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Quality, Quantity and Nutritional Impact of Rice Price Changes in Vietnam

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Abstract

Asian governments intervene in the world rice market to protect domestic consumers. Whether consumers are nutritionally vulnerable depends on the elasticity of calories with respect to rice prices. Common demand models applied to household survey and market price data ignore quality substitution and force all adjustment onto the quantity (calorie) margin. This paper uses data from Vietnam on market prices, food quantity and quality. A ten percent increase in the relative price of rice reduces household calorie consumption by less than two percent but this elasticity would be wrongly estimated to be more than twice as large if quality substitution is ignored.

Keywords

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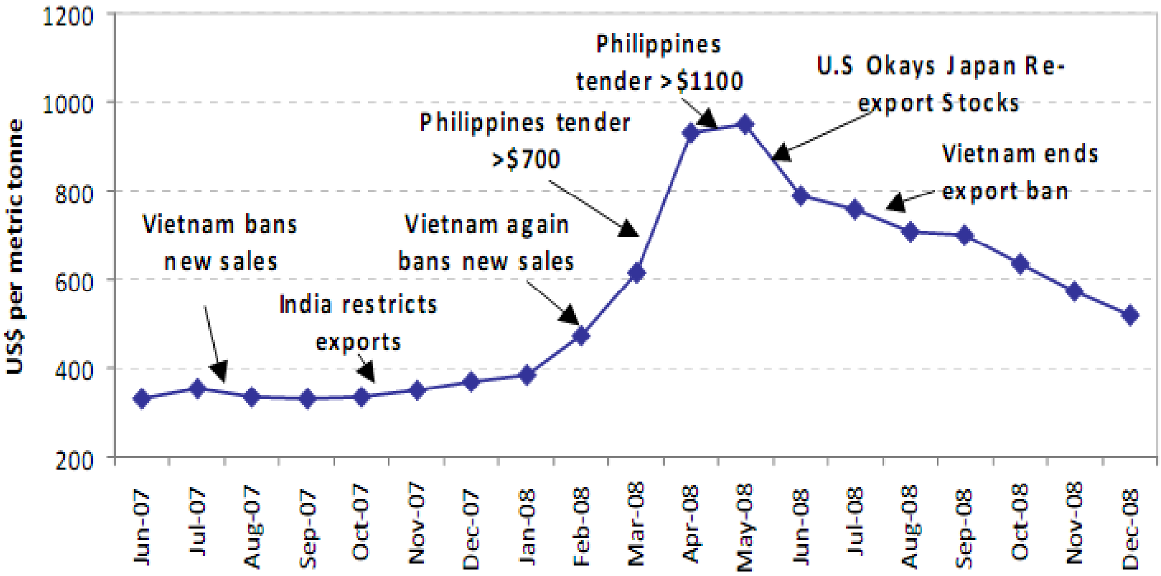
1. INTRODUCTION

Rice is arguably the world's most important crop, with nearly one-half of the population eating it as a staple. But the world market is thin, with only seven percent of rice crossing borders.[1] A thin market and 'beggar thy neighbor' policies of major traders create big fluctuations in world rice prices. For example, world prices trebled within four months in early 2008, due partly to export bans by the second and third largest rice exporters (Vietnam and India), panic buying by the Philippines (the largest importer), and resulting hoarding by small traders and households as talk of a price spiral induced a real price spiral (Timmer, 2009). These events are aptly described by Slayton (2009) as "Asian governments carelessly setting the world rice market on fire" and are illustrated in Figure 1, which charts the course of world rice prices in 2007/08.

Figure 1: Movements in world rice price (Thai 100% B) and government interventions



Source: Slayton (2009)

The export bans by Vietnam and India that helped drive up world prices, reflect political goals of protecting local consumers from rice price inflation.[2] Yet despite trying to reduce local prices the opposite occurred. In Ho Chi Minh City, buyers reacted to news of prices in the April import tender of the Philippines' National Food Authority being almost $500 per ton higher than in the March tender by buying all available rice, and local prices doubled as rice disappeared from city markets over two days (Slayton, 2009). This rapid inflation eventually eased but longer

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[1] Internationally traded rice is around 30 million metric tons, out of 440 million tons (milled rice equivalent) produced in a typical year (Timmer, 2009). In contrast, over 18 percent of world wheat production is exported.

[2] Vietnam may gain, in aggregate, from higher rice prices (Ivanic and Martin, 2008), but gains are concentrated while loses are spread, so higher rice prices make the majority of households worse off (Linh and Glewwe, 2011).

term damage is likely. Volatile prices discourage governments from relying on the world rice market, making the thinner market even more unstable (Timmer, 2009). Withdrawal from trade lets political goals of rice self-sufficiency (rather than food security) persist, slowing farmers' diversification away from rice growing. Yet despite the short-run price increases in 2007/08, the long-term trend is for rice prices to decline by more than prices of other staples.[3] Thus Asian farmers may be locked into producing a crop with declining prospects rather than diversifying into higher valued crops that might better help them escape from poverty.[4]

Asian governments may intervene in rice markets due to a belief that consumers are nutritionally vulnerable to rice price rises. Despite two decades of rapid economic growth, the depth of hunger in India and Vietnam is hardly changed,[5] and average calorie consumption is falling (Deaton and Dr□ze, 2009). Recent evidence of a large, negative, elasticity of calories with respect to rice prices in Vietnam (Gibson and Rozelle, 2011) may affirm this potential concern of policy makers. But this evidence is from a demand specification that ignores quality responses to price rises, forcing all adjustment onto the quantity margin (and hence onto calories). Yet as McKelvey (2011) shows, quality substitution in response to price changes is very important, and if ignored may bias quantity demand elasticities even if market prices are perfectly observed.

In light of these findings, we revisit the elasticity of calories with respect to rice prices in Vietnam. We use new household survey and market price data, along with a demand model that allows quality substitution as prices change, to estimate an eight-food demand system. The own- and cross-price elasticities of quantity demanded with respect to rice prices are weighted by each food's share of total calories to derive the elasticity of calories with respect to rice prices. We find that, *ceteris paribus*, a ten percent increase in the relative price of rice reduces calories available to households by less than two percent.[6] We would wrongly claim this elasticity to be more than twice as large if quality substitution is ignored. In other words, households in Vietnam

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[3] Timmer (2009) calculates trends in real prices of rice, wheat and maize since 1900 and notes (p.26) that "even if maize and wheat prices remained stable in real terms, rice prices would be lower by more than 40 percent after a century." Likely reasons for the faster decline in rice prices are slower population growth in rice eating countries, low and declining income elasticities, lack of use of rice for livestock feed and biofuels, and the impact of self-sufficiency goals which raise overall rice production and contribute to the long-run decline in prices.

[4] This lock-in is especially likely in Vietnam, which mandates that certain land can *only* be used for rice growing.

[5] The World Bank reports "depth of hunger" in the *World Development Indicators* as the average shortfall in calories per day that undernourished people face, compared with their dietary requirements. For 1997, 2002 and 2006 the estimates are 270, 260 and 280 kilocalories per person per day for Vietnam and 220, 220 and 260 for India.

[6] Clearly some households in Vietnam would have real income increases (and likely more calories) if rice prices rise so the *ceteris paribus* assumption may make our estimates especially conservative. However the main aim of the paper is to illustrate the implications of ignoring quality substitution and for this task it is sufficient to consider only the consumption side of household activities and not the production side.

have considerable scope for protecting calorie consumption in the face of higher rice prices by downgrading the quality of the foods that they consume.

These findings suggest that recent efforts to raise rice quality in Vietnam may remove a means of coping with high prices, in the form of consumers downgrading quality to maintain calories.[7] The results also suggest that Vietnamese households are less nutritionally vulnerable to rice prices than found by Gibson and Rozelle (2011), weakening a potential justification for the government of Vietnam to periodically ban rice exports. Since Vietnam is the second largest rice exporter and one of the instigators of world rice market instability, this is of broad interest.

The results also may be of interest to economists who apply demand models to household survey data, since they corroborate McKelvey's (2011) finding of large quality substitution. In contrast, previous studies (e.g. Deaton, 1997; Gibson and Rozelle, 2011) find measurement error to be the bigger problem when unit values (expenditures divided by prices) from household surveys are used as a proxy for price in demand studies. One implication of quality substitution being important is that if demand parameters are to be estimated from budget share models, as has been popular at least since Deaton and Muellbauer (1980), it will be necessary for surveys to simultaneously collect price and quality data (with unit values as one available indicator of quality). Hence our findings can inform data collection strategies, since most household surveys currently do not collect both market prices and unit values.

The rest of the paper is as follows. Section 2 describes the demand specifications that we use, which rely both on unit values, as a measure of quality, and on market prices. This discussion draws heavily from methods proposed by McKelvey (2011) and Deaton (1990). Section 3 describes the survey data, and explains how the market prices and unit values were collected. Section 4 contains the main results, with comparisons amongst the elasticities from the alternative procedures, while Section 5 has the conclusions.

2. DEMAND SPECIFICATION AND ESTIMATION METHODS

Since the seminal work of Deaton and Muellbauer (1980), applied demand studies mostly use budget share models, for analytic convenience and improved estimation. When the data are from a household survey, the dependent variable is w_{Gi}, the share of the budget devoted to food group G by household i. The typical variables that theory suggests would explain budget shares are the logarithm of total expenditure, $\ln x$, the logarithm of prices for foods in group H, $\ln p_H$, and a set of household characteristics and conditioning variables (e.g. demographics, education, labour market status and expenditures on non-food goods) that are captured in the vector $\mathbf{z}$:

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

[7] See, for example, Decree 109 of the Socialist Republic of Viet Nam regarding rice warehouse storage capacity, drying machine systems, and husking machines which aims to improve rice quality.

One departure from textbook theory when using household survey data is to allow for consumers choosing both quantity and quality. Thus, expenditure on group G represents price, quantity, *and* quality, and can be defined as the product of the unit value (v_G, average expenditure per unit) and total quantity, $v_G Q_G$. So, differentiating the logarithm of the budget share with respect to $\ln x$ and $\ln p_H$ does not give the usual expenditure and price elasticities. Instead, a second equation is needed to model quality choice (based on the unit values, v_{Gi}):

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

The variables are as defined for equation (1), with superscripts 0 and 1 used to distinguish parameters on the same variables in each equation, and u_{Gi}^0 and u_{Gi}^1 are idiosyncratic errors. Noting that $w_G = v_G Q_G / x$, differentiating equation (1) gives:

$$\partial \ln w_G / \partial \ln x = \beta_G^0 / w_G = \varepsilon_G + \beta_G^1 - 1 \tag{3a}$$

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

where ε_G and ε_{GH} are elasticities of quantity demanded with respect to total expenditure and to the price of H, β_G^1 the elasticity of the unit value with respect to total expenditure (the *quality elasticity*) and ψ_{GH} the elasticity of the unit value to the price of H (the *quality substitution elasticity).* The key parameters for calculating how rice prices affect calories are the ε_{GH}.

If quality substitution is ignored, the elasticity formula becomes:

$$\varepsilon_{GH} = \left(\theta_{GH} / w_G\right) - \delta_{GH}, \tag{3c}$$

(where δ_{GH} equals 1 if G=H, and 0 otherwise), rather than $\varepsilon_{GH} = (\theta_{GH} / w_G) - \psi_{GH}$. Rewriting equation (2) in terms of $\ln p_H$ shows that if unit values are used in lieu of prices in the budget share equation (as done in many studies), the coefficient would not be the θ_{GH} from equation (1) but rather $\psi_{GH}^{-1}\theta_{GH}$. Since ψ_{GH} cannot be estimated without prices the resulting elasticities therefore cannot be identified, unless some restrictions are applied to indirectly derive ψ_{GH}.

The most common restrictions for deriving ψ_{GH} are from a method developed by Deaton (1990). This method first purges household-specific demographic and income effects from the budget shares and unit values by estimating variants of equations (1) and (2), with dummy variables for each cluster in place of unobserved prices. This relies on surveys being clustered by location so that households in the same cluster can be assumed to face the same local prices. Residuals from these regressions capture measurement errors in unit values and budget shares, which are corrected for in 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 (only household-specific quality effects previously being purged), so a final step in deriving ψ_{GH} is needed, which relies on two key assumptions: weak separability of commodity groups and fixed price relativities within a commodity group.

The weak separability assumption allows the unobserved effects of price on quality to be imputed from the price elasticity of quantity and the income elasticities of quality and quantity:

$$\begin{aligned} \frac{\partial \ln v_{Gic}}{\partial \ln p_{Hc}} = \psi_{GH} &= \delta_{GH} + \beta_G^1 \frac{\varepsilon_{GH}}{\varepsilon_G} \\ &= \delta_{GH} + \frac{\beta_G^1}{1 + \beta_G^0 / w_G} \left(\theta_{GH} / w_G - \delta_{GH} \right) \end{aligned} \tag{4}$$

This restriction and the coefficients estimated in the regressions provide Deaton's method with all parameters needed to calculate the price elasticity of quantity demand that allows for quality substitution: $\varepsilon_{GH} = (\theta_{GH} / w_G) - \psi_{GH}$. The fixed price relativities assumption is that when the price vector for all 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, it is the inter-area scalar variation that dominates the intra-group variation in relative prices.

Depending on the type of data used and assumed quality substitution, there are four ways to calculate the price elasticity of quantity demand. Two methods ignore quality substitution, and calculate elasticities using equation (3c); the Standard Price Method, which uses equation (1) as written, and the Standard Unit Value Method which replaces market prices with unit values in equation (1).[8] Deaton's method allows non-zero quality substitution, but under the strictures imposed by weak separability, and only needs unit values, relying on variants of equations (1) and (2) with cluster dummy variables in lieu of the unobserved market prices. The Unrestricted Method uses information on both market prices and unit values to estimate equations (1) and (2). Hence, ψ_{GH} can be directly estimated without restrictions and equation (3b) can be used to calculate a quantity elasticity that allows quality substitution. Table 1 summarizes the four methods and the equations that they rely upon for their elasticity calculations.

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[8] The names given to the methods follow those used by McKelvey (2011).

Table 1: Summary of the methods used to estimate price elasticities of quantity demanded

		Assumption About Quality Substitution	
		Zero	Non-zero
Data	Market prices	Standard Price Method (Equation 1 and 3c)	
	Unit values	Standard Unit Value Method (Equations 1# and 3c)	Deaton Method (Equations 1*, 2*, 3b, 4)
	Both unit values and market prices		Unrestricted Method (Equations 1, 2, 3b)

Notes:

Equation (1) is estimated with unit values instead of market prices.

* Equations (1) and (2) are estimated with cluster dummy variables instead of market prices.

3. DATA

The budget shares, unit values, and all explanatory variables except for the market prices, come from the nationally representative 2010 Vietnam Household Living Standards Survey (VHLSS). The VHLSS samples in 3,130 communes, with consumption data collected from three surveyed households per commune.[9] In 2010, the fieldwork was split into three rounds, in June, October and December, surveying in one-third of the sampled communes per round. The consumption questionnaire uses a 30-day recall, for purchases and consumption from own-production and gifts, for 53 food and beverage groups. For 39 of these groups, the quantities consumed are reported (in either kilograms or litres) while no quantities are available for the other 14 groups.[10]

The focus of the demand models is on the eight most calorically important food groups with quantity information available: rice, instant noodles, pork, beef, chicken, fish, fats and oils, and sugar. These eight groups provide almost 70 percent of average total calories for households in Vietnam, due especially to rice.[11] The calories from the quantified foods are straightforward to estimate, simply combining quantity data from the VHLSS with the average calorie content of typical foods in each group. But it is more difficult to estimate calories from the 14 food groups without quantities, which include street meals and the residual categories at the end of groups of similar types of quantified foods (e.g. 'other meats', 'other vegetables', 'other fruits'). The budget shares for these food groups are rising with higher incomes but the VHLSS questionnaire

[9] Vietnam's 9000 communes are the lowest level administrative unit. They average about 10,000 people or 2,500 households. A larger VHLSS sample from the same surveyed communes is given an income-only questionnaire.

[10] The quantity data were carefully checked for outliers, trimming any whose unit value was more than five standard deviations from the mean.

[11] The least important of the eight groups, beef, provides just one-half of one percent of total calories, so extending to more groups would make little difference to the final results since the elasticities are weighted by calorie shares.

has adapted only slowly to this dietary diversity due to a desire to maintain comparability with surveys from earlier years when the non-quantified foods were less widely eaten.

The calorie shares for each food group are needed to derive the elasticity of calories with respect to rice prices from the quantity demand elasticities. To form these shares, we assume that since the unquantified foods have processing margins, convenience value (such as street meals), or provide diversity (the 'other' categories), their cost per calorie should be higher than for the quantified foods. Therefore the calorie shares were calculated under three different assumed premiums in the cost per calorie of the unquantified food groups; 50 percent, 100 percent and 150 percent. Based on this, the unquantified groups may contribute 15-21 percent of total calories, with a larger share if their cost premium is lower (Table 2).[12] The calorie contributions of each quantified food group vary little with the assumed premiums, so even though these assumptions will be carried throughout the analysis, this source of uncertainty about calorie shares should not greatly affect the interpretation of the calorie elasticities.

Table 2: Calorie shares for each food group

	Assumed price per calorie premium for unquantified foods		
	50% premium	100% premium	150% premium
Rice	0.496	0.518	0.533
Instant noodles	0.017	0.018	0.018
Pork	0.051	0.054	0.056
Beef	0.005	0.005	0.005
Chicken	0.012	0.013	0.013
Fish	0.017	0.018	0.018
Fats and Oils	0.048	0.050	0.052
Sugar	0.016	0.017	0.018
Other quantified foods (31)	0.129	0.136	0.140
Non-quantified foods (14)	0.208	0.171	0.146
Implied calories per person per day (median)	*2194*	*2088*	*2027*

Notes: Author's calculations from VHLSS data.

The market price data are from a spatial cost of living survey fielded in conjunction with the second and third rounds of the VHLSS. Specifically, in all communes in the October round of the VHLSS sample (n=1049) and in one-half of the December round sample (n=539, chosen at random) a detailed price survey of 64 items was conducted in the main market in the commune. Of these, 16 items are from the eight food groups studied here; except for sugar and instant noodles, all groups have prices for multiple specifications (e.g. both 'pork belly' and 'pork rump' are priced within the pork group). Multiple specifications for the same food group allow a test of the fixed price relativities assumption used by the Deaton method, and the data firmly reject this assumption (Gibson and Kim, 2011). We therefore form a price index for each food group, using the geometric mean of the prices of all of the available specifications from the

12 The apparent calorie consumption is also higher, at 2190 calories per person per day, with the lower premium.

group, rather than relying on the price level of a single specification in a particular market to indicate the local price level for the entire group.[13]

The type of price survey used here can face problems with missing values and with lack of consistency over space. Therefore the surveyors were instructed to take two observations on the price of a detailed specification (aided by a photograph to ensure standardization) and to also record whether that particular specification was the most common one in the market. A particular size, and brand name (for packaged goods), was specified to avoid variation due to either bulk discounting or quality discounting. In 80 percent of the market-food combinations, the requested specification was the most common. For a further eight percent, the target specifications were available but were not the most common in the market. The 12 percent of market-food combinations with the target specification missing are due mainly to sugar (32 percent of markets), fish (26 percent) and chicken (21 percent). But these figures overstate the extent of the missing price problem since they treat each individual specification separately, even when there were multiple specifications priced for the same food group. For example, in only three percent of markets were *none* of the three specifications of chicken available, and for fish the comparable rate was just 15 percent.

To deal with the missing prices problem, the surveyors also gathered the price of the most commonly available specification that was not the target specification. These data were used in a regression for the price of the target specification on the prices of the alternate specifications (using brand name fixed effects, or for unbranded items creating quasi-brands by dividing into intervals based on their unit prices) and a set of regional fixed effects. These regressions were used to impute the price of the target specification in the few markets where it was missing so that no observations are dropped due to missing prices. To check if this strategy affects the results, one sensitivity analysis reported below restricts the estimation sample just to communes where prices of the target specification were observed rather than imputed.

The price survey was carried out in only one-half of the communes sampled for the VHLSS, so the estimation sample falls to n=4758, from the 9,300 households with consumption data. This sample should still be nationally representative since it has all communes from one round of the VHLSS (and allocation to rounds is random) and one-half of the communes in another round, chosen at random. Descriptive statistics on these observations are reported in Appendix Table 1, for the budget shares, unit values and control variables (including the group price indexes).The other control variables include the logarithms of real total expenditure and household size, the share of the household who are young children, youths, elderly, and migrants (defined as 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

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[13] The use of the geometric mean for aggregating primitives into a price index is recommended by the literature on ‘formula bias’ in the Consumer Price Index. Earlier evidence on the failure of the fixed price relativities assumption is reported by Minten and Kyle (1999).

are not mutually exclusive), the budget shares for other food and other items (since this is a conditional demand system), and a dummy for the December survey wave.[14]

4. RESULTS

A total of 48 equations are estimated to get all of the parameters required for the elasticities: eight budget share equations that use market price indexes, eight budget share equations that use unit values, and 16 equations each for Deaton's method and for the Unrestricted Method. Since these equations produce too much detail to report every parameter, we briefly summarize the estimation results before turning to a comparison of the various elasticities that are derived from the parameters. The budget share regressions range in explanatory power from an R^2 of 0.68 for rice to 0.08 for instant noodles (see Appendix Table 1 for the full list of explanatory variables).[15] If the market price indexes are replaced with cluster fixed effects, as used by Deaton's method, the R^2 values increase by almost 40 points, to range from 0.87 for the rice budget share equation to 0.50 for the budget share equation for instant noodles.

In Table 3 the own-price elasticities of quantity demand, ε_{GG} that come from the four methods are reported for each of the eight food groups. These are from specifications that also include cross-prices and the other covariates, but to simplify the presentation only the own-price elasticities are reported. In addition, the quality substitution elasticities, ψ_{GH} from the unit value equations (equation (2)) for the Deaton Method and the Unrestricted Method are also reported. The last four columns of Table 3 report the results of comparing the quantity elasticities produced by the various methods, including tests of the statistical significance of the differences.

The results in the first column come from regressing budget shares on group price indexes formed from the market price survey. These own-price elasticities are calculated under the assumption that price changes do not cause households to change the quality mix of the items demanded in each food group so all adjustment is forced onto the quantity margin. The range of elasticities is from -0.70 to -1.08 so rice price changes may be expected to have a large impact on calorie consumption due to the substantial quantity responses and the variation in calorie density between the food groups.

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[14] The real expenditures account for inflation of 4.7% between the October and December survey rounds and for spatial price differences (distinguishing between urban and rural sectors in each of six regions). The spatial price differences are calculated from a Törnqvist index formed from the 64 items in the price survey. The between rounds temporal inflation rate is derived from a food Engel curve, with nominal expenditures, relative prices, demographics and round dummy variables as explanatory variables, using the approach developed by Hamilton (2001) to derive true deflators from an Engel curve.

[15] The detailed regression results are available from the authors. For budget share regressions where unit values replace prices, any missing unit values were replaced with cluster averages, and if these were unavailable with District averages or Province averages. There are 642 Districts and 63 Provinces in the dataset, so these averages still provide a substantial amount of variation to reflect local prices.

The results in the second column come from regressing budget shares on unit values, and also ignore quality substitution. If it is appropriate to ignore such substitution, the two sets of elasticities should be similar but for the effect of any measurement errors in the unit values.[16] In fact, a consistent pattern when comparing the first two columns is that the unit value-based elasticities are always closer to zero, with the differences always statistically significant (Table 3, column (7)). This is to be expected in a budget share equation if quality substitution is important and demand is own-price inelastic. The reason is that with quality substitution, unit values will not change by as much as do prices. Hence the same movement in budget shares is attributed to smaller movement in the right-hand side variable when unit values act as the proxy for price, increasing the magnitude of the estimated θ_{GG} coefficient and moving elasticities further from their 'default value' of -1 in a budget share equation (as occurs if $\theta_{GG} = 0$).

Moreover, a direct test refutes the assumption of the Standard Price Method and Standard Unit Value Method that households do not alter the quality mix of the foods that they consume as prices change. For all eight food groups, the quality substitution elasticities, ψ_{GH} from the unit value equations in the Unrestricted Method (column (5), Table 3) are significantly less than 1.0, which is the value that is required if all adjustment to price changes is on the quantity margin and none is on the quality margin. In other words, as prices rise the unit values rise less than proportionately, due to the action of households in downgrading the quality of foods bought within each group as a means of coping with higher prices. Indeed, for the major calorie sources of rice, pork and fats, the values of ψ_{GH} are just 0.44, 0.39 and 0.24 indicating that an increase in the price index for a food group elicits a percentage increase in the unit value which is less than one-half as large, because households respond to higher prices by substituting towards lower quality, cheaper, items within the food group.

Since few studies have data on both unit values and market prices, directly estimating ψ_{GH} from equation (2) is typically infeasible. Absent such data, studies that want to allow for quality substitution have to apply restrictions to indirectly derive ψ_{GH} from parameters estimated from the available data. The most common of these restrictions are due to the weak separability assumptions used by Deaton's method, as described in equation (4). But at least for Vietnam, the derived values of ψ_{GH} obtained by applying the weak separability assumptions appear to provide a poor approximation to the unrestricted estimates of ψ_{GH}, as seen by the results in column (10) that compare the quantity elasticities that depend on the estimates of ψ_{GH}, which is a finding in common with previous study.[17]

[16] Gibson and Rozelle (2011) show that for price-inelastic items, if errors are in quantities (and unit values) but not in expenditures, it will bias estimated elasticities away from zero (ie., more elastic), while if the errors are in expenditures (and unit values) but not in quantities the bias will be towards zero (ie., less elastic).

[17] McKelvey (2011) carries out a similar test (but reports Ψ_{GH}-1 rather than Ψ_{GH}). For the food groups he considers, the quality substitution elasticities from Deaton's method are significantly different from the unrestricted values, with the effect being to make quality substitution appear substantively much smaller than it actually is.

Table 3: Own-price elasticities of quantity and quality substitution and tests of elasticity differences between methods

	Standard Price Method	Standard Unit Value Method	Deaton Method		Unrestricted Method		Column differences			
			Quality	Quantity	Quality	Quantity	(1)-(2)	(1)-(6)	(2)-(6)	(4)-(6)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Rice	-0.827***	-0.599***	0.145***	-0.363***	0.437***	-0.265***	-0.228***	-0.562***	-0.333***	-0.097***
(*n*=2693)	(0.023)	(0.054)	(0.006)	(0.094)	(0.039)	(0.037)	(0.039)	(0.039)	(0.034)	(0.037)
Noodle	-0.897***	-0.435***	0.051***	-0.998***	0.203	-0.110	-0.462***	-0.796**	-0.334***	-0.897***
(*n*=3071)	(0.104)	(0.037)	(0.019)	(0.126)	(0.193)	(0.091)	(0.112)	(0.193)	(0.092)	(0.091)
Pork	-0.871***	-0.682***	0.068***	-0.918***	0.390***	-0.260***	-0.187***	-0.609***	-0.422***	-0.658***
(*n*=4356)	(0.023)	(0.054)	(0.005)	(0.104)	(0.027)	(0.031)	(0.037)	(0.027)	(0.036)	(0.031)
Beef	-0.931***	-0.691***	0.049***	0.222*	0.257***	-0.188***	0.239**	-0.742***	-0.503***	0.410***
(*n*=1908)	(0.045)	(0.168)	(0.009)	(0.126)	(0.045)	(0.058)	(0.125)	(0.045)	(0.127)	(0.058)
Chicken	-0.698***	-0.344***	0.115***	-1.315***	0.451***	-0.150***	-0.354***	-0.548***	-0.193***	-1.164***
(*n*=1840)	(0.043)	(0.050)	(0.013)	(0.108)	(0.055)	(0.027)	(0.046)	(0.055)	(0.036)	(0.027)
Fats	-0.752***	-0.067	0.060***	0.893***	0.243***	0.004	-0.684***	-0.756***	-0.072*	0.888***
(*n*=4430)	(0.030)	(0.048)	(0.008)	(0.066)	(0.028)	(0.012)	(0.044)	(0.028)	(0.038)	(0.012)
Fish	-1.084***	-0.820***	0.256***	-1.638***	0.047	-0.132***	-0.264***	-0.952***	-0.688***	-1.505***
(*n*=3779)	(0.016)	(0.037)	(0.014)	(0.102)	(0.049)	(0.043)	(0.038)	(0.049)	(0.058)	(0.043)
Sugar	-1.061***	-0.274***	0.013**	1.214***	-0.106***	0.045***	-0.786***	-1.106***	-0.320***	1.168***
(*n*=3628)	(0.038)	(0.073)	(0.006)	(0.092)	(0.046)	(0.024)	(0.090)	(0.046)	(0.088)	(0.024)

Notes:

***, **, * represent levels of statistical significance of 1%, 5% and 10%.

Standard errors in ( ).

Elasticities come from models that include cross-prices and the other covariates described in Appendix Table 1, with sample sizes for each food group listed in the row headings. The "quality elasticity" in column (3) is for the expenditure elasticity of quality.

The importance of quality substitution causes the unrestricted estimates of the own-price elasticity of quantity demanded to differ significantly from the estimates that come from either Deaton's method or from the Standard Price Method or Standard Unit Value methods. For example, the unrestricted estimate of the own-price elasticity of quantity demanded for rice is -0.27 (±0.04), which is a much more sluggish response to price changes than is implied by the estimates from the Standard Price Method of -0.83 (±0.02) or from the Standard Unit Value Method of -0.60 (±0.05). While the own-price elasticity of -0.36 (±0.09) from Deaton's method is closer to the unrestricted values, the difference reported in column (10) is still statistically significant. Moreover, when results for the other food groups are examined the Deaton method results are sometimes further from the unrestricted values than are the estimates from either of the two standard methods. The estimates from Deaton's method do not appear to be reliable here because they are based on separability assumptions that do not hold in the current data.

In summary, the general pattern for the own-price elasticities that ignore quality substitution (Table 3, columns (1) and (2)) is to be much closer to -1.0 than in the benchmark estimates from the Unrestricted Model. The hypothesis test results in columns (8) and (9) of Table 3 show that these differences are statistically significant. In other words, single equation approaches that do not allow for quality substitution all overstate the responsiveness of quantity to price, irrespective of whether a market price index or a unit value is used as the price variable in the budget share regression. The quantity elasticities are overstated because any demand responses along the quality margin that cause budget shares to change get wrongly attributed to quantity responses. In contrast, while Deaton's method allows for quality substitution, it does so only under the restrictions imposed by weak separability and those restrictions are rejected by the data in the current setting and the resulting quantity elasticities give a poor approximation to the unrestricted estimates.

(a) Calorie elasticities

To explore how different assumptions about quality substitution alter inferences about nutritional vulnerability to rice price rises in Vietnam, the quantity demand elasticities from the previous section (and the unreported cross-price elasticities) are converted into elasticies of calories with respect to rice prices. Specifically, for each of the four ways of calculating the elasticity of quantity demanded that are described in Table 1 and for which own-price results are reported in Table 3, we calculate the elasticity of caloric consumption with respect to rice price, ε_{cr}:

$$\varepsilon_{cr} = \sum_{i=1}^{I} \varepsilon_{ir} c_i , \qquad (5)$$

where ε_{ir} is the elasticity of quantity demanded of food group i with respect to the price of rice (that is, this is the own-price elasticity for rice and the cross-price elasticity for all other foods with respect to the price of rice) and c_i is the contribution of food i to total calories. Since there is uncertainty about the calorie shares due to the assumed premium in the price per calorie for the unquantified items in the VHLSS, the calculations are done three times, corresponding to each of the three sets of calorie shares in Table 2. In order to account for the impact of rice prices on calories from foods that are outside the eight groups studied here, adding up restrictions are used to derive the cross-price elasticity of quantity of all other foods (including those with quantities reported and those without) with respect to rice prices. These derived cross-price elasticities are quite small, at -0.021 when using prices and -0.033 when using unit values, although they are multiplied by a reasonably large calorie share (of 29-33 percent, depending on the assumed calorie price premium for the unquantified items).

If the calorie elasticity is calculated with the Standard Price Method, a ten percent rise in relative rice prices appears to cause over a four percent fall in calorie consumption (Table 4, column (1)). This estimate is not very sensitive to the assumed premium in the price per calorie for unquantified foods, ranging between -0.41 and -0.44. If the higher assumed price premium is used the calorie share for rice and the other modeled food groups rises and the share for the other, unmodeled, groups falls. Since demand for the other foods is inelastic with respect to rice prices, assuming a higher price premium for the unquantified items slightly increases the estimated responsiveness of calories to rice prices.

Table 4: Elasticity of calories with respect to rice prices from various calculation methods

	Standard Price Method	Standard Unit Value Method	Deaton Method	Unrestricted Method
Assumed cost premium for nonquantified foods				
50 percent	-.413	-.309	-.257	-.174
100 percent	-.430	-.322	-.268	-.181
150 percent	-.441	-.330	-.275	-.186

If the Standard Unit Value Method is used, the calorie elasticity is about three-quarters as high as when using market prices (Table 4, column (2)). This is less than the gap in Gibson and Rozelle (2011), who calculate an elasticity of -0.54 from prices and -0.22 from unit values. But unlike the discussion by those authors, not only does the choice of unit values versus prices matter to the calorie elasticity so too do the assumptions about quality substitution. Specifically, the elasticities in the first two columns that ignore quality substitution are larger than those in the other two columns that come from methods that allow quality substitution. This comparison is most apparent with the calorie elasticities from the Unrestricted Method while those from Deaton's method are only slightly less than those from the Standard Unit Value Method.[18]

[18] The similarity of calorie elasticities in columns (2) and (3) of Table 4 gives indirect evidence that possible measurement error in unit values has little impact on the results. The Standard Unit Value method makes no adjustment for measurement error, while Deaton's method uses a between-clusters errors-in-variables approach, so if measurement error were a major feature of the data the two sets of calorie elasticities should differ. Thus the findings here are similar to those of McKelvey (2011) that quality substitution may be a more substantial problem than measurement error, when demand analysis is carried out on household survey data.

Specifically, the results from the Unrestricted Method suggest that a ten percent increase in the price of rice reduces calorie consumption by less than two percent. This estimate is considerably smaller than the estimate from the Standard Price Method. The reason is that some household responses to higher rice prices are on the quality margin but these are wrongly treated as quantity responses when standard demand models ignore quality substitution.

(b) Sensitivity analysis

To check if the less elastic response of calories to rice prices that comes from recognizing quality substitution is a robust finding, four sensitivity analyses were carried out. These use different ways to deal with unobserved unit values and unobserved prices and also let the estimation samples vary. Specifically, to form standard errors and test differences between various elasticities (as reported in Table 3, columns (7) to (10)), a seemingly unrelated regression (SUR) was used to estimate equations (1) and (2). The SUR estimator needs balanced samples, which are determined by the number of observations with unit values for each food group (as reported in the row headings of Table 3).[19] This approach may raise concerns about potential sample selectivity bias since not all observations are used. These concerns are addressed here by altering the modeling assumptions (and sample size) and seeing if the results differ.

The first variation was to impute missing unit values, from a regression of unit values on the group price indexes, the other control variables in Appendix Table 1, and the cluster, district or province mean unit value, where the mean from the smallest geographical level available was used. In contrast, the results in Table 4 had just used the cluster, district or province means of the unit values as the proxy for cluster level prices. Using imputed unit values on the right-hand side of the budget share equations allows only slight increases in estimation samples and makes little difference to the calorie elasticities derived from either of the standard methods or from the Unrestricted Method (Table 5, row 2). Using imputed unit values does make more difference to the calorie elasticities derived from Deaton's method, pushing them further from the benchmark value provided by the Unrestricted Method.

A bigger variation is to also use the imputed unit values in place of missing values on the left-hand side of equation (2), giving a measure of predicted quality choice for all households. All households have budget shares and (under this variation) all have predicted unit values, so the estimation samples for all four methods are now all 4,758 observations, alleviating concerns about sample selectivity. The results in the third row of Table 5 show that this variation makes little difference to the estimated calorie elasticities, which are still approximately -0.4 when

[19] The need to balance the number of observations in the SUR is not a constraint on Deaton's method, which first collapses household-level data to cluster-means, so the fact that a cluster may have three households with a budget share and only one with a unit value causes no difference in sample size for the between-cluster budget share and unit value equations. But most studies using unit values do not collapse the data to run between-cluster regressions, although McKelvey (2011) is an exception. Hence we follow the typical approach in the literature, of working with samples at the household level, and therefore face the problem of unbalanced samples for the SUR.

quality substitution is ruled out (or only indirectly allowed, via the separability assumptions of Deaton's method) and are only -0.16 when the Unrestricted Method is used.

Table 5: Sensitivity analysis
Impacts of modeling assumptions on calculated elasticity of calories with respect to rice prices

	Standard Price Method	Standard Unit Value Method	Deaton Method	Unrestricted Method
Baseline results (from Table 4)[a]	-.430	-.322	-.268	-.181
Using imputed unit values on RHS[b]	-.431	-.309	-.392	-.175
Using imputed unit values on LHS[c]	-.429	-.305	-.360	-.155
Not using any imputed prices[d]	-.460	-.368	-.369	-.173
Using consumption unit values[e]	-.441	-.259	-.362	-.146

Notes:

[a] All results use calorie shares calculated under the assumed cost per calorie premium of 100% for non-quantified food groups (middle row of Table 4).

[b] When unit values are used in lieu of prices in the right-hand side (RHS) of equation (1) the unit values are the predictions from the regression of raw unit values on prices, the control variables in Appendix Table 1, and on mean unit values for each cluster, district or province, using the mean for the smallest geographical level available.

[c] When unit values are used in the left-hand side (LHS) of equation (2), they are the predictions described in the note above and the unit values on the right-hand side of equation (1) come from a similar imputation procedure. This allows estimation to use the full sample, since there is an imputed unit value available for every observation.

[d] Communes where prices of the target specifications are missing are dropped from the estimation samples.

[e] The ratio of the value of consumption from purchases, own-production and gifts to the total quantity consumed.

Missing values were also a problem for the market price survey, so a third sensitivity analysis was to see if the results change if communes with imputed prices are dropped from the sample. The results in the fourth row of Table 5 show that this change also makes very little difference. The Unrestricted Method gives a calorie elasticity of -0.17 while for the other three methods the estimates vary between -0.36 and -0.46. In other words, the pattern of a less elastic response of calories to rice prices when quality substitution is recognized does not appear to be driven by our imputation strategy of predicting missing prices in communes where the target specifications were not observed in the market.

The unit values used thus far are *purchase unit values* – spending divided by the quantity bought for each food group. The design of the VHLSS also lets us form a *consumption unit value* – the value of consumption from purchases, own-production and gifts divided by total quantity. The purchase unit value is the appropriate proxy for market prices since reported values for own-production and gifts are not based on market transactions. But the consumption unit value is more widely available, especially for rice which has 2,700 households reporting purchases but 4,600 households reporting consumption. So as a final sensitivity check the consumption unit values were used instead of the purchase unit values, with consequent increases in the estimation samples for all methods. The last row of Table 5 reports the results, showing that the less elastic response of calories to rice prices when quality substitution is recognized persists even with these alternative unit values. While the calorie elasticity from the Standard Unit Value Method is smaller, at -0.26, than in the other sensitivity analyses, it is still almost twice as large as the elasticity of -0.15 that the Unrestricted Method provides.

5. CONCLUSIONS

The world rice market works poorly, in part due to market interventions by Asian governments. One belief that may motivate such interventions is a concern that consumers in rice-dependent Asian countries are nutritionally vulnerable to rice price rises. We therefore examined the elasticity of calories with respect to rice prices in Vietnam, which is the second largest rice exporter and an instigator of world market instability due to its resort to export bans in attempts to hold local rice prices lower. Vietnam is also of interest because of recently published evidence of a large, negative, elasticity of calories with respect to rice prices, which, if true, might be taken as justification for rice market intervention by the Vietnamese authorities. However, this evidence came from a demand specification that ignores quality responses to price rises, forcing all adjustment onto the quantity margin (and hence onto calories).

More generally, most applied demand studies using household survey data rely on demand specifications that either rule out or understate the extent of quality substitution. It has only recently been shown by McKelvey (2011) that quality substitution in response to price changes is very important, and if ignored may bias quantity demand elasticities even if market prices are perfectly observed. In light of this observation and the existing evidence on calorie elasticities for Vietnam, we used new household survey and market price data to estimate an eight-food demand system, allowing for both quality and quantity responses to price changes. The results suggest that, *ceteris paribus*, a ten percent increase in the relative price of rice reduces household calorie consumption by less than two percent. We would wrongly claim this elasticity to be more than twice as large if quality substitution is ignored. Thus, households in Vietnam appear to have considerable scope for protecting calorie consumption in the face of higher rice prices by downgrading the quality of the foods that they consume. There may be less of a tradeoff between nutritional objectives (which benefit from lower rice prices) and export revenues (which benefit from higher rice prices and fewer trade barriers) than appears to be the case when quality substitution is *a priori* ruled out.

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Appendix Table 1: Weighted Descriptive Statistics, N = 4758

Variable	Mean	Std Dev	Min	Max
Budget Shares				
Rice	0.088	0.070	0	0.748
Instant noodles	0.007	0.009	0	0.123
Pork	0.048	0.036	0	0.371
Beef	0.009	0.013	0	0.155
Chicken	0.024	0.026	0	0.340
Fats and oils	0.009	0.008	0	0.108
Fish	0.032	0.035	0	0.333
Sugar	0.005	0.005	0	0.064
Unit Values				
Rice	10.144	2.127	5.000	28.653
Instant noodles	24.052	11.679	1.600	162.369
Pork	54.940	9.678	25.000	120.000
Beef	111.795	20.109	30.000	200.000
Chicken	67.172	17.160	20.000	150.000
Fats and oils	29.999	8.894	9.551	95.511
Fish	35.651	19.360	2.865	200.000
Sugar	18.368	2.706	6.667	40.000
Control Variables				
Log real total expenditure	11.084	0.732	8.138	14.073
Log household size	1.267	0.453	0	2.708
Age of household head	48.660	14.234	18	89
Children share of household	0.094	0.147	0	.666
Youth share of household	0.110	0.162	0	.75
Elderly share of household	0.088	0.224	0	1
Migrant share of household	0.050	0.201	0	1
Dummy: Female head	0.259	0.438	0	1
Dummy: Head earns wages	0.416	0.492	0	1
Dummy: Head farms	0.500	0.500	0	1
Dummy: Head is self-employed	0.210	0.407	0	1
Dummy: Head is tertiary qualified	0.065	0.246	0	1
Dummy: Head is primary qualified	0.707	0.454	0	1
Price index: rice	10.670	1.212	7.734	14.750
Price index: instant noodles	26.609	2.140	20.000	35.000
Price index: pork	52.916	8.358	33.388	78.797
Price index: beef	100.192	11.454	56.292	150.259
Price index: chicken	74.097	9.199	50.903	123.463
Price index: fats and oils	27.176	6.135	12.748	53.605
Price index: fish	75.497	16.849	33.563	151.202
Price index: sugar	20.849	1.328	17.500	28.653
Budget share other food	0.233	0.099	0.015	0.879
Budget share other items	0.444	0.151	0.069	0.946
Dummy: Survey Wave 3	.359	.479	0	1

Note: Other items include petrol, firewood, infrequent purchases, durables, education, health, utilities, and rent.