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# Testing an IV method for reducing quality bias in demand systems estimations*

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**Abstract**: Price elasticities of substitution estimated with demand systems and household survey data might suffer of an endogeneity bias due to measurement errors and unobserved quality substitution. The paper compares Deaton's and Cox and Wohlgenant's approaches commonly used to reduce this bias with a method based on instrumental variables. The test is conducted on selected food and beverage goods in Vietnam. Price elasticities not corrected for quality substitution obtained with standard market prices are used as a benchmark. Results show that the instrumental variable method significantly reduces the endogeneity bias and performs better than the compared methods. Moreover, it is based on fewer assumptions and controls for measurement errors. Its main limitations are that it still implicitly assumes that price changes have no impact on quality and that it relies on identifying suitable instruments.

**Keywords**: price elasticity; quality substitution; QUAIDS; instrumental variable; endogeneity; household survey.

**JEL**: C30; D10; O12;

## Introduction

Demand systems are frequently used to estimate price and income elasticities of goods and services, which are essential to assess how demand and consumption respond to price and income changes and are generally decisive for the results of economic models that use them to parametrize their demand systems (Beckman et al., 2011).

The main source of data for demand analyses are household surveys that provide micro-data on consumption quantities and expenditure but rarely collect market prices, especially in less developed countries. To obviate the lack of household-level market prices, economists frequently use 'unit values' as proxies, calculated by dividing the quantities by the values of the goods in the survey. Many authors demonstrated that unit values are imperfect proxies for market prices (e.g., Cox and Wohlgenant, 1986; Deaton, 1988; McKelvy, 2011) because they can measure quantity substitution but not quality substitution. In other words, households can protect their consumption quantities by switching to the

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same amounts of lower quality goods. Quality substitution is particularly important for food, where consumers downgrade to lower quality commodities before putting at risk their total calorie intake (for example, switching from sweet Jasmine rice to glutinous rice). Moreover, unit values can be subject to measurement errors. Ultimately, failing to control for quality substitution and measurement errors generates an endogeneity problem in the demand system with unit values correlated with the equation errors, which result in overestimated quantity demand elasticities. Using market prices collected at the household level, Gibson and Kim (2019) demonstrated that when the quality bias is removed, food price elasticity can be 85% lower.

There are two main approaches in the literature addressing this endogeneity bias, and comparisons with robustness analyses have been conducted between them (e.g. McKelvey, 2011; Gibson and Kim, 2013). The first approach comes from Cox and Wohlgenant (1986), which assumes that the quality effect can be measured as the deviation between the unit values from regional or seasonal means. The second comes from Deaton (1988) and consists of exploiting the within-cluster variation of unit values and expenditures to correct both quantities and unit values. Both approaches correct the unit values assuming that the variation that cannot be explained by the household characteristics is caused by quality differences.

A novel approach based on instrumental variables (IV) methods for reducing the endogeneity bias has been developed by Lecocq and Robin (2015). This method seems particularly promising as i) it relies on fewer assumptions, ii) it does not require a clustered structure of the data, iii) it is computationally efficient, and iv) can potentially rely exclusively on the data available in the household surveys. However, its performance with respect to the previously mentioned methods has not been tested yet.

This paper aims to compare the Lecocq and Robin (2015) IV method and the most commonly used methods for reducing the endogeneity bias in demand systems. We use as a benchmark the price elasticities of some food and beverage products estimated with standard market prices in Vietnam. This benchmark incorporates both quality and quantity substitutions, therefore representing an ideal benchmark to test the IV approach. We, therefore, compare own-price elasticities obtained with the IV method against estimations of i) standard market price (SMP) elasticities (benchmark); ii) elasticities with the Cox and Wohlgenant's method (CW); iii) elasticities with the Deaton's method.

## Data and methods

We use data from the 2016 Vietnam Household Living Standards Survey (VHLSS). After cleaning by removing missing values and observations with unit values larger than five standard deviations from the sample average, the dataset comprised 580 households.

As in Lecocq and Robin (2015), we estimate the following demand system, which is the Banks et al. (1997) quadratic extension of the Deaton and Muellbauer's (1980) Almost Ideal Demand System (AIDS) model:

$$w_i^h = \alpha_i + \gamma_i' p^h + \beta_i\{x^h - a(p^h,\theta)\} + \lambda_i \frac{\{x^h - a(p^h,\theta)\}^2}{b(p^h,\theta)} + u_i^h \qquad (1)$$

where $w^h_i$ is the expenditure share of good $i = 1, \ldots, N$ for household $h = 1, \ldots, H$; $x^h$ is the household's total expenditure; $p$ is a vector of prices; $u$ is the error term; and $\alpha, \beta, \gamma, \theta$ are the parameters to be estimated. $a$ and $b$ are non-linear price aggregator functions defined as:

$$a(p^h,\theta) = \alpha_0 + \alpha' p^h + \frac{1}{2} p^{h\prime} \gamma p^h$$

$$b(p^h,\theta) = exp(\beta' p^h)$$

The parameters $\alpha$, $\beta$, $\gamma$, $\theta$ must satisfy the theoretical restrictions of additivity, homogeneity and symmetry, which are: $\sum_{i=1}^{n} \alpha_i = 1$; $\sum_{i=1}^{n} \beta_i = 0$; $\sum_{j=1}^{n} \gamma_{ij} = 0$; $\sum_{i=1}^{n} \lambda_i = 0$; and $\gamma_{ij} = \gamma_{ji}$.

Equation (1) is estimated with Iterated Linear Least-Squares (ILLS) estimator. The selected goods *i* are foods and beverages typically present in Vietnamese consumption baskets and frequently included in empirical works (e.g. Gibson and Kim, 2019). Household heterogeneity is controlled for by parametrizing the intercepts α's with sociodemographic variables $s^h$, such that $\alpha^h = As^h$; $A = (\alpha_i')$. The sociodemographic variables included are: the logarithm of household size; the household's share of children, youth, and elderly; the age of household head; six dummy variables equal to 1 if the head is female, earns wages, farms, is self-employed, is primary qualified, is tertiary qualified. Elasticities are calculated at the mean of the household sample.

For the benchmark elasticities, equation (1) is estimated using market prices at province level (*tinh*) from the General Statistics Office of Vietnam. For the IV model, the error $u^h_i$ in equation (1) is augmented with the vector $Z^h$ predicted from estimating reduced forms for $p^h$: $u_i^h = \rho_i \hat{Z}^h + \varepsilon_i^h$. A Wooldridge's endogeneity test on the reduced form confirmed that exogeneity can be rejected at the 1% level. Therefore we use the following instruments: one-year lagged unit values calculated as unit values corrected with 2015 price indexes; the sociodemographic variables in $s^h$.

Equation (1) is also estimated correcting unit values with the CW approach. In this instance, we first estimate the following equation with OLS:

$$v_i = \bar{v}_i + \varphi_i x_{pc} + \omega_i f_i + \sum_{1}^{h} \sigma_i s^h + e_i$$

where $v_i$ is the unit value of food item $i$; $\bar{v}_i$ is the mean unit value at area level (*diaban*); $f_i$ is the share of food budget spent on food away from home; $x_{pc}$ is the household food expenditure per capita; $s^h$ are sociodemographic characteristics and $e^i$ is the residual. The quality-adjusted prices $p_{qi}$ are finally obtained by: $p_{qi} = \bar{v}_i + \hat{e_i}$.

Finally, we estimate the Deaton's method following the two-steps procedure described in Deaton (1988) and the set of STATA do files in Deaton (1997).

## Results

Table 1 shows the own-price elasticity of demand for the selected food and beverage goods[1]. In columns 1 and 2 the SMP method consists of our benchmark price elasticities not correcting for quality substitution. Elasticities in columns 3 to 7 are the price elasticities obtained with Deaton's, CW's and IV methods.

Across methods, the demand of the selected goods is inelastic or rigid (below unity), meaning that their demand does not respond much to price changes (necessity good). Compared to the SMP model, all other methods give smaller own-price elasticities as they correct for the quality bias.

However, the differences in mean elasticity between the SMP and the other methods (table 2 column 1) increases. A larger difference with the SMP indicates a larger correction of the quality bias, therefore it is possible to rank methods according to the bias: SMP > Deaton's > CW's > IV. Both CW and IV have a significant difference with SMP and Deaton, but the smaller elasticity of IV suggests that it might have a slightly greater capacity of correcting for quality substitution. However, there is no significant

[1] Consumption behaviour in Vietnam may vary between regions, urban/rural areas, and income groups. See Bairagi et al. (2020) for different price elasticities between urban and rural households in Vietnam. Because the main objective of this paper is methodological, we use the full sample of the 2016 VHLSS providing average elasticities for all types of households.

difference between IV and CW. Finally, the difference between Deaton and SMP is not statistically significant, casting doubts on the capacity of Deaton's method to correct for quality substitution.

Table 1 – Own-price elasticities of selected food and beverage products in Vietnam

| | **SMP** | **SMP** | **Deaton** | **CW** | **CW** | **IV** | **IV** |
|---|---|---|---|---|---|---|---|
| | Unc. | Comp. | | Unc. | Comp. | Unc. | Comp. |
| | **(1)** | **(2)** | **(3)** | **(4)** | **(5)** | **(6)** | **(7)** |
| Rice | -0.918*** | -0.831*** | -0.933*** | -0.406*** | -0.300*** | -0.248*** | -0.143*** |
| | (0.055) | (0.055) | (0.003) | (0.032) | (0.031) | (0.037) | (0.036) |
| Pork | -1.399*** | -1.223*** | -1.021*** | -0.823*** | -0.631*** | -0.780*** | -0.583*** |
| | (0.104) | (0.100) | (0.001) | (0.077) | (0.076) | (0.081) | (0.080) |
| Beef | -1.105*** | -1.003*** | -0.986*** | -0.753*** | -0.647*** | -0.808*** | -0.703*** |
| | (0.064) | (0.064) | (0.000) | (0.089) | (0.089) | (0.090) | (0.090) |
| Chicken | -0.918*** | -0.810*** | -1.002*** | -0.534*** | -0.426*** | -0.503*** | -0.399*** |
| | (0.054) | (0.050) | (0.000) | (0.070) | (0.070) | (0.072) | (0.071) |
| Cooking oil | -0.908*** | -0.892*** | -0.965*** | -0.387*** | -0.369*** | -0.321*** | -0.302*** |
| | (0.069) | (0.068) | (0.003) | (0.073) | (0.072) | (0.082) | (0.082) |
| Fish | -0.873*** | -0.424*** | -1.174*** | -0.420*** | -0.021 | -0.395*** | 0.007 |
| | (0.084) | (0.093) | (0.001) | (0.042) | (0.042) | (0.041) | (0.040) |
| Beer | -1.075*** | -1.013*** | -0.407*** | -0.402*** | -0.331*** | -0.396*** | -0.326*** |
| | (0.071) | (0.074) | (0.019) | (0.053) | (0.052) | (0.066) | (0.066) |

Notes: Unc. and Comp. stand for uncompensated and compensated respectively. *** indicate significance level at the 1%.

Table 2 – Difference between methods to reduce endogeneity bias in demand systems

| **a** \ **b** | **SMP (1)** | **Deaton (2)** | **CW (3)** |
|---|---|---|---|
| *Uncompensated:* | | | |
| **Deaton** | 0.101 | | |
| **CW** | 0.496*** | 0.395*** | |
| **IV** | 0.535*** | 0.434*** | 0.039 |
| *Compensated:* | | | |
| **Deaton** | -0.042 | | |
| **CW** | 0.496*** | 0.538*** | |
| **IV** | 0.535*** | 0.577*** | 0.039 |

Notes: *** indicates significance level at the 1%. Values in cells are differences between row and column (a-b).

## Discussion

Household surveys are the most reliable, high-quality, and disaggregated data sources for demand analysis. To eliminate the endogeneity bias in the demand system estimations, they should be conducted in combination with price surveys. However, price surveys are rarely available. Therefore identifying the best method to deal with endogeneity bias in the demand system estimations will remain important.

In the analyses presented in this paper, Lecocq and Robin's (2015) IV method significantly reduces the endogeneity bias and performs better than the compared methods. However, it still implicitly assumes that price changes have no impact on quality. This assumption is shared with Deaton's and CW's methods, but a few elements indicate further advantages of the IV method. Deaton's method necessitates weak separability restrictions, which overstate quantity responses over quality responses. Besides, Deaton's method uses the geographical clustering structure of data assuming that households in the same cluster share the same market price. The CW's approach has the advantage of being easier to implement, but it does not deal with measurement error problems. These issues do not concern the IV method, which is based on fewer assumptions and has also the additional advantage of controlling for measurement errors. The IV method's main limitation is the availability of instruments orthogonal to the errors of all the equations of the demand system.

Our analysis focused on a small sample of goods and a single country. Further analyses based on multiple years and multiple countries, and with household level market prices to fully disentangle quality and quantity substitution could dig deeper into understanding the efficacy and robustness of the IV method.

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