

Estimating Household Responses to Trade Reforms

Net Consumers and Net Producers in Rural Mexico*

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Abstract

This paper explores an empirical methodology to assess the impacts of trade reforms on household behavior in developing countries. I focus on consumption and income responses: when price reforms take place, households modify consumption and production decisions and local labor markets adjust. The paper proposes a joint estimator of demand and wage price elasticities from survey data. The method uses an empirical model of demand to extract price information from unit values, and uses this information to estimate the response of households to price reforms. By correcting unit values for quality effects and measurement error, the method overcomes the problem of the endogeneity of unit values. By endogeneizing household income, the model corrects potential biases in the estimation of own- and cross-price elasticities in consumption. I apply the method to an expenditure and income survey for rural Mexico. It is shown that the corrections suggested in this paper are empirically important. In particular, I show that allowing for consumption and income responses is a key element of an accurate empirical assessment of trade policy.

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Non-Technical Summary

This paper explores an empirical methodology to assess the impacts of trade reforms, such as those being proposed in the WTO Doha Round negotiations, on household behavior in developing countries. I focus on consumption and income responses. When price reforms take place, households are affected on both the expenditure and the income sides. By facing changed prices for consumer goods, households modify consumption decisions. By facing different wages, household income responds. The paper proposes a joint estimator of demand and wage price elasticities from survey data.

The method uses an empirical model of demand to extract price information from unit values, and uses this information to estimate the response of households to price reforms. By correcting unit values for quality effects and measurement error, the method overcomes the problem of the endogeneity of unit values. By endogeneizing household income, the model corrects potential biases in the estimation of own- and cross-price elasticities in consumption.

I apply the method to an expenditure and income survey for rural Mexico. It is shown that using unit values instead of prices may lead to inconsistent results, and that the corrections suggested in this paper are empirically important. It is also shown that allowing for consumption and income responses is a key element of an accurate empirical assessment of trade policy. Concretely, I show that the standard proposition of the literature, that after an increase in the price of a good net consumers will be worse off but net producers will be better off, may be misleading. In a static context, the welfare effects of a price change can be assessed by comparing budget shares and income shares. This argument, however, fails to consider dynamic household responses. Consumers may respond by substituting away from the more expensive goods. In rural areas, farmers may increase agricultural production, farm employment and wages, and purchases of inputs and services in local markets. Importantly, thus, the net position of the household becomes endogenous: sufficiently large consumption and income responses may cause an ex-ante net consumer become an ex-post net producer, thus benefiting from the price increase. My empirical application to rural Mexico reveals that the evaluation of price/trade reforms is indeed sensitive to the inclusion of these consumption and income responses.

1 Introduction

Trade in agricultural products is perhaps one of the most promising instruments for poverty alleviation in developing countries. This is because agriculture is a key productive activity in poor countries and because world markets can provide new opportunities for rural producers. However, international markets for agricultural products have long been distorted by the policies of developed countries. Policies of domestic support, such as subsidies to production or exports, and policies of market access, such as tariffs and non-tariff barriers, are examples. Understanding and measuring the impacts of WTO reforms on poor households in developing countries is therefore critical to the current trade and poverty debate.

When price reforms are implemented, particularly in agriculture, households are affected both as consumers and as income earners. The standard proposition of the literature is that, after an increase in the price of a good, net consumers will be worse off but net producers will be better off (Deaton, 1989). In this static context, the welfare effects of a price change can be assessed by comparing budget shares and income shares. This argument, however, fails to consider dynamic household responses. Consumers may respond by substituting away from the more expensive goods. In rural areas, farmers may increase agricultural production, farm employment and wages, and purchases of inputs and services in local markets. Importantly, thus, the net position of the household becomes endogenous: sufficiently large consumption and income responses may cause an ex-ante net consumer to become an ex-post net producer, thus benefiting from the price increase.

The measurement of the total household welfare effect, one that jointly considers first order effects in consumption and production as well as consumption and income responses, is the objective of this paper. I propose a joint estimator of demand price-elasticities and agricultural wage price-elasticities from survey data. The empirical method relies on a two-step strategy, first estimating the responses of household behavior to prices and, second, linking prices to the reforms. The method requires the estimation of structural models: household responses are linked to prices through structural parameters that are in turn used to simulate policy outcomes.¹

¹Sometimes, standard methods for policy evaluation, such as natural experiments, are not feasible. Trade

The estimation of these structural parameters requires survey data with sufficient price variation at the household level. This is rarely the case. One possibility is to combine household surveys with official price information. Some studies exploit time and regional variation in official prices (Deaton, 1997; Porto, 2003; Ravallion, 1990; Wolak, 1996); others use community price questionnaires (Edmonds and Pavcnik, 2004a; 2004b). In this paper, I use unit values, the ratio of reported expenditures and quantities, as measures of prices.

The main advantage of using unit values in household models is the substantial cross-sectional variability. However, unit values are not the same as prices when consumers jointly choose quantity and quality (Deaton, 1987). Since unit values combine measures of price and quality, unit values can only be used as proxies for prices. This may lead to biases in the estimation of the relevant structural parameters. Further, endogenous income responses generate additional income effects that can bias the estimates of Marshallian demand elasticities.² Building on the seminal work of Deaton (1987, 1988, 1990), I develop methods to correct the estimates of consumption and income responses.

The procedure works as follows. By modeling consumer choices of quantity and quality simultaneously, I am able to extract the right price signals from unit values, expenditures, and quality choices. Then, I use this price information to estimate the response of consumption and wage agricultural income. To do this, I develop a general equilibrium econometric model of agricultural prices, quantities consumed, unit values, and household income.

I estimate the own- and cross-price elasticities as well as the wage-price elasticities using survey data for rural Mexico. It is shown that using unit values instead of prices may indeed lead to inconsistent results, and that the corrections suggested in this paper are empirically important. On the income side, the endogeneity of unit values and measurement error lead to attenuation bias in the estimates of the wage elasticities. On the demand side, the correction for the endogeneity of household agricultural income seems to make a difference in terms of both the Marshallian and Hicksian elasticities. These differences originate in the consistent estimation of the expenditure elasticities and in the account of the “profit effect”. I also

reforms, which are often accompanied by other simultaneous reforms, are an example. In many instances, in addition, there is an interest, or a need, to explore the effects of a policy that has not yet taken place. WTO reforms are an example. The method proposed here accommodates these cases.

²This is a version of the “profit effect” discussed in Singh, Squire and Strauss (1986).

show that the evaluation of the impacts of an increase in the price of major agricultural products (like corn) is sensitive to the inclusion of both consumption and income effects, as well as to the allowance for consumption and income responses.

The paper is organized as follows. Section 2 provides a general motivation and develops the econometric model. I provide an overview of the methodology and I introduce the general equilibrium econometric model of consumption and income responses. In section 3, I apply the methods to the Mexican data and I report the results on the demand and wage income price-elasticities. Section 4 simulates the welfare effects of the increase in the price of corn taking into account consumption and income responses of Mexican households. In Section 5, I conclude.

2 The Econometric Model

In most studies of price reforms, such as those summarized in Deaton (1997), the analysis is based on the responses of household consumption. Standard arguments of efficiency, based on price elasticities, and equity, based on expenditure elasticities, are used to characterize optimal taxes or to indicate direction of changes in the structure of taxation. This analysis omits important aspects of the effects of any policy, namely the responses of outputs, wages, and household income. To estimate the impacts of the reforms both on the expenditure and income sides, I argue that it is necessary to estimate own- and cross-price elasticities, on the one hand, and wage-price elasticities, on the other.

Discussions about the poverty impacts of trade reforms often make the argument that supply responses are critical for the poor. Specifically, WTO reforms on agricultural trade are expected to boost production opportunities in rural areas in developing countries. Proponents of this view argue that agricultural trade liberalization will bring about increases in international prices of agricultural goods. Faced with higher permanent prices, households will choose to devote more resources to agricultural production and firms will increase their labor demand in agriculture. This higher demand may involve higher employment in rural farms (for planting, weeding, or harvesting), or it may imply higher labor demand

in agricultural services (such as sales of fertilizers and tools and farm maintenance).

How can these effects be estimated? With a household survey database containing information on expenditures and quantities of agricultural goods, a naive model to estimate the responses of wages to changes in agricultural prices would be to run a regression of wages on unit values. Let a_{hc} be the agricultural wage income of household h living in region (cluster) c . Let $\ln v_c^g$ be the log unit values of good g reported by households in cluster c . A simple model would be

$$(1) \quad \ln a_{hc} = \alpha + \gamma' \mathbf{m}_{hc} + \sum_g \lambda_g \ln v_c^g + u_{hc},$$

where \mathbf{m}_{hc} is a vector of controls such as gender, age and marital status of the household head, his/her education, household size and demographic composition, and time and regional dummies.

There are three concerns with a regression model such as (1): endogeneity of unit values, bias due to proxy variables, and measurement error. Endogeneity may arise because households simultaneously choose quantity and quality. Therefore, unit values are not a perfect measure of prices. Even when unit values are a good proxy for prices, the model may estimate the vector γ consistently, but λ inconsistently (i.e., the proxy bias). Measurement error arises if there are inaccurate responses, mainly on quantities consumed. In all these cases, OLS estimation of (1) will lead to inconsistent estimates of the wage agricultural income price-elasticities. The joint estimator developed in this section takes care of all these problems.

In a general equilibrium model with wage and supply responses, there may be additional problems in the estimation of own- and cross-price elasticities using standard empirical models of demand (such as those discussed in Deaton and Muellbauer, 1980a). Concretely, when a fraction of household income responds to price changes, the elasticities will be inconsistently estimated. To see this, let household preferences over agricultural and non-agricultural goods be defined by a utility function $u_h = u_h(\mathbf{c}_h)$, where \mathbf{c}_h is a vector of consumption. Utility is maximized subject to the budget constraint $\mathbf{p}\mathbf{c}_h = x_h$. The vector

of demand functions is $\mathbf{c}^h = \mathbf{c}^h(\mathbf{p}, x^h)$.

In a typical model of demand, total expenditure x_h is considered exogenous (both economically and statistically). In household production models, instead, at least a part of expenditure can be statistically endogenous (but still exogenous for the household as a decision maker). In my model, for example, wage agricultural income depends on the prices of the agricultural goods through changes in demand for labor in agricultural activities. In consequence, a decline, say, in prices has two sources of income effects: the usual income effect, whereby real income increases at constant relative prices, and the change in nominal income caused by the responses of agricultural wage income.

In the development literature, this effect has been labeled “profit effect” in the work of Barnum and Squire (1979) and Singh, Squire and Strauss (1986). In these household production models, a change in prices brings about a change in household profits in agriculture and a change in income. Singh, Squire and Strauss argued that, both in theory and in practice, the profit effect could significantly alter the magnitude, and even the sign, of the uncompensated quantity responses. To see this formally, differentiate the demand of good c_1 , say, with respect to the price p_1 to get

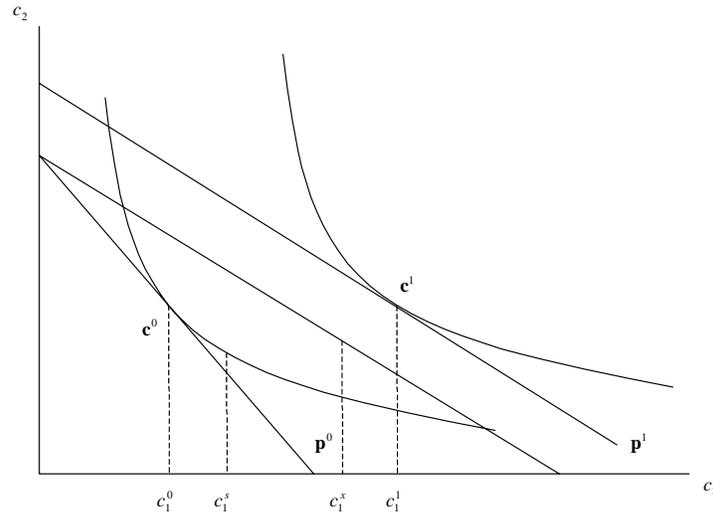
$$\frac{\partial c_{h1}}{\partial p_1} = \frac{\partial c_{h1}}{\partial p_1} + \frac{\partial c_{h1}}{\partial x_h} \frac{\partial x_h}{\partial p_1}.$$

Further, decompose the price effect captured by the first term on the right hand side in the usual compensated demand change, $\partial \tilde{c}_{h1} / \partial p_1$, and the standard income effect $-c_{h1} \partial c_{h1} / \partial x_h$ from the Slutsky equation. This leads to

$$\frac{\partial c_{h1}}{\partial p_1} = \frac{\partial \tilde{c}_{h1}}{\partial p_1} - c_{h1} \frac{\partial c_{h1}}{\partial x_h} + \frac{\partial c_{h1}}{\partial x_h} \frac{\partial x_h}{\partial p_1}.$$

Figure 1 provides an intuition. The initial price vector is \mathbf{p}^0 ; at these prices, the consumer chooses the bundle \mathbf{c}^0 of goods. Let’s assume that the price of good 1 (with quantities measured on the horizontal axis) declines and that wage agricultural income a_h is negatively associated with this price. This means that when p_1 declines, the budget line first rotates (with nominal income held constant) and then shifts, when a_h increases. The final

Figure 1
The Profit Effect and the Marshallian Demand Elasticities



Note: At price \mathbf{p}^0 , the consumer chooses bundle \mathbf{c}^0 . When the price of good 1 declines, the budget line rotates and shifts outward (if agricultural wages are negatively associated with p_1). The final equilibrium is at \mathbf{c}^1 at prices \mathbf{p}^1 . The “profit effect” generates an additional income effect that accounts for the difference between c_1^x and c_1^1 .

equilibrium at the price vector \mathbf{p}^1 is at \mathbf{c}^1 . The substitution effect is the movement from c_1^0 to c_1^s . The standard income effect is the movement from c_1^s to c_1^x and the remaining units, from c_1^x to c_1^1 , measure the additional income effect caused by my version of the profit effect, i.e., the response of household total expenditure through the changes in agricultural wages. In the case depicted in Figure 1, the consumption of good 1 increases with lower prices. But it is easy to build cases in which consumption actually declines when prices are lower, even for a normal good. The joint estimator developed next incorporates these additional income effects.

2.1 A simplified Model

The method proposed in this paper combines a model such as (1), with true unobservable prices instead of unit values as regressors, with the model of demand and quality shading developed by Deaton (1987, 1988, 1990). In order to introduce the method, I begin by setting

up a simplified version of the model with only one good.³

The demand for the good is modeled with an equation characterizing budget shares. For the moment, I ignore other goods that may complete the system. Deaton and Muellbauer (1980b) show that a suitable model (that is, a utility consistent model) for the budget share s_{hc} spent by household h in cluster c is

$$(2) \quad s_{hc} = \alpha_0 + \beta_0 \ln x_{hc} + \gamma'_0 \mathbf{z}_{hc} + \theta \ln \pi_c + f_c + u_{hc}^0,$$

where x_{hc} is total expenditure, \mathbf{z}_{hc} are household demographic characteristics, such as number of members and demographic composition. π_c is a price level that is assumed to be the same for all households in cluster c ; this price is unobservable. f_c is a cluster fixed effect and u_{hc}^0 is a standard error term, with zero mean (for a large number of households in each cluster) and variance σ^{00} .

The endogeneity of unit values can be solved by modeling unit values explicitly. Unit values are not the same as prices because they are part price and part quality. In fact, changes in prices and in total expenditure will cause consumers to respond partly by modifying quantities and partly by modifying quality. I assume that

$$(3) \quad \ln v_{hc} = \alpha_1 + \beta_1 \ln x_{hc} + \gamma'_1 \mathbf{z}_{hc} + \psi \ln \pi_c + u_{hc}^1.$$

Here, unit values v_{hc} are affected by prices and by household expenditure x_{hc} . The parameter ψ captures the shading of quality to price changes, and the parameter β_1 is called the “quality elasticity” or the “expenditure elasticity of quality”; β_1 would be zero if there were no quality shading, in which case $\psi=1$. Demographics \mathbf{z}_{hc} determine unit values, too. The error term u_{hc}^1 has mean zero (for a large number of h in cluster c) and variance σ^{11} .

Equations (2) and (3) will be used to extract true price signals from unit values. This price information is then used to estimate the endogenous determination of household wage

³I describe this artificial model just to provide an intuition for the more difficult formulas of the full model of section 3. No attempt to generality or general equilibrium is pursued here.

agricultural income, a_{hc} . I redefine (1) as

$$(4) \quad \ln a_{hc} = \alpha_2 + \gamma'_2 \mathbf{m}_{hc} + \lambda \ln \pi_c + u_{hc}^2,$$

where \mathbf{m}_{hc} are household characteristics that affect wage agricultural income. Some elements of \mathbf{m}_{hc} , such as education, are different from the determinants of the budget shares and unit values. u_{hc}^2 is a standard error term. The coefficient λ measures the price elasticity, or the proportional change in agricultural income brought about by the changes in product prices. In (4), all households in a given cluster are assumed to face the same price π_c .

While consumer prices are relevant in equations (2) and (3), producer prices are more important in determining wages. For a tradable good with exogenous international prices and no domestic distortions, producer and consumer prices would be the same. This interpretation, however, does not allow prices to vary by cluster. In practice, prices vary regionally because of local taxes, transport costs, and transaction costs. Since information on unit values in production is not available, I need to rely on consumer prices and unit values on consumption as a source of variation for producer prices. This is a common problem in the literature (see Edmonds and Pavcnik, 2004a).

If prices π_c were observed, it would be straightforward to estimate a model characterized by (2) and (4).⁴ This is a system of equations that can be handled easily with well-known econometric techniques. But prices π_c are not observed. In this model, the identification assumption is that every household in cluster c faces the same prices. This suggests a two-stage strategy. In the first stage, unobserved prices are controlled for with cluster dummies (which will absorb any fixed effects as well). In the second stage, the elasticities are estimated by using the information on prices contained in the residuals from the first stage. Details follow.

In the first stage, I recover β_0 , γ_0 , β_1 , γ_1 and γ_2 by consistently estimating the model, after demeaning all variables (s_{hc} , $\ln v_{hc}$, $\ln a_{hc}$, $\ln x_{hc}$, \mathbf{z}_{hc} , and \mathbf{m}_{hc}) from cluster means. Consistency may be achieved with OLS, if expenditures are considered statistically exogenous, or with IV. I elaborate more on this when I discuss the full model below. With

⁴Notice that when prices are observed the unit value equation loses its meaning.

estimates $\widehat{\beta}_0$, $\widehat{\gamma}_0$, $\widehat{\beta}_1$, $\widehat{\gamma}_1$ and $\widehat{\gamma}_2$, I construct three variables by subtracting the explained part of the model from the dependent variables in (2), (3) and (4). I get

$$(5) \quad \widehat{y}_{hc}^0 = s_{hc} - \widehat{\beta}_0 \ln x_{hc} - \widehat{\gamma}'_0 \mathbf{z}_{hc},$$

$$(6) \quad \widehat{y}_{hc}^1 = \ln v_{hc} - \widehat{\beta}_1 \ln x_{hc} - \widehat{\gamma}'_1 \mathbf{z}_{hc},$$

$$(7) \quad \widehat{y}_{hc}^2 = \ln a_{hc} - \widehat{\gamma}'_2 \mathbf{m}_{hc}.$$

Averaging (5), (6) and (7) at the cluster level, it follows that

$$(8) \quad \widehat{y}_c^0 \xrightarrow{p} \alpha_0 + \theta \ln \pi_c + f_c + u_c^0,$$

$$(9) \quad \widehat{y}_c^1 \xrightarrow{p} \alpha_1 + \psi \ln \pi_c + u_c^1,$$

$$(10) \quad \widehat{y}_c^2 \xrightarrow{p} \alpha_2 + \lambda \ln \pi_c + u_c^2,$$

where u_c^0 , u_c^1 , and u_c^2 are average error terms in cluster c (these averages would be zero for a sufficiently large number of households per cluster).

Notice that the “residuals” \widehat{y}_c^0 , \widehat{y}_c^1 , and \widehat{y}_c^2 contain the parameters of interest, θ , ψ , and λ , and unobserved prices. The slope of a regression of \widehat{y}_c^0 on \widehat{y}_c^1 , taking into account the covariance of mean cluster errors, is given by

$$\widehat{\phi}_1 = \frac{\widehat{cov}(\widehat{y}_c^0, \widehat{y}_c^1) - \frac{\widehat{\sigma}^{01}}{n_c}}{\widehat{var}(\widehat{y}_c^1) - \frac{\widehat{\sigma}^{11}}{n_c}} = \frac{\widehat{\theta}}{\widehat{\psi}},$$

where n_c is the (common) number of observations (households) in a cluster c , $\widehat{\sigma}^{01}$ is the estimated covariance between the residuals in the budget share equations and unit value equations, and $\widehat{\sigma}^{11}$ is the estimated variance of the residuals of the unit value equation.⁵

⁵Deaton (1987) discusses how to amend the formulas for the cases where the number of households is different across clusters and where not every household in a cluster reports both budget shares and unit values.

Similarly, the slope of a regression of \widehat{y}_c^0 on \widehat{y}_c^2 is given by

$$\widehat{\phi}_2 = \frac{\widehat{cov}(\widehat{y}_c^0, \widehat{y}_c^2) - \frac{\widehat{\sigma}^{02}}{n_c}}{\widehat{var}(\widehat{y}_c^2) - \frac{\widehat{\sigma}^{22}}{n_c}} = \frac{\widehat{\theta}}{\widehat{\lambda}},$$

where $\widehat{\sigma}^{02}$ is the estimated covariance between the residual in the equation for budget shares and the equation for wage agricultural income and $\widehat{\sigma}^{22}$ is the variance of the residuals in the wage agricultural income equation.

Without further restrictions on the parameters of the model, it is not possible to separate $\widehat{\theta}$, $\widehat{\psi}$ and $\widehat{\lambda}$ from the ratios $\widehat{\phi}_1$ and $\widehat{\phi}_2$. To recover the elasticities, I need to impose more structure on the relationship between quantities consumed, prices and unit values. Deaton (1988) developed a group-separable model of demand that delivers a restriction that helps identify the model. In Appendix 1, I show that

$$(11) \quad \psi = 1 + \beta_1 \frac{\epsilon_p}{\epsilon_x},$$

where ϵ_p is the price elasticity of quantity with respect to price π and ϵ_x is the total expenditure elasticity of the group. To interpret (11), notice that it is possible to define quality so that unit values can be written as the product of price and quality (see Appendix 1 for details). Hence, the response of unit value to price is one plus the effect of shading quality due to higher prices. This depends on the quality elasticity, β_1 , the price elasticity ϵ_p , and the income elasticity, ϵ_x . When price increases, ϵ_p captures the reduction in demand and β_1/ϵ_x captures the quality effect. If $\beta_1 = 0$ or $\epsilon_p = 0$, then there is no quality shading and $\psi = 1$. When there is quality shading to prices, $\psi < 1$.

To close the model, I need to relate the quantities ϵ_p and ϵ_x to the estimable parameters. I do this in Appendix 1, where I derive the empirical restriction that identifies the model. This is given by

$$(12) \quad \psi = 1 + \beta_1 \frac{\frac{\theta}{s} + b_a \lambda - \psi}{\frac{\beta_0}{s} + 1 - \beta_1},$$

where b_a is the average share of wage agricultural income in total expenditure, and s is the

average budget share. The empirical version of (12) can be combined with the estimates of $\widehat{\phi}_1$ and $\widehat{\phi}_2$ to solve for $\widehat{\theta}$, $\widehat{\psi}$ and $\widehat{\lambda}$. A generalization to the case of many goods follows.

2.2 The Full Model

In this section, I derive the formulas needed to implement the full model, with many agricultural goods, cross-price elasticities, and several agricultural wage income price-elasticities. To extend the simplified model, I begin by rewriting the general formulas for budget shares, unit values and agricultural wage income. With G goods, the budget share spent on good g by household h (in cluster c) is

$$(13) \quad s_{hc}^g = \alpha_0^g + \beta_0^g \ln x_{hc} + \gamma_0^{g'} \mathbf{z}_{hc} + \sum_{k \in G} \theta_{gk} \ln \pi_c^k + f_c^g + u_{hc}^{g0},$$

where $\ln \pi_c^k$ is the (log) price of good k in cluster c . As before, f_c^g is a fixed effect at the cluster level and u_{hc}^{g0} is the error term, with mean zero and variance σ_{00}^g . This is the AIDS model of demand developed by Deaton and Muellbauer (1980b).

The unit value equation for good g is

$$(14) \quad \ln v_{hc}^g = \alpha_1^g + \beta_1^g \ln x_{hc} + \gamma_1^{g'} \mathbf{z}_{hc} + \sum_{k \in G} \psi_{gk} \ln \pi_c^k + u_{hc}^{g1}.$$

Here, the “quality elasticity” for good g is β_1^g . The error term u_{hc}^{g1} has zero mean and variance σ_{11}^g . This is just the generalization of equation (3).

There are G equations (13) and (14); instead, there is only one agricultural wage income equation

$$(15) \quad \ln a_{hc} = \alpha_2 + \gamma_2' \mathbf{m}_{hc} + \sum_{k \in G} \lambda_k \ln \pi_c^k + u_{hc}^2,$$

where u_{hc}^2 is an error term. As argued above, changes in prices, particularly of agricultural goods, will cause some agricultural activities to expand and some others to contract. This, in turn, will lead to changes in agricultural labor demand and supply and, in the end, to

changes in the agricultural wage income of rural households. Equation (15) captures these effects.⁶

As in the simplified model, estimation proceeds in two stages. In the first stage, I demean budget shares, log unit values and log agricultural income to eliminate prices and cluster fixed effects. In principle, there is no problem with the consistent estimation of these parameters if the regressors are exogenous, as in Deaton (1990). Here, however, I am introducing an agricultural wage income equation and agricultural income may be correlated with total expenditure. This means that the model will not be identified if there is correlation between the errors of the share or unit value equations with the error of the agricultural wage income equation.

If I assume that this correlation is absent, then the model is triangular and I can estimate it consistently using OLS equation by equation. This assumption is not necessary. It is possible to allow for correlation between u_{hc}^2 , u_{hc}^1 and u_{hc}^0 and estimate consistently the parameters of the demeaned model using instruments in the share and unit value equations. In particular, since the set of explanatory variables in \mathbf{m}_{hc} is different from the set of explanatory variables in \mathbf{z}_{hc} , I use the variables that are in \mathbf{m} but not in \mathbf{z} as instruments. These exclusion restrictions allow me to fully identify the parameters of the first stage. The parameters of the agricultural wage income equation are identified provided \mathbf{m} is exogenous.⁷

In the second stage, I subtract the explained part of the model from each of the dependent variables, and I compute their averages by clusters. It follows that

$$(16) \quad \widehat{y}_{cg}^0 \xrightarrow{p} \alpha_0^g + \sum_{k \in G} \theta_{gk} \ln \pi_c^k + f_c^g + u_{cg}^0,$$

$$(17) \quad \widehat{y}_{cg}^1 \xrightarrow{p} \alpha_1^g + \sum_{k \in G} \psi_{gk} \ln \pi_c^k + u_{cg}^1,$$

$$(18) \quad \widehat{y}_c^2 \xrightarrow{p} \alpha_2 + \sum_{k \in G} \lambda_k \ln \pi_c^k + u_c^2,$$

⁶In section 3, I introduce a simple theoretical model of agricultural labor markets that describes the economics behind equation (15). Since I build this model to rationalize the empirical results for rural Mexico, I postpone its presentation until section 3.

⁷Notice that the model is recursive. That is, agricultural wage income does not depend on total household expenditure and thus I don't have to use instruments to estimate the wage equation.

where u_{cg}^0 , u_{cg}^1 , and u_c^2 are average error terms in cluster c .

Whereas in the simplified model I was interested in three parameters, ψ , θ and λ , here I need to estimate two matrices and one vector of parameters. The matrices are Ψ and Θ , with gth row denoted by $\psi_{\mathbf{g}} = (\psi_{g1}, \dots, \psi_{gg}, \dots, \psi_{gG})$ and $\theta_{\mathbf{g}} = (\theta_{g1}, \dots, \theta_{gg}, \dots, \theta_{gG})$, respectively. The vector of wage elasticities is $\lambda = (\lambda_1, \dots, \lambda_G)'$.

To solve for the matrices of parameters, Θ , Ψ , and λ , I need to manipulate the model and introduce some new notation. Let \mathbf{p}_c be a $G \times 1$ vector of the logarithm of (unobserved) prices in cluster c . Stacking the vectors \mathbf{p}'_c for all clusters, I get a $C \times G$ matrix \mathbf{P} of prices. Next, I stack observations on average unit values for good g , (17), into a $C \times 1$ vector $\hat{\mathbf{y}}_g^1 = \mathbf{1}_C \alpha_1^g + \mathbf{P} \psi'_g + \mathbf{u}_g^1$, where $\mathbf{1}_C$ is a $C \times 1$ vector of ones, ψ_g is the gth row of matrix Ψ and \mathbf{u}_g^1 is a vector of residuals. It follows that

$$(19) \quad cov(\hat{\mathbf{y}}_g^1, \hat{\mathbf{y}}_k^1) = \psi'_g \mathbf{\Pi} \psi_k + E[\mathbf{u}_g^1 \mathbf{u}_k^1],$$

where $\mathbf{\Pi}$ is the variance-covariance matrix of the vector of good prices (across clusters). Next, I construct a $G \times G$ matrix \mathbf{V}_1 with element gk given by (19)

$$(20) \quad \mathbf{V}_1 = \Psi \mathbf{\Pi} \Psi' + \mathbf{\Omega}_{11},$$

where $\mathbf{\Omega}_{11}$ is the matrix with gk element $E[\mathbf{u}_g^1 \mathbf{u}_k^1]$.

Following the same procedure, I generate the vector $\hat{\mathbf{y}}_g^0$ by stacking the estimated average budget shares spent on good g , equation (16), by clusters. This vector is $\hat{\mathbf{y}}_g^0 = \mathbf{1}_C \alpha_0^g + \mathbf{P} \theta'_g + \mathbf{f}^c + \mathbf{u}_g^0$, where θ_g is the gth row of matrix Θ , and \mathbf{u}_g^0 is a vector of residuals. It follows that

$$(21) \quad cov(\hat{\mathbf{y}}_g^0, \hat{\mathbf{y}}_k^0) = \psi'_g \mathbf{\Pi} \theta_k + E[\mathbf{u}_g^0 \mathbf{u}_k^0].$$

Next, I build a $G \times G$ matrix \mathbf{V}_{10} with element gk given by (21)

$$(22) \quad \mathbf{V}_{10} = \Psi \mathbf{\Pi} \Theta' + \mathbf{\Omega}_{10},$$

where $\mathbf{\Omega}_{10}$ is the matrix with gk element $E[\mathbf{u}_g^1 \mathbf{u}_k^0]$.

So far, I have shown how estimation of the model of demand delivers algebraic expressions involving the unknown matrices Θ and Ψ ; these are equations (20) and (22). These equations can be combined to express one of these matrices as a function of the other. For instance, by defining a matrix $\mathbf{B} = [\mathbf{V}_1 - \mathbf{\Omega}_{11}]^{-1} [\mathbf{V}_{10} - \mathbf{\Omega}_{10}]$, it follows that

$$(23) \quad \mathbf{B}'\Psi = \Theta.$$

This expression has an interpretation in terms of OLS regression coefficients –corrected for measurement errors– among the average cluster residuals of the unit value and budget share equations for the different goods.

The next step is to develop similar formulas involving the vector λ of wage agricultural income price elasticities. One option is to combine the agricultural income equation with the unit value equations. Writing the agricultural income equation for cluster c as a stacked vector $\hat{\mathbf{y}}^2 = \mathbf{1}_C\alpha_2 + \mathbf{P}\lambda + \mathbf{u}^2$, I find that the covariance between $\hat{\mathbf{y}}^2$ and $\hat{\mathbf{y}}_g^1$ is

$$(24) \quad cov(\hat{\mathbf{y}}^{2'}, \hat{\mathbf{y}}_g^1) = \lambda'\mathbf{\Pi}\psi_g + E[\mathbf{u}^{2'}\mathbf{u}_g^1].$$

This allows me to build a $G \times 1$ vector \mathbf{v}_{21} with element g given by (24)

$$(25) \quad \mathbf{v}_{21} = \Psi\mathbf{\Pi}\lambda + \omega_{21},$$

where ω_{21} is a vector with g element $E[\mathbf{u}^{2'}\mathbf{u}_g^1]$. Next, I define a $1 \times G$ vector $\mathbf{B}_1 = [\mathbf{v}_{21} - \omega_{21}]' [\mathbf{V}_1 - \mathbf{\Omega}_{11}]^{-1}$, so that

$$(26) \quad \mathbf{B}_1 = \lambda'\Psi^{-1}.$$

This relationship can also be interpreted as OLS slopes (corrected for measurement error).

To complete the model and solve for the parameters of interest (i.e., the price elasticities), I need to extend the quality model to many goods. In Appendix 1, I show that the

generalization of equation (12) is given by

$$(27) \quad \psi_{gk} = \delta_{gk} + \frac{\beta_1^g}{\beta_0^g + s_g(1 - \beta_1^g)} [\theta_{gk} + s_g b_a \lambda_k - s_g \psi_{gk}],$$

where δ_{gk} is the Kronecker delta. Defining a vector ξ with element $\beta_1^g / (\beta_0^g + s_g(1 - \beta_1^g))$ for good g , and a vector \mathbf{s} of average budget shares, I can write

$$(28) \quad \Psi = \mathbf{I} + D(\xi)\Theta + b_a D(\xi)D(\mathbf{s})\mathbf{1}_G \otimes \lambda' - D(\xi)D(\mathbf{s})\Psi,$$

where $D(\xi)$ and $D(\mathbf{s})$ are matrices with the elements of vectors ξ and \mathbf{s} on the diagonal (and zero off-diagonal elements), and $\mathbf{1}_G$ is a $G \times 1$ vector of ones. The symbol \otimes is the Kronecker product.

These are all the steps needed to close the model. The mechanics of the solution involves using (23), (26) and (28) to solve for the matrices Θ and Ψ , and the vector λ . Replacing (23) in (28), I get

$$\widehat{\Psi} = [\mathbf{I} - D(\xi)\mathbf{B}' - b_a D(\xi)D(\mathbf{s})\mathbf{1}_G \otimes \mathbf{B}_1 + D(\xi)D(\mathbf{s})]^{-1}.$$

This matrix is a function of the data. Plugging this into (23) and (26), I solve for $\widehat{\Theta} = \mathbf{B}'\widehat{\Psi}$ and for $\widehat{\lambda}' = \mathbf{B}_1\widehat{\Psi}$.

The matrix of uncompensated demand elasticities can be estimated with

$$(29) \quad \widehat{\mathbf{E}} = D(\mathbf{s})^{-1}\widehat{\Theta} - \widehat{\Psi} + b_a \mathbf{1}_G \otimes \widehat{\lambda}',$$

and the matrix of compensated, Hicksian demand elasticities, with

$$(30) \quad \widehat{\widehat{\mathbf{E}}} = \widehat{\mathbf{E}} + D(\zeta)D(\mathbf{s})^{-1}\mathbf{1}_G \mathbf{s}' + b_a D(\zeta)\mathbf{1}_G \otimes \widehat{\lambda}',$$

where a typical element of the vector ζ is $\beta_0^g + s_g(1 - \beta_1^g)$. Estimation follows.

3 Empirical Results

I exemplify the use of the method by estimating the responses of quantities consumed and agricultural wage income in rural Mexico. The case of Mexico is, in principle, a good case study because of the importance of the agricultural sector. Mexico is also close to the United States, and thus WTO reforms are likely to reach rural producers.

In Mexico, a good source of data is the Household Income and Expenditure National Surveys, ENIGH (Encuesta Nacional de Ingresos y Gastos de los Hogares). During the 1990s, the data were collected every other year; I use data from the 1994, 1996, 1998, and 2000 rounds. The surveys are representative of the population at the National level, and cover rural and urban areas. Since I am focusing on the impacts of price reforms on wage agricultural income, I use the rural modules only. Table 1 reports some summary statistics.

I begin with sample sizes and number of clusters c . The ENIGH is carried out at different weeks in different districts. To make the assumption of common prices in a given cluster c reasonable, I define them as district-week pairs. There are between 3306 and 5007 rural households in the samples. There are 1095 clusters in the pooled sample, approximately 275 in each ENIGH round. The number of households interviewed in each “cluster” is typically larger than in other surveys, with at least 20 households in each of them.

On the consumption side, expenditure data include food and non-food items. Since quantities are only reported for foodstuff, I estimate the model for the following six goods: corn, wheat, dairy, oils & fats, meat, and fruits & vegetables. These goods are aggregates of differentiated goods within each category. For instance, corn includes own-consumption, corn grain, and finely grinded corn; meat includes different types of beef, poultry and pork. These varieties are considered homogeneous goods. Consumers choose different varieties of good, but report expenditures and purchases of consumption aggregates (see Appendix 1). In rural areas, food consumption includes market purchases and own-consumption. Following Deaton and Grimard (1992), for instance, we compute unit values using market purchases only, but budget shares using all expenditure (purchases plus home production).

Fruits & Vegetables, Corn and Meat are the major categories of food expenses in the sample. Notice that average unit values for all these food products increase in real terms

from 1994 to 2000.⁸ As a result, budget shares decline with time. Notice that the number of households that report quantities (and, thus, unit values) is lower than the number of households in the sample. This is not surprising.

On the income side, information includes wage earnings, capital income, and other sources of income. In the estimation that follows, a_h is defined as wage income in agricultural activities (farm employment) and self employment income earned in agriculture. This includes, first, income from agricultural production (sell of corn, wheat, etc.). Unfortunately, the data do not identify the value of sales of different crops, but just the total income from all agricultural activities. Second, the definition of a_h includes wages related to agricultural activities, like off-farm employment and rural labor in the field. We do not know, however, whether these wages are earned in corn, wheat, or dairy production. Overall, agricultural wages as defined above account for around 60 percent of the total income of rural families. Notice that real wages decline by about 20 percent from 1994 to 2000.

Household characteristics include the size of the family, the demographic composition, and age, gender, marital status, and educational level. These are the controls that I include in the estimation of the first stage. The educational variables (primary school, secondary school, college) are assumed to affect the wage income but not the consumption decisions. In other words, the educational variables are in the vector \mathbf{m}_{hc} but not in the demographic vector \mathbf{z}_{hc} . In the first stage, I include year dummies to control for the different years in which the surveys were collected.

Since I am studying the agricultural sector in Mexico, I need to discuss PROCAMPO, a key agricultural policy in the country. PROCAMPO is a program that provides income support to rural farmers. It was implemented in 1994 to replace the policy of support to producer prices that was being eliminated at that time. For my purposes, there are two features of PROCAMPO that I want to highlight. First, the elimination of pan-seasonal and pan-territorial prices in agricultural commodities implies a movement towards market prices. This means that the variation in purged unit values that I use to identify the model truly originates in price differences across clusters. Second, PROCAMPO subsidies are

⁸All data on expenditures and wages are expressed in 2002 constant prices. In Table 1, the definition of corn excludes “tortillas”.

decoupled and thus are not set on the basis on current household behavior or outcomes (like production levels). In other words, lump-sum subsidies are unlikely to affect household behavior. Further, provided PROCAMPO money is spent in the same way as other sources on income, the role of these subsidies in demand will be correctly controlled for by including total household expenditure as a regressor (Case and Deaton, 1998). There are thus good grounds to believe that the presence of PROCAMPO will not affect the estimates and the procedure developed in this paper.⁹

3.1 Household Wage Income

I begin with a discussion of the economics behind the impacts that I am estimating. Suppose that WTO negotiations succeed and that developed countries eliminate production and export subsidies as well as trade barriers on agriculture. As international prices increase, outcomes and behavior in rural households are affected. In general equilibrium, changes in product prices (corn, for instance) may bring about changes in factor prices (like wages) and in household income. I want to rationalize these ideas with a theoretical model.¹⁰

In rural areas, household members may work in local farms in exchange for a wage, may work on their own farms, or may work in agricultural activities (provision of services, sales of inputs). Income derived from all these activities is denoted by a_h and is called agricultural wage income. Wages or other incomes earned in non-agricultural activities are denoted with i_h . For simplicity, I assume that this income i_h is exogenous.¹¹ Thus, total household income x_h is given by

$$x_h = a_h + i_h.$$

⁹Notice, however, that there are instances in which PROCAMPO could affect my results. If, for instance, receiving subsidies encourages some individuals not to participate in labor markets, there might be an unmeasured effect on wages. Since I am not modeling labor supply in this paper, such effects are left for future research.

¹⁰Notice that in the econometric model, demand, quality, and agricultural wage income were jointly analyzed. However, since consumption choices can be easily modeled with well-known models of utility maximization, and quality choices can be handled with restrictions on preferences (see Appendix 1), I focus on the behavior of agricultural factor markets.

¹¹In order to derive income effects on the demand side, it is necessary to have some exogenous income and I assume that i_h plays this role (instead of adding an additional term, x_h^0 , in the equation). Although this assumption is not really necessary, it makes the empirical estimation more tractable.

I discuss how a_h is affected by a change in agricultural prices. I assume that there are two types of agricultural activities: ag^1 comprises activities related to growing crops; ag^2 , instead, are activities related to animals, such as animal husbandry or production of dairy products. There are three differentiated labor inputs in rural areas: agricultural labor of type 1 (with total supply L^1), agricultural labor of type 2 (with supply L^2), and mobile labor (with supply L^m). L^1 is specific to agricultural activities 1. This includes labor for planting, weeding, harvesting, etc. I assume there are many agricultural activities ag_j^1 in sector 1; the common feature of activities j is that they use L^1 intensively. For instance, one activity can be growing corn and another, growing fruits & vegetables. Both activities require workers with agrarian skills. Similarly, there may be several activities k in sector 2, denoted ag_k^2 . Animal husbandry, veterinary services, etc. are examples. Activities 1 and 2 share mobile labor L^m . Notice that since labor types L^1 , L^2 , and L^m are differentiated inputs, they can earn a different wage.

The production function of activity j in sector 1 is $f_j^1 = f_j^1(l_j^1, l_j^m)$, where l_j^1 is employment of specific factor 1, and l_j^m is employment of mobile labor. There may be other factors used in the production of j (such as land or capital), but I omit this discussion for simplicity. Producers of agricultural activities j in sector 1 (corn, for instance) face exogenous prices p_j^1 , which depend on international prices and domestic conditions such as transport or transaction costs. Profit maximization leads to labor demand functions

$$l_j^1 = l_j^1(w^1, w^m, \mathbf{p}),$$

where w^1 is the agricultural wage in sector 1, w^m is the agricultural wage of mobile labor, and \mathbf{p} is a vector of agricultural price products.

Labor market clearing conditions are

$$\sum_j l_j^1(w^1, w^m, \mathbf{p}) = L^1,$$

$$\sum_k l_k^1(w^2, w^m, \mathbf{p}) = L^2,$$

$$\sum_j l_j^m(w^1, w^m, \mathbf{p}) + \sum_k l_k^m(w^2, w^m, \mathbf{p}) = L^m.$$

With endogenous factor supplies, L^1 , L^2 , and L^m are a function of several determinants of labor supply, denoted by χ . In the end, agricultural wages are given by

$$(31) \quad w^r = w^r(p_1^1, \dots, p_J^1; p_1^2, \dots, p_K^2; \chi),$$

for $r = 1, 2, m$. This equation shows how the agricultural wage income of the household (which is composed of w^1 , w^2 and w^m) depends on the prices of agricultural goods.

There is one important clarification that I should make. The goal of this section is to estimate functions relating agricultural wages, a_h , with agricultural prices. In the data, households report agricultural wages without identifying the agricultural activities on which wages are earned (type 1, type 2 or mobile). This means that I will only be able to estimate the average response of agricultural income in the different agricultural activities. This will be a weighted average of the responses of w^1 , w^2 and w^m .

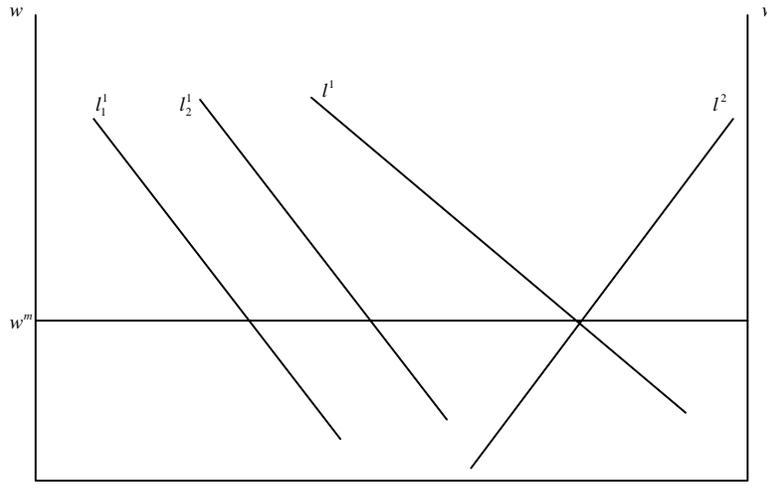
To see this, suppose that it is possible to estimate wages as a function of prices. Denote the response of the log of w^1 to the log of price g as $\beta_{w^1}^g$; similarly, let $\beta_{w^2}^g$ and $\beta_{w^m}^g$ be the elasticities of w^2 and w^m with respect to p_g , respectively. In the full model, I identified λ_g as the elasticity of a_h with respect to p_g . Since $\ln a = \mu^1 \ln w^1 + \mu^2 \ln w^2 + \mu^m \ln w^m$, it follows that

$$\lambda_g = \mu^1 \beta_{w^1}^g + \mu^2 \beta_{w^2}^g + \mu^m \beta_{w^m}^g,$$

where μ^r are weights given by the share of each type of labor on total labor supply. This equation shows that the average response of agricultural wage income can be positive or negative depending upon the relative importance of the different types of labor and the differential responses of w^1 , w^2 and w^m to prices.

Figure 2 plots the equilibrium in a standard specific factor framework. The horizontal size of the box measures L^m , the total labor supply of mobile labor. The curve labeled l^1 is the value of the marginal product of mobile labor in agricultural activities of type 1. As

Figure 2
Rural Agricultural Labor Markets



Note: The length of the horizontal box is the supply of mobile labor L^m ; its wage is w^m . The curves l_1^1 and l_2^1 represent the labor demand in activities of type 1 (which use specific labor L^1). The total demand of this specific labor is l^1 . The total labor demand in activities of type 2 is l^2 .

drawn, there are two such activities, say corn and fruits & vegetables. The curve l^2 represents the demand for mobile labor in agricultural activities of type 2. For simplicity, there is only one activity in sector 2, namely dairy.

In the Figure, I have purposely assumed a much larger demand for labor in activities 1 than in activities 2. Accordingly, an increase in prices p_1^1 or p_2^1 (the prices of corn and fruits & vegetables) would shift l^1 up, causing w^m to increase. In addition, while w^1 would increase as well, w^2 would decline. In contrast, an increase in p_1^2 (the price of dairy) would cause w^m and w^2 to increase, but w^1 to decline. In consequence, the situation plotted in Figure 2 suggests that increases in the prices of corn or fruits & vegetables would most likely cause average wage income to increase, but increases in the price of dairy would most likely cause wage income to decline. It is clear that, theoretically, anything can happen and that wage income can increase or decrease. This is, in the end, an empirical question which I address next.

Results are reported in Table 2. In column [1], I report the estimates of λ_g from a naive model that uses average cluster unit values as regressors. I find that a_{hc} is positively and

significantly associated with corn prices, with an elasticity of 0.58 and a t -statistic of 5.65.¹² Apart from the price of meat, which appears to affect wage agricultural income positively too, the remaining prices are statistically insignificant. These results suggest that the problems associated with the use of unit values as regressors in the wage equation may indeed be present. Attenuation bias due to measurement error, for instance, may be critical: all unit value regressors, except for corn and meat, are not statistically significant.

The remaining columns of Table 2 report results from the full model. In each specification and for each of the six price regressors, I report two elasticities, one for the model with exogenous expenditure in the share and unit value equations, and another for the model that uses instrumental variables in these equations. Following Deaton (1997), the standard errors are estimated with bootstrap methods by resampling the second stage and keeping constant the parameters of the first stage.

I begin by discussing the model with instrumental variables (column [2]). The prices of corn and fruits & vegetables are positively and significantly associated with household agricultural wage income. The elasticity of corn is 0.40, and that of fruits & vegetables, 1.29. In contrast, the price dairy is negatively associated with agricultural income, with an elasticity of -1.10 . There is no statistically significant effect of the prices of wheat, oils & fats, and meat.

There is an intuitive interpretation of these results. Corn and Fruits & Vegetables are arguably agricultural activities of type 1, which employ a large fraction μ^1 of the workforce. When the prices of these goods increase, the demand for mobile labor and specific labor of type 1 increase. This leads to increases in the wages of mobile labor and on the return to specific agrarian labor. When the price of dairy increases, instead, there is also an increase in the demand for mobile labor. However, this increase in w^m causes a decline in the surplus accruing to specific labor of type 1. If agrarian activities ag_j^1 are important enough, average agricultural income may decline in the end.

In column [3], I report the OLS estimates (assuming exogeneity of expenditure in the first stage estimation of the share and unit value equations). It is found that higher corn

¹²Notice that the standard errors are corrected for clustering since all households in a given cluster face the same averages for the unit values.

prices are associated with higher agricultural wage income, whereas higher prices of dairy products negatively affect agricultural income. No statistically significant effect is found in the rest of the cases, including fruits & vegetables.

Based on the estimates in Table 2, the price of corn seems to be systematically related with agricultural wage income, the relationship being positive and significant in all models. The use of average unit values as regressors in the naive model may be incorrect, however. First, dairy and fruits & vegetables have statistically significant impacts on household wage agricultural income in the Full Model. In addition, the price of meat, which is positively related with a_h in the naive model, it is no longer significant in the Full model. Since the Full method is robust to the inconsistencies that arise when using unit values as proxies for prices, the corrections of my method seem important. In one case, namely corn, the models deliver comparable elasticities; but in three out of the remaining five cases, results are significantly different.

The formulas for the joint estimator proposed in this paper are quite complex. Specifically, the full model requires the estimation of a complete system of demand and agricultural wage income, which implies a lot of work to prepare and compute the matrices of section 2. If the estimator is going to be used in the evaluation of policies, it seems important to inquire if slightly modified versions of the model can help simplify the formulas. In addition, since the model can only estimate linear regression functions for household outcomes, it may not be used in cases where the outcome involves discrete choices (such as labor supply decisions). Finally, since the model estimates a large number of parameters, there might be efficiency concerns.

A promising alternative is to assume that unit values are only affected by own prices, so that the cross-price effects in equation (14) are zero. This is, in fact, not a strong assumption, since the full model delivers, in the end, estimates of the off-diagonal elements of Ψ that are very close to zero.¹³ The diagonal elements of Ψ are instead estimated. Estimation can be carried out as in section 2, but replacing $\hat{\Psi}$ with $\tilde{\Psi}$, a diagonal matrix with the elements $\hat{\psi}_{gg}$

¹³These estimates are not reported in this paper to save some space. Similar results are obtained by Deaton and his coauthors in all their applications of the methodology to demand analysis. See Deaton (1997), Deaton and Grimard (1992), and Deaton, Parikh, and Subramanian (1994).

in the diagonal, and zero off-diagonal elements. Results are in columns [4] and [5] of Table 2. As expected, this version of the model improves the OLS estimation of the naive model and delivers estimates that are close to those in the Full model. This is because the estimates $\widehat{\psi}_{gk}$ are not significantly different from zero. Alternative 1 seems to be a good compromise between the Full model, which may be quite complicated to estimate and not be flexible enough in some applications (see Balat and Porto, 2004).

3.2 Own- and Cross-price Elasticities

There are two reasons why the elasticities estimated from the full model can differ from the elasticities in Deaton (1990) model. One issue is that the estimated expenditure elasticities and quality elasticities may be inconsistent if a fraction of household expenditure (the fraction that depends on agricultural wage income) depends on agricultural prices. The second issue is the presence of the “profit effect” the additional income effect generated by the endogenous response of household income. In this section, I assess empirically how important these problems are by comparing the results obtained from the full model with those obtained from Deaton’s model.

In Table 3, I report estimates of the expenditure elasticity (or income elasticity) of demand. I begin by discussing the estimates of β_0^g in columns [1] and [2]. Results are mixed: for corn, wheat, and dairy, the estimates from the Full and Standard Models are not too different. These differences are perhaps larger in the remaining three goods, oils & fats, meat, and fruits & vegetables. This suggests that the correction for endogeneity may be important in practice. These patterns are less evident in the case of the quality elasticity of expenditure (columns [3] and [4]), where the elasticities are not different (with the exception of meat). The estimated expenditure elasticities of demand, $\epsilon_x^g = (\beta_0^g/s_g) - \beta_1^g + 1$, are displayed in columns [5] and [6]. Notice that there are some differences in the estimated elasticities from the two models, particularly in the case of dairy.

I turn next to discuss the demand elasticities. Table 4 shows the estimates of the uncompensated (Marshallian) and compensated (Hicksian) own-price elasticities for three models. These are Deaton’s original model, the Full Model with instrumental variables, and

Alternative 1 (with $\Psi = \tilde{\Psi}$). I find that all the own-price elasticities, compensated and uncompensated, are negative and statistically significant. Comparing Deaton’s model with the Full Model, I find significant differences in the own-price elasticities for the cases of corn, dairy, and fruits & vegetables. For wheat, oils & fats, and meat, the corrections suggested here are less important. Alternative 1, which only estimates the own-price responses of unit values, produces results that are close to those of the Full Model. Standard errors are somewhat smaller, indicating that there may indeed be gains in precision in using Alternative 1 since a lower number of parameters is being estimated. Similar conclusions emerge from the study of the compensated own-price elasticities.

It is instructive to decompose the differences in the own-price elasticities between the different models. This decomposition can shed some light on the relative importance of the two factors that explain these differences. One is the correction that allows for the consistent estimation of expenditure elasticities (in demand and in unit values –or quality); the other factor is the “profit effect”. The decomposition is shown in Table 5 for the case of the uncompensated demand elasticities.

Column [1] reproduces the own-price elasticities from Deaton’s model with exogenous expenditure. In column [2], I isolate the effects of the potential inconsistencies in the estimation of β_0^q and β_1^q that would arise if household income were endogenous. To do this, I reestimate Deaton’s model (without the wage equation) using instrumental variables for household expenditure. The role of the “profit effect” can be illustrated by comparing columns [2] and [3], instead. In the case of corn, the two corrections of this paper decrease the estimated elasticity. The correction for the endogeneity of x_h is less important than the “profit effect.” In the case of dairy, the corrections of the paper drive the elasticity up, from -1.28 to -1.39 , due to endogeneity, and further up to -2.29 , due to the profit effect. It follows that most of the differences in the estimated elasticities is explained by this last effect – intuitively, an increase in the price of dairy (which reduces consumption) reduces agricultural wage income (with an elasticity of -1.1 in Table 2) and causes a negative income effect that pulls consumption of dairy further down. An interesting case is fruits & vegetables, where the correction for endogeneity is not really important but the addition

of the profit effect renders the demand elasticity statistically insignificant. This is because the increase in the price of fruits & vegetables has a strong wage effect, and thus a strong positive income effect.

To better understand the role played by the “profit effect”, notice that the additional income effects caused by the response of household income to prices have two effects on consumer choices. First, by facing changed incomes, households modify consumption choices according to the expenditure elasticity. Second, consumers modify their quality choices according to the quality elasticity of expenditure. This means, first, that there is an additional term in the income effects in demand, and, second, that there is an income effect on quality choices (the third term on the right hand side of (28)).

I separate these two effects in the last two columns of Table 5. In column [4], I correct the matrix Ψ in (28) by including the term $b_a D(\xi) D(\mathbf{s}) \mathbf{1}_G \otimes \lambda'$, but I exclude the term $b_a \mathbf{1}_G \otimes \lambda$ in equation (29). This term is computed in column [5]. It is observed that the additional income effect in consumption generated by the profit effect is much more important than the quality shading effect of the additional income. Indeed, in column [4], all the effects are small.

For completeness, I report the full set of own- and cross-price compensated and uncompensated demand elasticities for the full model in Table 6. The cross-price elasticities are generally small, and not always statistically significant. This result is in line with those reported in many previous studies and summarized in Deaton (1997).

4 Net Consumers and Net Producers

In this section, I use the estimated elasticities to assess the role of consumption and income responses in the evaluation of the welfare effects of a price change. Since the pioneering work of Deaton (1989) in Thailand, it is customary to state that, after a price increase, net consumers will be hurt while net producers will be benefited. The opposite happens after a drop in prices. I argue here that, while this prediction is true in a static scenario, it may be misleading in a more dynamic setting where households can adjust consumption and

income. In this case, the net position of the household is endogenously determined. Indeed, if household responses are large enough, it is possible for some net consumers to become net producers and be actually benefited by the price increase.

I illustrate these scenarios by exploring the corn sector, a key commodity produced in rural Mexico. For the sake of exposition only, I work with an increase in the price of corn.¹⁴ Following the usual practice in this literature (Deaton, 1989; 1997), I define the welfare effects of the price change as the compensating variation expressed as a share of total household expenditure. In Figure 3, the average welfare effects are plotted against the log of household per capita expenditure. The averages are estimated non-parametrically with locally (kernel) weighted regressions. The static impact of the price increase is given by the difference between the share of income from corn production and the share of corn expenditure in total consumption. I plot this difference with a solid line. As expected, households at the bottom of the income distribution are net consumers and households at the top are net producers of corn. In consequence, a price increase hurts the poor but benefits the rich.

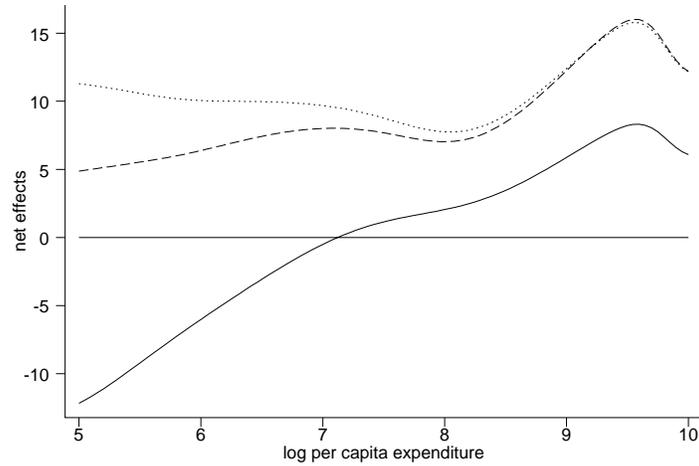
I turn now to income responses. I plot the welfare effects with a broken line. Here, income responses are allowed but consumption choices are kept constant. In my model, this means that the agricultural wage income of the household, including corn production and wages from local agricultural markets, react to the increase in the price of corn. This response is characterized by the income shares of agricultural wages and the elasticity of 0.4 reported in Table 2. Instead, consumption impacts are still measured with budget shares. In this scenario, an increase in corn prices would benefit households across the entire income distribution. The intuition is that agricultural income and agricultural wages are responding to the price increase.

To account for consumption responses, I estimate first and second order impacts using the corn budget share and the own-price elasticity.¹⁵ In Figure 3, I graph these welfare

¹⁴The increase in prices may be due to liberalization of corn world markets (as in the Doha development round), or other factors (like domestic agricultural reforms). There are two important issues regarding these price changes: the actual price change induced by the reforms (like Doha) and the pass-through rate to farmers. Even with credible estimates of price increases, segmentation of domestic markets may cushion farmers from international markets. These are important issues, but they are not the topic of the present paper.

¹⁵For simplicity, cross price effects are not computed. Although it is easy to do so given the cross-price

Figure 3
Net Consumers and Net Producers
Corn in Rural Mexico



Note: The lines represent the average welfare effects (compensating variations) as a share of household expenditure. The averages are estimated with non-parametric locally weighted regression using a Gaussian kernel and a bandwidth equal to 0.5. The solid line displays the first order effects given by the difference between corn budget shares and corn income shares. The broken lines allows for income responses and the dotted line, for income and consumption responses.

effects with a dotted line. It is clear that allowing for consumption responses makes the gains even higher. The reason is that consumers reduce quantities when prices increase so that consumption losses are in the end ameliorated. Notice also that the adjustment of consumption generates larger gains at the bottom of the income distribution. This is because corn is one of the major staples of the poor and the adjustment of quantities thus makes a larger difference for them.

5 Conclusions

This paper has introduced an empirical model designed to be used in the evaluation of price reforms. These reforms affect households both as consumers and as producers or income earners. Studying consumption effects is relatively straightforward. Budget shares can be used to approximate first order effects. Deaton's methods (Deaton, 1987, 1988, and 1990)

elasticities that I have estimated, the simpler approach of Figure 3 is, I believe, much clearer.

can be used to estimate demand elasticities and second order effects.

The estimation of labor income effects is harder due to lack of price variability at the household level. The simple idea of using unit values as a proxy for prices, which would deliver enough price variation, is problematic because of endogeneity of unit values, biases due to proxy variables, and measurement error. In this paper, I have proposed a method that uses unit values as measures of prices, but that is free from these problems. The method combines Deaton's model of demand with an equation that describes the agricultural wage income of the household. By estimating the demand model together with the quality shading model, I was able to extract the right price signal from unit value data. These data can then be plugged into the wage equation to identify the relevant elasticities.

When a fraction of household income is allowed to be endogenous, there are additional effects to consider in the estimation of the demand parameters. First, there is the "profit effect" whereby a change in an agricultural price causes a change in household income and additional income effects in consumption. Second, the change in household income brings about further quality shading responses that affect the elasticities of demand. In this paper, I have derived formulas to correct for these factors.

The method was applied to the estimation of consumption and agricultural wage income responses to agricultural prices in rural Mexico. It was found that the corrections suggested in this paper can make a difference and should be preferred to a simpler model that uses average cluster unit values as regressors. Failing to control for endogeneity, biases, and measurement errors may lead to inconsistent estimates of the price elasticities and to an incorrect or misleading evaluation of policy changes. In addition, I have assessed the role of consumption and income responses in the evaluation of trade reforms. I have shown that the proposition that net consumers will be hurt by price increases whereas net producers will be benefited is only true in a static scenario. When consumers adjust quantities, farmers adjust production, and local labor markets react to the changed prices, so that net consumers can become net producers, thus benefiting from price increases. Data from rural Mexico support these findings.

Appendix 1: Quality Model

This Appendix describes the model of quantity and quality used in the paper to extract price information from unit values. Within aggregates of goods, such as corn, there are different varieties that a consumer can choose. Low quality corn would comprise whole grain maize or badly grinded grains. High quality corn may comprise, for example, high-quality, finely-grinded maize meal. Unit values are not the same as prices because households choose quantity and quality simultaneously. In order to derive the formulas used in the text, I need to develop a model of consumer choices (allowing for a choice of quantity and quality) and I need to specify a suitable definition of quality. To do this, I follow Deaton (1987, 1988, 1990).

Let g be a group of goods, such as corn. This group comprises many varieties of homogenous goods, with price vector in cluster c denote by \mathbf{p}_{cg} . Since each good within group g is homogenous, the elements of \mathbf{p}_{cg} represent true prices, not unit values. For a typical household in cluster c , there is a quantity vector \mathbf{q}_{cg} , such that total expenditure on corn is $x_{cg} = \mathbf{p}_{cg}\mathbf{q}_{cg}$. I assume that the price vector \mathbf{p}_{cg} can be decomposed into an aggregate price level of corn, π_{cg} and a vector of relative prices \mathbf{p}_g^0

$$\mathbf{p}_{cg} = \pi_{cg}\mathbf{p}_g^0.$$

This requires the existence of a linearly homogeneous function $\pi_{cg}(\mathbf{p}_{cg})$ such as a standard price index with fixed weights. Notice that aggregate prices are allowed to vary across clusters c while the relative prices are held constant.

The definition of quality adopted here is based on a comparison of relative prices: more expensive goods are assumed to be higher quality goods. To make this definition more precise, let Q_{cg} be the quantity consumed of the aggregate good g (i.e. corn). I assume that $Q_{cg} = \mathbf{k}_g\mathbf{q}_{cg}$, where \mathbf{k}_g is defined in such a way that it is possible to aggregate the quantities consumed of the homogenous goods in \mathbf{q}_{cg} . As an example, let \mathbf{q}_{cg} be measured in kilos, and \mathbf{k}_g be a vector of ones. Then, Q_{cg} is just the total kilograms of corn consumed by the household. Quality ξ_{cg} is defined as

$$\xi_{cg} = \frac{\mathbf{p}_g^0\mathbf{q}_{cg}}{\mathbf{k}_g\mathbf{q}_{cg}}.$$

This definition implies that quality is higher when there is a higher quantity consumed of the more expensive goods. In fact, the price per kilo of corn variety i is p_{gi}^0/k_{gi} , and varieties with higher ratios are higher-quality varieties. This last assumption is needed to justify the definition of quality. In this model, thus, expenditure can be written as the product of quantity Q_{cg} , price π_{cg} , and quality ξ_{cg} .

To close the quality model, I need to impose some structure in preferences, which are henceforth assumed to be separable in the different aggregates of goods. This means that demands within good g are given by

$$\mathbf{q}_{cg} = f_g(x_{cg}, \mathbf{p}_{cg}) = f_g\left(\frac{x_{cg}}{\pi_{cg}}, \mathbf{p}_g^0\right).$$

Quality is a function of quantities \mathbf{q}_{cg} , reference prices \mathbf{p}_g^0 , and the quantity aggregator \mathbf{k}_g . Since \mathbf{p}_g^0 and \mathbf{k}_g are held constant, ξ_{cg} is a function of the ratio x_{cg}/π_{cg} . That is,

$$\xi_{cg} = \xi_{cg} \left(\frac{x_{cg}}{\pi_{cg}}, \mathbf{p}_g^0 \right).$$

This implies that

$$(A1) \quad \frac{\partial \ln \xi_g}{\partial \ln \pi_k} = \frac{\partial \ln \xi_g}{\partial \ln x_g} \left(\frac{\partial \ln x_g}{\partial \ln \pi_k} - \delta_{gk} \right),$$

where δ_{gk} is the Kronecker delta.

Differentiating $\ln x_g = \ln \pi_g + \ln \xi_g + \ln Q_g$ with respect to $\ln \pi_g$, it follows that

$$(A2) \quad \frac{\partial \ln x_g}{\partial \ln \pi_g} - 1 = \frac{\partial \ln \xi_g}{\partial \ln \pi_g} + \epsilon_p^{gg}.$$

Replacing (A2) in (A1), I get

$$(A3) \quad \frac{\partial \ln \xi_g}{\partial \ln \pi_g} = \frac{\epsilon_p^{gg} \frac{\partial \ln \xi_g}{\partial \ln x_g}}{1 - \frac{\partial \ln \xi_g}{\partial \ln x_g}}.$$

By definition, the expenditure elasticity of quality is

$$(A4) \quad \beta_1^g = \frac{\partial \ln \xi_g}{\partial \ln x} = \frac{\partial \ln \xi_g}{\partial \ln x_g} \frac{\partial \ln x_g}{\partial \ln x}.$$

Using once again the equality $\ln x_g = \ln \pi_g + \ln \xi_g + \ln Q_g$, I get

$$(A5) \quad \frac{\partial \ln x_g}{\partial \ln x} = \beta_1^g + \epsilon_x^g.$$

Replacing (A4) and (A5) in (A3), I get

$$(A6) \quad \frac{\partial \ln \xi_g}{\partial \ln \pi_g} = \beta_1^g \frac{\epsilon_p^{gg}}{\epsilon_x^g}.$$

If the same steps are applied to a change in the price of good k , (A2) is

$$(A7) \quad \frac{\partial \ln x_g}{\partial \ln \pi_k} = \frac{\partial \ln \xi_g}{\partial \ln \pi_k} + \epsilon_p^{gk},$$

and (A3) is

$$(A8) \quad \frac{\partial \ln \xi_g}{\partial \ln \pi_k} = \frac{\epsilon_p^{gk} \frac{\partial \ln \xi_g}{\partial \ln x_g}}{1 - \frac{\partial \ln \xi_g}{\partial \ln x_g}}.$$

Replacing (A6) in (A8), I get

$$(A9) \quad \frac{\partial \ln \xi_g}{\partial \ln \pi_k} = \beta_1^g \frac{\epsilon_p^{gk}}{\epsilon_x^g}.$$

Now, remember that unit values are the product of price and quality, ($\ln v_g = \ln \pi_g + \ln \xi_g$); differentiating with respect to $\ln \pi_g$ and $\ln \pi_k$, and using (A8) and (A9), it follows that

$$(A10) \quad \psi_{gg} = 1 + \beta_1^g \frac{\epsilon_p^{gg}}{\epsilon_x^g},$$

and

$$(A11) \quad \psi_{gk} = \beta_1^g \frac{\epsilon_p^{gk}}{\epsilon_x^g}.$$

To end, we need to write the restriction imposed by the assumption of separable preferences in terms of the parameters of the model. Unit value, the ratio of expenditure and reported quantity, is given by $v_{cg} = x_{cg}/Q_{cg}$. Differentiating with respect to the price of good k , I get

$$(A12) \quad \psi_{gk} = \frac{\partial \ln x_g}{\partial \ln \pi_k} - \epsilon_p^{gk}.$$

Expenditure on good g is equal to the budget share s_g times total expenditure x , or $\ln x_g = \ln s_g + \ln x$. This means that

$$(A13) \quad \frac{\partial \ln x_g}{\partial \ln \pi_k} = (\theta_{gk}/s_g) + b_a \lambda_k,$$

where θ_{gk} is the cross-price elasticity of budget shares and $b_a \lambda_k$ captures the change in total expenditure caused by the factor income effects of higher prices (see text). Replacing (A12) and (A13) in (A10), it follows that

$$(A14) \quad \psi_{gk} = \frac{\theta_{gk}}{s_g} + b_a \lambda_k - \epsilon_p^{gk}.$$

Next, differentiating the unit value with respect to total expenditure, I get

$$\frac{\partial \ln v_g}{\partial \ln x} = \frac{\partial \ln x_g}{\partial \ln x} - \frac{\partial \ln Q_g}{\partial \ln x}.$$

It follows that

$$(A15) \quad \beta_1^g = \frac{\beta_0^g}{s_g} + 1 - \epsilon_x^g.$$

Equation (27) in the text follows from the combination of (A10), (A11), (A14), and (A15).

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Table 1
Summary Statistics

	1994	1996	1998	2000
Sample Sizes				
households	5007	4684	3925	3306
clusters	275	269	277	274
Corn				
avg. budget share	8.0	10.8	9.5	6.4
avg. log unit value	0.20	0.82	1.18	1.40
number of obs. in eq (3)	3128	3127	2693	2364
Wheat				
avg. budget share	3.0	3.5	3.1	2.4
avg. log unit value	1.47	2.24	2.38	2.54
number of obs. in eq (3)	3657	3415	2816	2491
Dairy				
avg. budget share	3.3	3.6	3.8	3.1
avg. log unit value	1.55	2.01	2.38	2.54
number of obs. in eq (3)	2348	2254	1947	1881
Oils & Fats				
avg. budget share	2.0	2.5	2.2	1.4
avg. log unit value	1.33	2.23	2.30	2.31
number of obs. in eq (3)	2615	2681	1911	1710
Meat				
avg. budget share	7.4	6.8	6.9	5.6
avg. log unit value	2.36	2.91	3.22	3.33
number of obs. in eq (3)	3038	2905	2436	2330
Fruits & Vegetables				
avg. budget share	11.8	12.1	13.2	9.1
avg. log unit value	1.16	1.66	2.11	2.10
number of obs. in eq (3)	4367	4222	3435	2950
Agricultural Wages				
avg. (log)	6.65	6.41	6.44	6.45
share of total income	62.0	61.1	62.3	59.2
number of obs. in eq (4)	2923	2597	1937	1607
Avg. per capita expend. (log)	6.28	6.21	6.14	6.54
Household size	5.1	5.2	4.7	4.6
Males	50.6	50.2	50.1	50.1
≤ 16 yrs.	39.2	38.5	35.5	34.9
> 16 & ≤ 60 yrs.	48.8	49.4	49.7	49.8
> 60 yrs.	12.0	12.1	14.9	15.2
Years of education	3.0	3.5	3.4	3.5

Note: Own calculations based on the Encuesta Nacional de Ingreso y Gasto de los Hogares (ENIGH).

Table 2
Applying the Methodology

	Naive	Full Model		Alternative 1	
	Model	IV	OLS	IV	OLS
	(1)	(2)	(3)	(4)	(5)
Corn	0.58 (0.10)	0.40 (0.19)	0.64 (0.20)	0.39 (0.19)	0.67 (0.21)
Wheat	-0.05 (0.13)	-0.28 (0.19)	-0.26 (0.18)	-0.37 (0.17)	-0.29 (0.16)
Dairy	-0.07 (0.06)	-1.10 (0.18)	-0.59 (0.15)	-1.08 (0.19)	-0.59 (0.14)
Oils & Fats	-0.01 (0.30)	-0.48 (0.65)	-0.78 (0.53)	-0.44 (0.63)	-0.72 (0.51)
Meat	0.45 (0.20)	-0.45 (0.27)	-0.09 (0.28)	-0.42 (0.25)	-0.05 (0.27)
Fruits & Vegetables	0.10 (0.18)	1.29 (0.47)	0.43 (0.41)	1.31 (0.49)	0.43 (0.41)

(1) Naive model with average cluster unit values (standard errors are cluster corrected)

(2) Full Model using instrumental variables

(3) Full Model using OLS

(4) and (5) Alternative 1: $\tilde{\Psi} = D(\text{vecdiag}(\hat{\Psi}))$

All models include additional controls, such as demographics, education, age, gender and year dummies. The standard errors (in parenthesis) for the models in columns (2) to (5) are computed by bootstrapping the second stage.

Table 3
Expenditure Elasticities

	β_0		β_1		ϵ_x		Average Budget Share (7)
	Deaton (1)	Full Model (2)	Deaton (3)	Full Model (4)	Deaton (5)	Full Model (6)	
Corn	-0.041 (0.001)	-0.042 (0.004)	0.094 (0.008)	0.126 (0.050)	0.441	0.396	0.088
Wheat	-0.006 (0.001)	-0.009 (0.002)	0.064 (0.008)	0.087 (0.025)	0.721	0.614	0.030
Dairy	-0.001 (0.001)	-0.004 (0.003)	0.019 (0.020)	-0.018 (0.068)	0.964	0.903	0.035
Oils & Fats	-0.007 (0.0002)	-0.015 (0.001)	0.018 (0.005)	-0.006 (0.016)	0.632	0.290	0.020
Meat	0.011 (0.001)	0.001 (0.004)	0.075 (0.006)	0.113 (0.019)	1.089	0.906	0.064
Fruits & Vegetables	-0.045 (0.001)	-0.055 (0.004)	0.009 (0.006)	0.015 (0.040)	0.598	0.505	0.115

(1) and (2) Expenditure elasticity of budget shares (β_0) for Deaton and Full Model

(3) and (4) Quality Elasticity (β_1) for Deaton and Full Model

(5) and (6) Expenditure elasticity of demand (ϵ_x) for Deaton and Full Model

(7) Average budget Share in the sample

Standard errors in parenthesis

Table 4
 Compensated and Uncompensated Own-Price Elasticities
 Deaton Model and Full Model with Instrumental Variables

	Uncompensated			Compensated		
	Deaton	Full Model	Alt. 1	Deaton	Full Model	Alt. 1
	(1)	(2)	(3)	(4)	(5)	(6)
Corn	-0.92 (0.05)	-0.65 (0.09)	-0.66 (0.09)	-0.88 (0.05)	-0.61 (0.09)	-0.62 (0.09)
Wheat	-1.34 (0.09)	-1.44 (0.13)	-1.44 (0.11)	-1.32 (0.09)	-1.43 (0.13)	-1.43 (0.12)
Dairy	-1.28 (0.12)	-2.29 (0.24)	-2.12 (0.23)	-1.24 (0.12)	-2.28 (0.24)	-2.11 (0.23)
Oils & Fats	-0.77 (0.34)	-1.07 (0.63)	-1.04 (0.64)	-0.76 (0.34)	-1.07 (0.63)	-1.03 (0.64)
Meat	-1.35 (0.22)	-1.46 (0.24)	-1.46 (0.23)	-1.28 (0.22)	-1.42 (0.25)	-1.42 (0.24)
Fruits & Vegetables	-0.90 (0.13)	-0.12 (0.30)	-0.10 (0.32)	-0.83 (0.13)	-0.01 (0.31)	0.00 (0.33)

Note: Deaton Model is based on Deaton (1990). The Full Model is estimated with instrumental variables. Alternative 1 uses $\tilde{\Psi} = D(\text{vecdiag}(\hat{\Psi}))$. Standard errors in parenthesis.

Table 5
 Decomposition of Uncompensated Own-Price Elasticities
 Deaton Model and Full Model with Instrumental Variables

	Deaton	Endogeneity of hh income	Full Model	Profit Effect	
				Quality Effect	Income Effect
	(1)	(2)	(3)	(4)	(5)
Corn	-0.92 (0.05)	-0.83 (0.04)	-0.65 (0.09)	-0.06 (0.03)	0.24 (0.12)
Wheat	-1.34 (0.09)	-1.24 (0.08)	-1.44 (0.13)	0.03 (0.02)	-0.23 (0.12)
Dairy	-1.28 (0.12)	-1.39 (0.14)	-2.29 (0.24)	-0.23 (0.05)	-0.67 (0.11)
Oils & Fats	-0.77 (0.34)	-0.80 (0.38)	-1.07 (0.63)	0.01 (0.03)	-0.29 (0.40)
Meat	-1.35 (0.22)	-1.23 (0.19)	-1.46 (0.24)	0.05 (0.03)	-0.28 (0.17)
Fruits & Vegetables	-0.90 (0.13)	-0.86 (0.13)	-0.12 (0.30)	-0.04 (0.02)	0.79 (0.29)

Note: Estimates based on the Full model with instrumental variables.

Table 6
Uncompensated and Compensated Own- and Cross-Price Elasticities
Full Model with Instrumental Variables

	Corn	Wheat	Dairy	Oils & Fats	Meat	Fruits & Vegetables
(a) Uncompensated Elasticities						
Corn	-0.65 (0.09)	0.33 (0.13)	0.95 (0.26)	0.24 (0.18)	0.04 (0.12)	0.13 (0.12)
Wheat	0.00 (0.11)	-1.44 (0.13)	-0.05 (0.28)	-0.96 (0.17)	-0.16 (0.13)	-0.30 (0.12)
Dairy	-0.34 (0.09)	-0.55 (0.11)	-2.29 (0.24)	-0.87 (0.16)	-0.63 (0.13)	-0.76 (0.12)
Oils & Fats	-0.37 (0.32)	-0.00 (0.41)	-0.38 (0.85)	-1.07 (0.63)	-0.39 (0.50)	-0.00 (0.45)
Meat	-0.30 (0.15)	-0.21 (0.18)	0.31 (0.38)	-0.14 (0.27)	-1.46 (0.24)	-0.09 (0.20)
Fruits & Vegetables	0.54 (0.24)	0.66 (0.29)	0.86 (0.64)	1.41 (0.43)	1.29 (0.32)	-0.12 (0.30)
(b) Compensated Elasticities						
Corn	-0.61 (0.09)	0.38 (0.13)	1.03 (0.27)	0.27 (0.18)	0.13 (0.13)	0.19 (0.12)
Wheat	0.01 (0.11)	-1.43 (0.13)	-0.04 (0.28)	-0.96 (0.17)	-0.14 (0.14)	-0.30 (0.12)
Dairy	-0.35 (0.10)	-0.54 (0.12)	-2.28 (0.24)	-0.86 (0.16)	-0.64 (0.13)	-0.78 (0.12)
Oils & Fats	-0.38 (0.33)	0.00 (0.42)	-0.37 (0.86)	-1.07 (0.63)	-0.39 (0.51)	-0.01 (0.47)
Meat	-0.29 (0.16)	-0.18 (0.18)	0.36 (0.39)	-0.13 (0.27)	-1.42 (0.25)	-0.08 (0.20)
Fruits & Vegetables	0.61 (0.24)	0.74 (0.29)	0.98 (0.65)	1.44 (0.44)	1.44 (0.33)	-0.01 (0.31)

Note: Estimates based on the Full model with instrumental variables. Standard errors in parenthesis.