Food Price Crisis: Welfare Impact on Mexican Households

by

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Abstract

Staple food price increases in recent years resulted in social unrest, particularly in the developing world. Political responses to these food shocks varied, with countries like China restricting trade in certain foods, and others like Russia and Mexico capping prices on select staple commodities. We use a nationally representative, cross-sectional, Mexican household survey to estimate consumer welfare losses due to the recent staple food price increases from 2006 to 2009. While previous articles on Mexico mainly examined the effect of the corn tortilla price shock on poor consumers, the derived demand elasticities in this article more accurately predict changes in Mexican consumption patterns as they allow for substitution within consumer food budgets. Furthermore, we analyze staple commodities aggregated in six groups: tortillas, cereal, dairy, meat, fruits and vegetables and other commodities to obtain a more complete representation of the Mexican diet.

Regional and income heterogeneity in demand are accounted for to measure the impact of staple food price increases on low-income consumers in a developing country. We quantify the welfare effects of staple food price increases on low-income households who most depend on these goods for their daily caloric intake. By improving the measurement of income-specific consumer welfare losses our results and conclusions should assist policymakers better target assistance during future staple food price increases.

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1 Introduction

Whether it is rice in Asia, wheat in the Caucuses, or corn in Latin America, global food prices have reached levels previously not experienced (see figure 1). As globalization increases, market disruptions in one country may have large effects on supply in other geographic locations. To contribute to understanding these disruptions we determine the impact of price increases in basic food commodities on Mexican households who rely most heavily on those goods for their daily caloric intake. Quantifying the extent of loss for these individuals is important for addressing solutions specific to the consumers most affected by these price increases.

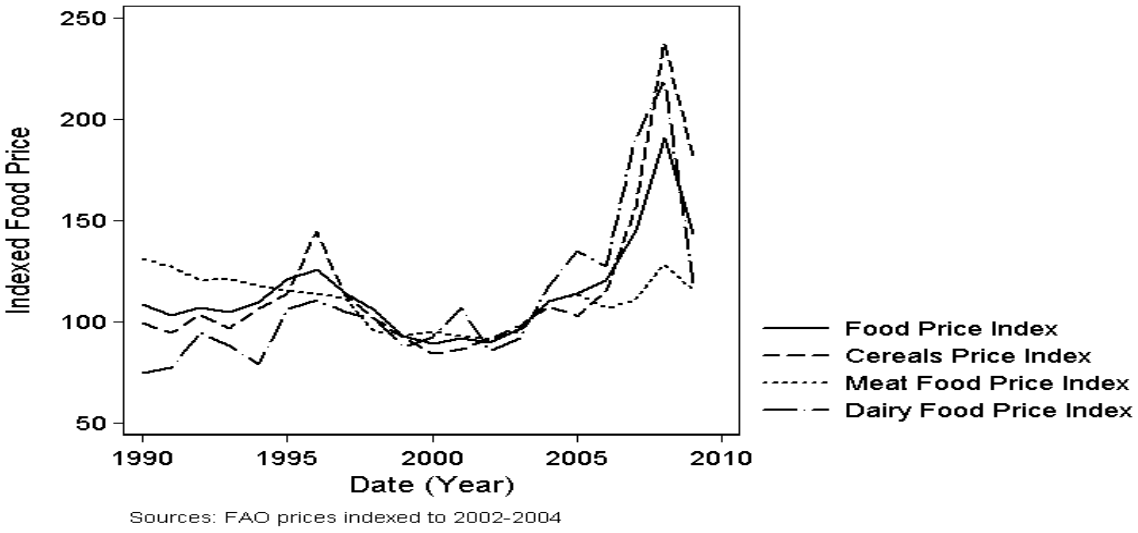

Figure 1: Global Food Prices FAO (2009)

Analysts have addressed the rise in global food prices in different manners. Many discussions center on the reasons behind the global food price increase (for

a general overview, see Headey and Fan (2008). The World Bank explores if lower food prices are advantageous to the poor (Aksoy and Isik-Dikmelik, 2008) and how higher food prices will generally affect poor consumers in developing countries (Ivanic and Martin, 2008; DeHoyos and Medvedev, 2009). But less attention has focused specifically on the welfare effects of increasing staple food prices on poor households in developing countries. DeHoyos and Medvedev (2009), in a recent publication from the World Bank, provide one of the few formal assessments of the direct and indirect impact of higher prices on global poverty. Their findings not only provide evidence of the vulnerability of poor consumers in developing countries but also highlight the significant variation in welfare effects depending on the specific regions being analyzed. Significant food price spikes, coupled with a large increase in food price volatility, may have severe effects on low-income households. Staple food price shocks are particularly concerning, as many households in developing countries are heavily dependent upon staple crops for their primary daily caloric intake (Cranfield et al., 2007).

In a recent study of Mexican households Valero-Gil and Valero (2008) measure the impact of food price increases on poverty rates using a first-order welfare measure that is the difference in food expenditure under two price regimes assuming fixed quantities. They identify the following foods as the basic components of Mexican diets: corn tortillas, poultry, soft drinks, milk, eggs, tomatoes, beans, beef, pastries (or sweet bread), sugar, and vegetable oil. We aggregate these commodities into corn tortilla, cereal, meat, dairy, fruit and vegetable, and other in order to estimate a demand system to evaluate the welfare impact of Mexican

food price increases. Food prices in Mexico began increasing toward the end of 2006, depending on the specific commodity (see figure 2). For example, in the beginning of 2007 researchers found Mexican corn tortilla prices had as much as tripled, from 5 to 15 pesos per kilo, in certain areas (Tilly and Kennedy, 2007). News reports covered rioting throughout Mexico in response to these new prices. The high tortilla prices forced many low-income Mexicans to reduce or skip meals due to unaffordable tortilla prices (Avila and Sanchez, 2007).

Low income households are expected to experience greater welfare losses from food price increases because food is a larger share of their budget, and they have fewer substitution options. We identify low income households using the receipt of an Oportunidades payment as a proxy for poverty status. The Mexican government started Oportunidades (originally Progresa) in 1998, as the lynchpin to their nationwide poverty alleviation program. Oportunidades attempts to decrease Mexico's poverty rates through targeting conditional cash-transfers directly at low-income households. The government identification of Oportunidades eligibility is split into a two-stage process, which initially identifies the most socioeconomically marginal population from the national census and then proceeds to select the poorest households within these disadvantaged communities (Coady, 2003). While the selection technique initially favored the rural poor, recent focus on expansion to urban areas has made the program more nationally representative (Angelucci and Attanasio, 2009). Oportunidades currently covers over 5 million households, accounting for practically all of the hungry Mexican households (Rosenberg, 2008). Implementation of Oportunidades coincided with the phas-

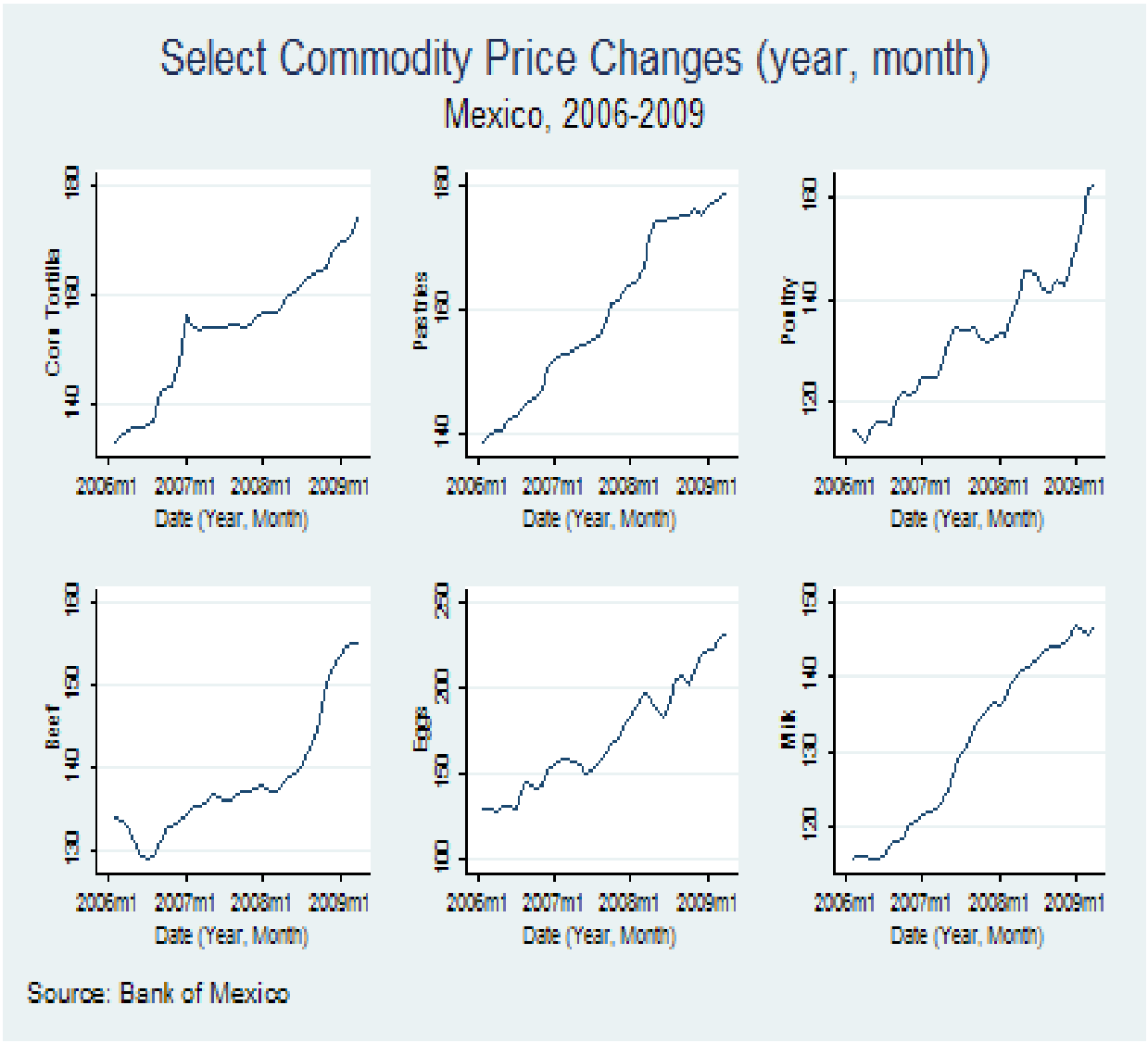

Figure 2: Average Prices for Selected Staple Foods in Mexico
Banco de Mexico ((various years)

ing out of earlier price distorting Mexican food assistance programs, such as the tortilla subsidies through the FEDELIST program (Coady, 2003).

Using Mexican survey data, we estimate a rank 2 demand system to identify demand elasticities, and welfare effects for poor and nonpoor households. Results indicate that recent food price increases caused poor Mexican households to lose 18 percent of their food budgets' on average. Demand system identification reveals demand for corn tortillas is perfectly inelastic for nonpoor and poor households, implying first-order welfare measures, assuming unchanged quantities, identify economic welfare changes. But other basic food commodities like cereal, meat and dairy have significant own and cross price elasticities. Results show that first-order welfare measures significantly overestimate economic welfare changes for such commodities, especially for nonpoor households. The average economic loss caused by the increase in the price of cereal, meat, and diary is 92 pesos per week by first-order measurement, and 50 pesos per week by equivalent variation measurement, indicating that substitution enables households with substitution options to recover a significant portion of the food budget. In contrast, the results show that poor households can not recover income lost from food price increases, as first-order and equivalent variation welfare measures are identically 68 pesos per week on average.

2 World Food Prices and Mexican Food Prices

Studies addressing poverty and price shocks abound in the literature. Debates continue on the extent to which poor households are exposed to price shocks, depending on their integration in the national economy, and the effect of food price increases on those households. Our study contributes to the literature by expanding on prior attempts to measure the effect of food price increases on low income households by estimating price and income responsive demand through a complete food demand system. We focus on one developing country: Mexico, as each country has its own unique characteristics that yield different responses and consequently, should be analyzed in detail to provide accurate policy recommendations. Furthermore, we analyze six commodity groups that represent the main staple foods consumed by Mexicans.

A significant amount of literature exists relating macroeconomic shocks to vulnerable and or low-income populations.[1] Glewwe and Hall (1998) consolidate these ideas by tightening the definition of "vulnerable" using Peruvian panel data. They found that a macroeconomic shock had different effects on the population, dependent upon family size, education, and other demographic variables. They also demonstrated that Peru's social security program failed to target vulnerable or poor groups during the time of economic instability. Mexico's Oportunidades attempts to overcome these concerns by working within marginalized groups to specifically assist those households most in need. Hence, it is natural to identify

[1]For an example of vulnerability in relation to low-income populations see Gaiha and Imai (2004).

poor Mexicans based on recipients of Oportunidades payments.

Our focus on associating food price increases or shocks with consumer welfare losses coincides with previous research. Ravallion (1989) supported the claim of disproportionate effects on low-income households by studying a simulated staple food price spike in Bangladesh. He demonstrated large short-run losses for rural low-income households after a ten percent increase in grain prices by measuring mean expenditures as a percentage of mean income.

Other studies reach different conclusions when examining the effect of food price increases on low income groups. Aksoy and Isik-Dikmelik (2008) challenge the view that low-income populations in developing countries are necessarily harmed by higher food prices. Although they find significant percentages of net food buyers in the nine countries they examined, they further differentiate the groups into marginal (less than ten percent of expenditures on staple food) and vulnerable (more than thirty percent of expenditures on staple food) consumers. Comparing net staple food purchases to total household expenditure, they uncover very low percentages of vulnerable consumers in most of their sample. By modeling a complete Mexican food demand system, our research contributes new information to this debate over the effects of staple food price increases on low-income consumers.

DeHoyos and Medvedev (2009) analyze the effect of the spike in food prices between 2005 and 2008 on poor consumers. They provide one of the few formal assessments of direct and indirect welfare effects on poor households around the world. The study uses data from a set of household surveys from a representa-

tive sample of the population in the developing world. Their findings are based on changes in the domestic food consumer price index (CPI) from January 2005 to December 2007, and suggest a 1.7 percent increase in global extreme poverty, taking into account both the direct and indirect effect of food price increases. The authors emphasize the significant regional variation, with poverty in Eastern Europe and Central Asia and Latin America remaining roughly unchanged. On the other hand, countries in East Asia and the Middle East and North Africa increased poverty by more than 6 and 2.4 percent, respectively. Therefore it is important to analyze countries individually to provide relevant understanding of poverty to inform policy recommendations. DeHoyos and Medvedev (2009) use information on national food CPI to calculate price changes for each country. We refine the welfare analysis by using the prices of staple food items, aggregated into six main categories. In this manner we allow for substitution effects, and we better capture consumer behavior. Consequently, our results yield a more accurate welfare analysis to inform more specific recommendations for Mexican policymakers.

Many papers focus on economic shocks in relation to low-income Mexicans, with one example being a study of how the 1995 Mexican peso crisis affected consumers Mckenzie (2006). McKenzie utilizes Encuesta Nacional de Ingreso-Gasto de los Hogares (ENIGH) data from between 1992 and 2000 to identify household consumption adjustments in the face of a general price shock. The study analyzes changes in durable and non-durable consumption patterns after the peso crisis. McKenzie demonstrates that mean expenditure shares on these goods adjusted more than what would normally be expected under Engel's law. By

including demographic variables, he adjusts for household size and the age of the household head. Engel curve analysis of these variables illustrates how Mexican consumers protect their basic food consumption by reducing their durable goods purchases during this time of general price increases (Mckenzie, 2006).

McKenzie (2002) also used the ENIGH dataset to examine changes in tortilla consumption in response to tortilla price liberalization in 1999. He focuses particularly on potential Giffen behavior, exploring whether Mexican tortilla purchases increased after their prices rose. McKenzie broke the population in total expenditure quartiles to examine fluctuations in the budget shares devoted to tortilla, included extra attention spent on the lowest decile of consumers. After controlling for age and education, he shows tortillas to be an inferior, although not a Giffen, good for low-income Mexican households.

One study analyzes the effect of recent food price increases on Mexican consumers, through a limited estimation of consumer demand. Valero-Gil and Valero (2008) combine ENIGH data from 2006 with 2006-2008 international commodity prices to estimate how increasing prices affected consumer poverty statuses. They define a poverty line as the lowest quartile of the distribution of household expenses. Alternatively, Valero-Gil and Valero also create an extremely poor line by applying percentages of urban and rural poverty defined by The National Council for Evaluation of Social Development Policy (CONEVAL) to the ENIGH dataset. Initially, they separate the consumers into quartiles and identify the eleven most commonly purchased food items by low-income Mexicans. By applying the after-survey international prices to the survey quantities and calculating differences in

expenditure and subtracting the change from income, the authors document increases in expected poverty and extreme poverty within Mexico. They find the number of poor Mexican households increases by almost three percent (800,000) and a little more than an additional one and a half percent (400,000) of households become extremely poor. The authors assume static consumption patterns after price increases, which may bias their results.

Our research differs from previous work by estimating a complete food demand system from a nationally representative Mexican household survey. By allowing for changes in purchases within the individual food categories, our work extends McKenzie's substitution findings by focusing on price increases in basic food commodities. Additionally, our results will provide a more accurate estimate of the welfare effects of food price increases on low income households than Valero-Gil and Valero (2008), due to estimation of a complete demand system and simulation of food price changes using Mexican prices. A food demand system approach captures consumer adjustments in food purchases caused by price changes, which may influence welfare measurements significantly.

3 The ENIGH Data

Our research utilizes ENIGH Mexican household surveys from 2006. These nationally representative surveys cover all areas in Mexico and include extremely detailed information on the expenditure, income, and demographics of the household. The survey began in 1984, become biennial in 1992, and added an additional

year in 2005. The Mexican government conducts this survey for 10 weeks in the 3^{rd} quarter of the year. We obtained survey data for 2000, 2002, 2004, 2005, and 2006. The 2006 survey is used to estimate the demand system because it is the survey closest to the significant increase in food prices. Expenditure data includes the quantities and prices paid for over 200 individual goods. Income is broken into quarterly and monthly levels, denoting the source of the money. Of particular importance, ENIGH records the payments received from Oportunidades.

The Mexican government transfers money to low-income individuals through the conditional cash transfer program currently called Oportunidades. The Mexican government started the conditional cash transfers in 1997, then called Progresa. The program serves as a model that has been adopted in many countries including Costa Rica, El Salvador, Nicaragua, Ecuador, Bolivia, Indonesia, and the Phillipines.

Oportunidades recipient households are used to identify poor households in Mexico. The Mexican government has invested significant resources in developing this poverty alleviation program, which focuses specifically on the poorest Mexican households (Adato et al., 2000). While truth-telling about payment receipt by household respondents is of concern, the program stresses accountability and publishes lists of the names and amounts received for all Oportunidades recipients. Additionally, the World Bank has, as recently as February 2009, approved of Mexico's identification and dispersion of Oportunidades aid (Jones, 2009). Officially, the program assisted 5 million of Mexico's 106 million people (4.7 percent) in 2006. The 2006 ENIGH survey recorded 3,866 of the 20,610 households (18.8

percent) receiving Oportunidades payments. It seems unlikely that a household would lie to say they actually received Oportunidades payments when they did not, thus the identification of extremely poor Mexican households works at worst as a lower bound.[2]

To estimate an empirical demand system the household consumption data is aggregated into expenditure categories. ENIGH provides both monthly and quarterly expenditure information, but the quarterly data appears more reliable as it accounts for multiple months of purchases and presents a more consistent picture of Mexican food expenditure. The USDA estimated food budget shares for 114 countries, including Mexico, in 2003. They found that Mexicans spent about 27 percent of their budget on food, which compares favorably with the quarterly estimate of 33 percent (Regmi, 2003). Figure 3 displays the mean expenditure of all surveyed households along general expenditure categories. And the food budget shares, before cleaning to remove outliers, are depicted in figure 4. Leverage and dfbeta statistics of simple Engel curve specifications revealed that extremely small values had very large leverage, and extremely large values had very large dfbetas. Therefore the data was trimmed at both extremes producing a data set with 7,505 observations on nonpoor households and 1,146 observations on poor households. Valero-Gil and Valero (2008) report removing large and small observations to lessen the impact of outliers, but they do not report their final sample size.

[2] The Mexican government controls for false receipt of Oportunidades payments by visiting many of the households who claim benefits (Martinelli and Parker, 2007).

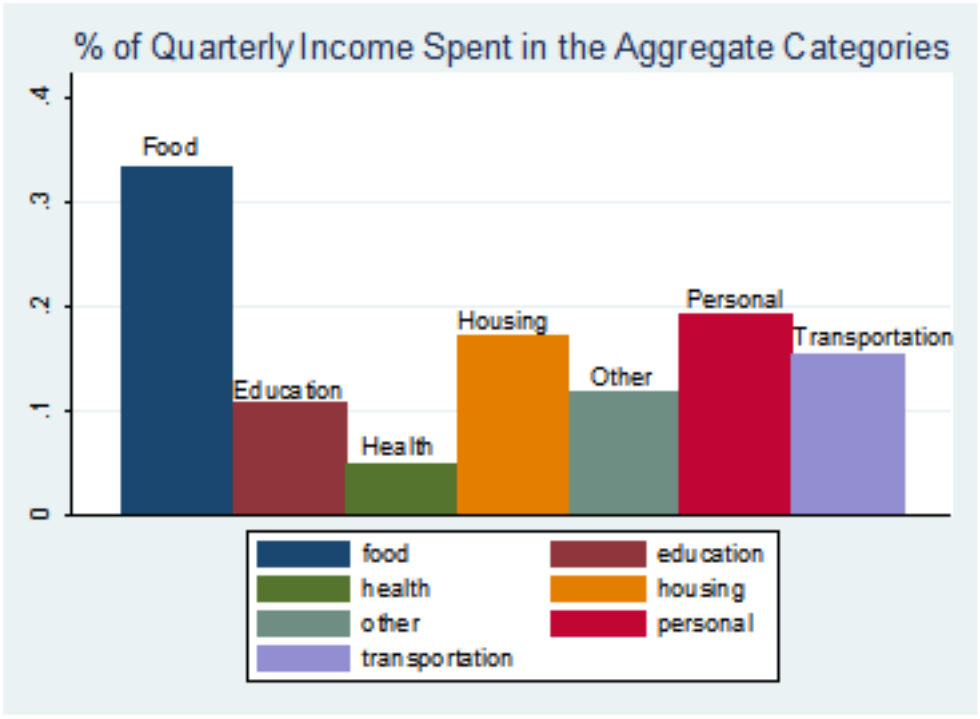

Figure 3: First Stage Budgeting, Quarterly Mean Expenditure

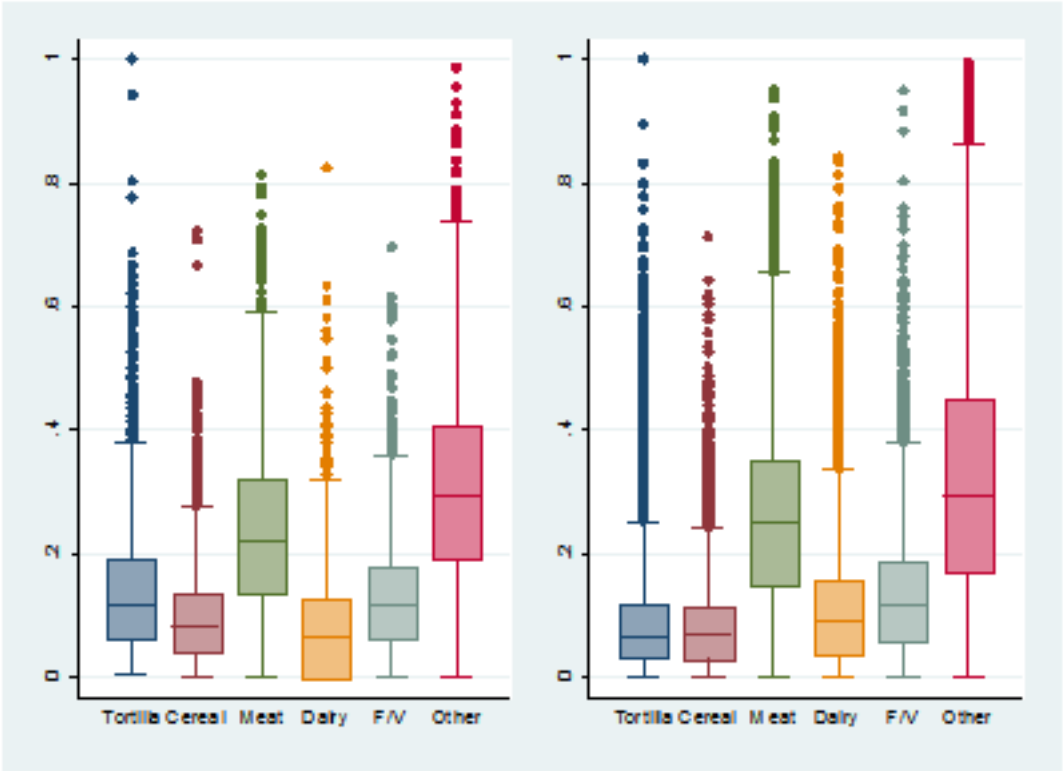

Figure 4: Food Budget Shares, Poor (left) and Non-Poor (Right) Households

The disaggregated food commodities are aggregated into corn tortilla, cereals, meats, dairy, fruits and vegetables, and other.[3] Budget shares of the aggregate commodities are calculated by dividing the expenditure on each sub-group by the overall food expenditure. The number of individual food items in the budget shares differ greatly; in total the food budget shares represent nearly 250 individual commodities.[4]

Summary statistics of budget shares and prices of the aggregate commodities are presented in table 1. The summary statistics reveal that even though tortilla consists of a single food commodity it has a budget share similar to the shares of the aggregate commodities. For poor households the mean tortilla share is greater than the mean cereal and dairy shares. The mean total food budget of poor households is 80 percent of the mean food budget of nonpoor households. These expenditures represent weekly food expenditure in pesos.

The specification and analysis of the food demand system begins with evaluation of the Engel curves for each food category. The Engel curve analysis is based on nonparametic regressions of the shares of food categories against the log of total food expenditure. The nonparametric regressions for the six food categories are presented in figure 5. These nonparametric regressions distinguish between rank 2 and rank 3 demand specification by differentiating between linear and quadratic functional structure (Banks et al., 1997). While there is some curvature to some of the regression lines, there does not appear to be significant deviation from lin-

[3] While the items included in most categories are self-evident, the "other" category incorporates various unrepresented goods from soda to cooking oil.

[4] Beans, an important component of the diet, are included in the other category.

Table 1: Summary Statistics

	(1) *nonpoor*		(2) *poor*	
	mean	*sd*	*mean*	*sd*
tortilla share	0.0842	0.0583	0.1280	0.0762
cereal share	0.0887	0.0573	0.0981	0.0639
meat share	0.2683	0.1210	0.2301	0.1097
dairy share	0.1219	0.0780	0.1095	0.0764
fruit and vegetable share	0.1394	0.0829	0.1373	0.0810
other share	0.2976	0.1639	0.2971	0.1349
tortilla price	7.7880	1.3067	7.7214	1.2672
cereal price	23.0165	12.4693	18.8533	11.8663
meat price	36.4628	13.1812	30.5072	10.9770
dairy price	20.0891	18.5044	22.3024	19.3903
fruit and vegetable price	12.8029	5.3778	12.7902	5.2146
other price	12.1568	10.8813	9.8343	7.2878
total food expenditure	620.0880	350.7273	498.2921	239.0709
Observations	7505		1146	

earity toward quadratic behavior. This is suggestive that demand for all the food commodities can be represented by rank 2 demand.

4 Empirical Model

Engel curve analysis identifies rank 2 demand as appropriate for estimating Mexican household food demand. Such demand systems, originally studied by Gorman (1953), are composed of two independent functions of prices interacting with functions of total expenditure. Muellbauer (1976) generalized Gorman's results on consistent aggregation of demand functions. As part of that research Muellbauer defined the rank 2 demand functional form known as PIGLOG. The PIGLOG functional form generates share equations of the form:

$$s_i(p, w) = a_i(p) + b_i(p) \ln w$$

where p represents prices and w represents total food expenditure. That is, budget shares are linear in log total expenditure and are composed of two independent functions of prices. Muellbauer also showed that the expenditure function of the PIGLOG functional form has the generic form:

$$\ln e(p, u) = a(p)\,(1 - u) + b(p)u \tag{1}$$

We follow Deaton and Muellbauer (1980) by specifying:

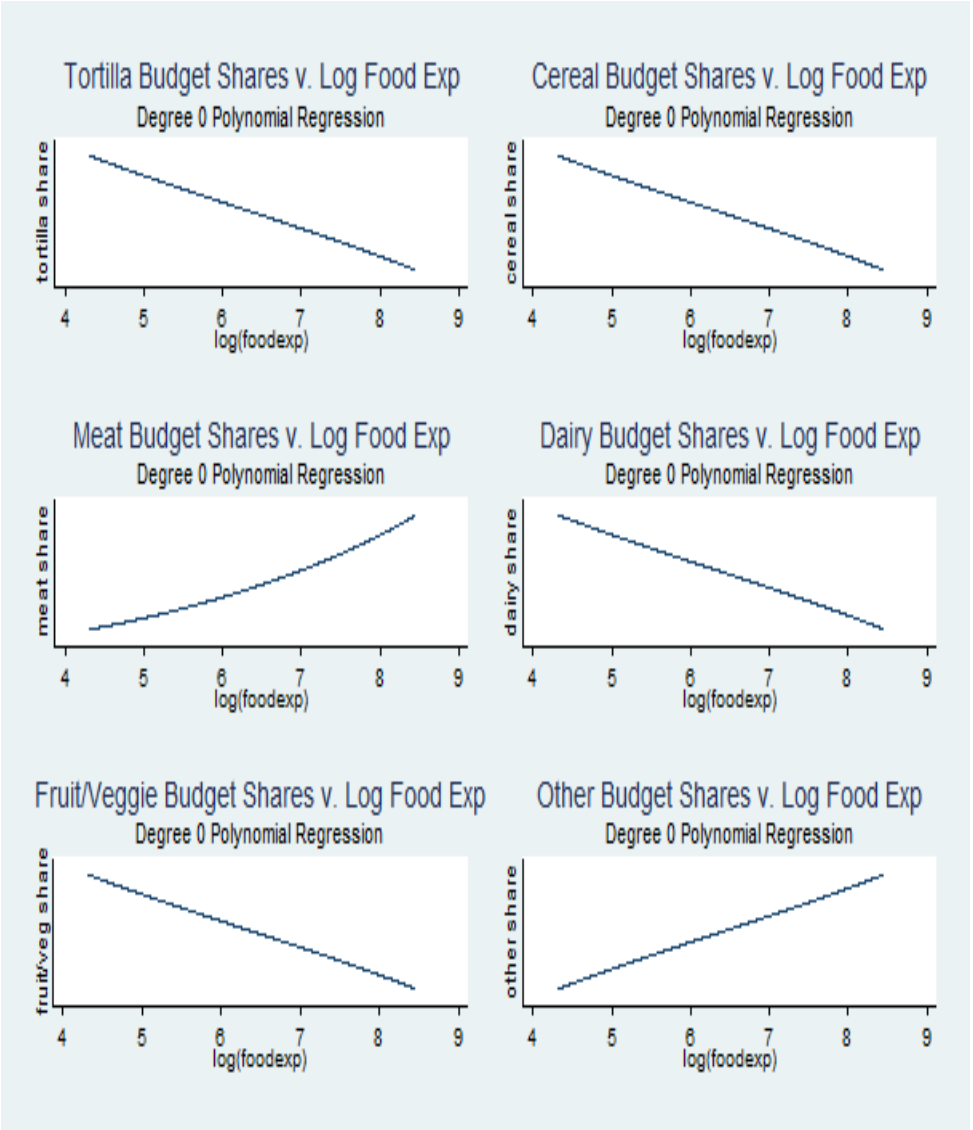

Figure 5: Engel Curves of Food Budget Shares on Log Food Expenditure

$$a(p) = \alpha_0 + \sum_i \alpha_i \ln p_i + \frac{1}{2} \sum_i \sum_j \gamma_{ij} \ln p_i \ln p_j \tag{2}$$

$$b(p) = a(p) + \beta_0 \prod_i p_i^{\beta_i} \tag{3}$$

Substituting (2) and (3) into (1) produces the expenditure function:

$$\ln e(p,u) = \alpha_0 + \sum_i \alpha_i \ln p_i + \frac{1}{2} \sum_i \sum_j \gamma_{ij} \ln p_i \ln p_j + u\beta_0 \prod_i p_i^{\beta_i} \tag{4}$$

and the indirect utility function:

$$V(p,w) = \frac{\left(\ln w - \left(\alpha_0 + \sum_i \alpha_i \ln p_i + \frac{1}{2} \sum_i \sum_j \gamma_{ij} \ln p_i \ln p_j\right)\right)}{\beta_0 \prod_i p_i^{\beta_i}} \tag{5}$$

To account for differences in household size we use a specification of returns to scale in consumption discussed by Deaton (2000). If there is constant returns to scale in consumption, and n represents household size, indirect utility would satisfy:

$$V(p,w) = n\frac{\left(\ln(w/n) - \left(\alpha_0 + \sum_i \alpha_i \ln p_i + \frac{1}{2} \sum_i \sum_j \gamma_{ij} \ln p_i \ln p_j\right)\right)}{\beta_0 \prod_i p_i^{\beta_i}} \tag{6}$$

meaning that the utility of a household with n individuals who share consumption equally is the sum of individual utilities where each individual is allocated $1/n$th of consumption resources. There are economies of scale in consumption if the need for goods do not grow as fast as the household size. A simple way to model this is to assume that the need for goods to achieve a given utility level grows more slowly than the number of individuals, say at a rate n^θ, where $0 < \theta < 1$. If $\theta < 1$ there are economies of scale in consumption. Deaton (2000) argues that little is gained by generalizing this isoelastic functional specification.

Using the economies of scale specification to account for household size, the budget share equations which form the system of estimating equations have the form:

$$\begin{aligned} s_i(p, w) &= \alpha_i + \sum_j \gamma_{ij} \ln p_j \\ &+ \beta_i \left(\ln w - \theta \ln n - \left(\alpha_0 + \sum_i \alpha_i \ln p_i + \frac{1}{2} \sum_i \sum_j \gamma_{ij} \ln p_i \ln p_j \right) \right) \end{aligned} \tag{7}$$

The parameters of the demand system are estimated by applying nonlinear seemingly unrelated regression to the system of five share equations (share other is dropped to avoid covariance matrix singularity). The estimator is a feasible nonlinear generalized least squares estimator that is implemented with the Stata command `nlsur`.

Parameter estimates will provide a clear understanding of household food consumption behavior in 2006, summarized through income and price elasticities.

And the parameter estimates provide a theoretically consistent model of household food demand that can be used to evaluate the welfare implications of food price increases that occurred after 2006. Such welfare estimates will provide significant new information about household welfare relative to the measurement of first-order effects of food price increases assuming perfectly inelastic demand as in Valero-Gil and Valero (2008).

5 Estimation Results

Parameter estimates of the demand system are presented in table 2. These estimates do not have direct interpretation. They are presented to provide information about the model fit for the poor and nonpoor households. Most coefficients have p-values smaller than 0.001, indicating a good fit of the demand system.

The one parameter in the demand system with direct interpretation is θ, the economy of scale in consumption. This parameter is 0.523 for non-poor households and 0.460 for poor households. These estimates suggest substantial economies of scale in food consumption. This means that if household size and household resources double nonpoor households experience a 48 percent increase in per capita resources and poor households experience a 54 percent increase in per capita resources. The increasing returns to scale in food consumption is likely due to additional household members making smaller demands on food resources, as well as benefitting from larger scale food preparation.

A full set of elasticity estimates, income elasticities and compensated price

Table 2: Parameter Estimates

	nonpoor	poor		nonpoor	poor
α_1	-0.0553^{***}	-0.0804^{***}	γ_{13}	-0.0281^{***}	-0.0266^{***}
	(0.00482)	(0.0185)		(0.00163)	(0.00522)
α_2	0.0691^{***}	0.0963^{***}	γ_{14}	-0.00174	-0.00471
	(0.00273)	(0.00958)		(0.000886)	(0.00311)
α_3	0.107^{***}	0.135^{***}	γ_{15}	-0.00123	-0.0124^{*}
	(0.0108)	(0.0270)		(0.00135)	(0.00486)
α_4	0.0769^{***}	0.0865^{***}	γ_{22}	0.0186^{***}	0.000881
	(0.00647)	(0.0173)		(0.00126)	(0.00379)
α_5	0.135^{***}	0.183^{***}	γ_{23}	-0.0144^{***}	-0.0109^{**}
	(0.00725)	(0.0198)		(0.00136)	(0.00389)
β_1	-0.0636^{***}	-0.0815^{***}	γ_{24}	-0.000247	0.00120
	(0.00134)	(0.00492)		(0.000777)	(0.00202)
β_2	-0.0145^{***}	-0.00501	γ_{25}	0.000255	0.0104^{***}
	(0.00147)	(0.00449)		(0.00114)	(0.00311)
β_3	-0.0173^{***}	-0.00395	γ_{33}	0.0883^{***}	0.0764^{***}
	(0.00302)	(0.00717)		(0.00316)	(0.00799)
β_4	-0.0141^{***}	-0.00743	γ_{34}	-0.00174	-0.00555
	(0.00194)	(0.00530)		(0.00145)	(0.00325)
β_5	-0.00119	0.0126^{*}	γ_{35}	-0.00460^{*}	-0.0121^{**}
	(0.00211)	(0.00565)		(0.00179)	(0.00464)
θ	0.523^{***}	0.460^{***}	γ_{44}	0.000690	0.00344
	(0.0190)	(0.0591)		(0.00140)	(0.00366)
γ_{11}	0.0735^{***}	0.0885^{***}	γ_{45}	0.0131^{***}	0.00714^{**}
	(0.00223)	(0.00871)		(0.00109)	(0.00270)
γ_{12}	-0.00447^{***}	-0.00340	γ_{55}	-0.00343	-0.00868
	(0.000954)	(0.00333)		(0.00193)	(0.00483)
Observations	7505	1146		7505	1146

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

elasticities, were calculated at the medians of the nonpoor and poor households. The elasticity estimates were bootstrapped 370 times in order to obtain reliable estimates of standard errors. Using a formula derived by Andrews and Buchinsky (2000), this implies that the relative difference between the bootstrap standard errors and standard errors based on infinite bootstraps is less than 10 percent with probability greater than 0.95, if the coefficient of excess kurtosis of the bootstrap estimates is 2. This is a conservative assumption as bootstrap samples are frequently assumed to be normally distributed implying an excess kurtosis of 0.

Estimates of income elasticities of demand for nonpoor and poor households are presented in table 3. It is striking that the income elasticity of demand for tortilla by nonpoor households is very small, indicating that changes in income are unlikely to change tortilla demand. This is most likely a reflection of the status of tortilla as a staple that these households consume in the desired quantity. Poor households also have a small income elasticity of demand for tortilla, but it does indicate an increase in tortilla demand as income increases. The income elasticities reveal that none of the goods are inferior, while the other commodity is a luxury for nonpoor and poor households. This is a reflection of the various commodities aggregated into other, including meals away from home.

The income elasticities of cereal, meat, dairy, and fruit and vegetable are all close to 1, indicating that welfare analysis of price increases needs to account for change in demand caused by the income effect of the price increases. The elasticities indicate that the income effect could be large for these commodity categories. In contrast, the small tortilla income elasticities suggest that first-order expendi-

ture differences might be appropriate welfare measures for tortilla price changes. Further evidence about these effects will be provided by the compensated price elasticities.

Table 3: Income Elasticities

	(1) nonpoor	(2) poor
tortilla	0.0968^{***}	0.279^{***}
	(0.0194)	(0.0467)
cereal	0.815^{***}	0.941^{***}
	(0.0192)	(0.0584)
meat	0.934^{***}	0.982^{***}
	(0.0122)	(0.0335)
dairy	0.870^{***}	0.921^{***}
	(0.0180)	(0.0627)
fruit and vegetable	0.991^{***}	1.102^{***}
	(0.0170)	(0.0477)
other	1.406^{***}	1.298^{***}
	(0.0154)	(0.0382)
Observations	7505	1146

standard errors in parentheses, 370 bootstrap replications

$^{*}\ p < 0.05$, $^{**}\ p < 0.01$, $^{***}\ p < 0.001$

Compensated price elasticities are reported in table 4. Own price elasticities for nonpoor and poor households appear in columns (1) and (3). Columns (2) and (4) contain cross price elasticities between tortilla and the other food categories. These cross price elasticities are of interest given that the income elasticities suggest tortilla is a staple for these households. It is important to understand how changes in the price of the staple impacts demand for other foods.

Table 4: Compensated Price Elasticities

	(1)	(2)	(3)	(4)
	nonpoor		poor	
	own price	cross price	own price	cross price
tortilla	-0.00275		-0.238^{***}	
	(0.0300)		(0.0707)	
cereal	-0.690^{***}	-0.0114	-0.906^{***}	0.0461
	(0.0157)	(0.0133)	(0.0465)	(0.0289)
meat	-0.403^{***}	-0.170^{***}	-0.432^{***}	-0.0222
	(0.0113)	(0.0228)	(0.0377)	(0.0490)
dairy	-0.889^{***}	0.0580^{***}	-0.871^{***}	0.0406
	(0.0130)	(0.0120)	(0.0368)	(0.0242)
fruit and vegetable	-0.900^{***}	0.107^{***}	-0.949^{***}	0.0345
	(0.0151)	(0.0177)	(0.0370)	(0.0414)
other	-0.526^{***}	-0.0632^{***}	-0.529^{***}	0.0600
	(0.0111)	(0.0100)	(0.0306)	(0.0313)
Observations	7505		1146	

standard errors in parentheses, 370 bootstrap replications

$^{*}\ p < 0.05$, $^{**}\ p < 0.01$, $^{***}\ p < 0.001$

The own price elasticity of tortilla demand is not significantly different from 0 for nonpoor households, and it is very small for poor households. This is significant information because tortilla is a disaggregate commodity, while all other commodities are aggregated. Economic reasoning suggests that disaggregate commodities should have larger own price elasticities than aggregate commodities because there are more substitutes for disaggregate commodities. Thus the small own price elasticity for tortilla is unexpected, and it reveals important information about tortilla demand. Furthermore, for poor households, all cross price elasticities are not significantly different from 0, suggesting tortilla demand is strongly separable from demand for the other food commodities. This implies that an increase in tortilla price does not influence demand for other food commodities.

Examination of the income and compensated price elasticities for tortilla for nonpoor households provides an interesting picture of demand. Using the Slutsky equation in elasticities:

$$\eta_{ii} = \eta^*_{ii} - \eta_i s_i$$

where η^*_{ii} is compensated own price demand elasticity, η_i is income elasticity, and s_i is the budget share of the good, we find that the own price elasticity of Marshallian demand, η_{ii}, is -0.007. Thus Marshallian demand for tortilla is almost perfectly inelastic. A 25 percent increase in the price of tortilla would induce a 0.2 percent decrease in tortilla demand. And compensated demand is perfectly in-

elastic. This implies that compensating and equivalent variation for tortilla price changes are rectangles defined by the change in price along vertical lines that are virtually identical. We observe tortilla demand in the third quarter of 2006, before the increase in world food prices, so we can calculate compensating variation by the change in tortilla expenditure with quantity demanded fixed. This is equivalent to the first-order measure of food price increases used by Valero-Gil and Valero (2008).

The significant income and compensated price elasticities for the aggregate food categories suggest that the first-order change in expenditure measure of the welfare effect could be substantially different than compensating and equivalent variation measures. These differences will be explored in the following section.

6 Welfare Analysis

As depicted in figure 2, the prices of many items in Mexican household food budgets increased significantly between the third quarter of 2006 and the first quarter of 2009. These increases have the effect of lowering the income of Mexican households, resulting in a loss of economic welfare. In order to define efficient policy responses to the welfare loss of Mexican households it is necessary to quantify the losses with accurate measures of household food demand. First-order measures assuming fixed quantities provide an approximation of the welfare loss, but compensating and equivalent variation provide a more precise measure of the loss of household economic welfare. To measure these changes in economic wel-

fare we use the estimated parameters of the demand system and observed price changes to calculate:

$$EV(p^0, p^1, w) = e(p^0, u^1) - e(p^1, u^1) = e(p^0, u^1) - w \text{ equivalent variation}$$

$$CV(p^0, p^1, w) = e(p^0, u^0) - e(p^1, u^0) = w - e(p^1, u^0) \text{ compensating variation}$$

For normal goods, we know that equivalent variation is greater than compensating variation.

The price changes are calculated for representative commodities, differentiated by geographic region, based on state level constructed from city level data of the Bank of Mexico. Following Chiquiar (2008) we group Mexican states into the regions depicted in figure 6, with the exception that the capital is incorporated into the center. The representative commodities are corn tortilla, sweet bread, beef, chicken, eggs, and milk. Sweet bread is representative of the cereal commodity. Beef, poultry, and eggs are representative of the meat commodity. And milk represents dairy. The regional price changes are presented in table 5. The price increases demonstrate that world corn prices had the largest impact on Mexican food prices through chicken and egg prices, since corn is the primary ingredient in Mexican poultry feed. Tortilla prices are not directly related to world corn prices, since tortillas are made from white corn domestically produced in Mexico.

To weight the beef, chicken, and egg price changes in constructing a meat price change we use the average share of each in total meat expenditure, as rep-

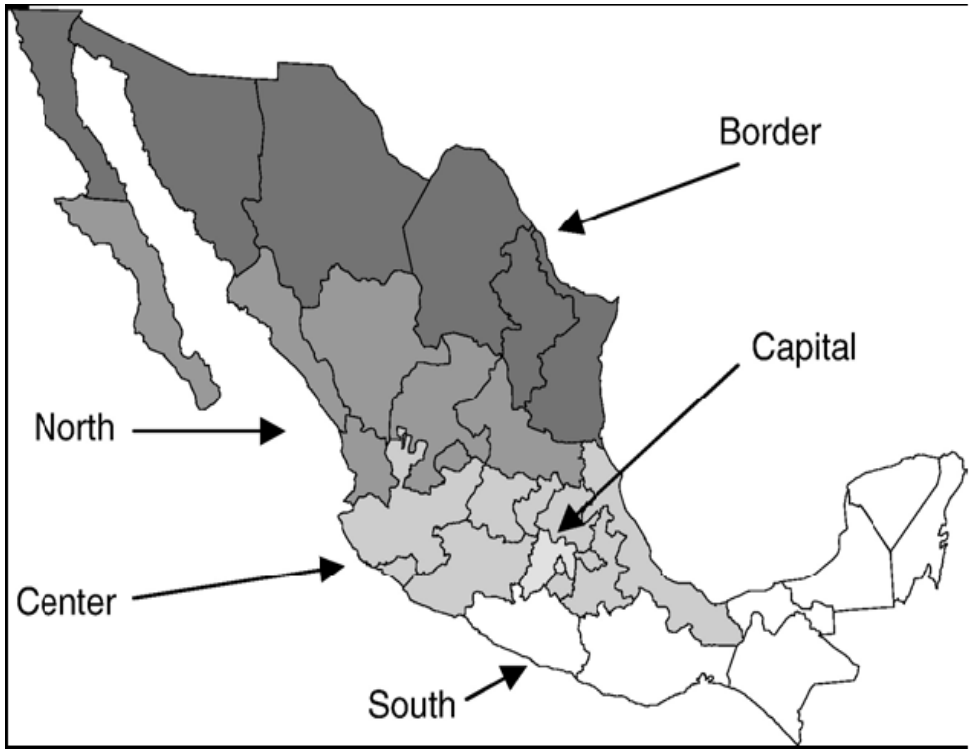

Figure 6: Regional Classification of Mexican States, (source Chiquiar (2008))

Table 5: Regional Food Price Changes (9/06-4/09)

	(1) *Border*	(2) *North*	(3) *Center*	(4) *South*
tortilla	0.23	0.24	0.25	0.23
sweet bread	0.31	0.27	0.26	0.27
beef	0.19	0.21	0.19	0.16
chicken	0.33	0.43	0.35	0.32
eggs	0.60	0.55	0.58	0.59
milk	0.20	0.21	0.26	0.28

resented in table 6. These shares are used to create a representative meat price change, as if meat consumption was entirely from these three commodities. For all other commodities in table 5, the price change of the commodity is taken to be representative of the commodity group.

Table 6: Components of Meat Category

	(1) *nonpoor*		(2) *poor*	
	mean	*sd*	*mean*	*sd*
beef share	0.2711	0.2539	0.1837	0.2445
chicken share	0.2609	0.2405	0.2752	0.2663
egg share	0.1356	0.1870	0.2032	0.2352
Observations	7505		1146	

We first present welfare measures from the change in tortilla prices. As discussed in section 5 the demand analysis found that tortilla demand is perfectly inelastic, therefore welfare change is calculated by multiplying regional price change by mean consumption of nonpoor and poor households. There was little regional variation in the tortilla price change, thus there is little variation in the welfare loss. The average loss is 6.45 pesos per week for nonpoor households, and 10.48 pesos per week for poor households.

Welfare changes for the change in the price of sweet bread, meat, dairy are presented in table 7. These results clearly show that first-order welfare measurement can significantly misrepresent theoretically consistent welfare measurement. By first-order measurement it looks like the absolute loss is 33 percent larger for the nonpoor households than the poor households. Compensating and equiva-

lent variation measures show this conclusion is wrong. The absolute loss is actually smaller for nonpoor households. This is evidence that failure to account for substitution can produce income loss measures that are significant overestimates. Adding tortilla income loss to compensating variation we find that nonpoor households lose 9 percent of their food budget, on average, and poor households lose about 18 percent of their food budget, on average. So the relative loss of poor households is double the loss of nonpoor households, demonstrating the vulnerability of these households to food price increases.

Table 7: Welfare Effects of Regional Food Price Increases

	(1) *Border*	(2) *North*	(3) *Center*	(4) *South*
			(nonpoor)	
compensating variation	−54.50	−57.84	−55.21	−54.13
equivalent variation	−50.06	−52.83	−50.65	−49.75
first-order expenditure	−90.47	−95.62	−92.96	−90.95
			(poor)	
compensating variation	−79.96	−82.82	−81.40	−80.52
equivalent variation	−68.39	−70.46	−69.45	−68.82
first-order expenditure	−68.84	−72.14	−70.66	−68.92

Further the comparison of first-order and theoretically consistent welfare measures for poor households reveals that these households have few options for substituting away from food commodities whose prices increase. The first-order measures for poor households are almost identical to equivalent variation. The theoretically consistent measures provide the additional information that compensat-

ing variation is significantly larger than equivalent variation, providing evidence that the utility level achieved at higher food prices is significantly lower than that achieved at lower prices.

The insignificant difference between compensating and equivalent variation for the nonpoor provides further insight into this conclusion. The welfare loss for these households is approximately 8 percent of their food budget, which does not appear to significantly decrease their welfare. These results are strong evidence that poor households are the ones who experience significant welfare losses from significant food price increases. This implies that policy responses, such as income subsidies or tax reductions, should be targeted at the poor households.

7 Conclusion

This article focuses on quantifying the welfare losses for Mexican households due to the world food price increases from 2006 to 2009. Specifically, we measure the welfare effects of tortilla, cereal, dairy and meat price increases, differentiating by household status (poor and nonpoor) and by region (border, north, central and south). Our study has several contributions to the literature: we use the receipt of an Oportunidades payment as a proxy for extreme poverty status; we focus on the main staple foods to accurately represent the Mexican diet; we estimate a complete food demand system allowing for substitution effects to better capture consumer behavior; and we incorporate dynamic changes in consumption patterns. Consequently, our results provide a more accurate welfare analysis to inform specific

recommendations for Mexican policymakers. Furthermore, we analyze price increases from 2006 to 2009 to give a feasible representation of longer term welfare effects of staple food price increases for Mexican households.

We find evidence of the need to account for the income effect when performing welfare analysis of food price increases through the income elasticities of cereal, meat, dairy and fruit and vegetable (all close to one), but not for tortillas. We confirm tortillas as a staple food for both poor and nonpoor households, while none of the goods studied are inferior goods. One of the most striking results we obtain is that all the cross price elasticites relative to tortillas are not significant for poor households, confirming the staple status of tortillas.

To perform an appropriate welfare analysis, we calculate compensating and equivalent variation for the representative commodities, differentiated by geographic region and household status. While differences by regions are not significant, we observe large differences for poor and nonpoor households, providing evidence for Mexican policymakers of the need to design different policies depending on the segment of the population being targeted. Our results indicate the degree of vulnerability that the poorest Mexicans have regarding staple food price increases. Furthermore, this study represents a first step to design policies towards alleviating poverty in the developing world by measuring the welfare effects that staple food price increases have on the different socioeconomic groups in Mexico.

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