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Welfare consequences of food prices increases: Evidence from rural Mexico

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ABSTRACT

This paper presents an analysis of the welfare consequences of recent increases in food prices in Mexico using micro-level data. We estimate a QUAIDS model of demand for food, using data collected to evaluate the conditional cash transfer program *Oportunidades*. We show how the poor have been affected by the recent increases and changes in relative prices of foods. We also show how a conditional cash transfer program provides a means of alleviating the problem of increasing staple prices, and simulate the impact of such a policy on household welfare and consumer demand. We contrast this policy with alternative policy responses, such as price subsidies, which distort relative prices and are less well-targeted.

1. Introduction

The substantial increases in world food prices over the decade up to 2009, and especially between 2006 and 2008, have raised considerable concerns about the welfare of poor households, for whom food represents a substantial share of consumption, and who might already be at levels of consumption close to subsistence. The implications that deterioration in nutrition and food security might have in the long run make this a key policy issue for developing country governments who need to implement appropriate policy responses.

Quantifying the impact of the increases observed in recent years on household welfare is not easy for a variety of reasons. First, as prices of different foodstuffs have been changing at different rates, households may have been able to alter their spending patterns, exploiting relative price changes to limit the impact of food price rises on their welfare. Assessing these substitution possibilities requires estimating a demand system. Second, some households might be net producers of some of the items whose prices increase. Therefore, for some poor households, some price increases might result in an increase in welfare.

In this paper, we develop a demand system to analyze the impact of food price rises on poor households in rural Mexico. This means we can account for the impact of substitution on the demand-side and by using data on consumption of home-produced food, we can also control for the income effects that changes in the prices of these goods have. Hence, our work is most similar to that of Ravallion and van de Walle (1991) who analyze the effect of rice price changes in Indonesia. However, we do not model changes in the production of foodstuffs by households in response to price changes, either for consumption by the household or for sale in the market. While this is a limitation in our analysis, in the context of rural Mexico it does not, in fact, look like a major one: for instance, only 5% of households are observed producing an amount equivalent to more than 13% of their food expenditure in our data.[1]

Our approach, in addition to the estimates of the impact of food price rises on consumer welfare, allows us to consider the welfare impact of policy responses to the price increases, including subsidies to specific commodities, or cash transfers. From an efficiency point of view, interventions that do not try to affect prices are probably to be preferred: price controls can lead to problematic rationing and reductions in supply, and while general price subsidies avoid these problems, they are usually poorly targeted and, by definition, distort relative prices. However, direct transfers can be difficult to design and to target, particularly in a developing-country context. It is therefore natural to look at existing programs to see if they can be used to address the specific need for

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[1] As for the supply side, in the future we plan to consider only the effect that a change in price has on a producer's income. This exercise can be considered as a first order approximation of the type considered by Deaton (1989) and Ravallion and Lokshin (2004).

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intervention induced by increases in food prices. The presence of conditional cash transfer programs (CCTs) gives policy makers in some developing and middle income countries an important opportunity to respond to price increases by increasing the value of these transfers.

There is another sense in which CCTs can be useful. Many of these programs have been rigorously evaluated, and in order to do this, detailed survey data have been collected that include information on expenditure and consumption patterns and, in some cases, unit values and prices. These surveys therefore provide an invaluable data source for estimating the impact of food prices on poor households. In particular, one can use them to estimate detailed and theory consistent demand systems that can then be used to estimate 'true' price indices for different types of households that reflect substitution possibilities when relative prices change. These price indices then allow one to evaluate the consequences of food price increases for consumer welfare.

In this paper, we use information from the evaluation of the rural component of the very large Mexican CCT known as *Oportunidades* (formerly PROGRESA). The program was accompanied by a large evaluation effort that included the collection of extensive household surveys in, initially, 506 localities. Multiple waves of this survey were gathered: in this paper we use five surveys collected between October 1998 and October 2003.[2] This data, unlike that available from the national household budget survey (the *Encuesta Nacional de Ingresos y Gastos de los Hogares* or ENIGH, for short) is not representative of the entire population of Mexico. However, there are two main reasons why we chose to use the evaluation sample. First, the data is very much focused on the population eligible for *Oportunidades* and geographic areas that have been targeted by the program. This means that the surveys cover mainly the poor and vulnerable households that food price rises are likely to hit hardest. A survey like ENIGH might not have enough low income people. Second, and more importantly, use of the evaluation sample allows us to identify reliable local-level prices for the various foodstuffs entering our demand system. As we discuss later, this would not be possible using the ENIGH data, for which problems of conflating variations in price with variations in quality of individual purchases would be much more significant.

The exercise we propose – the estimation of a demand system to construct true price indices for the population of interest and the assessment of the welfare losses implied by observed food price increases – is conceptually straightforward. We estimate a model of demand using data on expenditure and prices between 1998 and 2003, and assuming that preferences are stable after 2003, we can use the estimated demand system and observed changes in consumer prices since 2003 to simulate the welfare impact of the food price boom. Implementing such an exercise, however, is not trivial. We have to address many methodological, empirical and practical issues.

From a theoretical point of view, we need to specify a theory-consistent demand system and decide on the econometric techniques to be used to estimate it. From an empirical point of view, there are a number of practical issues to resolve. First, a very detailed and long list of commodities needs to be grouped into appropriate aggregate commodities to allow feasible estimation of a demand system. Defining the consumption aggregates involves trading off simplicity and feasibility with the need to maintain sufficient detail to capture the effects of changes in relative prices and substitution possibilities. Second, we need to compute price indices for the commodity groups using the prices of the component commodities that make each group. As our approach requires us to allow for and use the presence of different prices in different localities and regions, these indices must be constructed at the local level. Making the information on prices consistent across time (and in some instances, across localities) is not always easy. Third, information on prices of foods is not directly available; instead the survey records expenditures and quantities, from which unit values are constructed. This poses a number of difficulties detailed in Section 4.

The rest of the paper is organized as follows. We start by presenting some background information on the increases in world food prices and in Mexico in Section 2. In Section 3 we discuss the data sources used and Section 4 discusses how we construct the necessary information on prices and quantities from this data. We then discuss the demand system that we will be estimating. This is done in Section 5, which presents the specific model of demand we estimate, the quadratic almost ideal demand system (QUAIDS, Banks et al., 1997), and the econometric techniques employed to estimate it. Section 6 presents the results we obtain from our estimated demand system. Rather than presenting the coefficients, we discuss both the income and price elasticities implied by the estimates. Using this demand system, we analyze the welfare implications that different price change scenarios have for the households in our sample in Section 7. We look both at averages and the distributional consequences of the price changes. We also consider several policy experiments, including price subsidies and cash transfers. Section 8 concludes.

2. Food price increases: Mexico and the world

Between 2006 and 2008, world food prices increased dramatically. The increase was particularly stark for commodities such as rice, corn and wheat, which constitute the staple foods for many poor households around the world. World food prices (like other commodity prices) subsequently fell considerably from their 2008 peaks, although in the case of wheat and corn, further large increases took place in 2010 and 2011, and in the case of rice, prices remain well above the levels seen prior to the commodity-price boom (see, for example, Timmer, 2008).

Figs. 1 to 3 plot the price of rice, corn, and wheat for the world from 1985 to January 2012 and for Mexico from 1996 to January 2012. We also include the average prices observed in the *Oportunidades* survey data for each survey wave (with the latest survey taking place during autumn 2007). For international prices we use IMF primary commodity prices, while for Mexico we use the national consumer price index. This allows us to put the increased prices observed in our data into a proper international and national context. The rise in the international price of rice, corn and wheat in recent years is spectacularly evident in the figures and it dwarfs the other spikes visible in the series.

Mexico was obviously not immune from these increases. What matters for consumers, however, are not commodity prices per se, or producer prices, but the extent to which movements in these are reflected in consumer prices. The latter are not nearly as volatile as producer prices. Hence, while the Mexican retail prices of rice, corn

Fig. 1. Rice prices.

[2] Although there exist later waves of the survey, we do not use them for different reasons as explained below in Section 3.

Fig. 2. Maize prices.

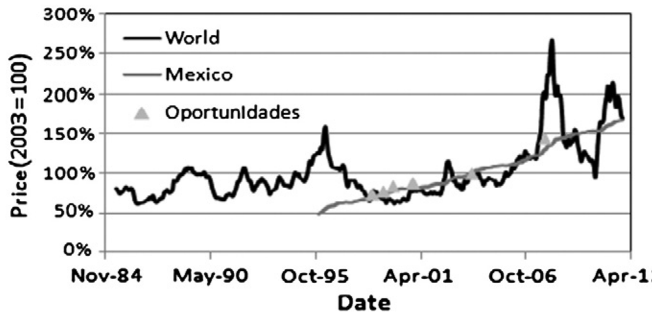

Fig. 3. Wheat prices.

and wheat have all risen significantly over time, the wide swings in international prices are not replicated in the national data. For instance, while the retail price of rice did jump in early 2008, the increase was much smaller than the increase in international prices (see Fig. 1). The consumer price of maize and corn products has likewise increased steadily over time but has not mirrored the peaks (e.g. early 2008) or troughs in international producer prices (see Figs. 2 and 3). Focusing on consumer prices in Mexico, the average level of prices observed in the localities in our *Oportunidades* sample moves closely with the national Mexican price indices. This constitutes an important check on the quality of our data which we now discuss.

3. The PROGRESA/*Oportunidades* data

As discussed and justified in the Introduction, our source of data on both prices and expenditure patterns is the surveys collected to evaluate the rural component of PROGRESA/*Oportunidades*. PROGRESA/*Oportunidades* is a program of conditional cash transfers (for education and health behaviors) and associated information on health, education and nutrition provided to poor households in rural, and more recently, urban areas of Mexico. Because of this program targeting, the evaluation sample is not representative of Mexico as a whole, with poor rural households over-represented due to the choice of localities included in the sample.

In order to evaluate the impacts of *Oportunidades*, at the inset of the program, all households living in 506 rural localities in seven Mexican states were surveyed as part of an extensive data collection exercise. In 320 localities, randomly chosen from the 506, the program was started in May 1998, while in the remaining 186, the program did not start until October/November 1999. The 320 communities where the program started early are usually defined as 'treatment' communities, while the others are usually called 'control' localities, although by the later waves (from 2000), all localities were included in the program.

The surveys (called the Encuesta Evaluation de los Hogares or ENCEL) operate largely as a panel with the sample households being interviewed multiple times: in March and October 1998, in May and November 1999, in April and November 2000, in 2003 and in 2007. A unique and important feature of the ENCEL is that, within each locality, all households are interviewed, regardless of whether they are a beneficiary of *Oportunidades* or not. In other words, the survey is a census, with new households automatically incorporated in the next survey wave.[3] In 2003, an additional 158 localities were added to the original survey, and in 2007, the 103 localities where fewer than 20 households were interviewed in 2003 were dropped from the sample. This amounted to 1120 households or 3.3% of the total households in 2003. The new 158 villages are systematically different from the original ones, having been considered not marginal enough to be targeted in the first phase of the PROGRESA/*Oportunidades* expansion. Introducing these villages would, therefore, lead to considerable sample compositional change. In order to prevent the changing sample of localities from affecting our analysis we exclude data from the 2007 survey wave and include only households from the original 506 localities surveyed in the first wave of the ENCEL in October 1998. We also excluded the March 1998 and April 2000 waves because they did not have sufficient information on consumption and expenditure. This means we use the following 5 waves of the ENCEL: October 1998, May and November 1999, and November 2000, and 2003.[4]

All-in-all demographic, expenditure and consumption data from 110,000 observations were used in the analysis, corresponding to roughly 21,000 households over 5 survey waves. Some attrition at the household level does occur. This happens mostly because the entire household migrated or because it was impossible to interview them or the interview is incomplete and data on consumption is not available. Of the total number of households we observe in the first wave of the ENCEL survey (October 1998), there was around 12% attrition during the first 2 waves of May and November 1999, around 15% by November 2000, and around 18% by 2003. This attrition does induce some small compositional change in terms of demographics. We take this into consideration to the extent that we control for demographics. The implicit assumption we make is that, conditional on the observed demographics the attrition is at random.

Within each village, not all households were eligible for the program. Eligibility status was defined on the basis of a census which was then used to compute a poverty score. Only households that were deemed 'poor' were offered the program. On average, 78% of the households in the evaluation sample were eligible for PROGRESA/*Oportunidades* (Skoufias, 2005), but there is some variability in eligibility rates across localities.

The surveys contain detailed data on demographic and socioeconomic variables. In what follows we use information on the sex, age and ethnicity of the head of household, the household size, the number of children, poverty status in 1997, current treatment status, and the earnings of the household head. Descriptive statistics for these variables can be found in Appendix A (Table A1).

The ENCEL surveys also contain detailed information on the consumption and expenditure of households. In the case of food and drink, the survey contains information on weekly expenditure and quantity purchased, for 36 goods, together with the quantity consumed and produced at home for own-consumption. The inclusion of both

[3] Because of the way PROGRESA and then *Oportunidades* are targeted, the program performs a census of all the households situated in all rural localities where the program operates. This survey, labeled ENCASEH, contains information on the variables used to target the program, but not on consumption and expenditure. The fact that this census was already being conducted aided the implementation of the ENCEL survey (used in this paper) as a census.

[4] In this paper we do not exploit the longitudinal dimension of the data.

expenditure and quantity allows the construction of unit values which we use as measures of the price of different goods (see Section 4). The food categories included in the survey (which is designed to be an exhaustive list of the types of food consumed by the surveyed households) and their share in the overall food budget can be found in Table A2.

In addition to information on food consumed and/or purchased in the last week, the survey contains information about several other items. In the case of some items, such as utilities, questions are asked about expenditure in the last month, while for some others, such as clothing and furniture, the questions in the survey refer to the last six months. For all these items, however, there is only information on purchase values, not on quantities. Therefore, one cannot compute unit values, as in the case of food. However, even in the case of food, there are a number of measurement and conceptual issues that need to be addressed before moving on to the estimation of the demand model.

4. Constructing expenditure shares and prices

In order to construct and estimate a demand system, we need to define the commodities we model (aggregating ‘elementary’ goods), how we construct price indices for these commodities from the prices of the ‘elementary’ goods and how we measure prices for ‘elementary’ commodities. We discuss these issues in turn.

4.1. Expenditures and expenditure shares

Before giving the details of the definitions of the commodities whose demand we are modeling, it is important to clarify what is meant by consumption, expenditure and how that relates to the objects measured in the data. While the questions in the survey make explicit reference to ‘consumption’ and ‘expenditure’ during the last week, it is likely that for many food items, purchases take place at discrete points in time and with a periodicity that may not coincide with the week. As a consequence, for some households, recorded expenditure might be higher than consumption (or long run average rate of weekly expenditure), while others might record a zero purchase even if they are consuming a positive quantity. As meeting the aims of the study requires us to estimate the responsiveness of consumption (or average weekly expenditure) of different foodstuffs to prices and income, it is necessary to include both types of households in the analysis.

For practical and computational reasons, we cannot model separately demand for the 36 commodities for which we have information in the ENCEL surveys. Instead, we aggregate 35 of the goods into eight groups: rice, corn, wheat, pulses, fruits, animal products, other foods and other starches as shown in Table 1 (we exclude alcohol, the 36th good, from our analysis).

The main difference between our commodity groups and those more typically used in analysis of overall food demand is that we do not aggregate grains (for instance, Del Campo et al. (2009) analyze price rises in Mexico and group grains and pulses together). Instead we keep rice, corn, wheat and other starches (which also include potatoes) as separate items. The rationale for such a detailed grouping of cereals is the specific interest we have in quantifying the welfare consequences of the increases in food prices. As we saw above, while the price changes of different varieties of grains were all large, they were not the same. We therefore want to be able to model explicitly the substitution between different types of cereals in the face of substantial changes in their relative prices. In other words, the conditions for Hicks-aggregation (constant relative prices) fail spectacularly over the relevant period and this is potentially important both for the estimation and for the policy relevance of the exercise.

Apart from grains, we are also especially interested in changes in consumption of fruits and vegetables, and animal products. These items are particularly important from a nutritional point of view, especially in the context of Mexico, where it is widely perceived that many poor households do not necessarily lack calories but proteins and appropriate micro-nutrients (Fernald and Neufeld, 2007).

Having defined what we mean by expenditure and consumption, we need to construct expenditure shares for each of our commodity groups. The first stage of doing this is to calculate expenditure for each individual good (which is then directly used to calculate the expenditure for each commodity group and total food expenditure). For items purchased by the household we use the expenditure they report. For items produced by the household for its own consumption rather than purchased in the market (e.g. tomatoes grown in the garden), we observe only the quantity produced, and not the value of the goods. In this case we use the appropriate median unit value in the locality (which we define and discuss below) to value these home-produced goods. This value is then added to actual expenditure to obtain an overall measure of expenditure that includes the value of home-produced goods.

Table 2 shows the average of the commodity group expenditure shares for each of the eight food groups for each of the 5 waves of the sample used in our estimation. Corn products consistently represent more than 24% of total food expenditure. Rice and wheat, together, account for typically 6% of the food budget in the sample. The share of animal products has risen considerably since 1998. Finally, households in the sample seem to be switching away from consumption of pulses (beans) over time.

4.2. Price indices

To obtain prices for these aggregate commodity groups, we construct Stone price indices using prices of the individual ‘elementary’ items that make up each commodity group and the expenditure share of the individual items in each commodity group, separately by locality. The sub-group weights are constructed by summing expenditure on each good within a group for a locality and dividing by the total locality

Table 1
Food groups.

Group	Group name	Foods
1	Rice	Rice
2	Corn	Maize tortilla, maize grain, breakfast cereals
3	Wheat	White bread, sweet bread, loaf of bread, wheat flour, biscuits
4	Pulses	Beans
5	Fruits and vegetables	Tomatoes, onions, carrots, leafy vegetables, oranges, bananas, apples, lemons, prickly pears
6	Animal	Chicken, beef and pork, goat and sheep, fish, tinned fish, eggs, milk, cheese, lard
7	Other foods	Sweets, carbonated beverages, coffee, sugar, vegetable oil
8	Other starches	Potatoes, pasta soup

Table 2
Commodity group expenditure shares.

Food type	Oct-98	May-99	Nov-99	Nov-00	2003
Rice	2.2	2.2	2.2	2.4	1.9
Corn	29.1	30.9	26.8	24.5	27.3
Wheat	2.9	3.0	3.4	2.9	5.3
Pulses	12.2	11.0	10.9	9.4	7.4
Fruits and vegetables	14.1	11.4	12.6	15.2	15.4
Animal	17.3	18.3	20.3	22.6	22.7
Other foods	17.5	18.8	18.8	18.3	15.3
Other starches	4.6	4.4	4.8	4.8	4.7

Table 3
Commodity group prices.

Food type	Oct-98	May-99	Nov-99	Nov-00	2003
	Mean of log prices				
Rice	1.99	2.03	2.01	1.97	1.88
Corn	0.99	0.98	0.99	0.98	1.52
Wheat	2.28	2.31	2.32	2.44	2.61
Pulses	2.42	2.32	2.31	2.21	2.34
Fruits and vegetables	1.93	1.65	1.66	1.76	2.02
Animal	2.67	2.73	2.74	2.82	2.92
Other foods	2.37	2.29	2.32	2.28	2.31
Other starches	2.18	2.15	2.15	2.12	2.35
	Standard deviation of log prices				
Rice	0.094	0.061	0.107	0.076	0.074
Corn	0.079	0.158	0.196	0.230	0.221
Wheat	0.266	0.280	0.406	0.408	0.126
Pulses	0.080	0.039	0.044	0.118	0.071
Fruits and vegetables	0.114	0.102	0.136	0.154	0.101
Animal	0.155	0.144	0.145	0.116	0.144
Other foods	0.156	0.150	0.153	0.169	0.157
Other starches	0.104	0.136	0.139	0.198	0.125

expenditure on that food group (this is sometimes termed plutocratic weighting). Where there is no expenditure on a group in a locality, municipality-level totals are used instead.

Table 3 reports the mean and standard deviation of the Stone price indices for the eight groups of goods. The two panels of the table, therefore, give an idea of the observed price variability which is used to identify the demand system and, therefore, the price elasticities. It should be stressed that there is a considerable amount of volatility in relative prices, both across communities and over time. This variability is extremely useful in estimating the parameters of our model.

4.3. Unit values

In our estimation and simulation exercises, we approximate prices of 'elementary' commodities (which are then used to compute the price indices of the aggregate commodity groups we model) with unit values. Computing a unit value requires both the expenditure and the quantity of a given item purchased.[5] Given these variables, a unit value is obtained by dividing expenditure by quantity purchased.

Obviously, the use of unit values is not exempt from criticism. Unit values may vary not only as a consequence of genuine variation in prices but also because of a variety of other reasons, ranging from measurement error, to non-linear price schedules (as discussed in Attanasio and Frayne (2006)) and quality effects (as discussed in Deaton (1988) and Crawford et al. (2003)).

If consumers react to changes in prices of elementary commodities by adjusting both quality and quantity, the observed variation in unit values will understate the actual variation in prices: those facing high prices will have substituted towards cheaper varieties of the good, and vice versa. Using unit values to estimate demand systems in these circumstances would induce a correlation between individual shares and individual unit values and could lead to important biases in the estimation of price elasticities. Such issues are especially relevant when using unit values that vary across households. For instance, if consumers with a higher taste for meat (and who therefore spend a higher fraction of their food budget on meat) also prefer higher quality meat (with a higher unit value), estimates of the own-price elasticity of meat demand would be positively biased. Using data from Indonesia containing both price and unit values, McKelvey (2011) shows the prevalence of quality variation and quality adjustment, even in an environment where this margin of adjustment would not have been thought to be important.

Deaton (1988) and Crawford et al. (2003) propose a method of modeling the choice of quality along with quantity within a linear demand system. Unfortunately, this approach cannot be used with non-linear demand systems such as the quadratic almost ideal demand system used in this paper (see Section 5). As the main purpose of this study is to estimate a flexible demand system that can be used to perform welfare exercises, this is a major shortcoming of such methods. Moreover, Deaton (1988) is based on a set of assumptions that the paper by McKelvey (2011) rejects strongly. For these reasons, in our application we do not use Deaton's (1988) or Crawford et al.'s (2003) method.

While we are aware of the fact that the assumptions necessary to use the variation in unit values are strong, in what follows we use them, for the lack of a better alternative. In an attempt to mitigate the endogeneity problems caused by *individual* tastes for quality, we use the median unit value for each locality (or when fewer than 8 households report positive consumption of a good, the median unit value at either the municipality or state level) as our measure of the price of a particular good in a given locality. Because the localities included in our sample are all relatively poor, rural districts of Mexico, we are confident that this means that any variation driven by variation in quality across localities is small. The fact that the commodities purchased by the sampled population are largely basic unprocessed foodstuffs as opposed to branded products also helps in this regard. Having said that, we are aware of the possibility that the elasticities we estimate will reflect variation in prices which is both genuine variation and variation that reflects differences in quality in different localities. Moreover, we are aware of the fact that variation in unit values across localities might underestimate the true variation in prices across localities.

We should also add that, when simulating the welfare implications of a relative price change of a commodity group (e.g. "animal products") for a given set of estimates, the extent to which households respond by changing the quality of items they purchase within that group and other commodity groups versus changing the quantity of goods they purchase does not matter. This is because, at the margin, consumers will adjust both quality and quantity so that the marginal cost/gain of adjustment on either dimension is equal[6] (provided that the relative prices of different qualities of a commodity are constant). In other words, quality variation represents a more serious problem for estimation rather than for simulation.

The possibility of constructing unit values and aggregating them at the locality level to minimize the problems that arise from using individual unit values as measures of prices is one of the main reasons that led us to use the ENCEL surveys. We would be much less confident using this approach for a nationally representative sample, for instance, from the ENIGH survey. First, the sample sizes for individual municipalities are often small, particularly in rural areas, making calculation of median unit values effectively impossible. Therefore we could not exploit the variation across areas to identify price elasticities. Second, there is much more variation in average wealth across the municipalities of Mexico than there is in the localities included in our sample: this means it is more likely that differences in median

[5] Quantities can be recorded in different units for which a credible conversion procedure is not always evident. All units are then converted into kilograms (or liters for liquids). Further information can be found in the working paper by Attanasio et al. (2009) where the specific procedures and adjustments used in making quantities consistent are described.

[6] This argument is similar to that made by Feldstein (1999) when discussing behavioral response via changes in labor supply or changes in avoidance and evasion in the context of income taxation.

unit values would reflect differences in quality instead of differences in price.

Details on the prices of each of the commodities included in our demand system by survey wave can be found in Appendix A (Table A3).

5. The model of demand

Along with information on quantities and spending patterns themselves, estimation of the effect of price rises on the expenditure patterns of households requires the use of a demand system. Furthermore, the demand system should be theory consistent (or integrable) so that it can be used to compute true price indices and the welfare costs associated with the increase in these price indices.

5.1. QUAIDS

The almost ideal demand system (AIDS) introduced by Deaton and Muellbauer (1980) combines analytical simplicity with consistency with consumer theory. More recently, however, Banks et al. (1997) suggested a generalization of the AIDS model. The quadratic almost ideal demand system (QUAIDS) allows expenditure shares to respond more flexibly with respect to total expenditure (in that it does not constraint them to be monotonic) while maintaining theory consistency.

We estimate a QUAIDS of the following form:

$$w_i = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} ln\left(p_j\right) + \beta_i ln\left(\frac{x}{a(p)}\right) + \frac{\lambda_i}{b(p)}\left(ln\left(\frac{x}{a(p)}\right)\right)^2 \qquad (1)$$

where w_i is the share of commodity i in total food expenditure, x is the total (food) consumption,[7] and $a(p)$ and $b(p)$ are price indices defined by the following equations:

$$\ln a(p) = \alpha_o + \sum_k \alpha_k \ln(p_k) + \frac{1}{2}\sum_k \sum_l \gamma_{kl} \ln(p_k) \ln(p_l)$$
$$b(p) = \prod_{i=1}^{n} p_i^{\beta_i}.$$

For this model to be consistent with utility maximization, the following theoretical restrictions have to hold:

(adding-up):

$$\sum_{i=1}^{n} \alpha_i = 1; \quad \sum_{i=1}^{n} \beta_i = 0; \quad \sum_{i=1}^{n} \gamma_{ij} = 0 \quad \forall j; \quad \sum_{i=1}^{n} \lambda_i = 0$$

(homogeneity):

$$\sum_{j=1}^{n} \gamma_{ij} = 0 \qquad \forall i$$

(symmetry):

$$\gamma_{ij} = \gamma_{ji}.$$

For homogeneity to hold, the price index $a(p)$ must be homogeneous of degree 1 in prices and expenditure, and $b(p)$ homogeneous of degree 0.

[7] As we mention below, we will be assuming separability between food and other commodities, so that we will be studying the sub-utility derived from food.

In this model, the price elasticities are as follows:

$$\eta_{ij} = \frac{\mu_{ij}}{w_i} - \delta_{ij}. \qquad (2)$$

And the income elasticity is

$$\eta_i = \frac{\mu_i}{w_i} + 1 \qquad (3)$$

where δ_{ij} is the Kronecker delta, and μ_{ij} and μ_i are given by

$$\mu_{ij} = \frac{\partial w_i}{\partial ln p_j} = \gamma_{ij} - \mu_i\left(\alpha_j + \sum_{k=1}^{n} \gamma_{jk} ln p_k\right) - \frac{\lambda_i \beta_j}{b(p)}\left\{ln\left(\frac{x}{a(p)}\right)^2\right\}$$
$$\mu_i = \frac{\partial w_i}{\partial x} = \beta_i + \frac{2\lambda_i}{b(p)}\left\{ln\left(\frac{x}{a(p)}\right)\right\}.$$

Banks et al. (1997) show that the QUAIDS can be derived from an indirect utility function of the following form:

$$lnV = \left\{\left[\frac{lnx - ln\, a(p)}{b(p)}\right]^{-1} + \lambda(p)\right\}^{-1} \qquad (4)$$

where $\lambda(p) = \sum_{i=1}^{n} \lambda_i ln p_i$ is homogeneous of degree 0 in prices.

In these equations, demographics are assumed to enter in the intercept term of the shares equations. In particular, for commodity i we assume that the parameter α_i is given by the following expression:

$$\alpha_i = \alpha_{0i} + \sum_{m=1}^{M} \alpha_{mi} z_m \qquad (5)$$

where z_m represents the M demographic variables that enter the system. Notice that homogeneity now implies the additional restrictions:

$$\sum_{i=1}^{n} \alpha_{0i} = 1; \quad \sum_{i=1}^{n} \alpha_{mi} = 0, \quad \forall m.$$

Note also that the α's enter the definition of $a(p)$. This makes the system non-linear and with a large number of cross equation restrictions.

5.2. Separability and commodity groups

In what follows, we assume that utility is separable between food and non-food consumption, and explicitly model only food consumption. That is, the 'total expenditure' in the indirect utility function in Eq. (4) is 'total expenditure on food' and the shares in Eq. (1) are shares of specific food items in total food. There are two main reasons for this choice. First, the quality of the information on non-food item consumption seems to be inferior to that for food consumption. This might be a function of the different time horizons (respondents are asked to recall expenditure on non-food items over a longer period) combined with the fact that many of these items are purchased only very irregularly. Second, and more fundamentally, we only have information on quantities (in addition to expenditure values) for food items. This implies that we cannot construct unit values or price indices for non-food items.

The assumption of separability is obviously a strong one and is mainly dictated by the lack of the necessary data to estimate a demand system covering all goods and services. If this assumption is invalid, welfare estimates derived from our model would be biased. First, by ruling out the possibility of substitution between food and non-food goods, we close off one way in which households may be able to reduce the extent to which they are hit by changes in food prices. This would tend to bias upwardly the estimated welfare cost of a given price change. However, an erroneous assumption of separability would also lead to biases in the estimated parameters and elasticities of demand within the set of goods included in our demand system (i.e. food goods). The direction in which this would bias welfare estimates is unclear meaning that we cannot say for certain that our estimates would be upper bounds on the welfare cost of food price increases.

When separability is tested empirically in other contexts it is often found to be rejected (see, for instance, Browning and Meghir (1991) or Hussain (2006) where separability of demand for non-durable goods is found to be non-separable from ownership and purchases of durable goods). However, in the context of our sample of poor households in Mexico, we think that the cost of imposing separability is likely to be small: food consumption represents on average, around, 70% of total expenditure with a further 15–20% on general household expenses such as rent, fuel or utility bills (this has been increasing over time, in part, because of increases in energy costs). There may be the possibility of some substitution between food and non-food goods and services, but with food such a major part of household budgets, this is likely to be relatively small. Assumptions of separability are a common feature of analyses of food demand: as noted in Edgerton (1997), many studies of components of food demand (e.g. meat) assume separability with other types of food.

Having assumed separability between food and non-food items, we divide food into eight categories to allow for feasible estimation of the model (see Section 2 for the goods included in each category).

5.3. Estimation

We estimate the demand system imposing all of the restrictions from theory (with the exception of negativity).[8] The model is estimated using a sample of about 23,000 households over 5 waves (giving almost 112,000 observations in total). Standard errors for income elasticities, the Marshallian and Hicksian price elasticities, and welfare effects are estimated using a bootstrap estimator that accounts for clustering at the locality level to take into account the correlation among households living in the same town.

Attanasio et al. (2009) and Attanasio and Lechene (2010) have shown that to estimate the demand system in Eq. (1), it is important to take into account the endogeneity of total expenditure and the possible presence of measurement error. To take into account this issue we use a control function approach, which consists of adding to the share equations a polynomial in the residuals of the first stage regression for log total expenditure and log total expenditure squared. This procedure, which in the linear case is equivalent to instrumental variables, requires the identification of an instrument that affects total expenditure, but is assumed to be excluded from the share equation. We use as an instrument a locality average of head-of-household earnings. The partial F statistic on this variable is very high, indicating that the instrument is a good predictor of total food expenditure. For it to be a valid instrument we also require that, except via total expenditure, local earnings do not affect spending patterns. While this is debatable, the relative poverty of all localities included in our sample, and the fact that the food items purchased by the sampled households are largely basic foodstuffs as opposed to branded goods mean that we feel that the assumption is more likely to hold than if a national sample were used (see Section 4.3).

The control function approach has several advantages, including the fact that an F-test on the joint significance of the coefficients on the powers of the estimated residuals from the first stage can be easily interpreted as a test of endogeneity of the relevant variables. The powers of the estimated residuals turned out to be statistically different from zero. Moreover, the pattern of the estimated coefficient and elasticities vary in an economically significant way when we allow for endogeneity. For this reason we report results that control for endogeneity.

Table 4
Quadratic term parameters.

Parameter	Value	St. error
d1	0.000	(0.001)
d2	0.033	(0.005)
d3	0.001	(0.001)
d4	0.003	(0.002)
d5	0.006	(0.003)
d6	−0.027	(0.004)
d7	−0.019	(0.003)
d8	0.003	(0.001)

6. Price and income elasticities of demand

This section discusses the results obtained from estimating the demand system discussed in Section 5. The coefficients of the demand system (Eq. (1)) are, for the most part, not easy to interpret. For this reason we instead use the estimated coefficients to compute the more easily-interpretable total food expenditure (or income) elasticities and price elasticities and report only the parameters on the quadratic expenditure term.

6.1. Income elasticities

Income elasticities at the mean values of the data sample (calculated using Eq. (3)) are shown in Table 5. As expected, corn and pulses are necessities, while animal products (meat, dairy product etc.) are luxuries within food expenditure. Fruits and vegetables and rice are close to unit-elastic with respect to total food expenditure. More surprising is the fact that wheat and other starches (mainly potatoes) are found to be luxuries within food demand. This must be understood in the context of poor rural households in Mexico for whom these are not the main staple products (corn tortillas are) but instead are, especially in the case of white and sweet breads, more aspirational goods.

As can be seen in Table 4, a number of the λ_i (the coefficient on the quadratic term in total expenditure, labeled d1 to d8 in the table) in Eq. (1) are statistically different from zero. This implies that the income elasticities are not constant with respect to the log of total expenditure, and that expenditure shares are not linear in log total expenditure. Hence, the AIDS model of demand is rejected in favor of the QUAIDS model of demand. The non-linearity of budget shares with respect to total expenditure can be seen in the Engel curves shown in Fig. 4a to h. These plot, for a representative household,[9] the share of each commodity as a function of the log of total expenditure. These show the share of rice, wheat, fruits and vegetables, animal products and other starches increasing with total food expenditure, and the share of corn, pulses and other foods declining. The non-linearity of the Engel curves can be seen, most notably for corn and fruits and vegetables.

To check the model's fit, in Fig. 5a to h we plot the average shares in the data and those predicted by the model against log food expenditure.

[8] It is important to note that symmetry does not imply that the estimated Hicksian elasticities are symmetric but instead that the products of the Hicksian elasticities and the expenditure shares at which the elasticities are evaluated are symmetric.

[9] We consider a family headed by a 45 year old male with primary education, not indigenous and with three children. All the other variables (prices in particular) are set to the sample average.

Table 5
Income elasticities.

Food type	Value	St. error
Rice	1.070	(0.118)
Corn	0.660	(0.096)
Wheat	2.207	(0.538)
Pulses	0.650	(0.109)
Fruits and vegetables	1.091	(0.079)
Animal	1.673	(0.177)
Other foods	0.320	(0.155)
Other starches	1.370	(0.091)

Fig. 5 differs from 4 because it does not keep demographics and prices fixed at some level, but lets them vary as in the sample. The figure shows that the model fits the data relatively well. With the possible exception of rice, the model mirrors the patterns in the data closely, with the possible exception of households with very low total food expenditure.

6.2. Price elasticities

Table 6 shows both the uncompensated (Marshallian) and compensated (Hicksian) own price elasticities evaluated at the mean values of the sample data and computed using the formula in Eq. (2): the full set of own and cross-price effects can be found in Appendix A (Tables A4 and A5).[10] The own price elasticities are all negative (as required by theory in the case of the Hicksian elasticities). Demand for corn, animal products and other foods is the least elastic with respect to prices. Demand for other starches is the most elastic.

Given the nature of the demand system, price elasticities can and generally will vary across households. Tables A6 and A7 in Appendix A show that Marshallian elasticities generally decline with total expenditure (meaning poorer households are more responsive to changes in prices),[11] but the same is not true for Hicksian elasticities (with these being relatively stable across the food expenditure distribution, with the exception of rice and pulses).

7. Welfare analysis

While the estimated QUAIDS parameters and the implied expenditure and price elasticities are interesting in their own right, the main focus of this paper is the estimation of the welfare effects of recent food price rises. As our demand system is based on household micro data, we can estimate not only the average welfare effect for our sample of rural poor, but also the distributional effects of these price changes *within this population*. Finally, we can also study the effect of alternative policies that could be designed to alleviate the impact of food price rises on these households.

Our measure of the welfare effect of a price change is the compensating variation: the amount of income that needs to be given to a household to make them indifferent between the old price vector (and original income) and the new price vector. This computation is performed using the expression in Eq. (4) for each household in the sample. For example, to assess the welfare effects of a specific set of price increases, such as the increases observed between 2003 and 2012, we compute x^*_{2012}; the total expenditure in 2012 that would obtain the same level of welfare as obtained in 2003, but given 2012 prices. This quantity solves the following equation:

$$\left\{\left[\frac{\ln x_{2003} - \ln a(p_{2003})}{b(p_{2003})}\right]^{-1} + \lambda(p_{2003})\right\}^{-1} = \left\{\left[\frac{\ln x^*_{2012} - \ln a(p_{2012})}{b(p_{2012})}\right]^{-1} + \lambda(p_{2012})\right\}^{-1}. \quad (6)$$

In making this computation we deflate the 2012 (and any post-2003 prices) by the increase in the index of nominal wages in the commercial and industrial sectors as recorded by the Mexican Central Bank (unfortunately there is no index of rural or agricultural wages). Our exercise, therefore, focuses on the welfare effect of the increase in food prices in excess of the increase in this index of average wages. We would prefer to deflate prices by an index of agricultural wages, as the change in agricultural wages may be expected to be more representative of the changes in wages faced by our sample of poor rural households than the changes in manufacturing and industrial wages we use. Unfortunately, an index of this is not available for the entire period in question. However, estimates are available for the years between 2003 and 2009 and show nominal agricultural wages increasing by only 6.2%, which is less than the approximately 26% increase observed for commercial and industrial wages. In the context of rising food prices this is surprising, but if believed, the actual welfare costs of food price rises would be even higher for poor rural agricultural workers than those we find.[12] If reliable, these agricultural price indices would also suggest that higher prices for food have not translated to higher wages for agricultural laborers in rural Mexico, which increases the credibility of our strategy of modeling only the demand side of the food market (and not the supply side or labor market).

7.1. Scenarios

We compute:

1. The mean welfare effect of the increase in prices between December 2003 and each month between January 2004 and November 2011, as recorded by the Mexican consumer price index.
2. Detailed analysis of the welfare effects of the increase in prices between December 2003 and the peak in relative prices observed in April 2011.
3. Detailed analysis of the welfare effects of the increase in prices observed between the 2003 and 2007 ENCEL survey waves, according to unit values in our data.

A number of households produce certain foodstuffs at home for their own consumption, and in this instance, food price rises will hit them less hard (because they will not have to pay more for goods they produce themselves). We present both results that take this effect into account, and (in order to gauge the importance of the effect) results that do not take this into account. We also show the impact of two policy measures that could be used to ameliorate the impact of the price increases:

- A 50 peso per week lump-sum transfer to households who are entitled to and receiving the *Oportunidades* program payments in 2003.[13]
- A government price subsidy equal to 5% of the new goods' price.

[10] It is often difficult to interpret and discuss cross-price effects. In this model, notable features include the relatively large and statistically significant cross-price effects; the pattern of substitutability between the starch sources (with corn a substitute for wheat and rice, for instance); and the fact that pulses and animal products, both sources of protein are complements, which may reflect their use together in a number of Mexican dishes.

[11] This agrees with results found by Chesher and Lechene (2002) on UK data.

[12] Information on agricultural wages in Mexico can be found in the CEPAL Agricultural Statistics System, available at http://websie.eclac.cl/sisgen/ConsultaIntegrada.asp?idAplicacion=4.

[13] In 2007, the program transfer was increased by 50 pesos per month as part of government plans to limit the impact of increases in energy prices on poor families with children. The use of the *Oportunidades* program as a response to price shocks is therefore established.

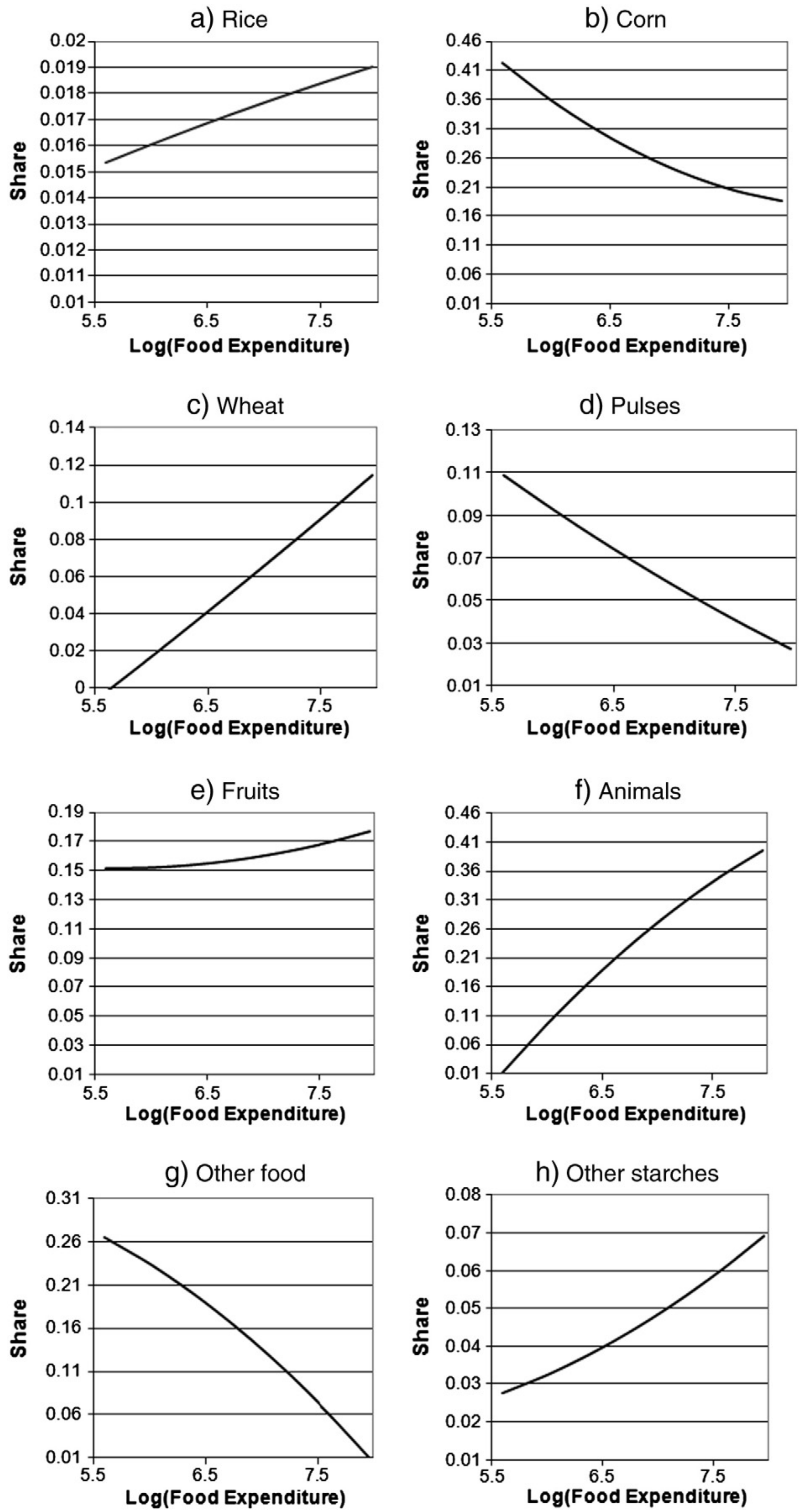

Fig. 4. Estimated Engel curves (holding prices and demographic characteristics fixed at mean values).

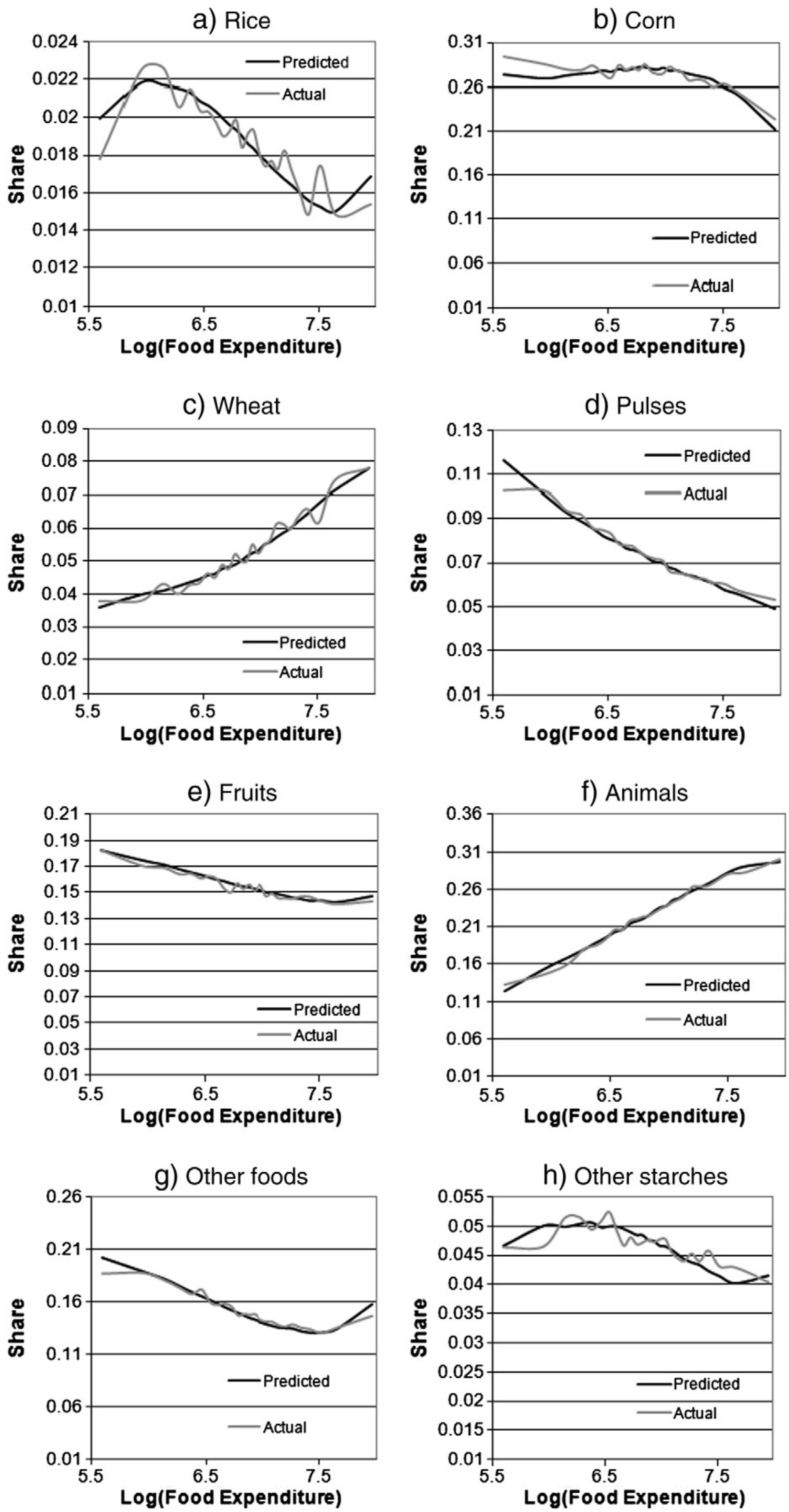

Fig. 5. Comparison of predicted and actual expenditure shares.

Table 6
Own-price elasticities.

	Marshallian		Hicksian	
Food type	Value	St. error	Value	St. error
Rice	−0.832	(0.098)	−0.809	(0.097)
Corn	−0.608	(0.065)	−0.436	(0.044)
Wheat	−0.963	(0.058)	−0.872	(0.057)
Pulses	−0.933	(0.083)	−0.871	(0.083)
Fruits and vegetables	−0.967	(0.041)	−0.818	(0.045)
Animal	−0.759	(0.045)	−0.403	(0.034)
Other foods	−0.306	(0.102)	−0.252	(0.075)
Other starches	−1.502	(0.081)	−1.433	(0.085)

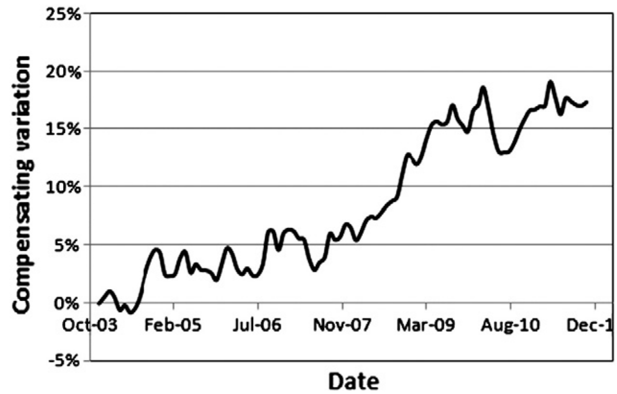

Fig. 7. Mean welfare loss (% of food expenditure) over time.

7.2. National level price increases: 2003 to 2011

Relative to wages, food prices in Mexico increased by around 14% between December 2003 and November 2011, peaking at over 15.6% higher in real terms in April 2011. Fig. 6 shows that this increase was not smooth, with prices increasing in notable 'spurts', and was not equal across different types of food. In particular, the prices of staple grains and pulses have increased more rapidly than those of other foodstuffs, and these foods make up a larger fraction of total food budgets for the poor households in our sample than the average Mexican consumer. This means one would expect the impact of price rises to be greater for our sample of poor households than for the average Mexican household.

Fig. 7 shows the average welfare impact of the increase in food prices, measured as a proportion of food expenditure, for each month between January 2004 and November 2011, allowing for home production. The welfare losses peak at 19% of food expenditure, on average, in April 2011 and are above 15% throughout 2011. For the rest of this sub-section we focus on the distribution of welfare losses at the peak of food price rises.

Table 7 shows the distribution of welfare losses in April 2011, measured as a fraction of food expenditure. The first column shows the losses when one allows for home production, while the second column shows the losses when one does not allow for home production (standard errors are in parentheses and are very small). The top panel of the table shows the losses before any compensation, the second panel shows the effect of the 50 peso per week lump sum transfer to households in receipt of *Oportunidades*, and the third panel shows the effect of the 5% price subsidy.

The first thing to note is that the welfare losses are substantial, and very precisely estimated. Allowing for home production or not does not seem to make much difference. This confirms what we have mentioned earlier regarding the absence of this margin of adjustment for most households in this population. Secondly, as we expect, the losses are for the most part of the distribution greater in the absence of policy. The price subsidy leads to a narrower range of values for the welfare loss (from 11.7% to 17%) than the 50 pesos transfer. However, of greater interest is to examine the distribution of welfare losses as a function of total expenditure.

Fig. 8 shows how the welfare losses vary by total expenditure. The price changes between December 2003 and April 2011 in Mexico are regressive among our sample of poor households: the welfare loss is 23% for the poorest consumers in our sample but around 17% for the least poor.[14] Unsurprisingly, an untargeted 5% price subsidy does not change the regressivity of the price changes. However, the targeted cash transfer focuses much more of the support to poorer households.

In addition to the welfare loss, it is interesting to estimate the effect on expenditure shares of the price increases and of the policy options. The pattern of expenditure shares has important implications for nutrition, for instance. It has been argued that the share of animal products, fruits and vegetables in these families' food baskets might be sub-optimal and might affect the nutritional status of young children (Fernald and Neufeld, 2007). Therefore, in Table 8 we report the effect of the 2003 to 2011 price changes on expenditure shares.

Changes in expenditure shares are not quite so precisely estimated as changes in welfare. However, the price rises are predicted to lead to economically and statistically significant reductions in the share of expenditure going towards animal products and wheat products and a notable increase in the share of expenditure going towards corn products. In other words, food price rises mean that a larger fraction of consumer budgets go towards the main staple good (tortillas). Reducing the impact of the price rises on spending power through subsidies or cash transfers reduces the magnitude of these changes.

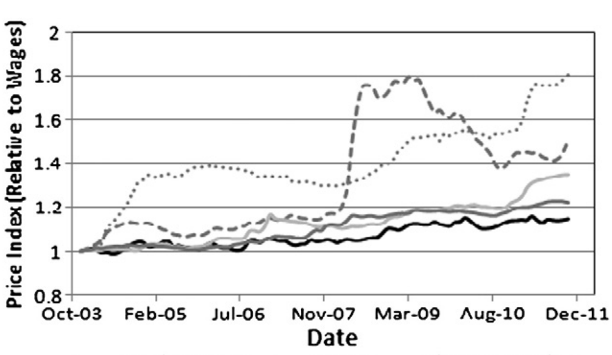

Fig. 6. Food price indices (relative to wages).

7.3. Locality-level 2003 to 2007 price changes

While relative food prices did not reach their peak until 2011, there were notable increases in the prices of grains and pulses during

[14] The standard errors of the welfare effects are, again, small, and the regressive pattern is very strongly statistically significant. For instance, the 95% confidence interval for the difference between the welfare effects at the 10th percentile of the expenditure distribution and the 90th percentile is [1.29%, 1.73%]. We have not shown confidence intervals on the graph because there is correlation in the size of the welfare effects at different points of the expenditure distribution. For instance, if the welfare effects were actually higher than estimated for the poorest households, they would also be higher than estimated for less poor households. This correlation makes graphical representation difficult.

Table 7
Distribution of welfare loss as a fraction of food expenditure, April 2011 prices.

Percentile of welfare losses	Allowing for home production		Not allowing for home production	
	Welfare loss	St. error	Welfare loss	St. error
No policy				
5th	17.1%	(0.1%)	19.3%	(0.1%)
10th	17.8%	(0.1%)	19.9%	(0.1%)
25th	19.0%	(0.1%)	20.8%	(0.1%)
50th	20.3%	(0.1%)	21.7%	(0.1%)
Mean	20.2%	(0.1%)	21.6%	(0.1%)
75th	21.7%	(0.1%)	22.6%	(0.1%)
90th	22.7%	(0.1%)	23.2%	(0.1%)
95th	23.2%	(0.1%)	23.6%	(0.1%)
50 peso transfer				
5th	9.2%	(0.1%)	11.1%	(0.1%)
10th	11.5%	(0.1%)	13.4%	(0.1%)
25th	14.1%	(0.1%)	15.7%	(0.1%)
50th	16.5%	(0.1%)	17.8%	(0.1%)
Mean	16.3%	(0.1%)	17.7%	(0.1%)
75th	19.1%	(0.1%)	20.7%	(0.1%)
90th	21.3%	(0.1%)	22.3%	(0.1%)
95th	22.2%	(0.1%)	22.9%	(0.1%)
Price subsidy				
5th	11.7%	(0.1%)	13.4%	(0.1%)
10th	12.4%	(0.1%)	13.9%	(0.1%)
25th	13.4%	(0.1%)	14.8%	(0.1%)
50th	14.5%	(0.1%)	15.7%	(0.1%)
Mean	14.4%	(0.1%)	15.6%	(0.1%)
75th	15.6%	(0.1%)	16.5%	(0.1%)
90th	16.6%	(0.1%)	17.1%	(0.1%)
95th	17.0%	(0.1%)	17.4%	(0.1%)

the period 2003 to 2007. Indeed, by October 2007, Fig. 6 shows that the welfare losses amounted to 5.5%, on average, when using national prices. However, the increase in average consumer prices in Mexico may mask significant variation in changes in prices in different parts of the country. In this exercise, we therefore make use of the 2007 wave of the ENCEL survey to calculate increases in the price of food at the local level, again deflating price changes by the change in average Mexican wages.

Table 9 shows the distribution of welfare losses due to the increases in relative food prices observed in the ENCEL surveys between 2003 and 2007, measured as a fraction of food expenditure (results are shown allowing for home production). Again, the top panel of the table shows the losses before any compensation, the second panel shows the effect of the 50 peso per week lump sum transfer to households in receipt of *Oportunidades*, and the third panel shows the effect of the 5% price subsidy.

The results are very striking. The welfare losses, expressed as a fraction of food expenditure, based on the increases in relative food prices observed in the data, rather than using the national data, are large. Again they are precisely estimated. They show that both the

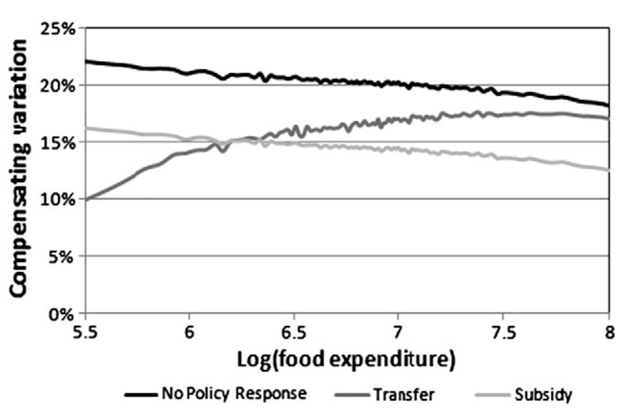

Fig. 8. Mean welfare losses (% of food expenditure) across the food expenditure distribution.

Table 8
Effect of the 2003 to 2011 price change on expenditure shares.

Good	Ppt. change	St. error
No policy		
Rice	−0.1%	(0.1%)
Corn	2.5%	(0.6%)
Wheat	−1.1%	(0.2%)
Pulses	0.4%	(0.4%)
Fruits and vegetables	0.9%	(0.3%)
Animal	−4.2%	(0.4%)
Other foods	0.9%	(0.4%)
Other starches	0.6%	(0.2%)
50 peso transfer		
Rice	−0.1%	(0.1%)
Corn	2.1%	(0.5%)
Wheat	−0.9%	(0.1%)
Pulses	0.3%	(0.4%)
Fruits and vegetables	0.9%	(0.3%)
Animal	−3.5%	(0.4%)
Other foods	0.5%	(0.3%)
Other starches	0.7%	(0.2%)
Price subsidy		
Rice	−0.1%	(0.1%)
Corn	2.0%	(0.5%)
Wheat	−0.8%	(0.1%)
Pulses	0.2%	(0.4%)
Fruits and vegetables	0.9%	(0.3%)
Animal	−3.4%	(0.4%)
Other foods	0.3%	(0.3%)
Other starches	0.7%	(0.2%)

Table 9
Welfare effects of locality price rises 2003–2007 (with home production).

Percentile of welfare losses	Welfare loss	St. error
No policy		
5th	1.8%	(0.1%)
10th	4.6%	(0.1%)
25th	8.3%	(0.1%)
50th	12.8%	(0.1%)
Mean	14.0%	(0.1%)
75th	18.1%	(0.1%)
90th	25.2%	(0.2%)
95th	32.9%	(0.4%)
50 peso transfer		
5th	−4.5%	(0.1%)
10th	−0.7%	(0.0%)
25th	4.2%	(0.1%)
50th	9.3%	(0.1%)
Mean	10.0%	(0.1%)
75th	15.1%	(0.1%)
90th	22.2%	(0.2%)
95th	28.2%	(0.4%)
Price subsidy		
5th	−3.0%	(0.1%)
10th	−0.4%	(0.1%)
25th	3.2%	(0.1%)
50th	7.4%	(0.1%)
Mean	8.5%	(0.1%)
75th	12.4%	(0.1%)
90th	19.1%	(0.2%)
95th	26.5%	(0.4%)

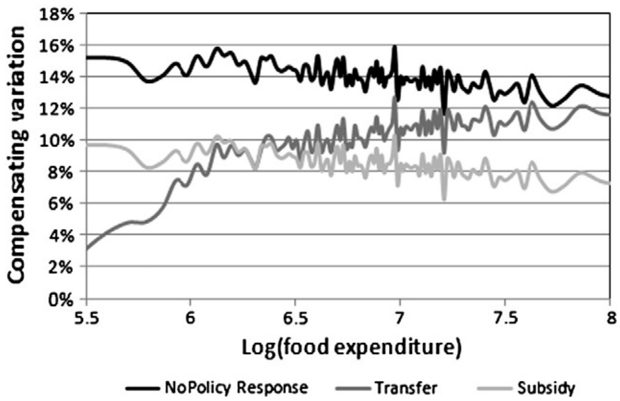

Fig. 9. Mean welfare losses (% of food expenditure) across the food expenditure distribution, accounting for home produced food.

50 peso transfer and the price subsidy alleviate considerably the losses. However, this does not paint a full picture of the situation, as it does not allow the measurement of the effect of the policy at different levels of the distribution of total expenditure.

Fig. 9 shows how the welfare losses vary by total expenditure under the various policy scenarios, and accounting for home-production. This shows the same pattern of evidence as in the case of Fig. 8, when the increase in price was that reported in the national data. Transfers are preferable to subsidies, as they correct the regressive effect of the price increase.

Table 10 shows the impact of the price changes on average spending patterns. The changes are similar to previous results: the share of corn products increases and the share of animal products decreases. Interestingly, this time, the share of other foods (such as sugar, oil, and coffee) increases fairly substantially. Both policy experiments ameliorate these effects.

Table 10
Effect of the locality level 2003 to 2007 price changes on expenditure shares.

Good	Ppt. change	St. error
No policy		
Rice	0.0%	(0.1%)
Corn	2.2%	(0.4%)
Wheat	−0.8%	(0.1%)
Pulses	0.1%	(0.2%)
Fruits and vegetables	−1.1%	(0.2%)
Animal	−2.2%	(0.3%)
Other foods	1.4%	(0.2%)
Other starches	0.4%	(0.1%)
50 peso transfer		
Rice	0.0%	(0.1%)
Corn	1.8%	(0.3%)
Wheat	−0.6%	(0.1%)
Pulses	0.0%	(0.1%)
Fruits and vegetables	−1.1%	(0.2%)
Animal	−1.5%	(0.3%)
Other foods	1.0%	(0.2%)
Other starches	0.4%	(0.1%)
Price subsidy		
Rice	0.1%	(0.1%)
Corn	1.8%	(0.3%)
Wheat	−0.6%	(0.1%)
Pulses	−0.1%	(0.1%)
Fruits and vegetables	−1.1%	(0.2%)
Animal	−1.4%	(0.2%)
Other foods	0.9%	(0.2%)
Other starches	0.5%	(0.1%)

8. Conclusion

This is the first large scale estimation of an integrable model of demand using a detailed disaggregation of food groups for Mexico using individual household data, and probably one of the first such exercises on any data from the region. We exploit variation in prices across localities and over time to estimate the parameters of a rich demand system which, in turn, allows us to assess both income and substitution effects of price changes.

Having estimated the relevant parameters, and having described the elasticities they imply, we use the relevant indirect utility function to estimate the welfare consequences of the price increases for each household in our sample. Using the indirect utility function is equivalent to computing a ‘true’ price index that takes into account the substitution possibilities and the relevance of the shares of each food group in overall food expenditure for different households. We can therefore characterize both the mean welfare effect of the price increases and their distributional consequences.

Using the national data on prices, we find that the price rises observed in recent years have had a significant impact on household welfare, with average welfare loss peaking at 19% of food expenditure in April 2011. The average welfare loss in 2007 with national price data is 5.5%. This compares with an average welfare loss of 14% computed using the price data from the 2007 wave of the *Oportunidades* data. The impact of price increases is not uniform, for three main reasons. First, the *Oportunidades* data show that food prices did not increase at the same rate in all localities, at least up until 2007. Second, prices rose by different amounts for different goods, and different households spend different proportions of their food budget on different goods. Third, households differ in the extent to which they are willing and able to substitute between goods as prices rise. The consumption of home-produced goods also plays a role in ameliorating welfare losses from food price rises, but represents less than 18% of food expenditure for 99% of households.

In addition to quantifying the welfare consequences of different sets of price increases for the households in our sample, we also compute the effects of alternative policies designed to alleviate the impact of the increases on welfare. In particular, we consider two policies that are often considered in the policy debate. The first is a subsidy to prices. The second is a cash transfer. It should be noticed that the latter policy has many advantages over the first, some of which are not considered in our simulations. First, it is much better targeted and, therefore, much less expensive than a generalized price subsidy. Hence, as our simulations show, it can reverse the regressivity of observed price increases. Second, it avoids the introduction of price distortions. Our model can be feasibly used to simulate other forms of cash-transfers given the rich demographic and income data that the survey data we use contains.

Our work is not without limitations and much has been left for future research. Two extensions seem particularly important. First, we have not considered commodities other than food nor have we

Appendix A. Further tables

Table A1
Descriptive statistics.

Demographic variable	Oct-98	May-99	Nov-99	Nov-00	2003
Headed by male	89.3%	89.2%	88.1%	87.8%	86.2%
Age of head	47.1	47.5	46.5	49.0	47.9
Headed by indigenous person	33.3%	33.6%	31.1%	32.7%	33.9%
Treatment area	60.5%	60.9%	59.0%	100.0%	100.0%
Poverty status (1997)	53.1%	53.2%	50.9%	52.1%	53.1%
Household size	5.7	5.8	5.8	6.0	6.3
Number of children under 11	1.6	1.8	1.4	1.8	1.3
Number of children over 11	1.5	1.5	1.4	1.5	1.5
Food expenditure	803	780	775	795	1086

Table A2
Shares of food categories.

Food type	Oct-98	May-99	Nov-99	Nov-00	2003
Tomatoes	5.6%	3.9%	4.4%	5.0%	5.2%
Onions	2.9%	2.5%	2.5%	3.0%	2.4%
Potatoes	2.3%	2.2%	2.4%	2.6%	2.6%
Carrots	0.2%	0.2%	0.1%	0.2%	0.3%
Leafy vegetables	0.3%	0.2%	0.2%	0.5%	0.4%
Oranges	1.6%	0.7%	2.0%	2.7%	1.6%
Bananas	1.4%	1.5%	1.5%	1.7%	2.1%
Apples	0.7%	0.3%	0.6%	0.7%	1.6%
Lemons	0.8%	0.8%	0.8%	0.8%	1.0%
Prickly pears	0.6%	1.2%	0.4%	0.5%	0.7%
Tortilla	21.3%	19.3%	21.1%	19.5%	24.0%
Maize grain	7.8%	11.5%	5.6%	4.9%	3.1%
White bread	0.8%	0.7%	0.7%	0.6%	1.4%
Sweet bread	1.3%	1.5%	2.0%	1.7%	2.7%
Loaf of bread	0.1%	0.1%	0.0%	0.1%	0.2%
Wheat flour	0.2%	0.2%	0.2%	0.1%	0.4%
Pasta soup	2.3%	2.2%	2.4%	2.2%	2.1%
Rice	2.2%	2.2%	2.2%	2.4%	1.9%
Salt cakes	0.5%	0.5%	0.4%	0.5%	0.7%
Beans	12.2%	11.0%	10.9%	9.4%	7.4%
Breakfast cereal	0.1%	0.1%	0.1%	0.1%	0.2%
Chicken	5.2%	5.9%	6.8%	8.3%	7.1%
Beef and pork	2.2%	2.6%	3.2%	2.9%	3.8%
Lamb and goat	0.1%	0.1%	0.0%	0.1%	0.1%
Fish	0.1%	0.2%	0.1%	0.2%	0.3%
Tinned fish	0.3%	0.4%	0.7%	0.3%	0.6%
Eggs	5.2%	5.5%	5.5%	6.1%	4.4%
Milk	2.4%	2.1%	2.5%	2.8%	4.1%
Cheese	0.8%	0.6%	0.7%	1.1%	1.7%
Lard	1.0%	1.0%	0.9%	0.8%	0.7%
Sweets	0.0%	0.0%	0.0%	0.0%	0.1%
Carbonated drinks	1.4%	2.0%	1.5%	2.3%	3.1%
Coffee	5.1%	5.0%	5.0%	4.4%	2.6%
Sugar	5.2%	5.7%	6.0%	5.5%	4.8%
Vegetable oil	5.8%	6.2%	6.3%	6.1%	4.7%

Table A3
Unit values.

Food type	Oct-98	May-99	Nov-99	Nov-00	2003
Tomatoes	10.08	5.74	6.32	7.45	9.54
Onions	7.36	5.61	5.86	6.36	7.90
Potatoes	7.43	6.62	6.48	6.34	8.51
Carrots	5.85	5.19	5.41	6.11	7.28
Leafy vegetables	8.98	9.36	7.80	7.86	13.27
Oranges	3.37	3.15	3.22	3.21	4.40
Bananas	3.82	3.76	3.70	3.86	4.66
Apples	9.36	10.22	8.58	10.44	10.16
Lemons	5.07	5.45	5.18	5.99	6.37
Prickly pears	6.23	4.93	6.47	7.76	8.84
Tortilla	2.93	3.22	3.03	2.93	4.96
Maize grain	2.10	2.11	2.13	2.10	2.75
White bread	10.39	10.52	11.45	13.87	14.29
Sweet bread	11.50	11.43	12.29	13.08	14.56
Loaf of bread	9.50	9.39	8.09	14.13	17.31
Wheat flour	4.32	4.28	4.74	5.02	5.01
Pasta soup	10.78	11.48	11.26	11.45	13.89
Rice	7.36	7.64	7.53	7.21	6.58
Salt cakes	12.78	12.92	11.09	11.46	15.95
Beans	11.34	10.17	10.13	9.18	10.43
Breakfast cereal	13.28	11.59	11.48	13.42	28.98
Chicken	21.21	22.10	20.92	23.10	23.88
Beef and pork	26.71	26.14	27.05	31.77	33.24
Lamb and goat	28.13	26.40	35.55	36.03	46.90
Fish	18.25	21.41	23.53	23.34	29.17
Tinned fish	52.11	55.98	39.17	24.75	40.17
Eggs	10.08	9.87	10.00	10.42	11.31
Milk	4.92	5.84	6.05	6.36	7.54
Cheese	31.96	38.52	32.60	33.39	41.77
Lard	11.70	10.89	11.11	12.17	12.16
Sweets	21.20	29.23	37.16	24.27	28.78
Carbonated drinks	6.64	5.46	5.64	6.08	6.62
Coffee	25.51	23.52	24.19	25.28	46.14
Sugar	5.99	6.00	6.00	5.99	6.92
Vegetable oil	10.28	10.30	10.30	10.20	10.29

Table A4
Marshallian elasticities.

Goods	R	C	W	P	F	A	O	OS
R	−0.832*	−0.124*	−0.198*	−0.117	0.327*	−0.187*	0.170*	−0.109
C	−0.001	−0.608*	0.021*	−0.009	−0.047*	0.045	−0.092*	0.030*
W	−0.127*	−0.268*	−0.963*	−0.167*	−0.379*	−0.175*	−0.328*	0.200*
P	−0.017	−0.022	−0.007	−0.933*	0.346*	−0.247*	0.030	0.201*
F	0.051*	−0.194*	−0.073*	0.204*	0.967*	0.003	−0.179*	0.063
A	−0.031*	−0.212*	−0.010	−0.202*	−0.070*	−0.785*	−0.249*	−0.115*
O	0.038*	−0.059	0.000	0.047	−0.077*	−0.021	−0.306*	0.058
OS	−0.053	−0.028	0.198*	0.313*	0.137	−0.451*	0.015	−1.502*

R = rice, M = maize, W = wheat, P = pulses, F = fruits and vegetables, A = animal products, O = other foods and OS = other starches.
Results indicated with an * are statistically significantly different from 0 at the 5% level.

Table A5
Hicksian elasticities.

Goods	R	C	W	P	F	A	O	OS
R	−0.809*	0.155*	−0.154*	−0.014	0.473*	0.057	0.349*	−0.055
C	0.013*	−0.436*	0.049*	0.054*	0.043*	0.196*	0.019	0.064*
W	−0.080*	0.306*	−0.872*	0.045	−0.078	0.330*	0.042	0.312*
P	−0.003	0.148*	0.020	−0.871*	0.434*	−0.098*	0.139*	0.233*
F	0.074	0.091*	−0.028	0.309*	−0.818*	0.253*	0.004	0.118*
A	0.005	0.223*	0.060*	−0.041*	0.158*	−0.403*	0.032	−0.030
O	0.045*	0.024	0.013	0.078*	−0.033	0.052	−0.252*	0.075*
OS	−0.023	0.329*	0.255*	0.444*	0.324*	−0.137	0.245*	−1.433*

R = rice, M = maize, W = wheat, P = pulses, F = fruits and vegetables, A = animal products, O = other foods and OS = other starches.
Results indicated with an * are statistically significantly different from 0 at the 5% level.

Table A6
Marshallian elasticities by food expenditure decile groups.

Decile	R	C	W	P	F	A	O	OS
Lowest	−0.836	−0.630	−1.011	−0.948	−0.961	−0.881	−0.545	−1.572
2nd	−0.845	−0.616	−0.972	−0.943	−0.963	−0.799	−0.476	−1.530
3rd	−0.845	−0.617	−0.960	−0.940	−0.965	−0.779	−0.424	−1.517
4th	−0.843	−0.622	−0.952	−0.938	−0.965	−0.767	−0.384	−1.513
5th	−0.840	−0.628	−0.947	−0.935	−0.966	−0.759	−0.343	−1.515
6th	−0.836	−0.632	−0.945	−0.933	−0.967	−0.755	−0.302	−1.517
7th	−0.831	−0.638	−0.943	−0.931	−0.967	−0.753	−0.259	−1.523
8th	−0.826	−0.643	−0.942	−0.929	−0.968	−0.750	−0.212	−1.530
9th	−0.817	−0.650	−0.943	−0.926	−0.968	−0.747	−0.155	−1.547
Highest	−0.811	−0.647	−0.943	−0.919	−0.970	−0.737	−0.102	−1.570

R = rice, M = maize, W = wheat, P = pulses, F = fruits and vegetables, A = animal products, O = other foods and OS = other starches.

Table A7
Hicksian elasticities by food expenditure decile groups.

Decile	R	C	W	P	F	A	O	OS
Lowest	−0.812	−0.502	−0.935	−0.854	−0.812	−0.526	−0.394	−1.516
2nd	−0.820	−0.467	−0.899	−0.862	−0.815	−0.446	−0.360	−1.468
3rd	−0.820	−0.453	−0.883	−0.865	−0.816	−0.421	−0.331	−1.452
4th	−0.818	−0.445	−0.873	−0.867	−0.817	−0.408	−0.305	−1.447
5th	−0.816	−0.439	−0.866	−0.868	−0.818	−0.396	−0.278	−1.448
6th	−0.813	−0.435	−0.860	−0.869	−0.819	−0.389	−0.249	−1.449
7th	−0.809	−0.431	−0.856	−0.870	−0.820	−0.382	−0.218	−1.455
8th	−0.803	−0.428	−0.852	−0.870	−0.820	−0.376	−0.182	−1.462
9th	−0.796	−0.425	−0.847	−0.870	−0.821	−0.369	−0.139	−1.479
Highest	−0.790	−0.420	−0.838	−0.867	−0.820	−0.357	−0.095	−1.503

R = rice, M = maize, W = wheat, P = pulses, F = fruits and vegetables, A = animal products, O = other foods and OS = other starches.

considered labor supply. This assumes that food is separable both from other commodities and from labor supply. If these assumptions are violated, our results could be biased. Second, we have not allowed for any income effects induced by supply factors (except for goods that are produced and consumed within the household). If some of our households are net producers of items whose price increases, this would be reflected in an increased income. This point, made by Deaton (1989), Ravallion and Lokshin (2004) and Ravallion and van de Walle (1991) could be easily incorporated in our analysis, especially if one is interested in a situation where production decisions are not modeled explicitly and one takes them as given in the short run. In this case, the price increase has a positive income effect for a producer whose size, as a first order approximation, is simply given by the current output times the price increase.

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