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Working Papers

N° 2015-16

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August 2015

Documento de Investigación
2015-16

Working Paper
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The Impact of Food Price Shocks on Consumption and Nutritional Patterns of Urban Mexican Households*

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Abstract: During the 2000s, recurrent food price shocks due to volatility in international markets and extreme weather events affected consumption and nutritional patterns of Mexican urban households. This research quantifies the impacts of food price shocks on the purchase of nutrients and on the weight gain of children in urban Mexican households. We find differentiated patterns of food consumption across income quintiles, which result in heterogeneous effects of price shocks on the purchase of nutrients and on weight gain according to age and sex in children. In particular, cereal price shocks are more detrimental and more regressive than price shocks on other categories like meats or beverages.
Keywords: Food price elasticities, Nutrient elasticities, Food security, Nutrition, Welfare
JEL Classification: D12, C31, O12

Resumen: Durante la década de los 2000, los recurrentes choques en los precios de los alimentos debido a la volatilidad en los mercados internacionales y a eventos climáticos extremos afectaron los patrones de consumo y de nutrición de los hogares urbanos mexicanos. Esta investigación cuantifica los impactos de los choques en los precios de los alimentos sobre la compra de nutrientes y sobre el aumento de peso en los niños de hogares urbanos mexicanos. Encontramos patrones diferenciados en consumo de alimentos a través de los quintiles de ingreso que resultan en efectos heterogéneos de los choques de precios sobre la compra de nutrientes y la ganancia de peso en niños de acuerdo a su edad y sexo. En particular, los choques de precios en cereales son más perjudiciales y más regresivos que los choques en los precios de otras categorías como carnes o bebidas.
Palabras Clave: Elasticidades precio de los alimentos, Elasticidades de nutrientes, Seguridad Alimentaria, Nutrición, Bienestar

*I am grateful to Daniel Sámano, Santiago Guerrero, Juan Carlos Martinez and Daniel Vaughn and seminar participants at Banco de Mexico and AAEA meetings for their feedback and extremely helpful comments and suggestions. I also thank Jonathan Puigvert for excellent research assistance.

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1. Introduction

In the last decade food security has been an increasing concern for national governments, particularly in developing countries. Persistent rising food prices can aggravate disparities in the nutritional intake between different segments of population, thus deteriorating the nutrimental status of the poorest groups. Primary undernutrition is the dominant status of the poorest population that builds slowly over time based on daily reductions in food access but with long-term effects for their productivity, income and welfare[1].

During the 2000's, unexpected climatic shocks and volatility in international markets, among other factors, created volatility and uncertainty in international food prices. Between 2006 and 2008 the upward tendency of food prices in international markets had important implications for food consumption and nutrition in Mexican households (Pérez and Minor, 2012). According to the National Council for the Evaluation of the Social Policy Development (CONEVAL by its Spanish acronym) (2014) from 2006 to 2012 the urban population in condition of food poverty increased from 7.6 to 12.9 million of persons.[2]

Moreover, many international organizations claimed that food price increments would be a recurrent element affecting people's food security around the world. Food security is conceptualized by the Food and Agriculture Organization (FAO) in four dimensions that must be simultaneously fulfilled: availability, access, utilization and stability[3]. For the first dimension, availability, indicators at the national scale are well known but they do not reflect the other three dimensions. Access, utilization and stability dimensions remain unidentified and insufficiently measured since they require disaggregated information to reflect the intra-

[1] Primary under nutrition refers to a chronic and insufficient or poorly structured diet because of errors and food access limitations due to economic, availability and/or cultural reasons (Bourges, 2006).

[2] The CONEVAL defines the income as the unique dimension to evaluate the food poverty situation of households, which means the percentage of the population below the Minimum Welfare Line (MWL). Households in this condition are not able to afford a minimum basket of food consumption defined by the CONEVAL, (CONEVAL, 2010).

[3] Food availability addresses the "supply side" of food security and is determined by the level of food production, stock levels and net trade. Access dimension reflects the demand side of food security identifying inter-household food consumption patterns. Utilization allows identifying intra-household distribution and nutritional responses in diets to adverse price shocks. Stability dimension means that population; households or individuals must have access to adequate food at all times (FAO, 2008).

national conditions of purchase, distribution within the household utilization, consumption and nutritional quality of food (Pelletier et al., 2012).

Conventional methods for measuring food security of the population have been broadly criticized because they largely reflect the national food availability but do not adequately reflect people's ability to access and to utilize food at the household or individual level (Pelletier et al., 2012). In this context, the purpose of this paper is to assess the impact of past and hypothetical shocks across different food price categories on the food security of urban households and individuals by measuring their effects on consumption and nutrition patterns.

How the consumption of households across different income quintiles is affected as a result of increasing food prices; how these people tend to change their diets to obtain the necessary nutrients and to cope with more restricted budgets, and how price shocks can affect the children's weight gain in the short term, are some of the questions that this research addresses.

The main contribution of this article relies on a deeper analysis of food security in the dimensions of access and utilization by assessing the effects of price increments on the utilization of food and on the weight gain in urban children, emphasizing their differentiated effects across income quintiles. The results could be used in the design of policies that intent to minimize the impacts of food price shocks on the most vulnerable people.

To my knowledge, this is the most complete assessment carried out in Mexico to measure the effects of increasing food prices along two dimensions of food security (access and utilization). Such dimensions have remained unexplored in Mexico by previous research. Authors have focused in other aspects of food security, for example, Perez and Minor (2012) analyze changes in households' food consumption patterns, while Valero and Valero (2013), assess variations in calorie intake and their main causes. Furthermore, this research combines an estimation of a complete food demand system with the analysis of Mexican households' nutritional patterns.

This research focuses on urban households to avoid bias from higher food auto-consumption of rural households. Rural households, situated in localities with less than 2,500 inhabitants, usually perform farming activities that allow maintaining a minimum level of food consumption (auto-consumption) or even smoothing their consumption during food price shocks. In this context, food auto-consumption could implicitly modify the response of households to variations in prices generating bias in price elasticities. On average, 27% of all rural households declare food auto-consumption from farming activities; in contrast, only 7% of urban households report auto-consumption related to services activities, and only 2% declare food auto-consumption associated with farming activities.

The method of this research consists of three stages and partially follows the methodology of Allais et al. (2010). The first stage estimates a complete food demand system by aggregating 184 food commodities in eight composite food categories using the Linear Approximation of Almost Ideal Demand System model (LA/AIDS) and the pseudo-panel approach of Deaton (1985). The second stage estimates the nutrient elasticity following the methodology of Huang (1996) based on households' food consumption patterns and the previously estimated demand elasticities. Finally, the third stage evaluates the effects of three periods of accumulated food price variation in Mexican food markets. All the analysis is performed for five income groups, where estimations show the existence of differences in consumption patterns, own-price and cross-price elasticities and nutrient elasticities for each group.

This paper is structured as follows: section 2 analyzes food consumption patterns of Mexican households for the 2002-2012 period. Section 3 describes the model, the data employed and the treatment given to these. Section 4 shows the results of the estimations, and welfare impact analysis on nutrition across income quintiles. Finally, section 5 concludes.

2. Food consumption, nutrition patterns and food price shocks in Mexico

Since late 2007 continuous food price increments and volatility in international food markets have impacted domestic food prices affecting households' food security. In the period 2002-2012, the real cost of the Basic Food Basket (BFB) increased by 17.1% (see table 1, column 2) affecting households' food security, in terms of access and utilization, especially for households in the lowest income quintile. In general, the price variation of the BFB was higher than the general inflation (based on the Consumer Price Index), for example, between January 2010 and January 2012 the accumulated price variation of the BFB was 16.1 percentage points, while for the same period the general inflation was 7.7 percentage points.[4]

Table 1 summarizes the dynamics of households' expenditure for this period using data from the National Survey of Households' Income and Expenditure (ENIGH, in Spanish), which contains household level information about food consumption patterns. Between 2002 and 2012, 144.9 million of urban households, across seven surveys, reported information on food expenditure.

Table 1. Indicators of food expenditure for urban households

Year	Basic Food Basket (BFB) cost in urban localities (2002 Mexican pesos)	Price variation of the BFB in urban localities (Percentage points)	General Inflation in urban localities (Percentage points)	Urban households with records on food expenditure*	Expenditure share of food by quintile				
					Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5
2002	605.8	3.8	5.0	18,408,909	35.35	31.70	28.26	23.89	16.67
2004	642.2	16.0	9.4	19,474,390	40.76	36.33	32.14	27.57	18.61
2005	619.7	0.3	4.0	19,506,597	34.11	31.73	28.12	24.18	16.67
2006	640.8	7.2	3.6	20,107,536	34.34	30.37	26.67	23.55	15.68
2008	663.5	13.2	9.3	20,859,177	35.43	31.63	29.18	25.71	18.21
2010	657.9	8.8	9.7	22,461,881	35.76	31.45	29.50	26.25	19.16
2012	709.4	16.1	7.7	24,172,723	36.74	32.85	29.27	25.67	19.42

Source: Own estimations based on ENIGH surveys and prices from the INEGI .

*/ Total households considering expansion factors.

According to ENIGHs, between 2002 and 2012 the average household spent about 28% of their current food expenditure. However, this percentage varies with household's income level: while the first quintile spends on average about 36% of its total expenditure on food; the fifth quintile spends in average 17.8%. About 90% of households in food poverty situation, those that cannot afford the cost of the basic food basket for all of its members, are

[4] The upward trend in food price was a widespread phenomenon across the globe. FAO (2012) reports that between 2003 and 2008 the real price of food and agricultural products grew at its fastest pace since the 30's. In general, real food prices around the world increased, on average, 66.6 percent between 2002 and 2012.

situated in the first income quintile. Across the surveys, the recurrent patterns are the increments of the households' share of expenditure allocated for food.

Table 1 shows an interesting pattern happening during 2004, where for all income quintiles the share of food consumption on total expenditure increased noticeably, except for the highest income quintile. This period characterizes by a widespread increase in food prices, which marked the upward trend in food prices that culminated in the spike seen in 2008. However, meat and dairy prices stayed relatively stable during this period. Since, these food categories are widely consumed by top quintiles, they resulted significantly less affected by these events. So, the identification of the most vulnerable groups of population during upward food price episodes by analyzing consumption patterns and price elasticities is a priority for the design policies well-targeted food.

The food consumption profile of the population experienced important changes across income quintiles. Table 2 shows, in detail, the expenditure profile and per capita consumption dynamics for the eight composite food categories at the national level by income quintile.

Table 2. Allocation of urban households' budget shares and average annual consumption per capita in Mexico (2002-2012)

Category	Expenditure Shares Distribution for Urban Households							Annual Consumption Per Capita for Urban Population (kgs.)						
	2002	2004	2005	2006	2008	2010	2012	2002	2004	2005	2006	2008	2010	2012
Total Population														
Cereals[/1]	18.80	19.24	18.92	19.69	21.48	20.84	21.24	129.41	119.94	109.32	113.62	119.19	119.28	117.36
Meats[/2]	27.66	27.07	28.66	26.68	25.86	26.43	27.26	48.29	44.38	43.37	44.67	44.77	45.38	45.27
Fish[/3]	2.97	2.89	3.02	3.04	2.85	3.12	2.68	4.29	4.12	4.20	4.49	4.29	4.60	4.10
Dairy[/4]	18.68	19.30	17.99	18.14	18.82	18.21	18.30	123.12	104.44	88.52	94.46	93.52	94.11	90.86
Oils[/5]	1.48	1.46	1.46	1.36	2.07	1.64	1.62	8.21	6.95	6.40	6.55	6.47	6.84	6.03
Vegetables[/6]	19.43	19.16	19.02	19.88	19.13	19.60	18.72	133.19	122.72	119.32	121.91	130.59	130.51	134.43
Sugar & Desserts[/7]	2.86	2.80	2.82	3.08	2.40	2.98	2.91	11.80	10.76	10.14	13.91	9.11	10.22	9.89
Beverages[/8]	8.12	8.09	8.12	8.12	7.38	7.17	7.26	73.56	80.07	79.72	81.15	79.50	79.19	81.61
First Quintile of the Population														
Cereals[/1]	23.44	23.26	23.33	23.90	26.01	24.57	26.10	155.47	149.10	130.32	140.09	147.42	151.33	149.97
Meats[/2]	24.09	23.39	24.27	23.24	21.90	22.87	23.70	37.67	36.76	33.46	37.07	36.86	39.27	38.76
Fish[/3]	2.10	2.20	2.46	2.10	1.76	2.22	1.77	3.46	4.13	3.57	3.94	2.95	3.93	3.10
Dairy[/4]	16.89	18.35	16.88	16.89	18.11	17.62	17.73	96.49	88.48	70.87	75.51	78.71	87.56	78.26
Oils[/5]	2.12	2.03	2.03	1.88	2.99	2.35	1.81	10.50	8.50	7.63	8.25	7.99	8.77	6.13
Vegetables[/6]	21.14	20.61	20.85	20.93	20.35	20.56	19.55	119.40	110.10	104.18	107.53	123.73	123.51	128.46
Sugar & Desserts[/7]	2.98	3.36	3.21	3.63	2.64	3.23	2.91	13.77	12.92	11.15	12.82	10.55	11.68	10.41
Beverages[/8]	7.24	6.79	6.97	7.42	6.24	6.57	6.41	55.86	58.64	57.25	66.83	61.63	69.47	71.78
Second Quintile of the Population														
Cereals[/1]	20.90	21.84	20.61	22.00	23.65	23.27	23.88	134.77	132.09	123.20	123.69	126.30	129.53	127.05
Meats[/2]	27.52	25.34	27.78	25.72	24.58	25.04	25.49	46.20	41.16	42.62	42.96	42.51	43.02	42.72
Fish[/3]	2.15	1.99	2.47	2.47	2.20	2.22	1.53	3.24	3.22	3.70	3.42	3.19	3.31	2.57
Dairy[/4]	17.87	18.98	17.28	17.28	18.71	17.58	18.00	114.28	98.00	83.79	85.36	88.63	86.53	87.91
Oils[/5]	1.68	1.80	1.69	1.57	2.45	1.93	2.05	8.30	7.74	7.37	7.20	6.89	7.63	7.24
Vegetables[/6]	20.02	19.67	19.75	20.39	18.96	19.64	18.84	121.33	117.78	118.16	121.10	121.43	123.84	130.53
Sugar & Desserts[/7]	2.46	3.10	2.60	3.04	2.31	2.97	3.01	10.68	11.50	10.63	10.85	9.13	10.04	10.94
Beverages[/8]	7.39	7.27	7.82	7.53	7.14	7.35	7.19	61.33	71.19	74.49	75.68	75.12	79.74	81.46
Third Quintile of the Population														
Cereals[/1]	19.39	19.83	19.85	20.83	22.15	21.75	22.31	130.08	120.42	113.16	115.36	121.40	120.54	116.08
Meats[/2]	28.03	27.35	29.42	27.05	26.35	26.92	27.44	49.50	44.85	45.83	45.34	47.39	46.22	46.20
Fish[/3]	2.84	2.11	2.17	2.32	2.36	2.57	2.13	4.38	3.31	3.49	3.84	3.86	4.02	3.45
Dairy[/4]	18.07	19.31	17.51	17.67	18.45	18.38	18.18	124.22	104.07	88.08	89.41	93.05	95.61	87.32
Oils[/5]	1.75	1.37	1.45	1.37	2.12	1.64	1.62	8.79	6.49	6.43	6.18	6.50	6.71	5.84
Vegetables[/6]	18.88	19.49	18.71	19.65	18.64	19.03	18.54	131.26	122.82	118.14	117.59	130.23	129.17	136.56
Sugar & Desserts[/7]	2.94	2.43	2.48	2.69	2.41	2.85	2.65	12.25	9.56	9.24	9.26	9.37	9.77	9.83
Beverages[/8]	8.09	8.11	8.41	8.42	7.53	6.86	7.13	73.54	83.18	80.69	86.74	84.47	77.97	82.10
Fourth Quintile of the Population														
Cereals[/1]	18.25	18.63	18.36	18.84	21.17	20.55	20.94	127.07	110.65	98.18	98.33	108.21	107.57	103.98
Meats[/2]	28.50	28.46	29.77	28.34	26.64	27.62	28.72	51.07	47.72	45.15	47.36	45.80	48.38	45.88
Fish[/3]	2.66	2.82	3.07	3.20	2.94	2.69	2.42	4.44	3.90	4.33	4.65	4.77	4.23	3.59
Dairy[/4]	19.37	18.96	18.26	18.13	19.09	18.24	18.20	138.02	109.39	92.59	93.98	96.72	94.12	87.91
Oils[/5]	1.27	1.28	1.21	1.16	1.84	1.59	1.45	7.12	6.03	5.09	5.58	5.80	6.53	5.18
Vegetables[/6]	18.59	18.48	18.02	19.15	18.20	19.08	17.95	132.50	123.33	116.35	119.92	125.25	127.36	124.93
Sugar & Desserts[/7]	2.55	2.37	2.61	2.71	2.29	2.79	2.58	10.45	9.37	8.55	9.48	7.89	9.48	7.51
Beverages[/8]	8.81	8.99	8.71	8.47	7.86	7.45	7.74	83.03	93.19	83.72	85.07	85.13	82.90	84.10
Fifth Quintile of the Population														
Cereals[/1]	15.51	15.82	15.57	15.99	17.59	16.91	16.60	99.77	87.31	81.37	90.67	92.77	87.19	89.77
Meats[/2]	28.41	28.50	29.75	27.32	27.64	27.78	28.92	56.95	51.41	49.85	50.59	51.26	50.05	52.81
Fish[/3]	4.17	4.40	4.21	4.27	4.11	4.97	4.46	5.95	6.07	5.95	6.63	6.68	7.56	7.84
Dairy[/4]	19.83	20.20	19.11	19.69	19.30	18.77	18.93	142.44	122.32	107.52	128.24	110.46	106.85	113.06
Oils[/5]	1.05	1.18	1.25	1.15	1.54	1.12	1.37	6.36	6.01	5.45	5.54	5.19	4.54	5.77
Vegetables[/6]	19.39	18.50	18.75	19.82	19.77	19.95	18.97	161.50	139.66	140.04	143.46	152.42	148.86	151.88
Sugar & Desserts[/7]	3.23	2.97	3.20	3.45	2.44	3.13	3.28	11.86	10.46	11.14	27.30	8.60	10.14	10.77
Beverages[/8]	8.41	8.43	8.15	8.31	7.61	7.38	7.46	93.96	94.01	102.76	91.36	91.00	85.88	88.62

Source: Owns estimation with information 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.

During the decade 2002-2012, in general, the most significant changes in terms of annual consumption per capita are concentrated in cereals, vegetables and dairy. The annual per-capita consumption of cereals and dairy decreased across all income quintiles, while the consumption of vegetables increased for lower income quintiles and decreased for the highest income quintiles. Expenditure shares of cereals have experienced increments along the seven surveys, while expenditure share of vegetables has decreased. Meats and dairy expenditure share have remained relatively stable along the whole period.

Between 2002 and 2012, households from the lowest quintiles adjusted in a more significant way their expenditure allocation patterns, by increasing the expenditure shares in cereals and dairy and decreasing their expenditure shares in meat and vegetables. In contrast, households in the highest quintiles basically showed relatively smaller variances in their budget allocations across surveys[5].

There are significant differences in consumption patterns across income quintiles. Households in upper income quintiles show more diversified diets. In contrast, households in the bottom quintiles show a cereal-based diet, with about one quarter of their expenditure allocated to cereals. For the total population, during the same period, the annual per capita consumption of cereals and dairy products fell by 12 kg and 32.3 kg, respectively; in contrast, the annual per capita consumption of non-alcoholic beverages and vegetables increased by 8 kg and 1.2 kg, respectively. However, per capita consumption of vegetables in the lowest income quintiles increased, while in the highest income quintiles it decreased.

Although additional current income from transfers (remittances, governmental programs and transfers, scholarships, donations, and pensions) might indirectly induce variations in per capita consumption, this effect can be easily captured through the expenditure elasticity. It is important to point out that none of the transfers is conditioned to spend the additional current income on determined categories of food. According to ENIGH 2012, for the first income

[5] In terms of quantities, households from the fifth quintile expend an important share in food away from home which is not reflected in this table. This table reports only food consumed at home.

quintile, the 31.42% of their quarterly current income is obtained from transfers, while for the fifth income quintile the share of transfers is 15.5%[6].

Main changes in per capita consumed quantities are attributable to price changes. For example, the reduction in the per capita consumption of the category dairy products (where eggs are included) can be attributed to increasing egg prices during the second and the third quarter of 2012, which was directly captured in ENIGH 2012[7]. Thus, the study of the impacts of price shocks on food consumption can be useful for improving our understanding about how households from lower quintiles cope with food price variation. In particular for lower income quintiles, the increment in per capita consumption of vegetables can be attributed to a substitution effect of dairy products by vegetables (see Table 2).

3. Data, data sources and empirical strategy

The empirical strategy is described in four subsections. Subsection one develops the model used for the estimation of the complete food demand system. Subsection two describes the main issues on pseudo-panel estimation. Subsection three describe data sources, data treatment and cohort construction. Subsection four explain the methodology used for adjusting prices for quality.

3.1. *Demand model*

The demand system is estimated using the LA/AIDS model of Deaton and Muellbauer (1980). This model is a flexible demand specification that avoids nonlinearities and allows attaining an appropriate fit for food demand systems with highly collinear prices.

A basic assumption is that preferences are separable, which allows the grouping of food commodities into broad aggregates. In particular, weak homothetic separability is assumed

[6] According to the ENIGH 2012, for the first income quintile 54.5% of transfers are from government programs and transfers, while for the fifth income quintile 75.2% of the transfers correspond to pensions.

[7] The national egg production was severely affected after June 2012 due to the outbreak of avian influenza in Los Altos de Jalisco, one of the most important producer regions. By mid-September 2012, about 15.3% of the laying birds have been sacrificed. The egg price increased from 13 pesos per kg. to 34 pesos per kg. experiencing high volatility. By August 2012, the annual variation in egg price was 24.4% and its contribution to the annual general inflation was 0.23 percentage points (Banco de Mexico, 2012).

to justify the construction of a composite price index. Also, this assumption implies that direct utility, indirect utility and cost functions written in terms of their quantity and price indices possess all the same properties as the corresponding functions of individual goods (Lewbel, 1997)[8].

One of the main advantages of aggregating a complete food demand using composite commodities is avoiding the problem of the multicollinearity of prices, associated with separability[9]. The aggregation reduces other problems, such as infrequency in purchases, discreteness of purchases and differences between purchases and consumption (Lewbel, 1997).

A known problem in the estimation of demand systems is the endogenity of total expenditure, which may lead to inconsistent demand parameter estimates. Total expenditure and the expenditure shares of commodities are jointly determined creating a problem of endogeneity for the expenditure. In this study this problem is controlled following the technique of Blundell and Robin (1999), explained in detail in the next section.

At the household level, the consumption behavior during period t can be represented by the budget share equations. 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 group of analyzed commodities for the household, P_{jt} are the unit values that replace prices of the commodity j and P^*_{ht} is a price aggregator (price index).

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

[8] Aggregation allows solving the dimensionality problem by reducing the number of estimated parameters.

[9] In practice, collinearity of prices results in insignificant parameter estimates because each equation in the demand system depends on prices of all goods in the 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, 1997).

The translog price index[10] is the most common price aggregation method; however, to obtain a linear demand system we use the Stone's price index described in equation (2).

$$lnP_{ht}^{*} = \sum_{i=1}^{I} w_{ih} lnP_{iht} \tag{2}$$

The error term can be disaggregated in the following expression $u_{ht} = \mu_h + \vartheta_{ht}$, where μ_h denotes the household non-observable heterogeneity, static in time, and ϑ_{ht} refers to the random error component identically and independently distributed across time. For the $i = 1, \dots, I$ commodity categories and $h = 1, \dots, H$ 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 $\boldsymbol{Z}_h$ is a vector of households' sociodemographic characteristics . So, α_i, γ_i and β_i are the estimated parameters of the system.

The equations in the demand system for the I commodities must satisfy the following restrictions to adequately represent a demand system: 1) the adding up condition, which implies that expenditures on individual goods must 'add up' to total expenditure ($\sum_{i=1}^{N} w_i = 1$); 2) homogeneity of degree zero in prices and total expenditure taken together; and 3) Slustky symmetry. Therefore the following restrictions must be imposed on parameters of equation (1) (Deaton and Muellbauer, 1980).

$$\sum_{i=1}^{I} \alpha_i = 1, \quad \sum_{i=1}^{I} \gamma_{ij} = 0 \ , \sum_{j=1}^{J} \beta_i = 0, \sum_{j=1}^{J} \gamma_{ij} = 0 \ , \quad \gamma_{ij} = \gamma_{ji} \tag{3}$$

The quality of the approximation of the LA/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 following Green and Alston

[10] In cases where prices are highly collinear, Stone index is a good approximation of the price index $lnP = \alpha_{ih} + \sum_{i=1}^{I} \alpha_{jh} lnP_{jht} + \frac{1}{2} \sum_{j=1}^{J} \sum_{i=1}^{I} \gamma_{ih} lnP_{iht} lnP_{jht}$.

(1990), while the calculation of the expenditure elasticities followed the approach of Green and Alston (1991)[11].

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

3.2.Econometric estimation of pseudo-panel

The demand analysis with a nutritional approach is a powerful instrument to analyze the effects of price increments on food consumption patterns and nutrition. Demand systems provide a characterization of expenditure, estimates of price and expenditure elasticities and the effects of demographic variables that determine demand. In addition, the analysis of profiles of individual nutrient intake provides a comprehensive approach about the utilization of food at the intra-household level.

The LA/AIDS model is estimated within a pseudo-panel data approach (Deaton, 1985) that uses cohorts as observation units that incorporate information on relevant food consumption patterns of the groups of households with the same characteristics that are invariant through time. This technique is used in absence of real panel data that allows tracking the unit of observation over time. The usual advantages of panel are present in pseudo-panel approach. Precision of regression estimates is higher; it allows the possibility of isolating effects of unobserved heterogeneity between cohorts and time; temporal ordering allows making causal inference and it allows controlling by temporal effects and variables that may vary over time. Furthermore, representativeness of surveys is maintained while attrition problems are absent.

According to Deaton (1985), the aggregation to cohorts of repeated cross-sections include variance, while households' micro data provide means cohort estimates with sampling errors. Thus, the sample cohort means from surveys are consistent but error-ridden estimates of unobservable cohort population means. Therefore, the construction of cohorts with members that are distinct from one another and internally homogeneous will minimize the errors-in-

[11] The advantage of the LA/AIDS is its simplicity for estimation.

variable problem and will improve the estimation. Since households' micro data are used to construct the means, they can be also used to construct variance and covariance estimates of the sample means, which allows estimating consistent errors-in-variable estimators of the population relationships (Deaton, 1985).

According to Verbeek (2008), under this approach the necessary condition for consistency of estimators is that exogenous variables show time-varying cohort specific variation. However, this condition is not easily verifiable because estimation errors in the reduced form parameters may hide collinearity problems, sample cohort averages may exhibit time-variation while the unobserved population cohort averages do not.

The cohort aggregation of the LA/AIDS model is performed by the calculation of the means over the households as the weighted sums of household's shares. The socio-demographic variables are calculated as the weighted mean characteristic using the weighting factors for each household and different between surveys. Thus, equation (4) in terms of pseudo-panel is rewritten in the following expression:

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

where $c = 1, \dots, C$ denotes the constructed cohorts for every survey. The error term has the following composition $\overline{u_{ct}} = \overline{\mu_{ct}} + \overline{\vartheta_{ct}}$, where the term μ_{ct} indicates that the mean values of the cohort are calculated for a different set of individuals from different surveys. In the next section, a detailed explanation of the construction of cohorts is provided.

Verbeek (2008) suggests 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 ($\overline{\mu_{ct}}$ = $\overline{\mu_c}$). Verbeek and Nijman (1993) consider that if cohort averages are based on a large number of household observations, the sample means are an accurate estimator of the population means (cohort size must include at least 100 individual observations). Thus, the natural estimator is the fixed effects model because the grouping in cohorts tends to homogenize individual effects among the individuals grouped in the same cohort, so that the average specific effect is approximately invariant between periods and is efficiently removed by within or first difference transformations.

The econometric estimation of this pseudo-panel demand system model was performed in Matlab following the standard methodology detailed in Baltagi (2008). First, we carried out the estimation of a Similar Unrelated Regression (SUR) system with an error component for a balanced panel. For such purpose, regardless of the panel specification of the data, equation (5) was separately estimated using Ordinary Least Squares (OLS) for the eight equations (food categories). The vector of residuals $\overline{u_{\iota ct}}$ obtained from this former process was used to calculate the SUR variance-covariance matrix and time fixed effects and cohort fixed effects were specified to eliminate invariant unobserved effects across time and cohorts to obtain the fixed effect panel model estimators. Constraints for additivity, homogeneity and symmetry were imposed in the model in every stage of the estimation.

Additional procedures were included in the econometric estimation to control for two issues: the endogeneity of total household food expenditure and the heterocedasticity, created by the aggregation process of the household data into cohorts, generating information loss that resulted in less efficient parameters. The heterocedasticity is controlled by implementing the Feasible Generalized Least Squares.

The endogeneity problem, previously explained, was corrected following Lecocq and Robin (1999). These authors use the augmented regression technique in two stages. In the first stage we estimate a reduced form regression of the endogenous variable on the set of instrumental variables with at least one additional exogenous explanatory variable for expenditure. In the second stage, the residuals from the first-stage are included as an additional explanatory variable in the original system equations. According to Blundell and Robin, (1999), the OLS parameters of the augmented model are identical to the Two-Stage Least Squares (2SLS) estimator, the significance of the residual in the augmented regression is the test for exogeneity.

We use household income as instrument because it is exogenous in the household food expenditure allocation. Furthermore, household income satisfies two basic conditions of a good instrument: the relevance condition (income is highly correlated with total expenditure, the endogenous variable) and the exogeneity condition (total income must not be correlated with the error term in the demand system).

First we regress total household food expenditure $\ln X_{ct}$ on the sociodemographic variables Z_{ct}, prices $\ln P_{ct}$ and the logged incomes of cohort c at period t, the mean of the income $\overline{lnY_c} = \frac{1}{T}\sum_{t=1}^{T}\overline{lnY_{ct}}$ and the mean of total household food expenditure $\overline{lnX_c} = \frac{1}{T}\sum_{t=1}^{T}\overline{lnX}_{ct}$. The set of sociodemographic variables (Z_{ct}), aggregated over cohorts, includes the number of household's members younger than 18 years as a proportion of the household size, age, education of the household head and the number of breadwinners in the household as a percentage of household's members. We corroborated the exogeneity of the instrument by the significance of the residuals on the augmented regression of the system equations.

3.3.Data sources, data treatment and cohorts construction

For the sake of analysis, a complete food demand system for eight composite commodities was constructed using food consumption data from ENIGHs rounds 2002, 2004, 2005, 2006, 2008, 2010 and 2012. Estimates for own-price, cross-price and expenditure elasticities were calculated. Then, the nutrient elasticities for 18 nutritional components in response to changes in the 8 food categories' prices provide further information regarding the effects of price changes on nutritional patterns of Mexican households.

ENIGH surveys collect information about the structure of households' income, as well as the expenditure allocation and purchases of different type of commodities including food. ENIGHs weekly record expenditure and purchased quantities of food and beverages by item, so this allows me to indirectly obtain prices as the unit value of food products through division of the total expenditure by the quantity of household's consumption to each observation unit. This enables me to acquire the complete distribution of the purchasing prices that households face at markets in contrast with other methods as using indirect price surveys, such as the CPI, which only gives us a representative price for each item for all households. A standardization process was applied on data to guarantee that all quantities and prices were expressed in the same units (pesos per kilograms). Thus, the estimated elasticities are closed under unit scaling, which means elasticities are invariant to simultaneous change in unit.

Although ENIGHs gather information on about 247 food products and beverages, food away from home, alcoholic beverages, herbs and spices were excluded and a set of 184 food products was considered for the analysis[12]. For the sake of estimation and reduction of the number of parameters, food products were aggregated in eight composite food commodities. The referred eight composite food commodities are: (1) cereals, including corn, wheat, rice, bread and processed cereal based foods; (2) meats including beef, pork, poultry, lamb and processed meats; (3) fish and seafood; (4) milk, dairy products and eggs; (5) oils and fats; (6) vegetables, potatoes, fresh fruits, pulses and dried pulses; (7) sugar, honey, sugar-fat products, desserts, processed sugar based foods, chocolate and coffee; (8) non-alcoholic beverages. Each of these composite commodities is an average aggregate (Laspeyres) index derived from independent household observations.

Due to their structure, ENIGHs allow estimating differentiated consumption patterns using the purchases of food, per capita consumption (using equivalence scales) and nutritional equivalences. In contrast, the main shortfalls of the data are the impossibility of measuring the effective consumption, the quantity of waste, the intra-household distribution of food and the conversion to nutritional content of food consumed away from home, more frequent in households from the highest quintiles[13].

This study also uses adult equivalence scales, developed by Teruel et al. (2005) instead of the household size. The equivalence scales are used to convert the household-level measures to individual-level measures, taking into account the household composition. The nutritional content information of food items to construct the nutritional content tables was obtained from Bourges et al. (2008), the National Institute of Medical Science and Nutrition, Salvador Zubiran (NIMSNSZ) (2007) and Pérez et al. (2008).

[12] Also, two types of beverages are not considered because they present unexplained variations on recorded consumptions between different surveys.

[13] This research does not consider food consumed away from home in the analysis, since its effect is low in the lowest income quintiles since its consumption is not frequent for these households.

For the construction of the cohorts (observation units) we used as instruments four geographical regions and income deciles[14]. Thus, forty cohorts were constructed averaging household level observations across these dimensions (regions and income). In order to guarantee the consistency of the estimators, we corroborated that the cohort observations show time-varying cohort specific variation across exogenous variables.

3.4.Quality adjusted prices for Mexican foods

According to Deaton (1997), quality can be considered as a property of commodity aggregates used by surveys to collect data and at the finest level of disaggregation, goods are perfectly homogeneous. The sources of price variation can be spatial and temporal mainly reflecting supply factors that might result in biased and misleading demand elasticities; however, once controlled for, the remaining variation is assumed to reflect quality effects induced by household characteristics and nonsystematic supply related factors, such as retail-merchandising behavior (Cox and Wohlgenant, 1986).

Prices are not explicitly provided in the ENIGHs, instead expenditures and quantities for all households are provided. Prices are imputed by calculating unit values of the consumed merchandise by dividing expenditures by their corresponding quantities at the household level. In data obtained in this way there are three dimensions: quantity, quality and prices; unit values are part price and part quality.

The methodology of Cox and Wohlgenant (1986) was applied, consisting in subsequently adjusting for quality differences at a household level for each ENIGH survey. Independent regressions for every commodity (184) in every survey were estimated. Quality-adjusted prices for each commodity in the surveys were generated by adding the intercept of the regression to the residuals obtained from each commodity regression. In cases when

[14] We considered the regions defined by Banco de Mexico: North, North-Center, Center and South. The North región contains Baja California, Sonora, Chihuahua, Coahuila, Nuevo León and Tamaulipas. The North-Center region comprises Aguascalientes, Baja California Sur, Colima, Durango, Jalisco Michoacán, Nayarit, San Luis Potosí, Sinaloa and Zacatecas. The Center región 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.

households did not purchase a given commodity (expenditure and quantity were zero), the quality-adjusted price was equal to the intercept for that commodity.

Temporal variation was treated by estimating separately for every ENIGH survey the methodology of Cox and Wohlgenant (1986), while spatial variation was treated including variables of regions. The specification included sociodemographic characteristics such as age, square age, size of household and square of the size of household and income.

Quite significant price-quality effects are present for all commodities and across all groups. A total of 92 from the set of 184 food items showed significant quality effects at the household level. Most of the quality-adjusted price items are from the cereals, meats and vegetables composite groups. In contrast, for beverages and dairy composite groups, the quality effect is comparatively lower.

4. Results

In this section, the results of the estimation are analyzed. Subsection one describes the demand system estimation. Subsection two depicts the estimation method of nutrient elasticities. Subsection three provide welfare measures. Finally subsection four show an application that assess the impact of increasing prices in food security.

4.1.Demand system estimation

The estimation of the SUR system was carried out with satisfactory goodness of fit for all seven equations, with R^2 values in a range of 0.20 to 0.63. In general terms, socio-demographic variables were significant at the 10% level but the magnitude of the effect varied depending to the specific food category.

The size of household has the most significant effect on food budget allocated to meats, fish and vegetables with the highest effect in meats. Children (individuals less than 18 years old) in families, as a percentage of the size of the family, is associated with higher food budget allocated for cereals and vegetables and less food budget allocated for meats. Higher education of the head of household is associated with more food budget allocated to dairy, meats, and fish, with the highest effect in dairy. Higher age of the head of households is associated with higher food budget allocated for cereals and vegetables, with the highest effect in vegetables. The more members of the family that are breadwinners, the more food budget allocated for meat and dairy.

The regression of total household food expenditure on sociodemographic variables to correct endogeneity shows a reasonable goodness of fit with R^2 values between 0.64 and 0.96[15]. The significance of $\overline{lnX_c}$ for all food categories with the exception of oils and $\overline{lnY_c}$ for all equations of the food categories, except for oils, reveals a satisfactory instrumental variable implementation that control for the endogeneity of total food expenditure in the demand system and avoids bias due to unobserved heterogeneity.

The uncompensated price elasticity calculation used the averages estimated shares and the mean point of the sociodemographic variables (Z_t) for five income groups of households. As expected, all prices have a positive relationship with households expenditure as well as the size of the household. Standard errors of elasticity estimators were calculated by bootstrap methods and simulated 500 times.

Table 3 shows the own-price and cross-price elasticities as a measure of how purchase quantity changes as a result of a 1% price variation of the composite food commodity. In general terms, the results are consistent: own-price elasticities are all negative and significant, with the exception of beverages in the first quintile, which is not significant. As expected, expenditure elasticities were consistently higher for lower income quintiles, which is consistent with previous findings of Park et al. (2006). Also, demand elasticity for meats are consistent with the findings of Golan et al. (2001), who obtained more disaggregated estimations.

In general terms, cereals, fish and dairy food categories show the top own-price elasticities (higher than one), which means high sensitivity to price changes. In contrast, nonalcoholic beverages show the lowest price elasticity. Fish and meat categories show the highest expenditure elasticities, while cereals and beverages show the lowest expenditure elasticities.

[15] Durbin Watson test showed a statistic close to 2 indicating no evidence of autocorrelation.

Nevertheless, there are significant differences in elasticities for food categories across income quintile. Own price elasticities that show important variation between income quintiles are meat and fish with higher magnitudes for upper income quintile; while dairy show a constant elasticity across income quintile, as well as vegetables (see Table 3).

In terms of cross-price elasticities, meat and fish show high sustituibility across income quintile (an increment in meat prices strongly decreases fish purchase), also the same effect occurs between sugar and desserts and nonalcoholic beverages. In contrast, fish and dairy show strong complementarity (increments in fish prices increase dairy consumption), which decreases with higher quintile income. Meats and nonalcoholic beverages show an important complementarity: when meat prices rise, nonalcoholic beverages consumption decreases. This report shows the most relevant results, additional details on estimations are available upon request.

Table 3. Own-price, cross-price and expenditure elasticities for urban households

Composite Food Category	Cereals/1	Meats/2	Fish/3	Dairy/4	Oils/5	Vegetables/6	Sugar & Desserts/7	Beverages/8	Expenditure
					First Quintile of the Population				
Cereals/1	-1.173 ***	0.123 ***	-0.044 ***	0.258 ***	0.020 ***	-0.025	0.003	0.114 *	0.724 ***
Meats/2	0.001	-0.770 ***	-0.085 ***	-0.009	-0.084 ***	0.035	0.018 *	-0.364 ***	1.258 ***
Fish/3	-0.736 ***	-0.998 ***	-1.555 ***	1.782 ***	-0.077 ***	0.053	-0.075 ***	-0.058	1.664 ***
Dairy/4	0.306 ***	0.068	0.219 ***	-1.298 ***	0.093 ***	-0.239 ***	0.014 **	-0.060 **	0.897 ***
Oils/5	0.159 ***	-0.775 ***	-0.060 ***	0.734 ***	-0.804 ***	-0.123 **	-0.021	-0.128	1.019 ***
Vegetables/6	-0.081 ***	0.119 **	0.022 **	-0.227 ***	-0.012	-0.824 ***	0.055 ***	0.034	0.914 ***
Sugar & Desserts/7	-0.103 *	0.125	-0.040 **	0.020	-0.019	0.274 ***	-0.976 ***	-0.520 ***	1.239 ***
Beverages/8	0.377	-0.909 ***	0.003	-0.104	-0.031	0.135	-0.196 ***	0.044	0.682 ***
					Second Quintile of the Population				
Cereals/1	-1.194 ***	0.143 ***	-0.047 ***	0.280 ***	0.021 ***	-0.031	0.003	0.125 *	0.700 ***
Meats/2	0.005	-0.805 ***	-0.075 ***	-0.008	-0.073 ***	0.034	0.016 **	-0.321 ***	1.226 ***
Fish/3	-0.658 ***	-0.927 ***	-1.506 ***	1.622 ***	-0.068 ***	0.055	-0.066 ***	-0.055	1.604 ***
Dairy/4	0.304 ***	0.071	0.220 ***	-1.298 ***	0.092 ***	-0.240 ***	0.014 **	-0.059 *	0.897 ***
Oils/5	0.185 ***	-0.903 ***	-0.070 ***	0.854 ***	-0.772 ***	-0.143 **	-0.024	-0.149	1.022 ***
Vegetables/6	-0.088 ***	0.129 **	0.023 **	-0.242 ***	-0.013 *	-0.813 ***	0.058 ***	0.037	0.909 ***
Sugar & Desserts/7	-0.110 *	0.131	-0.045 **	0.023	-0.020	0.309 ***	-0.973 ***	-0.581 ***	1.266 ***
Beverages/8	0.348	-0.846 ***	0.004	-0.098	-0.030	0.123	-0.185 ***	-0.017	0.701 ***
					Third Quintile of the Population				
Cereals/1	-1.212 ***	0.158 ***	-0.049 ***	0.300 ***	0.022 ***	-0.035	0.002	0.135 *	0.679 ***
Meats/2	0.008	-0.822 ***	-0.071 ***	-0.007	-0.067 ***	0.033	0.015 **	-0.301 ***	1.211 ***
Fish/3	-0.588 ***	-0.849 ***	-1.460 ***	1.469 ***	-0.060 ***	0.053	-0.060 ***	-0.052	1.547 ***
Dairy/4	0.302 ***	0.073	0.219 ***	-1.298 ***	0.092 ***	-0.240 ***	0.014 **	-0.059 *	0.897 ***
Oils/5	0.214 ***	-1.043 ***	-0.081 ***	0.986 ***	-0.736 ***	-0.165 **	-0.028	-0.173	1.026 ***
Vegetables/6	-0.092 ***	0.135 **	0.024 **	-0.249 ***	-0.014 *	-0.808 ***	0.060 ***	0.038	0.906 ***
Sugar & Desserts/7	-0.111	0.132	-0.047 **	0.024	-0.020	0.324 ***	-0.971 ***	-0.608 ***	1.278 ***
Beverages/8	0.329	-0.805 ***	0.004	-0.093	-0.030	0.117	-0.178 ***	-0.058 *	0.713 ***
					Fourth Quintile of the Population				
Cereals/1	-1.233 ***	0.173 ***	-0.051 ***	0.322 ***	0.022 ***	-0.039 *	0.002	0.146 *	0.656 ***
Meats/2	0.011	-0.830 ***	-0.069 ***	-0.008	-0.065 ***	0.032	0.015 **	-0.291 ***	1.204 ***
Fish/3	-0.486 ***	-0.716 ***	-1.387 ***	1.229 ***	-0.049 ***	0.045	-0.049 ***	-0.045	1.458 ***
Dairy/4	0.296 ***	0.073	0.217 ***	-1.293 ***	0.090 ***	-0.237 ***	0.013 **	-0.058 *	0.899 ***
Oils/5	0.250 ***	-1.217 ***	-0.095 ***	1.150 ***	-0.693 ***	-0.192 **	-0.033	-0.201	1.030 ***
Vegetables/6	-0.095 ***	0.138 **	0.025 **	-0.253 ***	-0.014 *	-0.805 ***	0.061 ***	0.039	0.905 ***
Sugar & Desserts/7	-0.111	0.135	-0.051 **	0.024	-0.021	0.339 ***	-0.970 ***	-0.636 ***	1.290 ***
Beverages/8	0.313	-0.771 ***	0.006	-0.089	-0.029	0.111	-0.171 ***	-0.093 *	0.724 ***
					Fifth Quintile of the Population				
Cereals/1	-1.289 ***	0.209 ***	-0.055 ***	0.384 ***	0.026 ***	-0.043	0.004	0.172 *	0.592 ***
Meats/2	0.017	-0.836 ***	-0.070 ***	-0.008	-0.063 ***	0.030	0.014 **	-0.282 ***	1.199 ***
Fish/3	-0.326 ***	-0.497 ***	-1.272 ***	0.848 ***	-0.033 ***	0.029	-0.035 ***	-0.030	1.317 ***
Dairy/4	0.286 ***	0.072	0.213 ***	-1.286 ***	0.088 ***	-0.231 ***	0.013 **	-0.057 *	0.901 ***
Oils/5	0.287 ***	-1.393 ***	-0.109 ***	1.315 ***	-0.648 ***	-0.220 **	-0.038	-0.230	1.034 ***
Vegetables/6	-0.093 ***	0.133 **	0.025 **	-0.242 ***	-0.014 *	-0.813 ***	0.059 ***	0.037	0.909 ***
Sugar & Desserts/7	-0.088	0.114	-0.047 **	0.019	-0.017	0.290 ***	-0.975 ***	-0.546 ***	1.250 ***
Beverages/8	0.320	-0.810 ***	0.010	-0.092	-0.031	0.120	-0.179 ***	-0.047 *	0.710 ***

Source: Own estimations based on data from ENIGHs.

/* It can be rejected the null hypothesis that the elasticity is zero at the 10% level; /**It can be rejected the null hypothesis that the elasticity is zero at the 5% level; /*** It can be rejected the null hypothesis that the elasticity is zero at the 1% level.

/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.

4.2.Nutrient elasticities, the Huang's matrix

The nutrient elasticity matrix was estimated using the Huang's (1996) methodology, which links the determinants of the food choice with the consumer nutrient availability. Given the demand structure for composite food commodities and the set of nutrient contents for every food commodity, Huang (1996) derived the relationship between nutrient availability and changes in food prices and expenditure. The nutrient elasticities are able to link food choice with the nutritional status in the context of the classical demand framework. The interdependent demand relationships including own-price, cross-price and expenditure elasticity of a complete food demand system are incorporated directly into the measurement of nutrient elasticities (Huang, 1996).

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

The methodology to measure nutrient elasticities for the Mexican population includes the construction of a comprehensive nutrient profile of the Mexican consumer diet. The nutrient profile summarizes information of the nutritional content of 184 food items aggregated in eight food categories with their food nutrition attributes and food amounts consumed per capita. This information was gathered from seven ENIGHs (2002, 2004, 2005, 2006, 2008, 2010 and 2012) and the detailed foods nutrition content for 18 selected nutrients was obtained from Bourges et al. (2008), NIMSNZ (2007) and Pérez et al. (2008).

Table 4, constructed following the approach of the former section, provides key information about diets and nutrition patterns of the Mexican population across income distribution, three food categories (cereals, dairy and vegetables) define the main sources of the 18 nutrients.

Cereals provides mostly energy, protein, carbohydrates, fiber, calcium, iron; dairy products provide mostly cholesterol, calcium, phosphorus, vitamin A; vegetables and fruits provide mostly vitamin C, fiber, potassium, phosphorus, and iron. As expected, nonalcoholic beverages provide more than half of sugar consumption in the Mexican diet profile.

Table 4. Food share of nutrient based on per capita average food consumption, percentages (2002-2012)

Nutrient	Cereals/1	Meats/2	Fish/3	Dairy/4	Oils/5	Vegetables & Fruits/6	Sugar & Desserts/7	Beverages/8	Total
					First Quintile of the Population				
Energy	47.205	8.092	0.438	11.984	9.925	12.357	5.427	4.572	100.00
Protein	31.680	22.382	2.243	22.548	0.000	19.971	0.617	0.558	100.00
Fat	18.746	13.336	0.261	22.827	41.533	2.531	0.754	0.011	100.00
Carbohydrate	63.274	0.298	0.007	3.521	0.000	15.044	8.744	9.112	100.00
Cholesterol	0.170	16.865	1.044	81.309	0.530	0.000	0.082	0.000	100.00
Sugar	10.708	0.000	0.000	1.889	0.000	8.592	31.747	47.064	100.00
Fiber	43.123	0.118	0.003	0.000	0.000	56.373	0.056	0.327	100.00
Calcium	57.792	1.450	0.251	33.680	1.426	5.214	0.180	0.008	100.00
Phosphorus	17.678	10.973	3.070	27.109	0.014	39.973	1.036	0.147	100.00
Iron	51.559	8.576	0.378	6.059	1.933	30.104	1.236	0.155	100.00
Sodium	32.538	29.845	8.071	24.493	0.096	3.169	0.775	1.014	100.00
Potassium	11.791	10.801	0.879	13.958	0.481	56.202	0.862	5.026	100.00
Zinc	66.440	5.510	0.156	5.951	11.036	10.807	0.091	0.008	100.00
Thiamin	37.482	5.899	0.189	8.219	24.519	21.090	1.836	0.766	100.00
Riboflavin	7.892	7.215	0.163	36.033	31.521	15.399	1.687	0.090	100.00
Niacin	15.816	45.052	0.926	1.773	0.000	23.508	12.342	0.584	100.00
Vitamin A	0.000	11.071	0.080	73.909	0.000	14.795	0.096	0.049	100.00
Vitamin C	0.009	0.008	0.000	0.490	0.089	98.595	0.226	0.583	100.00
					Second Quintile of the Population				
Energy	44.306	10.074	0.454	13.062	9.583	11.691	5.114	5.716	100.00
Protein	28.733	27.373	2.223	22.561	0.000	17.630	0.737	0.742	100.00
Fat	17.560	15.834	0.268	24.404	38.680	2.496	0.747	0.011	100.00
Carbohydrate	60.742	0.381	0.014	4.017	0.000	14.675	8.398	11.773	100.00
Cholesterol	0.203	20.160	1.154	77.815	0.556	0.000	0.112	0.000	100.00
Sugar	10.695	0.000	0.000	2.348	0.000	8.765	26.868	51.325	100.00
Fiber	43.183	0.187	0.006	0.000	0.000	56.043	0.084	0.496	100.00
Calcium	54.544	1.749	0.257	36.065	1.364	5.781	0.229	0.011	100.00
Phosphorus	12.989	14.821	3.378	28.662	0.015	38.986	0.921	0.229	100.00
Iron	49.503	10.492	0.410	5.839	1.882	30.571	1.090	0.213	100.00
Sodium	33.181	33.999	6.087	21.966	0.082	2.763	0.863	1.058	100.00
Potassium	10.841	12.800	0.772	11.511	0.408	56.409	1.106	6.154	100.00
Zinc	64.285	7.483	0.157	5.573	10.788	11.610	0.098	0.005	100.00
Thiamin	28.792	7.938	0.219	8.308	25.723	25.299	2.525	1.197	100.00
Riboflavin	5.654	9.039	0.177	34.018	30.560	18.284	2.138	0.130	100.00
Niacin	10.719	51.575	0.916	1.593	0.000	24.506	9.881	0.810	100.00
Vitamin A	0.000	10.980	0.091	71.491	0.000	17.193	0.173	0.071	100.00
Vitamin C	0.006	0.006	0.000	0.417	0.075	98.537	0.225	0.733	100.00
					Third Quintile of the Population				
Energy	42.657	11.282	0.532	14.015	8.705	11.418	5.001	6.391	100.00
Protein	26.843	30.074	2.538	22.718	0.000	16.177	0.801	0.850	100.00
Fat	17.181	17.586	0.296	25.903	35.610	2.525	0.885	0.013	100.00
Carbohydrate	58.750	0.439	0.022	4.664	0.000	14.606	8.213	13.307	100.00
Cholesterol	0.226	22.831	1.399	74.949	0.439	0.000	0.156	0.000	100.00
Sugar	10.838	0.000	0.000	2.839	0.000	8.834	24.683	52.806	100.00
Fiber	42.618	0.282	0.011	0.000	0.000	56.344	0.120	0.625	100.00
Calcium	51.044	1.887	0.277	39.090	1.242	6.178	0.267	0.014	100.00
Phosphorus	11.945	16.625	4.053	28.121	0.014	37.944	0.989	0.308	100.00
Iron	48.200	11.706	0.481	5.431	1.730	30.940	1.237	0.275	100.00
Sodium	33.924	35.382	5.098	21.194	0.068	2.424	0.858	1.052	100.00
Potassium	10.417	13.905	0.837	9.709	0.341	56.739	1.339	6.714	100.00
Zinc	63.057	9.290	0.195	5.287	10.316	11.723	0.121	0.009	100.00
Thiamin	25.082	9.056	0.242	8.586	24.516	28.047	2.858	1.613	100.00
Riboflavin	4.587	10.289	0.193	34.006	28.639	19.696	2.417	0.172	100.00
Niacin	8.948	53.449	0.917	1.480	0.000	24.837	9.365	1.004	100.00
Vitamin A	0.000	11.821	0.109	68.421	0.000	19.367	0.189	0.092	100.00
Vitamin C	0.005	0.005	0.000	0.436	0.061	98.401	0.252	0.839	100.00

Source: Own estimation based on ENIGHs, Bourges et al. (2008), NIMSNZ (2007) and Pérez et al. (2008).

/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 4 (cont.). Food share of nutrient based on per capita average food consumption, percentages (2002-2012)

Nutrient	Cereals/1	Meats/2	Fish/3	Dairy/4	Oils/5	Vegetables & Fruits/6	Sugar & Desserts/7	Beverages/8	Total
	Fourth Quintile of the Population								
Energy	41.504	12.205	0.618	15.113	8.185	10.630	4.638	7.109	100.00
Protein	25.564	32.361	2.831	23.292	0.000	14.069	0.923	0.961	100.00
Fat	17.614	18.199	0.343	27.491	32.756	2.483	1.099	0.016	100.00
Carbohydrate	57.534	0.520	0.023	5.260	0.000	13.963	7.626	15.074	100.00
Cholesterol	0.220	24.282	1.620	73.280	0.433	0.000	0.165	0.000	100.00
Sugar	10.836	0.000	0.000	3.654	0.000	9.165	21.334	55.010	100.00
Fiber	43.764	0.380	0.012	0.000	0.000	54.922	0.151	0.772	100.00
Calcium	47.873	2.012	0.309	41.759	1.144	6.540	0.347	0.016	100.00
Phosphorus	10.978	18.421	5.278	29.380	0.014	34.522	1.059	0.349	100.00
Iron	47.833	12.820	0.572	5.426	1.606	30.246	1.183	0.315	100.00
Sodium	33.653	36.689	4.514	20.603	0.060	2.409	0.969	1.103	100.00
Potassium	10.419	14.604	0.981	8.937	0.293	55.996	1.678	7.091	100.00
Zinc	61.777	10.688	0.254	5.289	9.850	11.957	0.169	0.016	100.00
Thiamin	22.760	10.220	0.320	8.687	23.151	29.756	3.284	1.822	100.00
Riboflavin	4.054	11.194	0.249	33.293	26.244	22.004	2.772	0.189	100.00
Niacin	7.449	56.811	1.116	1.403	0.000	24.797	7.360	1.066	100.00
Vitamin A	0.000	12.784	0.130	67.100	0.000	19.609	0.275	0.103	100.00
Vitamin C	0.005	0.005	0.000	0.437	0.051	98.405	0.264	0.834	100.00
	Fifth Quintile of the Population								
Energy	35.920	13.603	0.944	17.625	7.319	10.702	5.739	8.148	100.00
Protein	21.162	34.845	4.187	24.863	0.000	12.189	1.420	1.333	100.00
Fat	15.745	19.184	0.548	30.748	29.384	2.659	1.705	0.027	100.00
Carbohydrate	50.445	0.669	0.050	6.834	0.000	14.784	9.342	17.876	100.00
Cholesterol	0.218	26.896	2.939	69.210	0.383	0.000	0.353	0.000	100.00
Sugar	9.997	0.000	0.000	5.529	0.000	11.027	22.935	50.512	100.00
Fiber	39.712	0.677	0.026	0.000	0.000	58.006	0.342	1.237	100.00
Calcium	37.258	2.212	0.545	50.206	1.050	8.084	0.624	0.020	100.00
Phosphorus	9.717	19.501	6.697	30.236	0.012	31.904	1.486	0.448	100.00
Iron	44.982	14.039	0.912	5.038	1.400	31.237	1.904	0.488	100.00
Sodium	31.504	37.585	5.786	20.237	0.048	2.212	1.449	1.181	100.00
Potassium	8.705	14.168	0.954	6.984	0.218	57.777	3.027	8.166	100.00
Zinc	55.448	14.307	0.348	5.434	10.320	13.724	0.312	0.107	100.00
Thiamin	17.726	10.848	0.468	8.825	20.538	34.073	5.251	2.271	100.00
Riboflavin	2.718	11.489	0.355	32.571	22.498	25.766	4.375	0.228	100.00
Niacin	5.777	54.659	1.430	1.200	0.000	25.326	10.403	1.204	100.00
Vitamin A	0.000	13.708	0.232	62.049	0.000	23.343	0.532	0.136	100.00
Vitamin C	0.005	0.006	0.000	0.454	0.037	98.275	0.373	0.851	100.00

Source: Own estimation based on ENIGHs, Bourges et al. (2008), NIMSNZ (2007) and Pérez et al. (2008).
/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.

In terms of income quintile, Table 4 depicts important differences in diets and sources of nutrients. Population in lower income quintiles shows a less diversified diet, cereals are their main source of nutrients. The consumption of cereals provide them at least half of the daily requirement in seven nutrients (zinc, carbohydrate, calcium, iron, energy, thiamin and sodium). The category of vegetables -that includes vegetables, pulses, tubers and fruits- is the second most important source of nutrients. This category provides more than 50% of fiber, potassium and vitamin C and more than one third of phosphorus and iron.

In comparison, the nutrition profile of the population in the highest income quintiles suggests a varied diet, in which individuals obtain their nutritional requirements mainly from a broader group of foods: cereals, meats, diary and vegetables. Although cereals are also an important source of nutrients that covers up to 50% in two nutrient components (carbohydrate and zinc), dairy, vegetables and meats also provide a good percentage of nutritional requirement (see Table 4).

Table 5. Nutrient elasticities based on food demand, 2002-2012

Nutrient	Cereals/1	Meats/2	Fish/3	Dairy/4	Oils/5	Vegetables & Fruits/6	Sugar & Desserts/7	Beverages /8	Nutrient Expenditure Elasticity
				First Quintile of Urban Population					
Energy	-0.503 ***	-0.098 ***	-0.013 ***	0.014 ***	-0.070 ***	-0.130 **	-0.053 ***	-0.018 ***	0.871 ***
Protein	-0.334 ***	-0.121 ***	-0.014 ***	-0.219 ***	0.004 ***	-0.215 ***	0.010 ***	-0.056 ***	0.944 **
Fat	-0.089 ***	-0.385 ***	0.002 ***	0.055 ***	-0.321 ***	-0.124 *	-0.009 ***	-0.097 ***	0.968 ***
Carbohydrate	-0.719 ***	0.024 **	-0.020 ***	0.076 **	0.009 ***	-0.112 *	-0.092 ***	0.033 ***	0.801 ***
Cholesterol	0.240 ***	-0.089 ***	0.147	-1.034 ***	0.056	-0.188 ***	0.013 *	-0.112 ***	0.967 **
Sugar	0.018 ***	-0.364 ***	-0.010 **	-0.059 ***	-0.018 ***	0.073 ***	-0.397 ***	-0.130 *	0.887 ***
Fiber	-0.550 ***	0.116	-0.007 ***	-0.017	0.002 ***	-0.475 ***	0.031 ***	0.068 ***	0.832 **
Calcium	-0.579 ***	0.076 *	0.044 ***	-0.285 *	0.029 **	-0.139 ***	0.008 **	0.039 ***	0.807 ***
Phosphorus	-0.180 ***	-0.028 ***	0.003 ***	-0.343 ***	0.012 ***	-0.390 ***	0.016 **	-0.030 ***	0.940 **
Iron	-0.611 ***	0.019 **	-0.018 ***	0.006 **	-0.011 ***	-0.271 ***	0.008 ***	0.025 ***	0.853 ***
Sodium	-0.365 ***	-0.259 ***	-0.111 ***	-0.100 ***	-0.004 ***	-0.075 ***	-0.004 ***	-0.093 ***	1.011 ***
Potassium	-0.129 ***	-0.050 ***	0.014 ***	-0.265 ***	-0.007 **	-0.486 ***	0.016 ***	-0.019 ***	0.925 **
Zinc	-0.754 ***	-0.031 ***	-0.027 ***	0.153 ***	-0.076 ***	-0.131	0.007 ***	0.041 ***	0.819 ***
Thiamin	-0.393 ***	-0.165 ***	-0.017 ***	0.124 ***	-0.190 ***	-0.225	-0.010 ***	-0.017 ***	0.893 ***
Riboflavin	0.053 ***	-0.248 ***	0.051 *	-0.249 ***	-0.227 *	-0.246 ***	-0.008 ***	-0.083 ***	0.957 ***
Niacin	-0.216 ***	-0.298 ***	-0.055 ***	-0.021 ***	-0.039 ***	-0.151 ***	-0.101 ***	-0.203 ***	1.084 ***
Vitamin A	0.214 ***	-0.019 ***	0.154	-0.993 ***	0.057	-0.294 ***	0.019 *	-0.080 ***	0.940 **
Vitamin C	-0.076 ***	0.112	0.022 ***	-0.230	-0.012 **	-0.812 ***	0.051 ***	0.032 ***	0.914 *
				Second Quintile of Urban Population					
Energy	-0.470 ***	-0.126 ***	-0.013 ***	0.010 ***	-0.065 ***	-0.127 ***	-0.052 ***	-0.026 ***	0.867 ***
Protein	-0.301 ***	-0.167 ***	-0.014 ***	-0.222 ***	0.003 ***	-0.193 ***	0.009 ***	-0.064 ***	0.950 ***
Fat	-0.068 ***	-0.433 ***	0.003 ***	0.060 ***	-0.285 ***	-0.132 *	-0.009 ***	-0.105 ***	0.968 ***
Carbohydrate	-0.694 ***	0.017 **	-0.020 ***	0.073 **	0.009 ***	-0.107 *	-0.093 ***	0.027 ***	0.789 ***
Cholesterol	0.229 ***	-0.122 ***	0.138	-0.988 ***	0.052	-0.180 ***	0.012 *	-0.113 ***	0.972 **
Sugar	0.021 ***	-0.371 ***	-0.008 **	-0.066 ***	-0.018 ***	0.066 ***	-0.351 ***	-0.150 *	0.875 ***
Fiber	-0.563 ***	0.128	-0.007 ***	-0.015	0.001 ***	-0.468 ***	0.032 ***	0.073 ***	0.819 **
Calcium	-0.546 ***	0.082 *	0.049 ***	-0.314 *	0.032 **	-0.151 ***	0.007 **	0.040 ***	0.801 ***
Phosphorus	-0.124 ***	-0.062 ***	0.003 ***	-0.376 ***	0.011 ***	-0.380 ***	0.018 **	-0.041 ***	0.952 **
Iron	-0.599 ***	0.009 ***	-0.019 ***	0.011 ***	-0.011 ***	-0.273 **	0.010 ***	0.027 ***	0.847 ***
Sodium	-0.367 ***	-0.272 ***	-0.084 ***	-0.103 ***	-0.003 ***	-0.067 ***	-0.003 ***	-0.088 ***	0.988 ***
Potassium	-0.127 ***	-0.068 ***	0.012 ***	-0.246 ***	-0.010 **	-0.475 ***	0.014 ***	-0.022 ***	0.922 **
Zinc	-0.741 ***	-0.048 ***	-0.031 ***	0.173 ***	-0.072 ***	-0.140	0.007 ***	0.041 ***	0.812 ***
Thiamin	-0.293 ***	-0.225 ***	-0.018 ***	0.133 ***	-0.195 ***	-0.259	-0.015 ***	-0.038 ***	0.910 ***
Riboflavin	0.074 ***	-0.293 ***	0.044 *	-0.207 ***	-0.213 **	-0.266 ***	-0.012 ***	-0.094 ***	0.965 ***
Niacin	-0.156 ***	-0.370 ***	-0.053 ***	-0.038 ***	-0.040 ***	-0.157 ***	-0.075 ***	-0.202 ***	1.090 ***
Vitamin A	0.202 ***	-0.017 ***	0.151	-0.969 ***	0.056	-0.307 ***	0.020 *	-0.072 ***	0.936 **
Vitamin C	-0.083 ***	0.121	0.024 ***	-0.244	-0.013 **	-0.801 ***	0.054 ***	0.034 ***	0.908 *
				Third Quintile of Urban Population					
Energy	-0.453 ***	-0.140 ***	-0.012 ***	0.005 ***	-0.054 ***	-0.128 ***	-0.051 ***	-0.030 ***	0.863 ***
Protein	-0.282 ***	-0.194 ***	-0.018 ***	-0.220 ***	0.002 ***	-0.180 ***	0.007 ***	-0.068 ***	0.953 ***
Fat	-0.057 ***	-0.468 ***	0.003 ***	0.063 ***	-0.247 ***	-0.138 *	-0.011 ***	-0.111 ***	0.966 ***
Carbohydrate	-0.677 ***	0.016 **	-0.019 ***	0.069 **	0.009 ***	-0.108 *	-0.093 ***	0.023 ***	0.779 ***
Cholesterol	0.218 ***	-0.149 ***	0.127	-0.949 ***	0.049	-0.172 ***	0.011 **	-0.115 ***	0.979 **
Sugar	0.016 ***	-0.361 ***	-0.006 **	-0.070 ***	-0.017 ***	0.060 ***	-0.328 ***	-0.164 *	0.871 ***
Fiber	-0.566 ***	0.136	-0.008 ***	-0.013	0.001 ***	-0.469 ***	0.033 ***	0.077 ***	0.810 **
Calcium	-0.505 ***	0.087 *	0.056 ***	-0.354 *	0.035 *	-0.162 ***	0.007 **	0.039 ***	0.797 ***
Phosphorus	-0.117 ***	-0.082 ***	-0.006 ***	-0.365 ***	0.009 ***	-0.367 ***	0.017 ***	-0.044 ***	0.956 **
Iron	-0.595 ***	0.003 ***	-0.022 ***	0.020 ***	-0.010 ***	-0.274 **	0.009 ***	0.028 ***	0.841 ***
Sodium	-0.374 ***	-0.270 ***	-0.070 ***	-0.107 ***	-0.001 ***	-0.064 ***	-0.003 ***	-0.081 ***	0.969 ***
Potassium	-0.131 ***	-0.077 ***	0.007 ***	-0.228 ***	-0.011 ***	-0.469 ***	0.012 ***	-0.025 ***	0.922 **
Zinc	-0.737 ***	-0.066 ***	-0.034 ***	0.195 ***	-0.066 ***	-0.143	0.007 ***	0.040 ***	0.805 ***
Thiamin	-0.250 ***	-0.258 ***	-0.018 ***	0.138 ***	-0.178 ***	-0.282	-0.018 ***	-0.048 ***	0.915 ***
Riboflavin	0.088 ***	-0.325 ***	0.043 *	-0.192 ***	-0.189 **	-0.278 ***	-0.014 ***	-0.102 ***	0.968 ***
Niacin	-0.135 ***	-0.394 ***	-0.051 ***	-0.043 ***	-0.039 ***	-0.158 ***	-0.070 ***	-0.198 ***	1.088 ***
Vitamin A	0.189 ***	-0.023 ***	0.145	-0.935 ***	0.052	-0.316 ***	0.021 *	-0.070 ***	0.937 **
Vitamin C	-0.086 ***	0.126	0.025 ***	-0.251	-0.014 **	-0.795 ***	0.055 ***	0.035 ***	0.906 *

Source: Own estimation based on ENIGHs, Bourges et al. (2008), NIMSNZ (2007) and Pérez et al. (2008).

/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 5 (cont.). Nutrient elasticities based on food demand, 2002-2012

Nutrient	Cereals/1	Meats/2	Fish/3	Dairy/4	Oils/5	Vegetables & Fruits/6	Sugar & Desserts/7	Beverages /8	Nutrient Expenditure Elasticity
	Fourth Quintile of the Population								
Energy	-0.441 ***	-0.156 ***	-0.013 ***	0.007 ***	-0.047 ***	-0.125 ***	-0.049 ***	-0.032 ***	0.856 ***
Protein	-0.268 ***	-0.214 ***	-0.021 ***	-0.223 ***	0.002 ***	-0.162 ***	0.005 ***	-0.073 ***	0.954 ***
Fat	-0.057 ***	-0.497 ***	0.002 ***	0.075 ***	-0.211 ***	-0.145 *	-0.013 ***	-0.115 ***	0.961 ***
Carbohydrate	-0.668 ***	0.012 **	-0.018 ***	0.071 **	0.009 ***	-0.104 *	-0.089 ***	0.022 ***	0.765 ***
Cholesterol	0.210 ***	-0.165 ***	0.119	-0.924 ***	0.047	-0.165 ***	0.011 **	-0.115 ***	0.983 **
Sugar	0.017 ***	-0.361 ***	-0.003 **	-0.079 ***	-0.016 ***	0.047 ***	-0.295 ***	-0.170 **	0.861 ***
Fiber	-0.589 ***	0.143	-0.009 ***	0.002	0.001 ***	-0.458 ***	0.032 ***	0.083 ***	0.796 **
Calcium	-0.471 ***	0.090 *	0.061 ***	-0.385 *	0.038 *	-0.170 ***	0.007 **	0.038 ***	0.794 ***
Phosphorus	-0.105 ***	-0.104 ***	-0.020 ***	-0.368 ***	0.009 ***	-0.340 ***	0.014 ***	-0.050 ***	0.963 **
Iron	-0.600 ***	-0.002 ***	-0.024 ***	0.032 ***	-0.009 ***	-0.269 **	0.009 ***	0.030 ***	0.833 ***
Sodium	-0.371 ***	-0.268 ***	-0.060 ***	-0.111 ***	-0.001 ***	-0.063 ***	-0.003 ***	-0.078 ***	0.956 ***
Potassium	-0.137 ***	-0.083 ***	0.004 ***	-0.215 ***	-0.012 ***	-0.458 ***	0.009 ***	-0.029 ***	0.921 ***
Zinc	-0.733 ***	-0.083 ***	-0.038 ***	0.216 ***	-0.058 ***	-0.147	0.006 ***	0.040 ***	0.797 ***
Thiamin	-0.223 ***	-0.292 ***	-0.020 ***	0.154 ***	-0.160 ***	-0.297	-0.021 ***	-0.059 ***	0.918 ***
Riboflavin	0.091 ***	-0.350 ***	0.038 *	-0.169 ***	-0.162 **	-0.295 ***	-0.016 ***	-0.108 ***	0.971 ***
Niacin	-0.115 ***	-0.430 ***	-0.053 ***	-0.047 ***	-0.040 ***	-0.161 ***	-0.050 ***	-0.194 ***	1.089 ***
Vitamin A	0.181 ***	-0.032 ***	0.139	-0.917 ***	0.049	-0.312 ***	0.020 **	-0.070 ***	0.941 **
Vitamin C	-0.089 ***	0.129	0.025 ***	-0.255	-0.014 **	-0.792 ***	0.056 ***	0.036 ***	0.904 *
	Fifth Quintile of the Population								
Energy	-0.381 ***	-0.178 ***	-0.011 ***	-0.018 ***	-0.037 ***	-0.128 ***	-0.062 ***	-0.035 ***	0.849 ***
Protein	-0.218 ***	-0.243 ***	-0.034 ***	-0.236 ***	0.002 ***	-0.148 ***	-0.001 ***	-0.081 ***	0.960 ***
Fat	-0.033 ***	-0.512 ***	0.004 ***	0.049 ***	-0.172 ***	-0.153 **	-0.019 ***	-0.121 ***	0.957 ***
Carbohydrate	-0.595 ***	-0.010 ***	-0.013 ***	0.056 ***	0.009 ***	-0.109 *	-0.111 ***	0.027 ***	0.747 ***
Cholesterol	0.191 ***	-0.194 ***	0.090	-0.861 ***	0.041 *	-0.151 ***	0.008 **	-0.119 ***	0.994 ***
Sugar	0.018 ***	-0.343 ***	0.003 **	-0.102 ***	-0.014 ***	0.020 ***	-0.306 ***	-0.131 **	0.854 ***
Fiber	-0.562 ***	0.144	-0.008 ***	0.011	0.001 ***	-0.486 **	0.030 ***	0.085 ***	0.784 **
Calcium	-0.343 ***	0.089 *	0.078 ***	-0.504 *	0.044 *	-0.197 ***	0.007 **	0.026 ***	0.799 ***
Phosphorus	-0.087 ***	-0.114 ***	-0.033 ***	-0.373 ***	0.010 ***	-0.321 ***	0.008 ***	-0.054 ***	0.964 ***
Iron	-0.591 ***	-0.004 ***	-0.030 ***	0.057 ***	-0.007 ***	-0.277 *	0.003 ***	0.032 ***	0.817 ***
Sodium	-0.360 ***	-0.268 ***	-0.074 ***	-0.099 ***	-0.001 ***	-0.060 ***	-0.008 ***	-0.073 ***	0.943 ***
Potassium	-0.123 ***	-0.089 ***	0.002 ***	-0.193 ***	-0.013 ***	-0.467 ***	-0.007 ***	-0.029 ***	0.920 ***
Zinc	-0.681 ***	-0.128 ***	-0.041 ***	0.248 ***	-0.059 ***	-0.165	0.006 ***	0.031 ***	0.789 ***
Thiamin	-0.173 ***	-0.303 ***	-0.021 ***	0.144 ***	-0.134 ***	-0.329	-0.040 ***	-0.070 ***	0.924 ***
Riboflavin	0.096 ***	-0.345 ***	0.035 *	-0.172 ***	-0.128 **	-0.319 ***	-0.030 ***	-0.113 ***	0.975 ***
Niacin	-0.096 ***	-0.415 ***	-0.056 ***	-0.046 ***	-0.038 ***	-0.163 ***	-0.081 ***	-0.194 ***	1.088 ***
Vitamin A	0.157 ***	-0.041 ***	0.125	-0.854 ***	0.043	-0.327 ***	0.018 **	-0.068 ***	0.946 **
Vitamin C	-0.088 ***	0.124	0.026 ***	-0.244	-0.014 **	-0.798 ***	0.053 ***	0.034 ***	0.908 *

Source: Own estimation based on ENIGHs, Bourges et al. (2008), NIMSNZ (2007) and Pérez et al. (2008).

/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.

Using the demand elasticities reported in Table 3 and the food shares of nutrients from Table 4, nutrient elasticities in Table 5 show the response of eighteen nutrient intakes to changes in eight food price categories. The nutrient elasticities are a measure of how the change in a particular food price or per capita expenditure will affect all food quantities demanded through the interdependent demand relationships, causing the levels of consumer nutrient availability to simultaneously change (Huang, 1996).

Table 5 shows that nutrient elasticities are inelastic and quite significant, which is consistent with findings of Allais (2010) and Huang (1996). For all income quintiles, the findings make sense: cereals have the highest magnitudes for carbohydrate, zinc, iron, energy, fiber, protein and calcium. The dairy food category shows high cholesterol elasticity attributable to egg consumption. Also, vegetables display high nutrient elasticities for vitamin C, fiber, potassium, phosphorus, and calcium. Likewise, the sugar and desserts food category show high elasticity in sugar. In general, nutrient expenditure elasticities show higher magnitudes for sodium and niacin, while carbohydrate showed the lowest extents.

Comparatively, there is strong evidence of marked disparities in nutrient elasticities' patterns across income quintiles for some food categories. The population from the lowest income quintiles show higher nutrient elasticities for cereals, which implies that purchases are more sensitive to cereals' price changes. In contrast, persons from higher income quintiles show higher nutrient elasticities for meat and fish and, marginally, for dairy.

For the population from the lowest income quintile, a 1% increase in the price of cereals (holding other prices and expenditure the same) would produce a reduction in per capita food purchase, the energy per capita purchase will decreased by 0.50%, protein by 0.33%, carbohydrate by 0.72% (see Table 5).

In contrast, for individuals in the highest income quintile, a 1% increment in the price of cereals (holding other prices and expenditure the same) will reduce per capita food purchase of energy by 0.38%, protein by 0.22%, carbohydrate by 0.60%, fiber by 0.56%, calcium by 0.34%, see Table 5.

4.3.Evaluating impacts of accumulated food price variation on welfare

This section summarizes our findings regarding the impact of accumulated food price variation on welfare during three periods. The analysis is based on the estimation of welfare changes derived from the accumulated food price fluctuations using the equivalent variation as a percentage of daily per capita expenditure. The basic assumption behind the analysis is that price increments have a forward-shifted effect and the food industry and retailers do not respond to this variation in prices.

The equivalent variation refers to the amount of money to provide (or take away) to (from) the consumer at the original prices that allows him to be indifferent about accepting price increase (decrease), which can be seen as the change in consumer's wealth equivalent to the price change in terms of its welfare impact. With this amount he will continue consuming the same food basket (before the change of prices) and having the initial welfare before the price variation occurred. So, a negative amount implies that consumer is losing welfare after price variation; in contrast, a positive amount implies a higher welfare for the consumer. The equation for equivalent variation is derived from the expenditure function of the AIDS model (Deaton and Muellbauer, 1980).

$$lne(u, lnP_{ct}) = lnP_{ct}^{*} + \tilde{u}\,\beta_0 \prod_{i=1}^{I} \exp(lnP_{ct})^{\beta_k} \qquad (6)$$

where lnP_{ct} represents the vector of aggregated prices for cohort *c* and time *t*, while lnP_{ct}^{*} stands for the Stone price index defined by equation (2) and $\tilde{u}$ stands for a given value of utility. After some algebra, the equivalent variation ($\overline{\Delta x)}$ for cohort *c* is defined in the following equation.

$$(\ln x_c - \; lnP_{c1}^{*}) \prod_{i=1}^{I} \exp(lnP_{c1})^{-\beta_k} = (\ln(x_c + \Delta x) - \; lnP_{c0}^{*}) \prod_{i=1}^{I} \exp(lnP_{c0})^{-\beta_k} \qquad (7)$$

where lnP_{c0}^{*} and $lnP_{c1}^{*}$are the Stone Price index per category I before (t=0) and after (t=1) the food price shock; lnP_{c0} and lnP_{c1} are the price food categories before and after the shock. Then, solving for total expenditure we got the final expression for the equivalent variation.

$$\overline{\Delta x} = \exp\left[(\ln x_c - \; lnP_{c1}^{*})(1 + \Delta lnP)^{\sum_{i\epsilon I} -\beta_i} + \; lnP_{c0}^{*}\right] - \exp(\ln x_c) \qquad (8)$$

where $lnP_{c1} = \Delta lnP * lnP_{c0}$

Table 6 presents the accumulated price variation in the domestic market by food categories. The first period (2006-2008) shows that the accumulated food price variation between September 2006 and September 2008 was mainly dominated by shocks in oils, cereals and dairy with increments of 67%, 21.6% and 21%, respectively. During the second semester of 2006 and early 2007, rising prices stemmed from extreme weather events around the world that affected world supply of raw materials, agriculture and livestock products and growing world demand (Banco de Mexico, 2011). During the second semester of 2008, new turbulence in international markets due to extreme climate events affected domestic prices of agriculture and livestock products. The accumulated food price variation of the second period (2008-2010) reflects the price shocks in sugar and desserts (34.57%).

The third period (2010-2012) exhibits the main price shocks in oils and cereals of 25% and 23%, respectively. During this period, grain prices in international markets recorded high volatility, which reflected in increasing corn tortilla prices in domestic markets. In addition, during 2011 the increment of prices of tomato and beef resulted from adverse weather conditions in the State of Sinaloa that, on average, amounts to about 40% of the national production. Also, throughout the second semester of 2012 increasing prices of eggs and poultry were result of an outbreak of avian influenza in Jalisco which is the main producer state of poultry and eggs in the country, which is reflected in Dairy food category (Banco de México, 2013)[16].

Table 6. Accumulated price variation by food expenditure heading (Variation in percentage)

Composite Food Commodity	Oct. 2006 to Sept. 2008	Oct. 2008 to Sept. 2010	Oct. 2010 to Sept. 2012
Cereals[/1]	21.63	7.67	21.94
Meats[/2]	11.61	11.28	17.88
Fish[/3]	10.56	11.31	15.06
Dairy[/4]	23.05	4.87	17.49
Oils[/5]	67.41	-10.45	25.22
Vegetables[/6]	-3.83	12.63	7.89
Sugar & Desserts[/7]	-2.20	34.57	9.42
Beverages[/8]	8.27	12.46	6.51
Total	12.71	9.65	15.49

Source: Banco de Mexico.

/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.

[16] Between June and September 2012, the price of eggs increased by 40% (Banco de México, 2012).

Table 7 shows the results of a comparative statics exercise that describe the situation of the consumer in two periods of time (before and after a price variation). Results show welfare losses derived from the accumulated price variation for the appointed period in food products as a percentage of additional per capita daily expenditure required to purchase the basket and to have the nutritional status prevailing in the initial periods: 2006, 2008 and 2010, respectively, across all income quintiles.

Table 7. Equivalent variation as shares of daily food expenditure

(Percentages)

Income Quintile	2006-2008	2008-2010	2010-2012
First	-16.79	-13.47	-30.24
Second	-16.01	-13.74	-30.78
Third	-16.32	-13.65	-31.26
Fourth	-15.40	-14.34	-31.51
Fifth	-15.20	-14.47	-30.76
Total Population	**-15.94**	**-13.93**	**-30.91**

Source: Own estimations.

Although during the period 2006-2008 there was a great spike in particular categories of food prices such as Cereals, Dairy and Oils, other food categories maintained a downward trend in prices like the Vegetables and Sugar and desserts, which reduced the severity of welfare loss occurred reaching up to 16.6% of daily food expenditure for the whole population. Given that the cereal price increase was particularly relevant in this period, the first quintile which has a diet based predominantly cereals, was the most affected income group with a welfare loss of 16.79%. In contrast, the fifth quintile had the smallest welfare loss with only 15.2%. During this period, the welfare loss is particularly regressive.

The smallest welfare loss occurred during the period 2008-2010 for all income groups with a welfare loss of 13.93%. One important feature of this shock was its progressiveness; with the highest welfare loss concentrated in the top quintile with a welfare loss of 14.47%, while the bottom quintile experienced a welfare losses of 13.47%. For this period, the welfare effects of these price variations are progressive because price shocks were concentrated mainly on meats and dairy, consistently consumed by population in the top quintiles, as shown in Tables 4 and 5.

However, the most significant welfare loss (30.91%) occurred in the last period of analysis, 2010-2012, which is mostly attributable to price shocks in Cereals and Dairy that includes eggs, a primary source of nutrients for the population from the bottom income quintiles. During this period, all food categories showed upward price trends strengthening each other, so the welfare loss of this period resulted by far the greatest across all income groups.

4.4.Impact assessment of increasing food prices in food security

Undernutrition is an imperative public health problem in Mexico that builds slowly over time based on daily reductions in food access, mainly associated with economic factors, but with long-term effects for their productivity, income and welfare. Primary undernutrition is the dominant status of the population in food poverty, mainly located in the South and the Southeast regions and is stronger in rural areas with a more limited access to food supply (Bourges, 2006). The National Ranking for Child Nutrition (RANNI) showed that 31.4% of the children suffer from chronic undernutrition in the State of Chiapas and 34.5% of the children in the State of Campeche suffer from anemia, both states in the South of the country.[17] While in the world chronic undernutrition is heading downwards, its prevalence increased in México during the last six years. In 19 states of the country, the chronic undernutrition is persistent in children under 5 years and the anemia prevalence is higher than in Africa (RANNI, 2014).

Bourges (2006) points out that households should allocate at most up to 30% of their expenditure to food to obtain a good quality nutritional diet as well as access to other basic consumption goods and services. In contrast, data from the ENIGH 2012 shows that households from the first income quintile allocate, in average, 37% of the expenditure to food purchases and for some households within this quintile it is up to 60%. One of the most

[17] The RANNI is a ranking indicator that summarizes the status of the undernutrition and anemia in children and the exclusive breastfeeding in babies. This indicator is calculated with data from the National Survey for Health and Nutrition (ENSANUT), see http://ranni.org.mx/

relevant findings in this research are the disparities of energy elasticities across income quintiles: people from the first income quintile show an energy elasticity of -0.503 and -0.098 for the categories of cereals and meats, respectively, in contrast for the fifth income quintile energy elasticities, which were -0.381 and -0.178, see Table 5.

Numerous methods for quantifying the household and individual food security have been broadly discussed but without consensus (Pelletier et al., 2012). Factors such as prices, that can affect precursors such as income or total expenditure, are highly correlated with energy sufficiency through their effects on the dietary intake of individuals. For instance, we can assess some aspects of food security such as energy insufficiency and nutrient inadequacy since undernutrition is manifested by deviations from normal growth in early childhood.

Although growth status can be considered an indirect outcome because it also depends on other nutrients and factors such as health and child care, it could be the closest measure to the phenomenon[18]. Thus, for the purposes of this research, deficit in weight gain of children could be a proper indicator of how food price shocks affect food security of individuals. Other methods for measuring food security in individuals use perception-based surveys that potentially might introduce response bias and may overestimate food insecurity measures (Barnett, 2010).

In this context, even when the evaluation of price shocks on the nutrients purchase is a complex task because of the mixed effects of the cross nutrient elasticities, we follow Huang (1996) and Zheng and Henneberry (2012) to assess and to quantify the short-term effects from price increments in four food categories on the consumption of 18 nutrients using the nutrient elasticities. The assumption of weak homothetic separability allows relative changes in consumer nutrient intake to be expressed as functions of the relative changes in food prices and per capita food expenditure.

$$\Delta \ln \xi_\ell = \sum_i \pi_{\ell i} \Delta \ln P_i + \eta_\ell \Delta \ln y \tag{9}$$

[18] Studies show that insufficient intake of nutrients such as carbohydrate and micronutrients (for example, vitamin A or zinc) could also restrict growth but in a less severe grade (García, 2006).

where $\Delta\ln\xi_\ell = \Delta\ln\xi_\ell/\xi_\ell$ stands for the change in per capita consumed quantities of nutrient ℓ, ξ_ℓ is the daily amount of nutrient consumed by one person; $\Delta\ln P_i = \Delta P_i/P_i$ is the relative change in the i composite food commodity price; $\Delta\ln y = \Delta y/y$ is the percentage change in food per capita expenditure. Under this structure, a change in the i food price category or the per capita expenditure will result in nutrients' intake variations from changes in food quantities consumed. For the sake of the analysis, we assume that expenditure remains unchanged since the analysis is framed in a four-week period, thus the total effect can be attributed to price variation and substitution between food categories.

In the other hand, people have differentiated diets to satisfy their nutrient requirement depending on their food access mainly determined by their income level, see Table 4. To cope with food price shocks, households from the first income quintile have more propensity to reduce their purchase of nutrients or to substitute foods as a response to price increments. In contrast, households from the fifth income are able to increase their food expenditure, without carrying out an expenditure reallocation or reducing their nutrient purchases. For these reasons, we focus on results for children in the first income quintile.

Table 8 shows the effect of price raises in four of eight composed food categories. These categories were determined by their relevance for household's expenditure and contrasting results: cereals, meats, vegetables and beverages (see Table 2). The analysis was separately carried out assuming the same hypothetical magnitude of three-percentage-point shocks in the selected food categories while all other food categories remained unchanged[19].

[19] The magnitude of the shocks resemble the historical closest magnitude to the highest four-week increment occurred in these composed commodities For example, the highest accumulated price increment in cereals was 3.093 percentage points in January, 2007. For meats it was 2.737 during November, 2011. For beverages it was 1.006 during December, 2009. Finally, for vegetables it was 6.5479 during May, 2012.

Table 8. Percentage of quantity change in total nutrients purchased for the first income quintile given a three-percentage point increment in selected food categories

Nutrient	3 Percentage Points Increment in Cereals Prices	3 Percentage Points Increment in Meat Prices	3 Percentage Points Increment in Dairy Prices	3 Percentage Points Increment in Vegetables Prices	3 Percentage Points Increment in Beverage Prices
Energy	-1.509	-0.293	0.043	-0.391	-0.053
Protein	-1.001	-0.363	-0.656	-0.644	-0.169
Fat	-0.266	-1.155	0.164	-0.372	-0.292
Carbohydrate	-2.156	0.071	0.227	-0.336	0.098
Cholesterol	0.720	-0.267	-3.102	-0.564	-0.335
Sugar	0.053	-1.091	-0.176	0.218	-0.391
Fiber	-1.651	0.349	-0.052	-1.424	0.203
Calcium	-1.737	0.227	-0.855	-0.416	0.118
Phosphorus	-0.539	-0.083	-1.030	-1.170	-0.089
Iron	-1.833	0.056	0.019	-0.813	0.075
Sodium	-1.096	-0.777	-0.300	-0.224	-0.280
Potassium	-0.386	-0.149	-0.796	-1.459	-0.056
Zinc	-2.261	-0.093	0.459	-0.394	0.123
Thiamin	-1.179	-0.496	0.373	-0.674	-0.052
Riboflavin	0.158	-0.744	-0.746	-0.738	-0.248
Niacin	-0.648	-0.893	-0.064	-0.452	-0.610
Vitamin A	0.641	-0.056	-2.978	-0.882	-0.240
Vitamin C	-0.228	0.335	-0.691	-2.436	0.096

Source: Own estimations.

These results confirm the nutrient elasticities estimations of highly differentiated effects of price upsurge across food categories on the nutrients purchase. Price increments in cereals, meats and vegetables affect more significantly the energy purchase and show higher differentiation of the nutrients purchase. Comparatively, price increments in beverages show a lower and marginal impact on the energy purchases. A three-percentage point increment in the price of cereals decreases by 1.509% the purchase of energy daily requirement and by 2.156% the purchase of carbohydrate daily requirement for people in the first income quintile, see Table 8.

Growth can be considered an energy issue since it reflects the coverage of energy requirements. In practice, undernutrition is more frequent in toddlers (children under three years old), pregnant women and breastfeeding mothers because their nutritional requirements are comparatively higher (Bourges, 2006). Table 9 shows that energy requirements for weight gain in children vary across age and sex. Energy requirements are divided in two components: energy for the creation of new tissue and energy of tissular storage, allocated in tissues in form of fat and proteins (Bourges et al. 2008).

Table 9. Energy requirements for growth in children

Age	Average Weight	Daily Energy Requirement	Extra Energy Expenditure	Total Energy Expenditure	Basal Energy Expenditure	Average Weight Gain for Boys		Average Weight Gain for Girls	
Years	kg	kcal/day	kcal/day	kcal/day	kcal/day	kg/year	grm/day	kg/year	grm/day
1-2	12	948	14	934	654	2	7	2	7
2-3	14	1,128	11	1,117	773	2	6	2	6
3-4	16	1,252	12	1,240	861	2	6	2	5
4-5	18	1,360	11	1,349	906	2	6	2	5
5-6	20	1,467	11	1,456	952	2	6	2	5
6-7	22	1,573	12	1,561	997	2	6	2	6
7-8	24	1,693	14	1,679	1,049	2	7	3	8
8-9	27	1,830	16	1,814	1,111	3	8	4	10
9-10	30	1,978	19	1,959	1,179	3	9	4	11
10-11	33	2,150	22	2,128	1,247	4	11	5	12
11-12	38	2,341	25	2,316	1,321	5	12	5	12
12-13	42	2,548	29	2,519	1,406	5	14	5	13
13-14	48	2,770	33	2,737	1,504	6	16	4	12
14-15	54	2,990	33	2,957	1,601	6	16	3	9
15-16	60	3,178	30	3,148	1,711	5	15	2	6
16-17	64	3,323	24	3,299	1,797	4	12	1	2
17-18	68	3,411	15	3,396	1,857	3	7	0	0

Source: Compiled from Bourges et al. (2008).
Note: The daily Total Energy Expenditure (TEE) is calculated using an equation with differentiated parameters for age, gender, weight, height and the activity factor. Basal Energy Expenditure (BEE) or metabolic rate is a fair comparison indicator to quantifiy the required energy for the basic metabolic functions (breathing, ion transport, etc.) for an individual in idle state. The daily Extra Energy Expenditure (EEE) for growth is obtained dividing the TEE by the BEE and multiplying this rate for a factor of 1.01.

Although undernutrition is a multifactorial phenomenon, undoubtedly shock prices have an important impact through their effects on nutrients acquisition. Thus, based on the linear relationship between energy consumption and requirements for weight gain as well as the fact that the body is able to adjust by slowing down growth to save nutrients (adynamia), we assess the effect of a short-term (four-week) price increment on the nutrient purchase in child weight gain.

Comparatively, in terms of growth, the impact of cereals price rise is higher across all ages; in a four-week period, boys from the first income quintile and between two and three years would have an accumulated deficit of 238 grams, while girls will have an accumulated deficit of 260 grams (which is equivalent in both cases to 7% of the yearly weight gain). On the other hand, the deficit of weight gain derived from three percentage points in meat prices for children in the same age range is 46 grams and 50 grams, respectively. On the other hand, when we focus on vegetable price increment, the impact on the nutrient intake and deficit in children weight gain are lower than cereals.

In contrast with cereals, meats and vegetables, when we analyze a three-percentage-point increment in beverages the impact on nutrient consumption and gain weight is low, see Table 10. This findings suggest that nutrition in children is a matter particularly sensitive to price shocks in certain categories of food such as cereals.

Table 10. Weight gain deficit for urban children in the first income quintile

Age	Average Weight Gain		3 Percentage Points Increment in Cereals Prices		3 Percentage Points Increment in Meat Prices		3 Percentage Points Increment in Vegetables Prices		3 Percentage Points Increment in Beverage Prices	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
Years	grm/year	grm/year	grm/four-week	grm/four-week	grm/four-week	grm/four-week	grm/four-week	grm/four-week	grm/four-week	grm/four-week
1-2	2,000	2,000	188.8	188.8	36.6	36.6	49.0	49.0	6.7	6.7
2-3	2,000	2,000	238.3	260.0	46.2	50.4	61.8	67.4	8.4	9.2
3-4	2,000	2,000	255.7	229.2	49.6	44.5	66.3	59.4	9.0	8.1
4-5	2,000	2,000	287.3	245.5	55.7	47.6	74.5	63.7	10.1	8.7
5-6	2,000	2,000	309.9	276.1	60.1	53.6	80.3	71.6	10.9	9.8
6-7	2,000	2,000	332.3	348.9	64.5	67.7	86.2	90.5	11.7	12.3
7-8	2,000	3,000	337.2	419.0	65.4	81.3	87.4	108.6	11.9	14.8
8-9	3,000	4,000	372.1	488.1	72.2	94.7	96.5	126.5	13.1	17.2
9-10	3,000	4,000	395.9	483.8	76.8	93.9	102.6	125.4	14.0	17.1
10-11	4,000	5,000	441.8	507.9	85.7	98.5	114.5	131.7	15.6	17.9
11-12	5,000	5,000	486.6	486.6	94.4	94.4	126.2	126.2	17.2	17.2
12-13	5,000	5,000	527.1	467.7	102.3	90.7	136.7	121.3	18.6	16.5
13-14	6,000	4,000	563.9	407.8	109.4	79.1	146.2	105.7	19.9	14.4
14-15	6,000	3,000	620.1	356.0	120.3	69.1	160.8	92.3	21.9	12.6
15-16	5,000	2,000	662.4	268.5	128.5	52.1	171.7	69.6	23.4	9.5
16-17	4,000	1,000	672.7	128.7	130.5	25.0	174.4	33.4	23.8	4.5
17-18	3,000	0	672.5	0.0	130.5	0.0	174.4	0.0	23.8	0.0

Source: Own estimations.

5. Conclusions and further discussion

After decades of stability in food prices, recent food price shocks affected food security of households and individuals around the world. In Mexico, estimations of the effects of accumulated food price variation on individuals' food security are imprecise and ambiguous, little is known about magnitudes and how differentiated these effects are across income levels. This research quantifies the impact of some recent food price shocks on the purchase of nutrients for urban Mexican households across income quintiles using seven Mexican income-expenditure surveys. This research represents an effort to measure the effects of accumulated food price variation in the dimensions of food security: access and utilization.

For the econometric estimation, we developed a cohort model by aggregating an LA/AIDS model over cohorts using seven cross-section surveys of the ENIGHs for the period 2002-2012 and only considering urban households. As expected, most of the price elasticities, and all resulting nutrient elasticities, are inelastic.

Distinguished by their income level, households present differentiated access and consumption patterns as well as food use. Also, households show differentiated diversification strategies to cope with food price increments, for example, people in lower quintile (who spend more than 25% of their food budget on cereals, their main source of nutrients) tend to substitute cereal with vegetables to cope with increasing prices in cereals. On the contrary, people in the highest income quintile show more diversified consumption patterns and a lower tendency to substitute across food groups.

As a consequence of the expenditure and consumption patterns, people in lower quintiles have a nutrient acquisition pattern more sensitive to changes in cereals and vegetables prices. But people in higher quintiles show more sensitivity to changes in meat and dairy prices. Thus, there is not a single response to the question of who ends up more affected by food price variations; it depends on which food category is driving up prices. When cereals and vegetables are leading the upward trend, the poorest urban households will be the most affected, aggravating their nutrimental condition. In contrast, when meats and dairy products drive up food prices, people in the highest income quintiles will be the most affected.

Urban population welfare has been severely affected by food price shocks between 2006 and 2012. However, the accumulated price shocks occurred between 2010 and 2012 more adversely affected the welfare of the population with the strongest impact on households. Although undernutrition is a multifactorial phenomenon, we carried out an exercise to assess the effects of price shocks in four food categories on energy purchase and weight gain in children. The analysis showed that the impact of cereal price shocks on weight gain are comparatively higher and more regressive than price shocks in meats, vegetables and beverages.

This approach have some limitations, the first one refers to the impossibility of observing intragroup substitution; conversely, more disaggregate data could provide a better insight on this issue. The second one denotes that these estimates of food security represent a lower bound of the true measure. Economic literature have documented that adults within households prefer experiencing food insecurity (negative changes in diet quality and quantity) before children (Pelletier et al., 2012).

Thus, these results can provide some useful information to enhance the efficiency of food policy interventions by improving the quality of targeting for the poorest population and to face possible exogenous shocks (such as extreme weather events) that could potentially drive up food prices beyond ever thought.

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