Food Demand, Food Prices and Welfare Analysis utilizing EASI model

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Abstract

The impacts of rising food prices on poverty and welfare of Mexican households are examined by using a linearized version of the Exact Affine Stone Index (EASI) demand system. The distribution of monetary measures of welfare effects from food price changes is estimated as well as equivalence scales that allow inter-household comparison of welfare changes. After accounting for substitution effects, poverty related impacts were estimated. Findings indicate that the increase in prices of five food groups from 2006 to 2010 has led to an increment of 1.8 percentage points in the proportion of households with income below the food poverty line.

Keywords: Food Prices, Welfare Analysis, EASI Demand System, Mexico.

JEL Classification: D04, D10, D12, D60

I. Introduction

The proportion of Mexican population living below the food poverty line[1] increased from 13.8% in 2006 to 18.8% in 2010. Likewise, the proportion of population with income below the assets poverty line increased from 42.7% to 51.3% over the same period (CONEVAL 2011). This outcome is believed to be the result of several factors including the increase in local and global food prices. The increase in food prices has affected the purchasing power of the Mexican households in a more significant way from the third quarter of 2008. From then until 2010 the food basket price in Mexico increased faster than the global consumer price index (CONEVAL 2012).

Following the world food price spike in 2008, there has been increased attention on better understanding the drivers of food prices and their impacts on the poor (World Bank 2012). Several studies have focused on evaluating this impact, especially in developing countries. Ivanic and Martin (2008) pointed out that despite widespread concern about the impacts of high food prices on poverty and on social stability; little information appears to be available on actual impacts. The authors calculated first-order welfare changes in households for nine low-income countries. Among the findings they describe that overall impact of higher food prices on poverty is adverse especially for net consumers of food. They found that the welfare impact varies by commodity and by country.

[1] The Evaluating National Council of the Social Development Policy (CONEVAL, Spanish acronym) is in charge of defining official poverty lines in Mexico. Poverty lines are measured in monthly per capita income, adjusted monthly by the consumer price index, and classified for rural and urban households. The food poverty line is a monetary measure of the resources needed to buy a representative food basket in Mexico. For the last quarter of 2010, the food poverty line was MX$797.29 for a rural household, and MX$1,074.28 for an urban household. Likewise, the assets poverty line is defined as the income needed to afford food, education, health, clothing, housing and transportation. The assets poverty line was MX$1,446.76 for a rural household, and MX$2,155.43 for a urban household during the last quarter of 2010.

As for studies that have focused on Mexico, Porto (2010) found that increase in price of corn, one of the most important food products consumed in rural in Mexico, leads to consumption loss. The author points out that poor households tend to suffer higher losses since they consume more corn than rich households. Likewise, Chavez Martin del Campo et al. (2008) conclude that the recent upsurge in global food prices has affected more than proportionately the poorer sectors of the population. However, they find that the substitution ability of households helps to cushion the wealth loss of society's poorest segments.

Moreover, Wood, Nelson and Nogueira (2012) predicted the number of Mexican households falling below the food poverty line because of recent increase in food prices. They use a subsample from the 2006 ENIGH Mexican household survey and an Almost Ideal Demand System (AIDS), assuming linear Engel curves. In particular, a 50% increase in the price of cereal and meat is estimated to cause an increment of up to 6.0% in poverty. They calculated compensating variations for food groups, accounting for differences between urban and rural population and poverty status. The authors indicated the need for estimating a complete food demand system that accounts for substitution in order to obtain accurate measures of welfare and poverty effects due to food price escalation.

The objective of this research is to analyze the impact of rising food prices on poverty and welfare of Mexican households by accounting for the substitution among food commodity groups and relaxing the assumption of linear Engel curves. This paper presents an application of the Exact Affine Stone Index (EASI) demand system developed by Lewbel and Pendakur (2009). Advantages of this model over commonly used demand models include: a) EASI allows for complex Engel curves which vary across goods; b) the error term can be interpreted as unobserved preference heterogeneity; and c) an approximate model can be estimated by linear methods. This paper would represent one of the first applications of the EASI model for welfare analysis. Interpretation of error terms as unobserved preference heterogeneity allows the estimation of a distribution of welfare effects instead of only average welfare effects as it is done in traditional methods. Contributions of this paper also include the estimation of equivalence scales for households with different demographic characteristics. These equivalence scales allow inter-household comparisons of welfare effects and the estimation of meaningful food poverty impacts due to the actual increase in food prices in Mexico from 2006 to 2010.

This paper is organized as follows: Section II presents details about the model and a brief description on welfare effects estimation methods; Section III describes the household survey data used in this paper, as well as a discussion of consumer price indexes of food used for welfare effects estimations. Next, Section IV contains the discussion of the estimation results for semi-elasticities, equivalence scales, welfare effects as well as implications for food poverty in Mexico. Section V concludes the paper and points out opportunities to extend this research.

II. The Model

The analysis is performed using the Exact Affine Stone Index (EASI) implicit Marshallian demand system. This approach is superior to Almost Ideal Demand System in the sense that EASI demand can have any rank and its Engel curves for every commodity are not constrained by Gorman rank restrictions (Lewbel and Pendakur 2009). Moreover, EASI error terms can be interpreted as random utility parameters that represent unobserved heterogeneity of preferences. Further, EASI demand functions are linear in parameters, a property that parallels AIDS in terms of convenience at estimation (Lewbel and Pendakur 2009).

The model, without two-way interactions between variables y, $\boldsymbol{z}$ *and* $\boldsymbol{p}$, is specified as follows:

$$w^j = \sum_{r=1}^{R} b_r^j (y)^r + \sum_{t=1}^{T} g_t^j z_t + \sum_{k=1}^{J} a^{jk} ln\, p^k + \varepsilon^j \qquad (1)$$

Where w^j, the budget share of good j; z_t is a vector of demographic characteristics of the households; $ln\, p^k$ is the log of prices of good k; ε^j is a vector of unobserved preference heterogeneity parameters for the consumer; while b_r^j, g_t^j, and a^{jk} are parameters to be estimated. The parameters b_r^j define the shape of the Engel curve. The implicit utility is given by

$$y = \ln x - \sum_{j=1}^{J} w^j ln\, p^j + \frac{1}{2}\sum_{j=1}^{J}\sum_{k=1}^{J} a^{jk} ln\, p^j\, ln\, p^k$$

which can be approximated with $\tilde{y} = \ln x - \sum_{j=1}^{J} \bar{w}^j ln\, p^j$, and can be elevated to the r power – to generate a polynomial of degree r. The estimation is performed by iterated 3SLS and standard demand restrictions, such as adding up, homogeneity and symmetry are imposed as described in Lewbel and Pendakur (2009).

Using this model, elasticities are estimated and welfare effects of shocks in food prices are assessed. In particular, the Hicksian (compensated) price semi-elasticities for the implicit Marshallian demand system is calculated as the first derivative of (1) with respect to price. As mentioned by Lewbel and Pendakur (2009) in this framework price effects are most easily evaluated by analyzing budget-share semi-elasticities. Furthermore, as specified by Pendakur (2009), the EASI demand system is dual to cost function and consumer surplus measures originated from price changes are not complicated to calculate. It is assumed that the expenditure reported by a given household is the minimum nominal expenditure to attain a utility level u, giving a vector of prices $\boldsymbol{p}$. Let $C(\boldsymbol{p}_0, u, \boldsymbol{z}, \varepsilon)$ be the cost function of a household reporting budget shares $\boldsymbol{w}_0$ and implicit utility level $y = u$, and unobserved utility parameters ε, the welfare change measure for the price change from $\boldsymbol{p}_0$ to $\boldsymbol{p}_1$ is the log cost of living index and can be written in terms of observables as:

$$\ln\left[\frac{C(\boldsymbol{p}_1, u, \boldsymbol{z}, \varepsilon)}{C(\boldsymbol{p}_0, u, \boldsymbol{z}, \varepsilon)}\right] = \sum_{j=1}^{J} w_0^j \left(lnp_1^j - lnp_0^j\right) + \frac{1}{2}\sum_{j=1}^{J}\sum_{k=1}^{J} a^{jk} \left(lnp_1^j - lnp_0^j\right)\left(lnp_1^j - lnp_0^j\right) \quad (2)$$

This cost of living index has captures two effects: 1) first-order effects is driven by expenditure shares, and 2) the second term captures substitution effects –second-order effects- (Lewbel and Pendakur 2009). The welfare effect calculated by 3) is related to the reference household. A distribution of welfare effects is obtained after replacing w_0^j for the budget shares of every household in the sample.

Furthermore, in order to be able to make inter-household comparison of welfare effects, equivalence scales are estimated. This is achieved through Generalized Method of Moments (GMM) estimation (see online appendix of Lewbel and Pendakur (2009) for details). Finally, the corresponding net welfare effect is subtracted from the per capita income for every household. Updated per capita income is then compared to the Mexican food poverty line to evaluate the effects of increasing food prices on poverty levels.

III. The Data

The data used in this study was obtained from the National Household Income and Expenditure Survey (ENIGH, Spanish acronym) collected by the Mexican Statistical Institute (INEGI) during the third quarter of 2010. ENIGH is a survey of a nationally representative sample of Mexican households, which collects detailed information on household composition, income and expenditure. The dataset provides detailed information on food consumption (at home and away-from-home) and the money value of food consumed during one week. From this dataset, six food commodity groups that represent the Mexican diet were created –from a disaggregated list of about 250 commodities- to estimate a complete food demand system. The food groups used in our analysis are: 1) corn tortillas and corn products, 2) cereals, 3) meats, 4) dairy, 5) fruits and vegetables, and 6) other foods. Our final sample consists of over 27,000 households, which purchased at least one of the foods during the week of data collection.

For welfare effects the actual variation of prices from 2006 to 2010 was taken into consideration. That is, variation of consumer price index for every food group was calculated for the period under analysis. Data on price indexes was obtained from INEGI, which is the official source for this type of information in Mexico. Regarding information of official food poverty lines, it was obtained from the National Council for Evaluation of Social Development Policy (CONEVAL).

IV. Results

The summary statistics of the variables used in the model are presented in Table 1. With respect to budget shares of the food groups under study we observe that the average food budget share devoted to corn tortilla is 10%, which is higher than the corresponding budget share for the overall cereal group, 8%. This is consistent with the importance of corn tortilla in the Mexican diet. The average budget share for dairy products is 13%, whereas for fruits and vegetables it is 16%. Meat products account for an average of 20% of the food budget share, and other foods, which include prepared foods and food-away-from-home, report a mean of 33% of the total food budget share.

It is worth noting that, since we are working with aggregated food commodity groups, censoring is not an issue. The percentage of zeroes in budget shares is at or less than 10 percent for each food category. It is assumed that this low percentage of zeroes does not cause a problem in estimation.

As for the shape of Engel curves, there is evidence of non-linearity for most commodity groups, which justifies the use of a model that accounts for unrestricted Engel curves, such as the EASI model, to consistently estimate elasticities and welfare effects. In particular, the package developed by Hoareau et al. (2012) was used to graph the Engel curves for the six food groups. In Figure 2, Engel curves from the EASI package of Hoareau et al. (2012) are presented. An advantage of the EASI model is that one does not need to know nor impose in advance the shape of Engel curves, but instead we can let the data show the underlying shape. In our case, it seems that the non-linearity of Engel curves for the six food groups under analysis can be captured by a quadratic term. Hence, system given by equation (1) was estimated with $r = 2$. Finding Engel curves not too far from linear for the case of food is consistent with previous literature. In particular, using data from the U.K., Banks, Blundell, and Lewbel (1997) found that linear formulation provides a reasonable approximation for the food share curve. Similarly, Lewbel and

Pendakur (2009) found that the non-linearity of Engel curves for food-at-home and food-away-from-home in Canada is less pronounced than for other budget shares, such as rent, furniture, household operation, recreation, etc. Likewise, Wood, Nelson, and Nogueira (2012) found slight curvature of the shares of food categories against the log of total food expenditure in Mexico.

The EASI model allows us to take into consideration a reference household. In this paper we will consider as a reference a unitary household (a one-person household), whose age is 47 years old, and does not live in a rural community. That is, the reference household is located in a town/city with more than 2,500 inhabitants.

Therefore, the vector of demographic variables, $\boldsymbol{z}$, consist of: 1) $z1$ is a count variable that indicates the number of household members minus one, yielding a value of zero for the unitary (reference) household; 2) $z2$ is a variable that indicates the age of the head of the household minus 47, here the variable takes on value zero for those households with household head's age equals 47; and 3) $z3$ is a dichotomous variable that takes on a value of zero for the reference household type, which is a urban household, and one otherwise. In summary, following Lewbel and Pendakur (2009), the vector of demographic variables for the reference type is a vector of zeroes. That is, for the reference type the vector of unobserved preference characteristics satisfies $\boldsymbol{\varepsilon} = 0$. Summary statistics for the described demographic variables normalized with respect to the reference household can be found in Table 1.

Likewise, prices are normalized with respect to the price vector that the reference household faces. Specifically, a unitary household, which head is 47 years old, that lives in an urban setting and has median food expenditure among this group. That is, the normalized price vector for the reference consumer is (1,1,1,1,1,1). These observations define the base price vector, with log prices this vector is (0,0,0,0,0,0). The descriptive statistics for the normalized log of prices and normalized log of food expenditure for the reference household are presented also in Table 1.

Utilizing the data and the model described in (1), parameter estimates were obtained. Table 2 contains parameter estimated for the linearized EASI model for the reference household. Variable y presents the parameters for the implicit utility, which is followed by a number that represents the exponent of the polynomial. As usual in demand estimation the last equation -other foods-, was dropped from the system to avoid a singular covariance matrix for the errors.

Regarding semi-elasticities of the budget shares for the rural reference household, these are reported in Table 3. Most of them are large and statistically significant. The own-price compensated semi-elasticity for the cereal budget share is 0.015. This implies that a 10% increase in the price of cereal would be associated with a budget share 0.15 percentage points higher once expenditure is increased to reach the original level of utility. On the other hand, if the tortilla price rises by 10%, the tortilla budget share would be 0.07 percentage points lower, once expenditure is increased to compensate for the price increment and to reach the original level of utility. We found that the demand for tortilla is inelastic and this result is consistent with the findings of the existing literature.

Note that one of the own-price budget share semi-elasticities is positive and significant. This does not imply that the concavity of cost function is violated. In order to test this, a concavity test conducted using the package developed by Hoareau et al. (2012). We found that the EASI cost function is concave in more than 90% of the sample.

As for cross-price effects, the fact that most of the cross-price semi-elasticities are significant suggests that substitution effects are important. As an example, we can describe the case of tortillas with respect to fruits and vegetables, whose compensated cross-price semi-elasticity is 0.015. This implies that an increase of 10% in the price of fruits and vegetables is associated with an increase of 0.15 percentage points in the budget share for tortillas, as substitution effect. Similar analysis can be done for the rest of the off-diagonal elements of Table 3.

Welfare Analysis

The welfare effects of increased food prices for the reference household are calculated using equation (2) and parameter estimates from equation (1). Instead of considering hypothetical price changes, as done in previous studies, we are considering actual food price increments measured by the consumer price index for food groups in Mexico. All welfare estimation in this section takes into consideration the increase in price, as well as substitution effects, of five food groups: tortilla, cereal, meat, dairy, and fruits & vegetables. That is, the price and substitution effects of the group *other foods* was not considered.

Figure 3 shows the histogram of welfare effects as proportion of food expenditure that is obtained after replacing w_0^j in equation (2) for the budget shares of every household in the sample. The mean of this variable is 0.16 with standard deviation 0.056. Once the welfare effects as proportion of food expenditure is multiplied by food expenditure it yields monthly gross welfare effects in monetary terms. The corresponding histogram, with mean MX$302.73 and standard deviation 203.34, is presented in Figure 4. Since these welfare effects are not yet comparable across households we called them gross welfare effects. Net (comparable) welfare effects are those adjusted by household equivalence scales. Figure 5 presents the histogram for estimated equivalence scales. Monthly net welfare effects have a mean of MX$253.64, a median of MX$219.94, and a standard deviation of 179.67. Figure 6 shows the histogram of net welfare effects in Mexican pesos per month. The estimated net welfare effects differ considerably across households.

Since the group named *other foods* was not considered for welfare estimation purposes, households that devote most of their food expenditure to this omitted group have lower estimated net welfare effects in this exercise. That is, households that have a more diversified diet, including prepared foods and food-away-from-home suffer minor welfare effects given a price increase in a specific food group. Such households are the ones that have welfare effects on the left side of the histogram in Figure 6.

As for welfare analysis relative to poverty, we used the official food poverty line defined by CONEVAL in our calculations. In particular, we take the average value of the food poverty line for the last quarter of 2010, to be consistent with the time household data was collected. It is measured in monthly per capita income and classified for rural and urban households. For a rural household, the food poverty line was MX$797.29 and for an urban household it was MX$1,074.28. This amount represents a monetary measure of the resources needed to buy a representative food basket in Mexico and it is adjusted monthly by the consumer price index.

Per capita income, calculated from the original dataset, was compared to the food poverty line for every household before and after the subtraction of the per capita net welfare effects to evaluate the impacts of increasing food prices on poverty levels. The difference indicates an increase of 1.8 percentage points in the proportion of households with incomes below the food poverty line. This represents nearly 514,000 households in Mexico falling into food poverty due to the actual increase of price of five food groups from 2006 to 2010. The latter figure was estimated using the sampling weights provided in the ENIGH dataset.

Wood, Nelson and Nogueira (2012) showed the importance of substitution effects. That is, they demonstrate that analysis performed considering only first-order effects overestimates the impact of rising food prices on poverty. We found similar results, since omitting substitution effects would result in about 603,000 households falling into food poverty. This would represent an overestimation of 18% in the number of households compared to the results from the model that accounts for substitution ability.

Regarding the poverty impacts on rural households, we found that the proportion of households living below the food poverty level in rural communities increased 2.12 percentage points. That is, the number of households in the disadvantaged condition increased by 130,000 households. As for urban households, the proportion increased 1.70 percentage points, which means that nearly 384,000 additional households are now below the food poverty level.

V. Conclusions

In this paper a linearized EASI demand system was estimated in order to calculate the parameters needed to calculate the welfare effects due to food price increase for a specified reference household type in Mexico. Equivalence scales were estimated in order to compare welfare effects across households. After accounting for substitution effects, poverty related impacts were estimated. We found that increase in prices of five food groups from 2006 to 2010 has led to an increment of 1.8 percentage points in the proportion of households with income below the food poverty level in Mexico. This shows that nearly 514,000 additional households fell below the food poverty level. In terms of proportion of households, welfare effects on poverty seem to be higher on households located in rural communities than in urban households.

One possible way to extend this research would be to estimate a more comprehensive demand model, using other expenditure groups, such as clothing, transportation, health care, education, recreation, etc., along with a food group. The use of this model would allow the estimation of the expected welfare effects of a potential implementation of a food tax in Mexico. Given that with EASI model a distribution of welfare effects can be estimated, it would be possible to identify vulnerable sub-population groups that would suffer the most given a policy change. Although the question of whether compensating the consumers or not after a price or policy change is a normative one, the fact that it is feasible to estimate welfare effects in monetary terms, tailored for sub-population groups, has important implications and relevance for public policy in Mexico.

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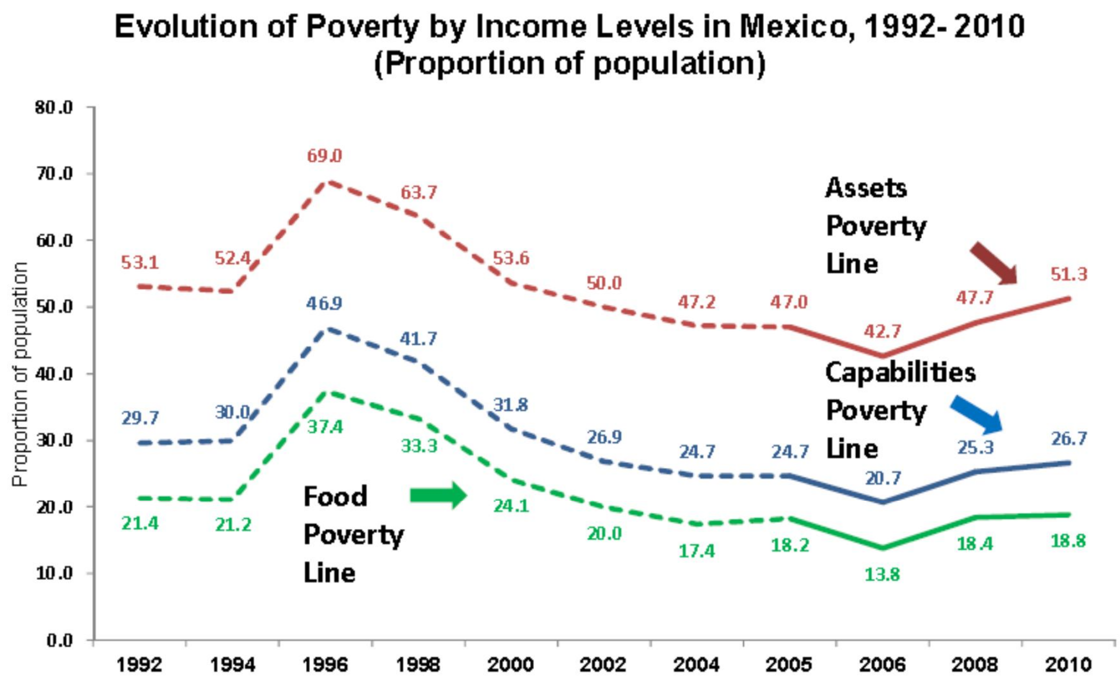
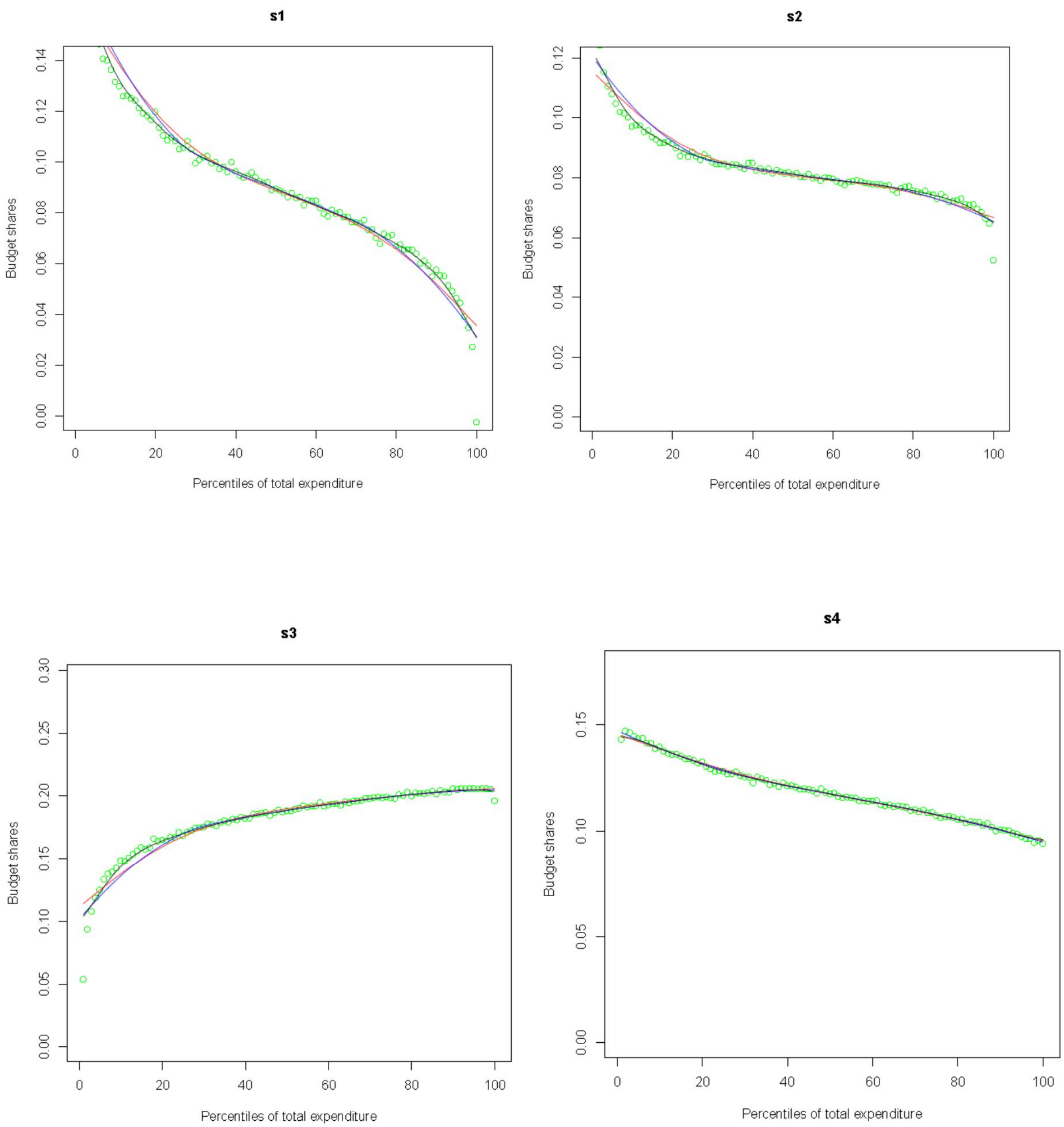
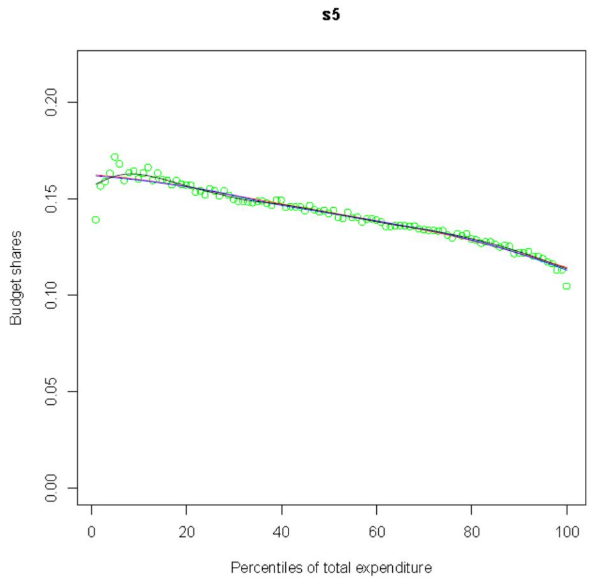
Figure 1.



Source: CONEVAL based on ENIGH from 1992 to 2010

Figure 2. Engel curves for Tortilla (s1), Cereal (s2), Meat (s3), Dairy (s4), Fruit and Vegetables(s5) and other goods using the package developed by Hoareau et al (2012).





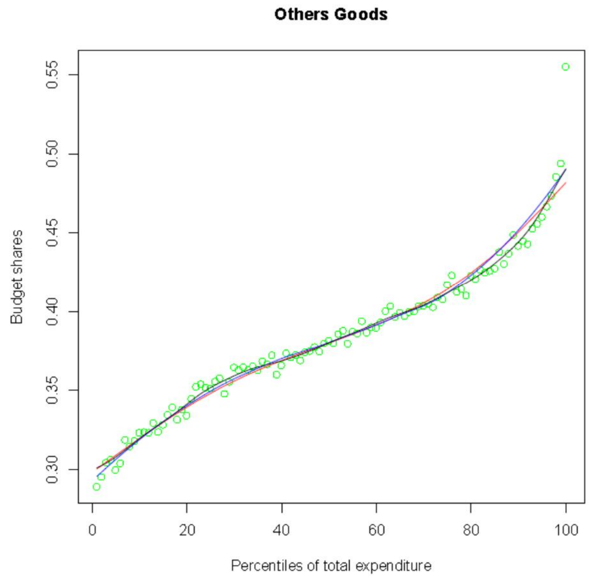


Table 1. Summary Statistics (n=27,398)

Variable		Mean	Std. Dev.
Budget Shares	Tortilla	0.10	0.11
	Cereal	0.08	0.08
	Meat	0.20	0.15
	Dairy	0.13	0.10
	Fruits and Vegetables	0.16	0.12
	Other Food	0.33	0.24
Demographics	Household Members - 1	2.90	1.98
	Household Head Age - 47	1.39	15.69
	Rural Setting = 1	0.22	0.41
Log-Prices*	Tortilla	-0.12	0.29
	Cereal	-0.30	0.47
	Meat	-0.51	0.33
	Dairy	0.14	0.48
	Fruits and Vegetables	0.03	0.37
	Other Foods	-0.51	1.01
Log-Expenditure*	x	0.16	0.75

*Normalized with respect to the reference household type.

Table 2. Parameter Estimates for the Reference Household

Variable	Tortilla	Cereal	Meat	Dairy	Fruit & Veg.
y1	-0.049***	-0.018***	0.028***	-0.02***	-0.013***
y2	0.001**	0.003***	-0.006***	-0.001**	-0.005***
Household Size	0.011***	0.004***	0.006***	0.004***	0.006***
Household Head's Age	0.0005***	-0.0001***	0.001***	-0.0002***	0.001***
Urban Setting	-0.005***	0.014***	-0.028***	-0.007***	0.048***
Tortilla Price	-0.007***	0.004***	0.002*	0.007***	0.015***
Cereal Price	0.004***	0.015***	-0.004***	-0.002***	-0.006***
Meat Price	0.002*	-0.004***	0.002	0.013***	0.003***
Dairy Price	0.007***	-0.002***	0.013***	-0.01***	0.007***
Fruits & Vegetables Price	0.015***	-0.006***	0.003**	0.007***	-0.007***
Constant	0.078***	0.074***	0.17***	0.128***	0.13***

*** p<0.01, ** p<0.05, * p<0.1

Table 3. Compensated Budget-Share Semi-Elasticities for the Reference Household

Variable	Tortilla	Cereal	Meat	Dairy	Fruit & Veg.
Tortilla	-0.007***	0.004***	0.002*	0.007***	0.015***
Cereal	0.004***	0.015***	-0.004***	-0.002***	-0.006***
Meat	0.002*	-0.004***	0.002	0.013***	0.003***
Dairy	0.007***	-0.002***	0.013***	-0.01***	0.007***
Fruits & Vegetables	0.015***	-0.006***	0.003**	0.007***	-0.007***
Constant	0.078***	0.074***	0.17***	0.128***	0.13***

*** p<0.01, ** p<0.05, * p<0.1

Figure 3.

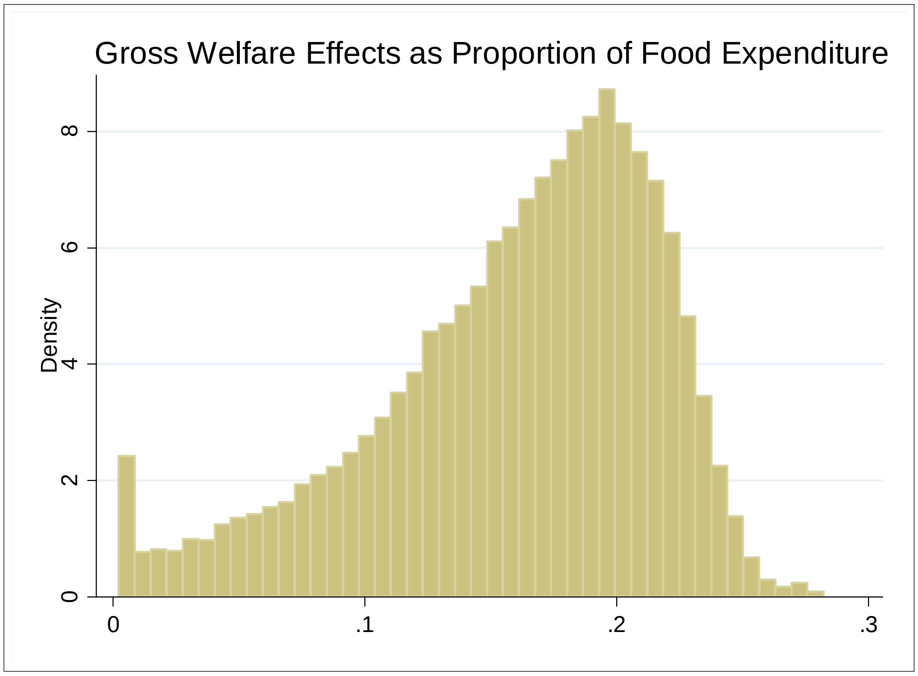


Figure 4.

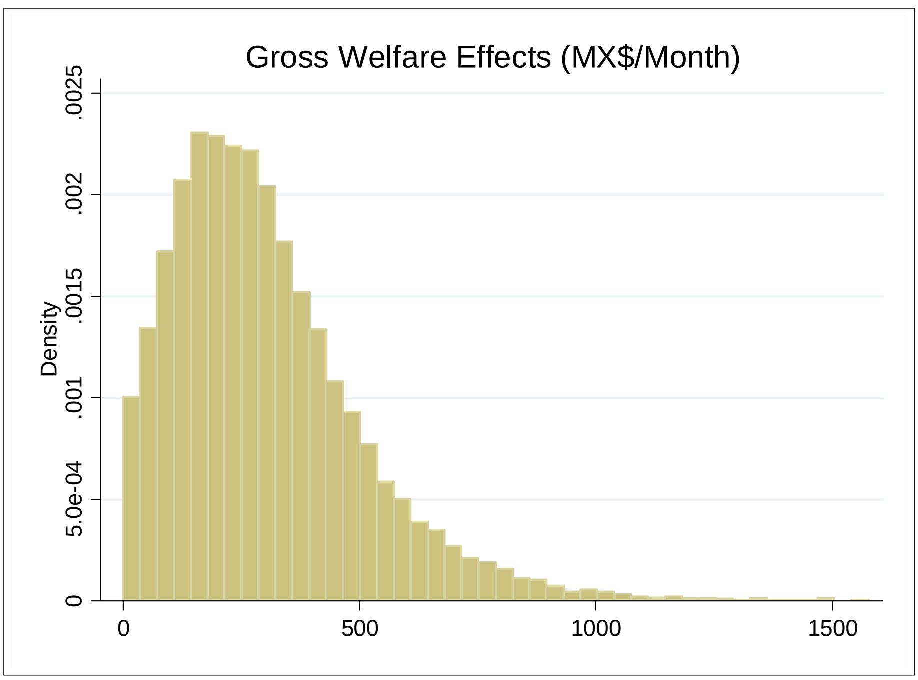


Figure 5.

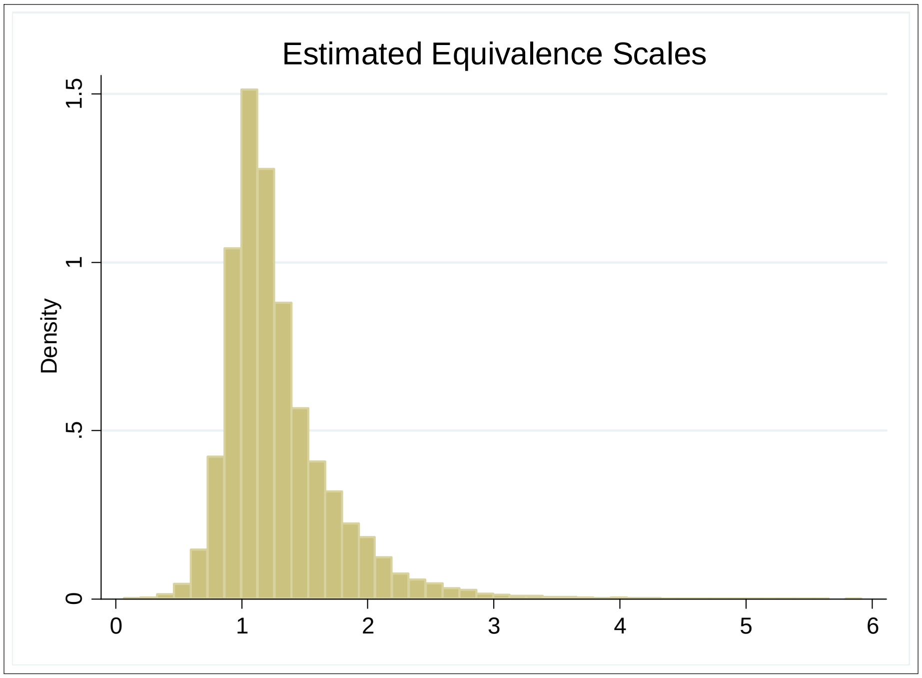


Figure 6.