweet potato	-0.704***	-0.147***	0.556***	-0.316***	-0.872***	-1.020***
	(0.019)	(0.025)	(0.031)	(0.020)	(0.025)	(0.002)
White bread	-1.030***	-0.001	1.029***	0.020	-1.008***	-1.009***
	(0.025)	(0.014)	(0.030)	(0.017)	(0.017)	(0.008)
Instant noodles	-0.632***	-0.037*	0.595***	-0.212***	-0.808***	-0.845***
	(0.132)	(0.019)	(0.132)	(0.076)	(0.057)	(0.055)
Fresh rice noodles	-0.481***	-0.002	0.480***	-0.185***	-0.665***	-0.667***
	(0.037)	(0.010)	(0.038)	(0.016)	(0.027)	(0.025)
Pork rump	-0.450***	-0.053***	0.396***	-0.263***	-0.659***	-0.712***
	(0.037)	(0.010)	(0.038)	(0.016)	(0.027)	(0.025)
Pork belly	-0.529***	-0.045***	0.483***	-0.224***	-0.708***	-0.753***
	(0.018)	(0.004)	(0.017)	(0.009)	(0.009)	(0.009)
Beef rump	-0.612***	-0.018***	0.593***	-0.384***	-0.978***	-0.996***
	(0.031)	(0.003)	(0.030)	(0.036)	(0.018)	(0.018)
Beef rib	-0.860***	-0.026***	0.834***	-0.144***	-0.978***	-1.005***
	(0.017)	(0.003)	(0.017)	(0.019)	(0.006)	(0.005)
Battery chicken meat	-0.566***	-0.033***	0.533***	-0.108***	-0.641***	-0.675***
	(0.020)	(0.005)	(0.020)	(0.006)	(0.016)	(0.016)
Live free range chicken	-0.415***	-0.017***	0.398***	-0.104***	-0.502***	-0.520***
	(0.022)	(0.003)	(0.021)	(0.007)	(0.018)	(0.019)
Free range chicken	-0.509***	-0.019***	0.489***	-0.099***	-0.589***	-0.609***
	(0.023)	(0.005)	(0.022)	(0.013)	(0.021)	(0.021)
Whole duck, fresh	-0.337***	-0.068***	0.268***	-0.877***	-1.146***	-1.214***
	(0.019)	(0.011)	(0.022)	(0.027)	(0.015)	(0.010)
Lard: pork fat	-0.941***	-0.086***	0.854***	0.010**	-0.844***	-0.931***
	(0.012)	(0.017)	(0.021)	(0.005)	(0.022)	(0.013)
Cooking oil	-0.338***	-0.027**	0.310***	0.052	-0.258***	-0.285**
	(0.110)	(0.012)	(0.099)	(0.034)	(0.107)	(0.119)
Saltwater shrimp	-0.710***	-0.327***	0.383***	-0.323***	-0.706***	-1.033***
	(0.026)	(0.023)	(0.034)	(0.029)	(0.024)	(0.012)
Freshwater shrimp	-0.769***	-0.285***	0.484***	-0.257***	-0.741***	-1.026***
	(0.020)	(0.018)	(0.027)	(0.022)	(0.019)	(0.008)
Fish (medium carp)	-0.511***	-0.263***	0.248***	-0.509***	-0.758***	-1.021***
	(0.027)	(0.016)	(0.031)	(0.029)	(0.018)	(0.013)
Salted fish	-0.944***	-0.537***	0.407***	-0.035*	-0.442***	-0.979***
	(0.034)	(0.100)	(0.103)	(0.021)	(0.100)	(0.012)
Chicken eggs	-0.398***	-0.013**	0.385***	-0.100***	-0.485***	-0.499***
	(0.023)	(0.005)	(0.023)	(0.003)	(0.019)	(0.019)

Table 1 *continued*	Elasticity of Quality Substitution			Own-Price Elasticity of Quantity Demand		
Price Survey Item	Unrestricted Method (Direct) (1)	Deaton Method (Indirect) (2)	Test of separability restrictions (3)=(2)-(1)	Unrestricted Method (Direct) (4)	Deaton Method (Indirect) (5)	Standard Price Method (6)=(1)+(4)
Tofu, fresh	-0.471***	-0.014	0.456***	-0.721***	-1.178***	-1.192***
	(0.022)	(0.032)	(0.039)	(0.032)	(0.035)	(0.015)
Green bean	-0.521***	-0.052***	0.469***	-0.427***	-0.897***	-0.949***
	(0.035)	(0.011)	(0.036)	(0.031)	(0.013)	(0.006)
Fresh pea	-0.646***	-0.089***	0.557***	-0.286***	-0.844***	-0.933***
	(0.024)	(0.013)	(0.026)	(0.020)	(0.013)	(0.005)
Water morning glory	-0.661***	-0.216***	0.445***	-0.216***	-0.661***	-0.878***
	(0.017)	(0.029)	(0.033)	(0.012)	(0.030)	(0.008)
Cabbage	-0.644***	-0.071***	0.573***	-0.374***	-0.948***	-1.019***
	(0.014)	(0.019)	(0.023)	(0.016)	(0.020)	(0.007)
Tomato	-0.564***	-0.038***	0.525***	-0.392***	-0.918***	-0.957***
	(0.015)	(0.010)	(0.018)	(0.014)	(0.012)	(0.014)
Orange	-0.717***	-0.038***	0.679***	-0.059***	-0.738***	-0.776***
	(0.016)	(0.005)	(0.016)	(0.003)	(0.012)	(0.012)
Banana	-0.668***	-0.186***	0.481***	-0.250***	-0.732***	-0.919***
	(0.020)	(0.024)	(0.030)	(0.015)	(0.024)	(0.005)
Mango	-0.674***	-0.102***	0.572***	-0.234***	-0.807***	-0.909***
	(0.025)	(0.010)	(0.025)	(0.019)	(0.013)	(0.005)
Fish sauce	-0.867***	-0.350***	0.517***	-0.070*	-0.587***	-0.937***
	(0.073)	(0.027)	(0.065)	(0.038)	(0.032)	(0.034)
Soy sauce	-0.956***	-0.363***	0.592***	-0.022*	-0.615***	-0.978***
	(0.024)	(0.028)	(0.034)	(0.012)	(0.028)	(0.011)
Salt	-0.973***	-0.238*	0.734***	-0.009	-0.744***	-0.983***
	(0.020)	(0.132)	(0.134)	(0.007)	(0.133)	(0.013)
White sugar	-0.942***	-0.023**	0.918***	-0.080*	-0.998***	-1.022***
	(0.031)	(0.009)	(0.033)	(0.044)	(0.015)	(0.013)
Fruit candy	-1.004***	-0.202***	0.802***	0.002	-0.800***	-1.002***
	(0.030)	(0.020)	(0.038)	(0.024)	(0.021)	(0.010)
Condensed milk	-0.210*	-0.075***	0.135	-0.341***	-0.476***	-0.551***
	(0.111)	(0.014)	(0.102)	(0.057)	(0.067)	(0.076)
Vodka	-0.884***	-0.215***	0.669***	-0.051***	-0.720***	-0.936***
	(0.033)	(0.025)	(0.038)	(0.015)	(0.029)	(0.019)
Beer (Hanoi brand)	-0.663***	-0.060***	0.603***	-0.318***	-0.921***	-0.981***
	(0.051)	(0.010)	(0.053)	(0.051)	(0.022)	(0.021)
Beer (Saigon brand)	-1.027***	-0.046***	0.980***	0.021	-0.959***	-1.006***
	(0.037)	(0.008)	(0.038)	(0.034)	(0.015)	(0.013)
Coca cola 330ml can	-0.330	0.874	1.205	-0.258*	-1.463	-0.589***
	(0.329)	(0.926)	(1.068)	(0.140)	(1.007)	(0.206)
Orange juice, 300ml	-0.662*	0.866	1.528	-0.132	-1.660*	-0.799***
	(0.357)	(0.757)	(0.928)	(0.143)	(0.849)	(0.219)
Bottled water, 19 liter	-0.626***	0.653	1.279**	-0.142***	-1.421***	-0.768***
	(0.083)	(0.500)	(0.515)	(0.035)	(0.509)	(0.054)
Tea, Nguyen brand	-1.067***	-0.172***	0.894***	0.035*	-0.859***	-1.032***
	(0.039)	(0.026)	(0.044)	(0.021)	(0.030)	(0.018)

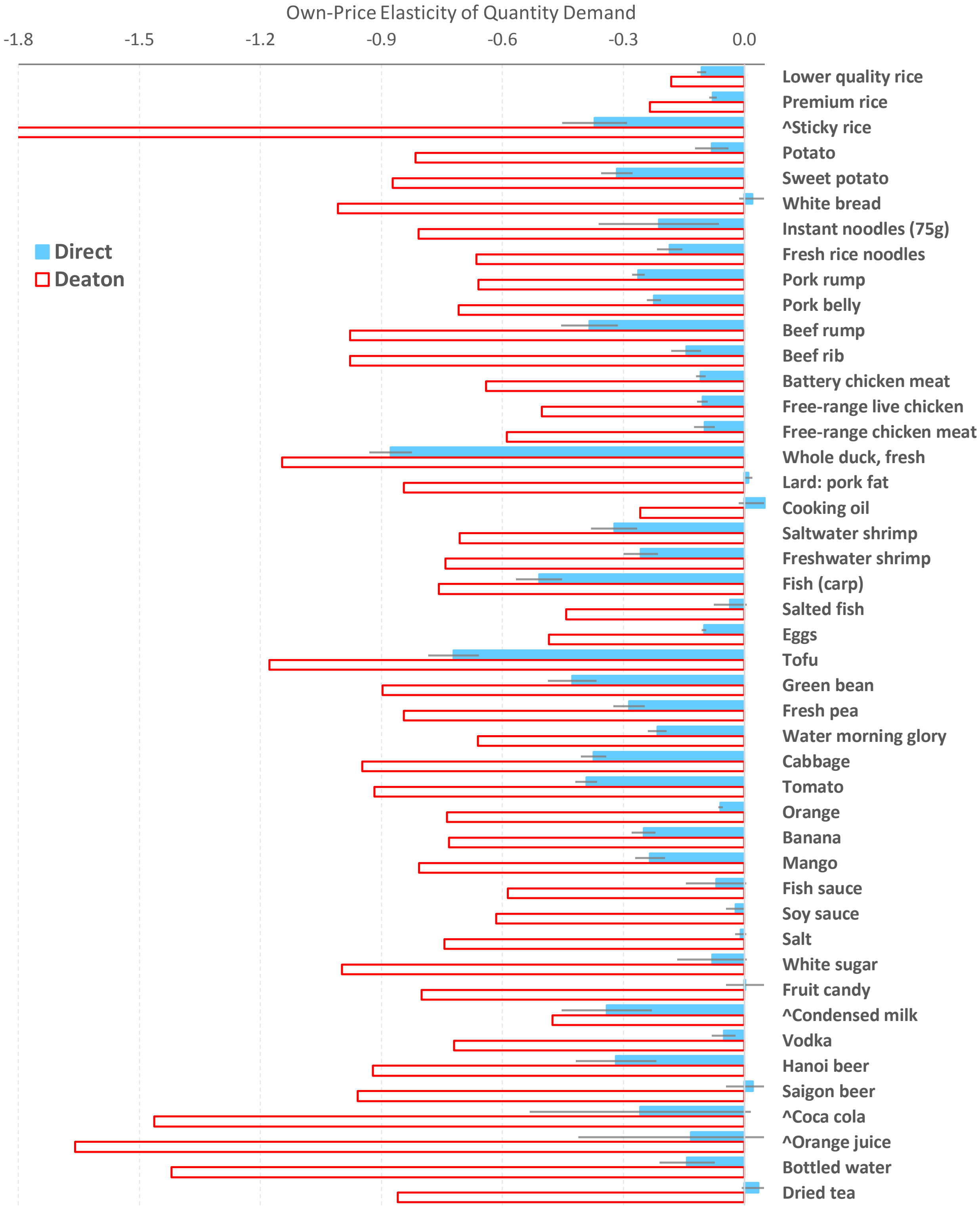
Notes: ***, **, * represent levels of statistical significance of 1%, 5% and 10%. Standard errors in ( ). The elasticities are derived from estimates of equations (1) and (2), and the restrictions imposed on those estimates. The concordances of price survey items to budget shares (and unit values) are in Appendix Table 1. The regressions include the other covariates described in Appendix Table 3, with equation statistics reported in Appendix Table 2.

Figure 2: Deaton's Weak Separability Restrictions Understate Quality Response to Price Changes



Notes: The direct estimates are all statistically significantly different from the Deaton estimates at $p<0.01$ except for the four foods with ^. The 95% CI for direct estimates is shown by the grey bars.

Figure 3: Own-Price Elasticities of Quantity Demand:
Direct Estimates *vs* Deaton Estimates



Notes: The direct estimates are all statistically significantly different from the Deaton estimates at $p<0.01$ except for four foods with ^. The 95% CI for direct estimates is shown by the grey bars.

In terms of the average item, the unrestricted own-price elasticity of quantity demand is -0.20 (with a median of -0.14), irrespective of whether we weight by budget shares or not. Thus, the quantity of food demand is not very own-price elastic once within-group quality substitution is accounted for. However, this lack of quantity response is hidden by typical approaches to using spatial price variation to estimate demand elasticities. If the standard price method is used, the average food item appears to have an own-price elasticity of quantity demand of -0.80 (mean) or -0.75 (median), weighting items by average budget shares (and in unweighted results the mean is -0.88 and the median is -0.94). The estimates based on weak separability restrictions are about the same, with a weighted mean (median) of -0.60 (-0.66) and an unweighted mean (median) of -0.83 (-0.80). Thus, compared to an approach that completely rules out within-group quality substitution, relying on weak separability to indirectly derive ψ_{GG} gives much the same (wrong) answer. It appears that using these separability restrictions leads one to understate the extent of quality substitution and therefore to overstate the extent to which quantity demand responds to price changes.

Sensitivity Analyses

The results in Table 1 are calculated separately for each price survey item, even for items that are part of the same consumption survey group. An alternative approach is to aggregate each price survey item into a group-level price index. The results of this more aggregate approach, using the harmonic means of the individual item prices to form the price index, are reported in Table 2. A test of the assumption of fixed price relativities within groups is also reported in this table.

For nine out of ten groups with multiple items in the price survey there is a significant difference between the directly estimated degree of quality substitution and the indirect estimate based on the separability restrictions. For the tenth group – bottled and canned water and soft drink – the indirectly (and very imprecisely) estimated elasticity of quality substitution ($\psi_{GG} - 1$) of 0.92 implies that consumers choose higher quality in places with higher prices. Putting aside that unlikely result, the average group-level elasticity of quality substitution with respect to own-price is -0.71 if directly estimated, but is just -0.17 if based on the separability restrictions.

Conversely, the responsiveness of quantity to own-price is greatly overstated if separability restrictions are used, with elasticities averaging -0.70 (excluding the soft drinks group). This is close to the average from the standard price method (-0.87). Yet the unrestricted own-price elasticity of quantity demand averages just -0.17, which is about as inelastic as the item-level analysis in Table 1 shows. Thus, using individual price survey items in the main analysis, rather than groups from the consumption survey, should not be a source of the gap between the unrestricted elasticities and those from either the standard price method or from using the weak separability restrictions. Instead, the switch to lower quality items in a group, while quantity hardly responds to price rises, seems inherent in household survey data, regardless of whether the analysis is pitched at item level or at group level.

Table 2: Group-Level Estimates of the Own-Price Elasticities of Quality Substitution and Quantity Demand and Tests of the Hicksian Separability Restrictions

Consumption Survey Group	Unrestricted Method (Direct) (1)	Deaton Method (Indirect) (2)	Test of separability restrictions (3)=(2)-(1)	Unrestricted Method (Direct) (4)	Deaton Method (Indirect) (5)	Standard Price Method (6)=(1)+(4)	Test for Hicksian separability, from item-level quality substitution terms
Rice (all qualities)	-0.521***	-0.428***	0.093***	-0.103***	-0.196***	-0.624***	0.000***
	(0.022)	(0.036)	(0.035)	(0.005)	(0.034)	(0.018)	
Roots and tubers	-0.710***	-0.178***	0.531***	-0.324***	-0.856***	-1.034***	0.000***
	(0.022)	(0.031)	(0.038)	(0.025)	(0.032)	(0.004)	
Pork	-0.424***	-0.045***	0.379***	-0.274***	-0.653***	-0.699***	0.002***
	(0.018)	(0.004)	(0.018)	(0.009)	(0.010)	(0.010)	
Beef	-0.788***	-0.023***	0.765***	-0.210***	-0.976***	-0.999***	0.000***
	(0.023)	(0.003)	(0.023)	(0.024)	(0.007)	(0.007)	
Chicken	-0.491***	-0.024***	0.467***	-0.098***	-0.565***	-0.589***	0.033**
	(0.020)	(0.004)	(0.020)	(0.005)	(0.017)	(0.017)	
Fats and cooking oil	-0.929***	-0.083***	0.846***	0.013**	-0.832***	-0.915***	0.000***
	(0.018)	(0.017)	(0.024)	(0.007)	(0.025)	(0.020)	
Fresh fish and shrimp	-0.710***	-0.327***	0.383***	-0.323***	-0.706***	-1.033***	0.074*
	(0.026)	(0.023)	(0.034)	(0.029)	(0.024)	(0.012)	
Cooking sauces	-0.932***	-0.361***	0.570***	-0.036**	-0.606***	-0.968***	0.237
	(0.033)	(0.026)	(0.037)	(0.017)	(0.027)	(0.015)	
Beer	-0.852***	-0.050***	0.801***	-0.131***	-0.932***	-0.983***	0.000***
	(0.037)	(0.007)	(0.038)	(0.035)	(0.017)	(0.016)	
Bottled/canned water or soft drink	-0.366*	0.922	1.289	-0.252***	-1.541	-0.618***	0.924
	(0.195)	(0.999)	(1.048)	(0.079)	(1.025)	(0.118)	

Notes

For estimates in columns (1) to (6) see Table 1. The Hicksian separability test reported in column (7) is described in the text.

The final column of Table 2 reports a test of whether price relativities within groups can be treated as fixed. This is carried out by comparing the elasticities of quality substitution for each item (as reported in column (1) of Table 1) within a group; for the seven groups with two items in the price survey it is just the *p*-value for the test of the two elasticities being equal. For the three groups with three items, every possible bilateral comparison is made and it is the largest *p*-value that is reported. For seven of the groups there is strong evidence against the assumption that price relativities within groups are fixed over space. For soft drinks and cooking sauces one cannot reject the equality of the item-level quality substitution elasticities. Finally, for the fresh fish and shrimp group the quality substitution elasticities for freshwater and saltwater shrimp are fairly similar ($p<0.08$ for the null of no difference) but both differ significantly from the quality substitution elasticity for fish.

Overall, these results suggest Hicksian separability is inconsistent with patterns of relative prices over space in Vietnam, corroborating Gibson and Kim (2015), who reject Hicksian separability when using multiple price specifications for six food groups. The Alchian-Allen effect of ‘shipping the good apples out’ makes this the expected pattern, since charges for processing, storage, or transport alter relative prices of high quality to low quality items within a group. Consequently, unit values should not be relied upon as a proxy for prices since within-group composition is likely to vary over time and space. However, unit values remain useful as an indicator of consumer choice over qualities since the equation (2) framework already controls for spatial price variation.

The second sensitivity check considers the type of unit values used to estimate equation (2). The main results used consumption unit values, based on the combined value and quantity of market purchases, own-production, and gifts. These give a more complete picture of consumer quality choice. However, when applied studies (wrongly) use unit values to proxy for price they mainly use purchase unit values, from the ratio of spending to purchase quantities, since these relate solely to market transactions. The different types of unit values should not matter; since they are on the left-hand side of equation (2) any random measurement error will not bias the elasticities. Thus, the direct estimate of quality substitution elasticities for pork (using rump as the price survey item) is -0.45 with either type of unit value, but the standard error is just 0.017 if using purchase unit values rather than 0.037 with consumption unit values. Since parameters from equation (2) are used to calculate all of the elasticities, this greater precision almost halves standard errors (compared with the Table 1 results) for all of the elasticities of quality and quantity. Therefore, the inferences about rejection of the weak separability restrictions, and the significant overstatement of quantity responses if these restrictions are imposed, are strengthened if purchase unit values are used.[14]

[14] The sensitivity analysis results for all 45 items using purchase unit values are available from the authors.

The final sensitivity analysis introduces cross-price effects, since the omission of these could be one reason for the estimates of ψ_{GG} being much less than one. In fact, this does not appear to be the case and the sluggish response of unit values to own-price is still apparent when cross-prices are added (but standard errors become wider). For example, if cross-prices for all of the meats (16 item prices from seven groups) are added to the equations for pork budget shares and pork unit values, the estimate of ψ_{GG} hardly changes, going from 0.55 with no cross-prices to 0.49 with cross-prices. The gap between the unrestricted elasticity of quantity demand and the quantity demand elasticities from either the standard price method or from using the weak separability restrictions is slightly larger than it was in Table 1. Thus the omission of cross-prices is not likely to affect the main findings about the importance of within-group quality substitution in response to price changes.

V. Conclusions and Implications for Demand Modelling

Policy makers in many countries are considering, or have imposed, taxes to cut intake of unhealthy items like fats and sugar-sweetened beverages. Proponents of taxes assume that quantity demand is fairly responsive to price. The empirical estimates of demand elasticities that applied economists have published over several decades undoubtedly contribute to this view. Yet evidence in many of these countries is from household surveys, with budget shares that vary with the choice of quantity and quality. If quality response to price is ignored, estimated price elasticities of quantity demand include quality responses, overstating likely effects of taxes. For example, Grogger (2016) uses elasticity estimates from Mexico to forecast that the one peso per liter tax imposed on soda from January 2014 will reduce steady state weight of Mexicans by up to four pounds. However, none of the studies providing the elasticity estimates have plausible (or in some cases, any) estimates of the adjustment of quality to price and so they are likely to have overstated the quantity response to price, causing expected health benefits of the soda tax to be exaggerated.

In this paper we used specially collected data on market prices and unit values for 45 food and drink items in Vietnam, to directly estimate the response of quality to price so that the elasticity of quantity demand is not tainted by quality responses. We also test the separability restrictions of Deaton (1988), which he proposed for untangling quality responses from quantity responses when price elasticities are estimated from household survey data. We reject these restrictions for 41 of the 45 items studied. Direct estimates show a much larger response of quality to price than do indirect estimates derived from Deaton's separability restrictions; for the average item the unit value rises by less than four percent for every ten percent increase in local prices and so the quality substitution elasticity is around -0.6. In contrast, the quality substitution elasticities derived from the separability restrictions are much closer to zero, with an unweighted average of just -0.05. In other words, these restrictions wrongly make it appear that quality responses are very small.

These different estimates of how quality responds to price matter greatly to the estimated magnitude of quantity responses. When no restriction is placed on quality responses, the average food and drink item that we study has an own-price elasticity of quantity demand of -0.20, and the 25th and 75th percentiles of the elasticities are -0.10 and -0.32. Instead, if quality adjustment is completely ruled out, by wrongly using the demand model for a homogenous good (the 'standard price method'), the elasticity for the average item is around -0.80, with 25th and 75th percentiles of -0.61 and -1.01. While Deaton's method does allow for quality substitution, it is subject to the separability restrictions, which greatly understate the extent of the quality response, so the quantity demand elasticities under these restrictions are not much different from those given by the standard price method, with 25th and 75th percentiles of -0.23 and -0.74.

Views about the likely efficacy of tax policy for meeting health objectives may be quite different if quantity demand elasticities that are purged of quality responses are used. Yet there are few reports of such elasticities in the literature, due partly to the lack of suitable data and partly to confusion about the appropriate framework for modeling demand with household surveys. Applied economists will make little headway in correctly using household surveys to estimate elasticities of quantity demand until better data on local prices and qualities are collected, so that consumer responses on both the quantity and quality margins can be directly estimated.

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Appendix
Table 1: Concordance between Items in the Price Survey and Groups in the Consumption Survey

	Price Survey		Consumption Survey	*n*:1
Code	Detailed Item Description	Code	Group Description	map
1011	Lower quality white rice (< 15% broken)	101	Rice	2
1012	Premium variety white rice (< 15% broken)	101	Rice	2
102	Sticky rice (Nep Nhung 5-7% broken)	102	Sticky rice	1
1051	Potato, unpackaged medium size (6-8/kg)	105	Roots and tubers	2
1052	Sweet potato, medium size (6-8 tubers per kg)	105	Roots and tubers	2
106	White bread (100g loaf, local)	106	Bread, flour	1
107	Instant noodles (Hao Hao brand, 75gram)	107	Instant noodles	1
108	Fresh rice noodles, tangled (unpackaged)	108	Fresh rice noodles	1
1101	Pork rump (boneless, not prepackaged)	110	Pork	2
1102	Pork belly (boneless, not prepackaged)	110	Pork	2
1111	Beef rump (boneless, not prepackaged)	111	Beef	2
1112	Beef rib (boneless, not prepackaged)	111	Beef	2
1131	Fresh battery chicken, whole, offal removed	113	Chicken	3
1132	Live free range chicken	113	Chicken	3
1133	Free range chicken, whole, offal removed	113	Chicken	3
114	Whole local duck, fresh, offal removed	114	Duck and other poultry	1
1171	Lard, pork fat, unpackaged	117	Fats and cooking oil	2
1172	Cooking oil, Neptune brand, 1 liter container	117	Fats and cooking oil	2
11811	Salt water shrimp, 7-10cm long	118	Fresh fish and shrimp	3
11812	Fresh water shrimp, 3-5cm long	118	Fresh fish and shrimp	3
1182	Fresh fish, medium size carp (≈2 per kg)	118	Fresh fish and shrimp	3
119	Dried, salted fish, regular	119	Dried fish and shrimp	1
121	Chicken eggs, medium size (≈65g per egg)	121	Eggs	1
122	Fresh tofu, not prepackaged	122	Tofu	1
124	Green bean, not prepackaged	124	Green bean	1
125	Fresh pea, not prepackaged	125	Fresh pea	1
126	Water morning glory, not prepackaged	126	Morning glory	1
128	Cabbage, medium size (≈ 2 per kg)	128	Cabbage	1
129	Tomato, medium size (≈ 8-10 per kg)	129	Tomato	1
131	Orange, local, large (≈ 4-5 per kg)	131	Orange	1
132	Banana, hand of local type, not prepackaged	132	Banana	1
133	Mango, from south of Vietnam (≈ 4 per kg)	133	Mango	1
1351	Fish sauce, Nam Ngu- Chinsu brand, 500ml	135	Cooking sauces	2
1352	Soy sauce, Trung Thành brand, 200ml bottle	135	Cooking sauces	2
136	Salt, MS brand, 500g bag	136	Salt	1
139	White sugar, Hoa brand, 1kg bag	139	Sugar	1
140	Fruit candy, 100-150g package, brand Hải hà	140	Confectionery	1
141	Condensed milk, Ong Tho brand, 380g can	141	Condensed milk	1
144	Vodka, Hà Nội brand, 300ml bottle, 29.5% alc	144	Alcohol	1
14511	Beer, Hà Nội brand, 450ml bottle, < 5% alc	145	Beer	2
14512	Beer, Sài gòn brand, 450ml bottle, < 5% alc	145	Beer	2
1461	Coca Cola, 330ml can	146	Bottled/canned water or soft drink	3
1462	Fruit Juice, Orange, Twister brand, 300ml can	146	Bottled/canned water or soft drink	3
1463	Bottled water, La Vie brand, 19 liter bottle	146	Bottled/canned water or soft drink	3
1501	Tea, Thái Nguyên dried tea, ordinary type	150	Tea	1

Note
'*n*:1 map' is the number of price survey items mapping to each consumption survey group.
Source
Based on the 2012 Vietnam Household Survey Living Standards Survey and Spatial Cost of Living Survey.

Appendix
Table 2: Weighted Descriptive Statistics and Summary Statistics for Budget Share and Unit Value Equations

Price Item Code	Consumption Group Code	Budget Shares Mean	Budget Shares Std Dev	Budget Shares R^2 of Eq (1)	Unit Values (log) Mean	Unit Values (log) Std Dev	Unit Values (log) R^2 of Eq (2)	Prices (log) Mean	Prices (log) Std Dev
1011	101	0.078	0.059	0.597	2.444	0.232	0.363	2.360	0.118
1012	101	0.078	0.059	0.594	2.444	0.232	0.328	2.683	0.140
102	102	0.005	0.024	0.078	2.900	0.244	0.173	2.884	0.222
1051	105	0.001	0.003	0.009	2.176	0.394	0.111	2.563	0.319
1052	105	0.001	0.003	0.008	2.176	0.394	0.151	2.274	0.293
106	106	0.001	0.003	0.015	3.190	0.450	0.007	3.338	0.258
107	107	0.007	0.010	0.053	3.343	0.502	0.012	3.559	0.056
108	108	0.002	0.004	0.023	2.511	0.424	0.058	2.199	0.162
1101	110	0.054	0.039	0.189	4.402	0.185	0.263	4.392	0.127
1102	110	0.054	0.039	0.188	4.402	0.185	0.212	4.318	0.138
1111	111	0.010	0.015	0.058	5.112	0.211	0.089	5.252	0.105
1112	111	0.010	0.015	0.058	5.112	0.211	0.071	4.906	0.172
1131	113	0.023	0.024	0.113	4.440	0.259	0.138	4.069	0.187
1132	113	0.023	0.024	0.117	4.440	0.259	0.172	4.596	0.166
1133	113	0.023	0.024	0.118	4.038	0.289	0.149	4.748	0.175
114	114	0.006	0.012	0.031	3.687	0.288	0.281	4.170	0.186
1171	117	0.009	0.009	0.282	3.687	0.288	0.020	3.314	0.332
1172	117	0.009	0.009	0.292	3.876	0.457	0.022	3.763	0.038
11811	118	0.039	0.036	0.154	3.876	0.457	0.242	5.230	0.294
11812	118	0.039	0.036	0.126	3.876	0.457	0.204	4.812	0.297
1182	118	0.039	0.036	0.110	4.435	0.524	0.243	3.919	0.226
119	119	0.004	0.009	0.081	0.986	0.256	0.177	4.349	0.222
121	121	0.007	0.007	0.145	2.780	0.411	0.179	1.181	0.138
122	122	0.005	0.006	0.125	3.365	0.380	0.119	2.720	0.254
124	124	0.001	0.002	0.041	2.429	0.426	0.067	3.462	0.162
125	125	0.001	0.003	0.025	1.784	0.482	0.127	2.584	0.245
126	126	0.004	0.005	0.075	2.002	0.501	0.163	1.930	0.384
128	128	0.002	0.004	0.032	2.388	0.360	0.181	1.962	0.474
129	129	0.002	0.002	0.029	2.953	0.395	0.172	2.423	0.324
131	131	0.002	0.004	0.079	2.064	0.533	0.138	3.203	0.361
132	132	0.003	0.004	0.038	2.780	0.497	0.177	2.116	0.374
133	133	0.002	0.003	0.025	3.048	0.465	0.190	3.267	0.290
1351	135	0.004	0.004	0.190	3.048	0.465	0.104	2.864	0.088
1352	135	0.004	0.004	0.184	1.739	0.497	0.107	2.494	0.301
136	136	0.001	0.001	0.176	3.030	0.165	0.017.	1.701	0.408
139	139	0.004	0.004	0.122	3.847	0.500	0.011	3.076	0.080
140	140	0.005	0.005	0.088	4.830	0.929	0.084	1.705	0.260
141	141	0.007	0.020	0.117	2.855	0.421	0.077	5.283	0.136
144	144	0.005	0.009	0.149	2.925	0.395	0.162	3.455	0.178
14511	145	0.004	0.008	0.067	2.925	0.395	0.070	2.135	0.146
14512	145	0.004	0.008	0.058	2.449	0.973	0.071	2.152	0.191
1461	146	0.002	0.005	0.142	2.449	0.973	0.057	2.000	0.100
1462	146	0.002	0.005	0.138	2.449	0.973	0.055	1.965	0.105
1463	146	0.002	0.005	0.132	4.465	0.645	0.073	2.749	0.453
1501	150	0.005	0.007	0.101	2.444	0.232	0.030	4.833	0.263

Note

There are *N*=4383 observations.

Appendix

Table 3: Weighted 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	0.501	0.142	0.076	0.964

Notes

There are N=4383 observations. Economic activity categories for the household head are not mutually exclusive, so add to more than 1.0.