The Impact of Food Price Shocks on the Consumption and Nutritional Patterns of Mexican Households

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1. Abstract

In the last years food security has been an increasing concern for national governments, in particular in developing countries. Although food security is conceptualized by the Food and Agriculture Organization (FAO) in four dimensions: availability, access, utilization and stability, this research focuses only in access and utilization dimensions because the analysis of these aspects reflects more accurately the demand and nutrition sides of food security.

During the 2000's decade, recurrent food price shocks have altered the consumption and nutritional patterns of Mexican households, having significant consequences in food security. However, little is known about their impacts on consumption quantities and on their effects in the quality of the individuals' diet.

This research represents an effort to measure the effects of food price changes in a wider dimension that allows reasonably accurate analysis of who and how are the most likely adversely affected by harmful food price shocks, such as food price inflation, droughts, frost, flooding, etc.

The methodological approach of this research uses six household-level survey-based variables within a pseudo-panel framework to carry out the estimations of demand analysis model. These estimators constitute a reasonably accurate description of household consumption patterns. Furthermore, nutrient elasticities estimates measure the effects of food prices shocks on the nutrient quantity purchase of the individuals.

For the sake of the analysis, estimations are based in two groups of households and people, those in food poverty situation and those who are not in this condition. The estimations show interesting results; as expected, there exists important differences in terms of consumption patterns. Nonfood poverty households present a more diversified expenditure than households in food poverty condition, who mainly obtain their nutritional requirements from cereals and vegetables, pulses, tubers and fruits. As a consequence, the most vulnerable population is highly effected by price shocks on cereals.

Additional evaluations on past rising food prices episodes were performed to measure the impact in terms of quantity percentage purchased by people in food poverty condition and people who is not in these circumstances.

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2. Introduction

The FAO forecasts that increments in food prices will be persistent affecting people's food security around the world. The FAO conceptualizes food security in four dimensions: availability, access, utilization and stability. Food security requires that all four dimensions must be simultaneously fulfilled.

Although national-level measures lead to national-scale food availability conditions, these indicators are a poor indicator of food insecurity at a more disaggregated level because they exclude the intra-national conditions of access and utilization of food. For this reason, this research will focus on two dimensions: the access and utilization of food. Access dimension reflects the demand side of food security including inter and intra-household food distribution, while utilization allows identifying nutritional responses in diets to adverse price shocks.

Under these two components, demand analysis of expenditures, income and prices offers a detailed description of the household consumption patterns, while the study of nutrient intake by individuals provide a comprehensive approach about the utilization of food at intra-household level.

During the 2000's, factors such as stochastic climatic shocks have created volatility and uncertainty in international food prices. In particular, the upward tendency of food prices in international markets between 2006 and 2008 had important implications in food consumption and nutrition status of Mexican households (Pérez and Minor, 2012). According to CONEVAL's[1] estimations, from 2006 to 2010 the population in condition of food insufficiency or food poverty increased from 13.8% to 18.8% of the population.

It is known that income is an important determinant of food consumption patterns and the strategy effectiveness of the households to cope with rising food prices. The most frequent household strategy is the substitution of food commodities, reducing the consumption of those with higher prices and increasing the consumption of food items with lower prices and close nutritional content. However, the efficiency of this strategy in most of the cases leads to uncertain results respect to the nutrients' quality of the diets.

The purpose of this paper is to assess the impact of food prices shocks on food household consumption and their nutrition patterns. In particular, the objective is to provide a comprehensive

[1] The National Council for the Evaluation of the Social Development Policy, in spanish Consejo Nacional de Evaluación de la Política de Desarrollo Social (CONEVAL).

approach about the consumption impact of food price changes for the most vulnerable population. In particular, the demand analysis approach could provide some directions on changes in nutritional patterns in the Mexican people's diet.

The demand analysis with a nutritional approach is a powerful instrument to analyze the effects of price increments on food consumption patterns and its nutrition quality. Demand systems provide estimates of price and income elasticities and the effects of demographic variables that determine the demand. In particular, the method used in this research allows identifying differentiated effects on vulnerable groups of the population.

This research is carried out in three stages. The first stage estimates a complete food demand system by aggregating the food commodities in eight food composite categories using the model Linear Approximation of Almost Ideal Demand System (LA/AIDS) and using the pseudo-panel approach of Deaton (1985). The second stage estimates the nutrient elasticity based on households' consumption patterns and the previously demand elasticities. Finally, the third stage evaluates the effects of recent increasing food prices episodes in Mexican economy. All estimations are calculated for two groups of persons, those who live in food poverty condition and those that live in nonfood poverty condition. The research show interesting results in terms of the differences in consumption patterns, own-price and cross-price elasticities and nutrient elasticities for each group.

To our knowledge, this is the first research that analyzes the effects of increasing food prices in households' food security using a complete food demand system and analyzing the nutritional patterns of Mexican households. The use a repeated cross-sections guarantees reasonable accuracy in relative magnitudes and direction of price elasticities and nutrient elasticities.

3. Inflation and Food Consumption Patterns in Mexico

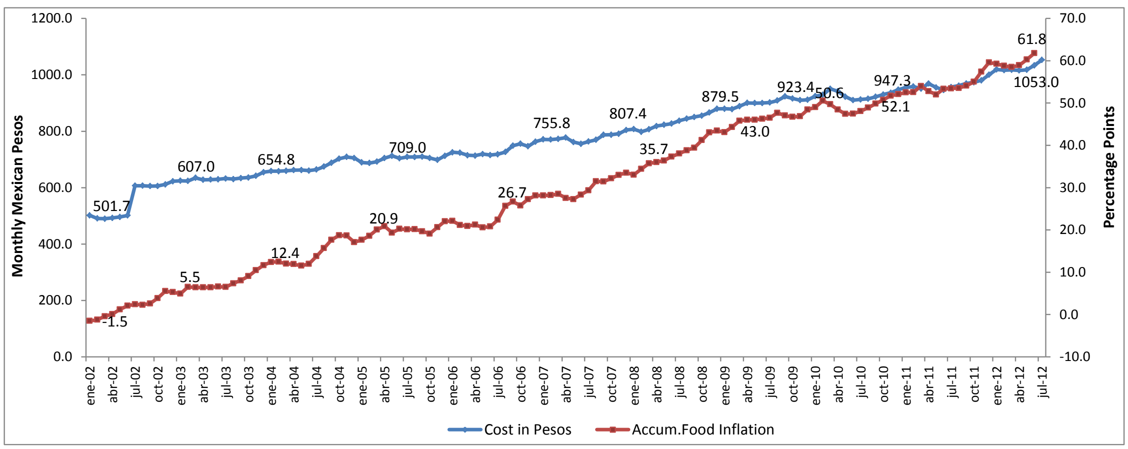
Based on information from the FAO's balance spreadsheets, the cereals, fruits and vegetables, meats, oilseeds, pulses and milk are the representative food in our country. According to Avila et al. (2011), since 1980's the consumption food pattern in Mexico has been changing by reducing the consumption in cereals, which in 2009 represent the 45% of the energy supply, while the corn and its products 33%, and pulses 4%. In contrast, an increasing trend in sugar consumption and food from animal sources nowadays provide 30% of energy supply.

The household expenditure is an indicator of the profiles of household preferences, the purchase power and the availability of the food supply that reflect the national food consumption patterns. The National Survey of Households' Income and Expenditure (ENIGH) summarize the food consumption patterns of Mexican households. According to ENIGHs, the average household between 2002 and 2010 spent 30.04% of their expenditure in food. However, this percentage varies with household's income level, while the first quintile expends in average about 37% of its total expenditure in food, the fifth quintile expends around 18%.

Thus, not only preferences determine the evolution of consumption patterns, but also the household's purchase power. In this context, in Mexico the new framework of monetary policy of inflation targeting since 1999 reduced the inflation from two digits to just one digit. Although during period 2003-2009 the inflation averaged 4.5 percentage points, since 2006 important shocks in food prices have had important effects on household food consumption. In particular for poor households the continuous increments in prices during late 2007 and mid 2008 increased the cost of the basic consumption food basket (see graph 1 below).

Graph 1. Accumulated Inflation in Food Commodities and Cost of Acquiring the Basic Consumption Food Basket 2002-2012

(Monthly Cost per Capita in pesos/ Inflation Percentage Points)



Source: Own estimations with information from Banxico prices and Coneval's basic consumption food basket.

This research recognizes that there are important differences in food consumption patterns that are implicitly related with income household level. How the consumption of households is affected as result of increasing food prices and how households deal with budget restrictions to obtain the necessary nutrients for satisfying their physiological requirements, is the kind of questions that this research solve.

Thus, this study provides a more complete perspective about how the shocks in prices affect household food security, by the evaluation of the nutritional effects and the emphasis of policy analysis is centered on households' food poverty status, thus household population is grouped in two categories. The first one is the household whose gross income does not allow them to afford the cost of the consumption food basic basket for all of its members, called household in nonfood poverty condition. The second category corresponds to households whose gross income does not allow them to afford the cost of the consumption food basic basket for all of its members, called households in food poverty condition.

This research uses the Minimum Welfare Line (MWL) as the unique criterion to define households in food poverty situation. Although the criterion of the consumption basic food basket to construct food poverty categories is taken from the CONEVAL; besides the MWL, CONEVAL additionally uses perceptions-based survey measures to define poverty classifications. As documented, Barret (2010) the use of perceptions-based survey to construct measures of food poverty could lead to inconsistent results, he find food insecurity rates several times higher than related hunger or insufficient intake measures. For the particular case of Mexico, Esquivel (2011) found evidence of the inconsistency of using this criterion. Table 1 present some empirical evidence of the effects of food prices in household's expenditure and consumption.

Table 1. Allocation of Households' Budget Shares and Average Annual Consumption per Capita Mexico (2002-2010)

Category	Distribution of Shares Expenditure in Food						Annual Consumption, Quantity Per-Capita (kgs.)					
	2002	2004	2005	2006	2008	2010	2002	2004	2005	2006	2008	2010
Population in non-Food Poverty Situation												
Cereals/1	18.93	19.32	19.00	20.13	21.79	21.07	137.94	127.93	115.93	121.14	125.26	125.41
Meats/2	26.12	25.78	27.49	25.86	25.08	25.62	45.30	43.03	42.14	42.91	43.15	43.89
Fish/3	2.81	2.70	2.86	2.96	2.79	3.03	4.25	3.98	4.13	4.45	4.38	4.56
Dairy/4	17.67	18.23	17.08	17.49	18.21	17.68	112.55	98.52	84.36	89.13	88.47	89.64
Oils/5	1.64	1.61	1.57	1.51	2.36	1.83	9.25	7.97	7.12	7.31	7.33	7.57
Vegetables & Fruits/6	19.50	19.12	19.03	20.36	19.50	20.09	131.32	121.36	118.38	121.74	128.56	130.03
Sugar & Desserts/7	3.11	2.99	2.83	3.27	2.58	3.19	14.26	12.96	10.96	14.88	10.48	11.26
Beverages/8	10.24	10.25	10.14	8.42	7.70	7.49	218.11	250.39	235.37	81.17	79.25	76.69
Population in Food Poverty Situation												
Cereals/1	25.69	24.39	25.66	26.18	25.98	26.14	127.18	102.63	111.28	114.91	118.81	115.83
Meats/2	20.31	18.42	20.31	18.30	18.12	18.75	19.13	17.33	16.84	15.88	19.57	19.67
Fish/3	1.62	2.60	1.87	2.14	1.90	1.77	1.87	3.01	2.16	3.21	2.40	2.05
Dairy/4	13.34	14.98	13.64	14.30	15.85	15.12	40.98	32.62	27.78	34.58	37.83	37.95
Oils/5	3.36	4.03	3.31	3.08	5.22	3.95	9.06	9.31	7.01	7.80	8.90	8.54
Vegetables & Fruits/6	24.08	23.32	23.33	23.72	22.48	23.51	70.15	65.89	62.25	67.83	79.80	75.71
Sugar & Desserts/7	5.16	5.62	5.30	5.39	4.51	4.81	16.41	15.98	13.88	13.41	15.86	11.29
Beverages/8	6.45	6.64	6.59	6.88	5.94	5.96	68.15	87.16	66.07	32.11	35.94	31.28

Source: Own estimation with information from ENIGH and Banco de Mexico.

/1. Cereals, grains and cereal products; /2. Meats includes beef, pork, poultry and processed meats; /3.Fish and sea food; /4.Dairy and dairy products; /5.Oils and fats; /6.Vegetables, fruits, tubers and pulses; /7.Sugar, honey, coffee, tea, chocolate and deserts; /8.No alcoholic beverages

Table 1 highlights the differences in food pattern consumption between these two groups of households. Persons in food poverty condition spend about 25% of their expenditure in cereals and 24% in vegetables and fruits; while persons in nonfood poverty condition spend about 25% in meats, about 17% in dairy and about 20% in cereals. The former group presents a more varied food consumption pattern than food poverty households.

In terms of per capita quantity annual consumption, it is possible to infer some households' strategies to cope with higher food prices during a 10-year period. Households in food poverty condition primarily reduced the annual average quantity of cereals consumed by 11.35 kg. per year and increased their consumption of vegetables and fruits, presumably tubers by 5.5 kg. per year, also in the case of sugar and desserts. During a 10-year period, nonfood poverty households decreased significantly their annual average consumption of dairy by 22.9 kg. and cereals by 12.5 kg.

For attaining these purposes, a complete food demand system for eight food composite commodities was constructed by aggregating194 food commodities. Estimates for own-price, cross-price and income elasticities were calculated. Then, the nutrient elasticities for 18 nutrients in response to changes in the 8 food categories prices can provide information on effects of changes of prices in consumption and nutritional patterns in Mexican households.

The econometric technique includes the construction of pseudo-panels (Deaton, 1985) where each cohort is the observation unit that incorporates relevant food consumption patterns information about groups of households that have the same common characteristics which are invariant through time. The demand system is estimated using the Linear Approximation of the Almost Ideal Demand System model (Deaton, 1980) and the nutrient elasticity matrix is estimated using the Huang's (1996) methodology which links the determinants of the food choice with the consumer nutrient availability. This study also uses adult equivalence scales, developed by Teurel et al. (2005) in lieu of household size. Finally some welfare analysis is applied on these results and some policy analysis is performed. Although this research follows the methodology of Allais et al. (2009), its objective completely diverges from such study.

This study obtained household consumption patterns from the National Survey of Households' Income and Expenditure (ENIGH) for the surveys 2002, 2004, 2005, 2006, 2008 and 2010. The nutritional content information of food items was obtained from publications of the Salvador Zubiran National Institute of Medical Science and Nutrition.

4. The Model

4.1. Cohorts construction and data treatment

The ENIGH is a survey that gathers information about the structure, distribution and amounts of households' income, as well as the expenditure in different type of consumption goods including food. ENIGH records weekly expenditure y quantities purchased in food and beverages by product. Prices are indirectly obtained as the unit value of the food products from dividing the total expenditure versus the quantity of household's consumption. A standardization process was applies to information in guarantee that all quantities and prices are expressed in the same units (pesos per kilograms), then the estimated elasticities are invariant to simultaneous change in unit, which means they are closed under unit scaling.

This research assumes that preferences are separable; such assumption allows the grouping of food commodities into broad aggregates. Different separability forms have different restrictions on preferences. This research assumes weak homothetic separability , which justify the practice of constructing price index for each good and defining quantities as total expenditures on each composite good divided by each good's price index. Also, this assumption implies that direct utility, indirect utility and cost functions written in terms of these quantity and price indices possess all the same properties as the corresponding functions of individual goods (Lewbel, 1997).

One of the main advantages of aggregating a complete food demand using composite commodities is to avoid the problem of the multicollinearity of prices, associated with separability.[2] The aggregation reduces other problems, such as infrequency in purchases, discreteness of purchases and differences between purchases and consumption are less severe.

The ENIGH gathers information on 244 food products and beverages. However, alcoholic beverages, herbs and spices are not considered. Finally, 194 food products are considered for the estimation. For the sake of the estimation and the reduction of the number of parameters to estimate, the 194 food products were aggregated in 8 composite food commodities. The eight composite food commodities are (1) Cereals, including corn, wheat, rice and cereal products, (2) meats including beef, pork, poultry, lamb, processed meats and others, (3) fish and seafood, (4) milk, dairy products and eggs, (5) oils and fats, (6) potatoes, vegetables, fresh fruits, and pulse, (7) sugar, honey, sugar-fat products, (8) no alcoholic beverages. Each of these composites is an

[2] In practice, collinearity of prices results in insignificant parameter estimates because each equation in demand system depends on prices of all goods in system. This problem could be present even in large survey data sets. The generalization of the Hicks-Leontief composite commodity theorem permits aggregation without separability, by assuming that within-group prices are multicollinear and not necessarily perfectly collinear, resulting in an integrable aggregate demand system (Lewbel, 1996).

average aggregate (Laspeyres) index derived from independent households' observations. A factor analysis was performed to determine the best aggregation criteria for the 194 food commodities; however, the results were not conclusive, and finally the aggregation criterion for measuring inflation of Banco de Mexico was adopted.

Such information allows calculating the nutritional equivalence, using equivalence scales for the households. Due to its structure, the ENIGH allow estimating differentiated consumption patterns using the purchases in food. However, one of its shortfalls is that this survey is not able to measure the effective consumption, the quantity of waste and intra-household distribution of the consumption. An amount of the purchases of food are recorded as current expenditure on food consumed away from home, which does not allows the conversion to nutritional content in contrast with consumption in household, where the quantities of food are registered.

In the context of this research, the cohort is a group of households that share some common characteristics and to treat the observed cohort means as error-ridden measurements of the population cohort means. Cohorts should be defined on the basis variables that do not vary over time and that are observed for all households in the sample and independent of the variables in the model, this research considered three variables in the universe of the households: geographical location, income distribution and the levels rural and urban.

Four groups of geographical locations (North, North-center, Center and South) were defined according to the geographical zones that the INEGI defines for the measure of inflation.[3] The quintiles of the distribution were considered for the construction of the cohorts. The two levels of the locations: rural households refer to households in localities with less than 2,500 inhabitants and urban households are considered as those located in localities with more than 2,500 inhabitants. Every survey is used to construct forty cohorts.

4.2. Demand Model Framework

This research uses the Linear Approximate Almost Ideal Demand System (LA/AIDS) created by Deaton and Muellbauer (1980), which is a flexible demand specification, avoids non-linearities, and appropriate for food demand systems, where prices can result highly collinear. The LA/AIDS incorporates the Deaton and Muellbauer's suggestion of approximating the price index by the Stone index (1953), where the price index varies across households, or cohorts.

[3] The regions are composed by the following States. The North includes Baja California, Sonora, Chihuahua, Coahuila, Nuevo Leon and Tamaulipas. The North-Center region includes Aguascalientes, Baja California Sur, Colima, Durango, Jalisco Michoacán, Nayarit, San Luis Potosí, Sinaloa y Zacatecas. The Center includes Distrito Federal, Estado de México, Guanajuato, Hidalgo, Morelos, Puebla, Querétaro and Tlaxcala. The South region includes Campeche, Chiapas, Guerrero, Oaxaca, Quintana Roo, Tabasco, Veracruz and Yucatán.

At the household level, the consumption behavior during period t can be represented by the budget share equations.

$$w_{iht} = \alpha_{ih} + \sum_{j=1}^{N} \gamma_{ij} lnP_{jt} + \beta_i ln\left[\frac{X_{ht}}{P_{ht}^*}\right] + u_{iht} \quad (1)$$

Where, in time t and for the household h, w_{iht} is the budget share of good i, $X_{ht}$is the total expenditure on the on the group of analyzed commodities for the household, P_{jt} are the unit values that replace prices of the commodity j and P_{ht}^* is the Stone's (geometric) price index. Finally, $u_{ht} = \mu_h + \vartheta_{ht}$ is the disaggregated error term, where μ_h denotes the household non-observable heterogeneity, static in time and ϑ_{ht} refers to the random error component.

$$lnP_{ht}^* = \sum_{i=1}^{N} w_{ih} lnP_{iht} \quad (2)$$

For i=1,…,N commodities categories and h=1,…, H households. Additionally the parameter α_{ih}can be modeled to consider the heterogeneity in consumption patterns under the following specification$\alpha_{ih} = \alpha_{i0} + \boldsymbol{Z}_h \alpha_i$, where the $\boldsymbol{Z}_h$ is a vector of the sociodemographic characteristics of the households. So, α_i, $\gamma_i$and β_i are the estimated parameters of the system.

This equation system for the I commodities must satisfy the following restrictions on the parameters.

$$\sum_{i=1}^{N} \alpha_i = 1, \quad \sum_{i=1}^{N} \gamma_{ij} = 0 \ , \quad \sum_{j=1}^{N} \beta_i = 0, \quad \sum_{j=1}^{N} \gamma_{ij} = 0 \ , \quad \gamma_{ij} = \gamma_{ji} \quad (3)$$

Thus, the equation (X) represents a system of demand functions which add up to total expenditure ($\sum_{i=1}^{N} w_i = 1$), are homogeneous of degree zero in prices and total expenditure taken together, and satisfy Slustky symmetry (Deaton and Muellbauer, 1980).

The quality of the approximation of the true AIDS specification depends on the parameters and the collinearity among the exogenous price variables elasticities (Alston, et al. 1994). This research used the uncompensated price elasticity formula for the LA/AIDS that increases the accuracy of the approximation (Alston, et. al 1994).

$$\eta_{ij} = -\delta_{ij} + \frac{\gamma_{ij}}{w_i} - \beta_i \left[\frac{w_j}{w_i}\right] - \frac{\beta_i}{w_i}\left[\sum_{i=1}^{N} w_{ih} lnP_{iht}\,(\eta_{kj} + \delta_{kj})\right] \quad (4)$$

4.3. Econometric Estimation of Pseudo-Panel

One of the main advantages of pseudo-panel are the absence of the attrition problem usually present in panel data, while the representativity of the surveys are maintained (Deaton, 1985).

According to Deaton (1985) the aggregation to cohorts allows that repeated observations provide the differencing, while the households microdata provides the estimates of cohort means with the sampling errors. According to Deaton, the sample cohorts' means from the surveys are consistent but error-ridden estimates of the unobservable cohort population means. For this reason, the construction of cohorts with members that are distinct from one another and internally homogeneous will minimize the errors-in-variable problem and enhance the estimation. Since households microdata are used to construct the means, they can be used to construct estimated of variance and covariances of the sample means. Furthermore, it is possible to estimate consistent errors-in-variable estimators of the population relationships.

The cohort Aggregation of the LA/AIDS model is carrying out by the calculation of the means over the households as the weighted sums of households shares and the socio-demographic variables are the weighted mean characteristic of a cell, using the weighting factors for each household and different between surveys. Thus, the equation (5) in terms of pseudo-panel is rewritten in the following expression.

$$\overline{w_{\iota ct}} = \alpha_{i0} + \overline{\boldsymbol{Z}^*_{ct}}\,\alpha_i + \sum_{j=1}^{N} \gamma_{ij} ln\overline{P_{jt}} + \beta_i ln\left[\frac{\overline{X_{ct}}}{\overline{P^*_{ct}}}\right] + \overline{\mu_{ct}} + \overline{\vartheta_{ct}} \quad (5)$$

Where c=1,…,C denotes the constructed cohorts for every survey and the error term has this composition $\overline{u_{ct}} = \overline{\mu_{ct}} + \overline{\vartheta_{ct}}$, and the term μ_{ct} indicates that the mean values of the cohort are calculated for a different set of individuals from different surveys.

Verbeek (2000) suggest that treating $\overline{\mu_{ct}}$ as part of the random error term could lead to inconsistent estimators. However, it is possible to treat $\overline{\mu_{ct}}$ as fixed unknown parameters assuming that variation over time can be ignored ($\overline{\mu_{ct}} = \overline{\mu_c}$). If cohort averages are based on a large number of household observations, in such case the sample means are an accurate estimator of the population means.[4] Thus, the natural estimator is the fixed effects model because the grouping in cohorts tends to homogenize the individual effects among the individual grouped in the same cohort, so that the

[4] Verbeek and Nijman (1993) found that the cohort size must include at least 100 individual observations.

average specific effect is approximately invariant between two periods and is efficiently removed by within or first difference transformations.

The econometric estimation of this pseudo-panel demand system model requires the estimation of the Similar Unrelated Regression (SUR) system with error component for a balanced panel. The estimation was carried out by following the methodology that details Baltagi (2008). In a first stage, the equation (5) is estimated by OLS regression separately for I equations (or eight food categories) without taking into consideration the panel specification of the data and the vector of residuals $\overline{u_{\iota ct}}$ and the SUR variance-covariance matrix is obtained. The second step includes to compute the matrices of within cohorts covariation and then the variance-covariance matrix is calculated for obtaining the fixed effect Panel model estimators. Constrains (additivity, homogeneity and symmetry) were imposed in the model while the estimation were carried out.

The econometric estimation of this model implies the solution of two important issues. The heterocedasticity that is originated by the aggregation process of the household data into the cohorts, which imply the loss of information results in a loss of the efficiency in the estimated parameters and the endogeneity from the total household food expenditure. Thus, additional processes to correct heterocedasticity and endogeneity are applied. The heterocedasticity is corrected implementing the Generalized Least Squares and applying an approximate correction by weighting each observation by a heterocedasticity factor that is a function of the size cell (see Gardes, et al. 2005).

The endogeneity problem is corrected by introducing sociodemographic variables into the demand system estimation with the residuals of the regression of the total household food expenditure lnxct on the sociodemographic variables Z_{ct} prices in lnP_{ct} and the logged incomes of cohort c at period t, the mean of the of income lnY_{c} and the mean of the total household food expenditure.

The set of the sociodemographic variables includes the number of household's members younger than 18 years as proportion of the household size, age years of education of the household head and the number of the household members that provide income.

Table 2. Own-Price and Cross-Price Elasticities

Composite Food Category	Cereals[1]	Meats[2]	Fish[3]	Dairy[4]	Oils[5]	Vegetables & Fruits[6]	Sugar & Desserts[7]	Beverages[8]	Income Elasticity
Population in non-Food Poverty Situation									
Cereals[1]	-0.886	-0.020	0.056	0.105	0.025	-0.229	-0.022	-0.030	1.001
Meats[2]	-0.019	-0.846	-0.057	0.009	-0.094	0.181	0.031	-0.205	0.999
Fish[3]	0.485	-0.528	-1.186	0.211	-0.169	0.536	-0.024	-0.320	0.995
Dairy[4]	0.136	0.013	0.032	-0.956	0.100	-0.291	-0.018	-0.018	1.001
Oils[5]	0.226	-0.915	-0.178	0.706	-0.577	-0.169	-0.276	0.181	1.002
Vegetables & Fruits[6]	-0.255	0.217	0.069	-0.251	-0.021	-1.069	0.111	0.199	0.999
Sugar & Desserts[7]	-0.132	0.198	-0.017	-0.081	-0.181	0.591	-1.265	-0.114	1.000
Beverages[8]	-0.065	-0.488	-0.082	-0.030	0.044	0.395	-0.042	-0.730	0.998
Population in Food Poverty Situation									
Cereals[1]	-0.907	-0.016	0.046	0.086	0.020	-0.187	-0.018	-0.024	1.001
Meats[2]	-0.027	-0.775	-0.084	0.014	-0.137	0.265	0.045	-0.300	0.999
Fish[3]	0.859	-0.935	-1.329	0.374	-0.299	0.950	-0.043	-0.567	0.991
Dairy[4]	0.152	0.014	0.035	-0.950	0.112	-0.325	-0.020	-0.020	1.001
Oils[5]	0.136	-0.553	-0.108	0.426	-0.744	-0.102	-0.167	0.109	1.001
Vegetables & Fruits[6]	-0.221	0.188	0.060	-0.217	-0.018	-1.059	0.096	0.172	0.999
Sugar & Desserts[7]	-0.086	0.130	-0.011	-0.053	-0.118	0.387	-1.174	-0.074	1.000
Beverages[8]	-0.081	-0.608	-0.103	-0.037	0.055	0.492	-0.053	-0.663	0.998

Source: Own estimations with data from ENIGHs.

/1. Cereals, grains and cereal products; /2. Meats, including beef, pork, poultry and processed meats; /3.Fish and sea food; /4.Dairy and dairy products; /5.Oils and fats; /6.Vegetables, fruits, tubers and pulses; /7.Sugar, honey, coffee, tea, chocolate and deserts; /8.No alcoholic beverages

Elasticities are calculated using the averages estimated shares and the mean point of the other variables for the two groups defined by their food poverty condition. The variances of the elasticities are computed using the variance-covariance matrix of the residuals.

The own-price and cross-price elasticities are a measure of how quantity purchases changes as a result of a 1% price variation of the compose food commodity. The results are consistent; the own-price elasticities are all negative and mostly significant.

The findings point out that for households in food poverty condition are significantly more sensitive than households in non-food poverty situation to own-price change for cereals, seafood, oils and vegetables. In contrast, households in non-food poverty condition are more sensitive than households in food poverty situation to own-price change for meat, dairy, sugar and desserts and non-alcoholic beverages.

4.4. Nutrient Elasticities, the Huang's Matrix

Given the demand structure for food products and the set of nutrient contents of every food commodity, Huang (1996) derived the relationship between nutrient availability and changes in food prices and income. The nutrient elasticities can be able to link food choice with nutritional status in the context of the classical demand framework. The interdependent demand relationships including own- and cross-price and income effects of a complete food demand system are incorporated directly into the measurement of nutrient elasticities (Huang, 1996).

For the calculation of the nutrient elasticity matrix ($\mathbb{N}$) for the case of ℓ nutrients and ($\mathbb{m}$) composite food category can be obtained by the product of the demand elasticities ($\mathbb{D}$) and the nutritional shares content for each composite food category ($\mathbb{S}$).

$$\mathbb{N} = \mathbb{S} * \mathbb{D}$$

Where $\mathbb{N}$ is a ($\ell\ x\ \mathbb{m}$) matrix of nutrient elasticities as a response of changes in composite food prices and income. $\mathbb{S}$ is a ($\ell\ x\ \mathbb{m}$) matrix with entries of each row indicating the composite food's share of a particular nutrient and $\mathbb{D}$ is a ($\mathbb{m}\ x\ \mathbb{m}$) matrix of demand elasticities.

The nutrient elasticities are a measure of how the change in a particular food price or per capita income will affect all food quantities demanded through the interdependent demand relationships, causing that the levels of consumer nutrient availability to change simultaneously (Huang, 2006).

Table 3. Food Share of Nutrient Based on per Capita Average Food Consumption (2002-2010)

	Energy	Protein	Fat	Carbohydrate	Cholesterol	Sugar	Fiber	Calcium	Phosphoru	Iron	Sodium	Potassium	Zinc	Thiamin	Riboflavin	Niacin	Vitamin A	Vitamin C
Population in non-Food Poverty Situation																		
Cereals/1	32.90	25.29	10.22	49.76	0.20	6.88	43.25	46.91	16.14	42.86	27.56	9.71	46.90	21.44	3.94	10.90	0.00	0.01
Meats/2	8.50	27.68	9.30	0.42	22.99	0.00	0.28	1.95	14.01	10.52	29.77	12.23	7.34	5.26	6.02	44.50	15.13	0.01
Fish/3	1.73	10.09	0.75	0.10	6.05	0.00	0.06	1.27	13.43	1.77	19.39	2.70	0.58	0.69	0.56	3.65	0.47	0.00
Dairy/4	10.10	19.62	13.53	3.72	68.90	2.09	0.00	37.75	23.15	4.46	16.50	8.15	4.04	4.65	18.74	1.12	64.46	0.41
Oils/5	21.48	0.00	63.21	0.00	1.56	0.00	0.00	4.09	0.04	4.88	0.19	0.98	27.50	45.79	55.26	0.00	0.00	0.18
Vegetables & Fruits/6	8.78	14.55	1.72	12.43	0.00	6.13	55.18	6.63	30.89	27.05	2.29	53.49	9.63	17.57	12.25	21.26	19.38	97.81
Sugar & Desserts/7	9.37	1.53	1.07	17.23	0.30	37.96	0.25	0.64	2.00	2.62	1.54	2.78	0.24	3.34	3.10	17.49	0.42	0.57
Beverages/8	7.13	1.24	0.19	16.34	0.00	46.94	0.97	0.77	0.35	5.84	2.75	9.97	3.78	1.26	0.14	1.08	0.13	1.02
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Population in Food Poverty Situation																		
Cereals/1	43.36	34.86	15.55	58.97	0.13	5.98	45.30	54.71	40.10	50.84	17.94	13.70	48.65	52.12	11.96	34.33	0.00	0.00
Meats/2	5.24	16.95	7.09	0.20	16.73	0.00	0.03	1.58	7.37	6.19	16.41	9.71	4.26	2.68	4.40	30.47	10.72	0.01
Fish/3	1.68	11.00	1.09	0.03	6.51	0.00	0.01	2.04	6.16	1.74	46.09	2.01	0.31	0.62	0.69	4.22	0.49	0.00
Dairy/4	6.28	15.69	9.44	1.91	74.79	0.42	0.00	31.24	14.60	4.79	15.00	14.53	5.40	4.15	22.65	1.14	75.03	0.77
Oils/5	18.26	0.00	63.85	0.00	1.72	0.00	0.00	4.51	0.02	4.38	0.19	1.42	28.09	30.92	52.29	0.00	0.00	0.32
Vegetables & Fruits/6	10.33	20.31	1.73	12.66	0.00	4.86	54.37	5.09	30.19	25.88	1.54	51.64	10.35	7.99	6.69	12.22	13.61	98.04
Sugar & Desserts/7	10.91	0.75	0.99	18.37	0.11	54.11	0.06	0.23	1.49	2.53	0.78	1.11	0.18	1.23	1.28	17.32	0.11	0.23
Beverages/8	3.94	0.44	0.25	7.87	0.00	34.62	0.23	0.60	0.07	3.65	2.07	5.89	2.77	0.30	0.05	0.30	0.05	0.64
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

/1. Cereals, grains and cereal products; /2. Meats, including beef, pork, poultry and processed meats; /3.Fish and sea food; /4.Dairy and dairy products; /5.Oils and fats; /6.Vegetables, fruits, tubers and pulses; /7.Sugar, honey, coffee, tea, chocolate and deserts; /8.No alcoholic beverages

Table 3 depicts the average nutritional patterns of the persons in nonfood poverty situation and in food poverty situation. There are evident disparities in the patterns where these two types of persons obtain their nutritional requirements. The persons in food poverty situation show a less diversified diet; the cereals are the main important source of nutrients where they obtain up to more than the half of the nutritional requirement from four nutrients (carbohydrate, calcium, iron and Thiamin) and at least one third from the nutritional requirements of five nutrients (energy, protein, fiber, phosphorus, zinc and Niacin).

In comparison, persons in nonfood poverty situation have a more varied diet and they obtain their nutritional requirements mainly from cereals, meats and diary. Although cereals are also an important source of nutriments that cover more than 40% of the requirement for four nutriment categories (carbohydrate, fiber, calcium, iron, zinc), they complement the nutritional requirement from other sources such as dairy, which food share of nutrient is comparatively higher than for persons in food poverty.

Table 4. Nutrient Elasticities Based on Food Demand, 2002-2010

Nutrient	Cereals/1	Meats/2	Fish/3	Dairy/4	Oils/5	Vegetables & Fruits/6	Sugar & Desserts/7	Beverages/8	Income Elasticity
Population in non-Food Poverty Situation									
Energy	-0.262	-0.280	-0.043	0.062	-0.132	-0.127	-0.178	-0.041	1.000
Protein	-0.194	-0.262	-0.106	-0.175	-0.022	-0.152	-0.007	-0.082	0.999
Fat	0.067	-0.657	-0.116	0.325	-0.361	-0.160	-0.188	0.088	1.001
Carbohydrate	-0.500	-0.032	0.020	-0.033	-0.011	-0.090	-0.223	-0.131	1.000
Cholesterol	0.120	-0.231	-0.066	-0.632	0.028	-0.127	-0.015	-0.076	1.000
Sugar	-0.154	-0.142	-0.036	-0.073	-0.045	0.322	-0.495	-0.376	0.999
Fiber	-0.525	0.104	0.061	-0.093	-0.001	-0.683	0.048	0.089	1.000
Calcium	-0.368	-0.053	0.019	-0.297	0.020	-0.278	-0.029	-0.014	1.001
Phosphorus	-0.131	-0.121	-0.130	-0.253	-0.019	-0.324	0.002	-0.024	0.999
Iron	-0.432	-0.116	0.003	-0.030	-0.034	-0.341	-0.027	-0.024	1.000
Sodium	-0.143	-0.365	-0.228	-0.091	-0.040	0.042	-0.023	-0.151	0.999
Potassium	-0.208	-0.055	-0.004	-0.193	-0.023	-0.527	0.017	-0.006	0.999
Zinc	-0.374	-0.323	-0.029	0.181	-0.151	-0.236	-0.079	0.010	1.001
Thiamin	-0.128	-0.432	-0.069	0.256	-0.269	-0.290	-0.154	0.085	1.001
Riboflavin	0.082	-0.526	-0.093	0.184	-0.313	-0.255	-0.180	0.101	1.001
Niacin	-0.164	-0.322	-0.051	-0.055	-0.080	-0.048	-0.188	-0.092	0.999
Vitamin A	0.037	-0.080	0.019	-0.663	0.045	-0.361	0.009	-0.007	1.000
Vitamin C	-0.250	0.207	0.067	-0.249	-0.021	-1.039	0.100	0.187	0.999
Population in Food Poverty Situation									
Energy	-0.381	-0.154	-0.023	0.033	-0.145	-0.138	-0.158	-0.033	1.000
Protein	-0.248	-0.201	-0.127	-0.120	-0.036	-0.177	0.004	-0.093	0.999
Fat	-0.037	-0.416	-0.078	0.197	-0.476	-0.109	-0.118	0.037	1.001
Carbohydrate	-0.582	-0.011	0.025	-0.007	-0.006	-0.140	-0.219	-0.059	1.000
Cholesterol	0.166	-0.189	-0.076	-0.677	0.029	-0.138	-0.014	-0.100	1.000
Sugar	-0.139	-0.132	-0.036	-0.051	-0.044	0.316	-0.650	-0.263	0.999
Fiber	-0.531	0.093	0.053	-0.079	-0.001	-0.659	0.043	0.081	1.000
Calcium	-0.438	-0.055	0.005	-0.234	0.004	-0.235	-0.022	-0.026	1.000
Phosphorus	-0.359	-0.061	-0.047	-0.147	-0.011	-0.358	0.002	-0.019	0.999
Iron	-0.497	-0.066	0.003	-0.035	-0.036	-0.329	-0.022	-0.018	1.000
Sodium	0.246	-0.569	-0.614	0.044	-0.141	0.396	-0.028	-0.329	0.996
Potassium	-0.205	-0.039	0.000	-0.226	-0.018	-0.543	0.029	0.004	0.999
Zinc	-0.419	-0.196	-0.010	0.088	-0.200	-0.218	-0.049	0.003	1.000
Thiamin	-0.439	-0.191	-0.014	0.122	-0.223	-0.208	-0.068	0.020	1.000
Riboflavin	-0.014	-0.314	-0.052	0.006	-0.372	-0.197	-0.101	0.043	1.001
Niacin	-0.324	-0.237	-0.060	0.003	-0.069	-0.008	-0.186	-0.118	0.999
Vitamin A	0.085	-0.051	0.019	-0.739	0.066	-0.354	0.002	-0.027	1.000
Vitamin C	-0.215	0.179	0.058	-0.219	-0.019	-1.037	0.091	0.165	0.999

/1. Cereals, grains and cereal products; /2. Meats, including beef, pork, poultry and processed meats; /3.Fish and sea food; /4.Dairy and dairy products; /5.Oils and fats; /6.Vegetables, fruits, tubers and pulses; /7.Sugar, honey, coffee, tea, chocolate and deserts; /8.No alcoholic beverages

The set of nutrient elasticities show the effects of eighteen nutrients in response to changes in eight composite food price categories. For example, an increase of 1% in the price of cereals would produce a change in food consumption, which will reduce per capita food energy in 0.262% for individuals in nonfood poverty situation and will affect in 0.381% the food energy consumption for persons that are in food poverty situation.

In general terms nutrient elasticities are higher for energy, protein, fat and carbohydrate because these nutritional elements depend more on quantities intake. As it is expected, nutrient price elasticities are inelastic, but higher than Huang (2006) because these nutrient elasticities are calculated for composite food commodities. Cereals and meats show the highest nutrient elasticities for elements such as energy, protein and carbohydrate, while the highest elasticities for vitamins and minerals are concentrated in the vegetables, fruit and pulses composite category.

Comparatively, there is strong evidence of significant disparities in nutrient elasticities patterns of persons in food poverty situation and nonfood poverty situation persons. As expected, persons in food poverty situation show higher nutrient price elasticities for cereals and vegetables, and lower nutrient elasticities for mainly fish, dairy and meat. In contrast, persons in nonfood poverty situation show higher elasticities in meat, fish and dairy.

Energy protein and fat elasticity purchased for non-poverty individuals is very sensitive to changes in the prices of meats. In contrast, for persons in food poverty situation energy and carbohydrate elasticity purchase is highly sensitive to price changes in cereals.

4.5. Evaluating Past Price Shocks in Persons' Nutrient Purchase

Once nutrient elasticities have been estimated, an evaluation on how increasing food prices affected the person's food security can be performed. In particular, the impacts of two shock scenarios in food price commodities in Mexico are evaluated. The first one corresponds to a nine-month accumulated food price increment from March 2008 to December 2008, which triggered an weighted average inflation in food heading prices about 10 points.

The second shock corresponds to a four-month period, from October 2011 to January 2012, when the weighted accumulated inflation was 6.03 points.

Table 5. Accumulated Inflation Per Period by Food Expenditure Heading
(Percentage Points)

Food Category	9-Month Period Mar-Dec 2008	4-Month Period Oct 2011-Jan 2012
Cereals/1	10.23	4.63
Meats/2	11.19	8.28
Fish/3	8.91	4.60
Dairy/4	6.46	4.82
Oils/5	25.95	3.09
Vegetables & Fruits/6	15.18	9.88
Sugar & Desserts/7	3.21	2.51
Beverages/8	7.70	2.89

Source: Banco de Mexico.

As table 5 shows, during both periods meats and vegetables and fruits showed the most important price inflation points. Meats are the main source of nutrients for persons in nonfood poverty condition, while vegetables and fruits are one of the main sources of nutrients for persons in food poverty condition. The overall impact of the food price inflation can be interpreted in terms of percentage of quantity change in total nutrients acquired by the two types of persons.

Table 6. Percentage of Quantity Change in Total Nutrients Purchased Per Capita by Food Poverty Condition

Nutrient	9-Month Period		4-Month Period	
	Nonfood Poverty	Food Poverty	Nonfood Poverty	Food Poverty
Energy	-12.03	-12.24	-5.66	-5.29
Protein	-10.52	-11.02	-6.22	-6.10
Fat	-17.30	-18.55	-7.01	-5.77
Carbohydrate	-8.88	-9.35	-4.51	-4.83
Cholesterol	-7.88	-7.64	-6.15	-6.02
Sugar	-4.72	-4.01	-1.69	-1.56
Fiber	-13.81	-13.69	-8.11	-8.00
Calcium	-10.01	-10.30	-6.29	-6.02
Phosphorus	-11.06	-11.58	-6.75	-6.71
Iron	-12.20	-12.16	-6.70	-6.47
Sodium	-9.81	-9.32	-5.37	-3.73
Potassium	-12.61	-12.60	-7.62	-7.71
Zinc	-14.21	-14.63	-6.63	-6.07
Thiamin	-16.33	-14.97	-7.09	-5.94
Riboflavin	-16.49	-16.72	-7.17	-6.10
Niacin	-10.19	-9.90	-5.38	-4.83
Vitamin A	-8.97	-8.19	-7.03	-6.88
Vitamin C	-15.83	-15.78	-9.88	-9.91

Source: Own estimations.

In general terms, during the period March-December 2008 the impact of the food price inflation mainly was on nutrients fat, fiber, energy and vitamins. Although the differences between the two types of persons are negligible, this inflation impact was marginally stronger for people in nonfood poverty condition, as table 6 shows.

During the second period, the persons in nonfood poverty condition had a stronger impact of food price inflation in terms of nutrients like fat, proteins and minerals. A possible explanation is the price increment in meats, which food prices recorded the highest accumulated inflation (8.28) and represent one of the most important sources of nutrients for nonfood poverty persons. The effect for persons in food poverty situation was lower because cereals recorded less percentage points of inflation (4.63).

5. Conclusions and Further Discussion

Around the world, food security of households and persons has been affected by recent shocks in food prices. Although in México there is some evidence about the effects of food price inflation on household's consumption patterns, little is known about magnitudes and how food price inflation affects differentially people's food security depending on their food poverty condition. This research is focused in providing a detailed analysis on such matter.

For carrying out this objective, this research developed a cohort model by aggregating an LA/AIDS model over cohorts using six cross-section surveys of the ENIGHs for the period 2002-2010. As expected, price elasticities and the resulting nutrient elasticities are inelastic.

Distinguished by their food poverty condition, households present differentiated consumption patterns and use different diversification strategies to cope with food price increments. People in nonfood poverty condition have diversified consumption patterns, opposing to people in food poverty condition that spend more than 25% of their food budget in cereals, which is the main source of nutrients.

As a consequence of the expenditure and consumption patterns, the nutrient quantities acquisition of people in food poverty condition is quite sensitive to changes in cereals prices and vegetables prices. In contrast, for people in nonfood poverty situation, nutrients quantity purchase is more sensitive to changes in meat and dairy prices.

The evaluation exercise of the two food price shocks episodes confirmed the previous finding. Rising food prices in cereals and vegetables could aggravate the disparities in the nutritional content of food acquisition and could contribute to deteriorate the nutrimental condition of the most vulnerable population. In this context, this research provides further information to enhance the efficiency of food policy interventions by improving the quality of the targeting.

Effective targeting is the result of geographical indicators, observable individual or household characteristics and program restrictions. Paradoxically, the greatest food security gains typically does not come directly from food or feeding programs, but indirectly through policies that encourage poverty reduction. However, careful targeting is fundamental for long term programs that address the food insecurity of the most vulnerable population. Hopefully, this research could provide some highlights on such area.

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