Household Welfare and Multi-Commodity Price Risk: Evidence from Rural Ethiopia

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SCC-75 Conference
March 19-21, 2009
Galveston, TX

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Introduction

- Governments have often tried to stabilize commodity prices using buffer stocks, administrative pricing, variable tariffs, marketing boards, etc.

- Given the policy importance of the question, and although economists have commonly questioned the net benefit of price stabilization interventions (Newbery and Stiglitz, 1981; Krueger et al., 1988; Knudsen and Nash, 1990), our theoretical toolkit for understanding welfare w.r.t. price risk is limited.

- When studying risk, economists have almost always focused on *income* risk aversion.

- The effects of price risk on producer behavior have been studied theoretically by Baron (1970) and Sandmo (1971).

- The theoretical analysis has been extended to individuals (Deschamps, 1973; Hanoch, 1977; Turnovsky et al., 1980; Newbery and Stiglitz, 1981; Newbery, 1989; Besley, 1989) and to agricultural households (Finkelshtain and Chalfant, 1991 and 1997).

- Empirically, Barrett (1996) has looked at the effects of price risk over a single commodity.

- In this paper, we study price risk aversion over *multiple* commodities both theoretically and empirically.

Why Should We Care?

- Prices tend to fluctuate together.

- The welfare consequences of price fluctuations may be over- or underestimated by focusing only on a single price change.

- One may also wish to make transfers to compensate individuals and households for price fluctuations.

- So if $V(p, y)$ is the indirect utility function, we know what V_{yy} looks like. But what does V_{pp} look like? What are its properties?

- More importantly, can we estimate V_{pp} and use it to formulate policy recommendations?

Outline

1. Theoretical Framework
2. Empirical Framework
3. Descriptive Statistics
4. Estimation Results and Hypothesis Tests
5. Discussion
6. Conclusion

Theoretical Framework

The basic framework is the unitary agricultural household model (Singh et al., 1986).

We consider a two-period model in which product prices are unknown *ex ante* (i.e., when production decisions are made), but known *ex post* (i.e., when consumption decisions are made).

By Epstein's (1975) duality result, we can use the household's indirect utility function $V(\cdot)$, which is homogeneous of degree zero in prices p and income y.

We derive the matrix V_{pp}, which is such that

$$V_{p_i p_j} = \frac{M_i V_y}{p_j}[\beta_j(\eta_j - R) + \epsilon_{ij}], \text{ and where} \quad (1)$$

- M_i is the marketable surplus of i;
- p_j is the price of j;
- β_j is the budget share of j;
- η_j is the income elasticity of the marketable surplus of j;
- R is the household's coefficient of relative risk aversion; and
- ϵ_{ij} is the elasticity of the marketable surplus of i with respect to p_j.

By Young's Theorem, $V_{p_i p_j} = V_{p_j p_i}$ for all i and j, i.e., the matrix V_{pp} is *symmetric*.

The problem is that we don't observe V_y. But multiplying V_{pp} by $-\frac{1}{V_y}$ yields the matrix A of price risk aversion coefficients

$$A = \begin{bmatrix} A_{11} & \cdots & A_{K1} \\ \vdots & \ddots & \vdots \\ A_{1K} & \cdots & A_{KK} \end{bmatrix}, \quad (2)$$

where the (off-) diagonal terms represent (cross-) own-price risk aversion, and where

$$A_{ij} = -\frac{M_i}{p_j}[\beta_j(\eta_j - R) + \epsilon_{ij}], \quad (3)$$

is expressed in terms of observables and estimable parameters, except for R.

If $A_{ij} > 0$, the household is affected adversely by co-movements in the prices of commodities i and j. If $A_{ii} > 0$, the household is affected adversely by fluctuations in the price of commodity i.

The innovation the estimation of the off-diagonal elements: the previous empirical literature on price risk focused on estimating a single diagonal element.

Moreover,

- Relationship with Slutsky substitution matrix is *not* one-to-one

- Symmetry of A is equivalent to Slutsky symmetry, but the latter is easier to reject than the former.

- Willingness to pay to stabilize prices:

$$WTP_i \approx \frac{1}{2}\sigma_i^2 A_{ii} + \sum_{j \neq i} \sigma_{ij} A_{ij} \tag{4}$$

  for commodity i, and

$$WTP \approx \frac{1}{2}\sum_i \sum_j \sigma_{ij} A_{ij} \tag{5}$$

  for $K > 1$ commodities.

Data and Descriptive Statistics

We use the 1989, 1994a, 1994b, and 1995 rounds of the Ethiopian Rural Household Survey data (Dercon and Krishnan, 1998).

We chose the ERHS because it records household consumption and production of several commodities and has a low attrition rate.

The sample includes 1471 households with an attrition rate of around 2 percent.

In what follows, we consider up to seven commodities: (i) maize; (ii) coffee; (iii) barley; (iv) cooking oil; (v) wheat; (vi) beans; and (vii) sorghum.

Empirical Framework

The structural form is $M_i = s_i(z, p) - x_i(p, y)$, so we estimate the following marketable surplus equation for each commodity:

$$\begin{aligned} M_{ik\ell t} &= \alpha_i + \delta_i \ln y_{ik\ell t} + \phi_i \ln p_{ik\ell t} \\ &\quad + \varphi_i p_{jk\ell t} + \lambda_{ik\ell} + \tau_{i\ell t} + \nu_{ik\ell t} \end{aligned} \qquad (6)$$

where

- i denotes the commodity;
- k denotes the household;
- ℓ denotes the *woreda*;
- t denotes the time period;

$$
\begin{aligned}
M_{ik\ell t} &= \alpha_i + \delta_i \ln y_{ik\ell t} + \phi_i \ln p_{ik\ell t} \\
&\quad + \varphi_i p_{jk\ell t} + \lambda_{ik\ell} + \tau_{i\ell t} + \nu_{ik\ell t} \qquad (6)
\end{aligned}
$$

- y is household income net of revenue from commodity i;

- p_i and p_j are the prices of commodity i and the price of other commodities, respectively;

- λ is a household-*woreda* fixed effect;

- and τ is a *woreda*-round fixed effect included to imperfectly control for input prices.

This is estimated over 1471 households over three rounds and three seasons, for an unbalanced panel of 8722 observations, with an average of 5.9 observations per household.

The computation of the price- and income-elasticities necessary to estimate price risk aversion coefficients is such that $\widehat{\beta}_j = \frac{M_j p_j}{y}$; $\widehat{\eta}_j = \frac{\widehat{\delta}_i}{M_j}$; $\widehat{\epsilon}_{ii} = \frac{\widehat{\phi}_i}{M_i}$; and $\widehat{\epsilon}_{ij} = \frac{\widehat{\varphi}_i}{M_i}$. One can then combine these estimates to obtain

$$\widehat{A}_{ij} = -\frac{M_i}{p_j}[\widehat{\beta}_j(\widehat{\eta}_j - R) + \widehat{\epsilon}_{ij}]. \quad (7)$$

Caveats

1. In order to estimate mean elasticities (and not elasticities at means), we add 0.001 to every variable so as to avoid introducing selection bias by dropping observations for which $M_i = 0$ (MaCurdy and Pencavel, 1986).

2. Relative risk aversion R cannot be directly estimated in these data, so we estimate everything for $R \in \{1, 2, 3\}$, which are credible values based on the previous literature (Friend and Blume, 1975; Hansen and Singleton, 1982; Chavas and Holt, 1993; and Saha et al., 1994).

3. Due to the low power of the symmetry test, we test the symmetry of sub-matrix A for three, four, five, six, and seven commodities and for three possible values of R for a total of 15 robustness checks.

Table 1: Descriptive Statistics for the Dependent Variables (Full Sample)

Crop	Mean	(Std. Dev.)	Observations	Nonzero Observations
Maize Marketable Surplus (Kg)	63.83	(895.00)	8722	1763
Coffee Marketable Surplus (Kg)	1.08	(44.70)	8722	1534
Barley Marketable Surplus (Kg)	87.33	(553.69)	8722	1504
Cooking Oil Marketable Surplus (Kg)	-4.41	(21.77)	8722	1333
Wheat Marketable Surplus (Kg)	33.57	(325.15)	8722	993
Beans Marketable Surplus (Kg)	4.37	(178.43)	8722	733
Sorghum Marketable Surplus (Kg)	59.15	(503.34)	8722	625

Note: Although teff figures prominently in the average household's buying and selling behavior and 1089 households had a nonzero marketable surplus of teff, we omit this commodity from our analysis given that its price was always dropped from each marketable surplus equation due to collinearity.

Table 2: Descriptive Statistics for the Dependent Variables (Nonzero Observations)

Crop	Net Buyer Mean Marketable Surplus	(Std. Dev.)	Net Buyer Observations	Net Seller Mean Marketable Surplus	(Std. Dev.)	Net Seller Observations
Maize (Kg)	-309.48	(738.52)	895	960.46	(2552.17)	868
Coffee (Kg)	-16.96	(24.75)	1194	87.31	(201.53)	340
Barley (Kg)	-236.06	(869.29)	518	896.56	(1245.50)	986
Cooking Oil (Kg)	-28.87	(48.96)	1333	–	–	0
Wheat (Kg)	-90.29	(173.222)	664	1072.07	(1269.221)	329
Beans (Kg)	-108.19	(246.32)	576	639.98	(1049.71)	157
Sorghum (Kg)	-452.64	(703.63)	236	1600.95	(1667.06)	389

Table 3: Descriptive Statistics for the Independent Variables

Crop	Mean	(Std. Dev.)
Prices		
Maize (Birr/Kg)	1.22	(0.34)
Coffee (Birr/Kg)	12.21	(4.95)
Barley (Birr/Kg)	1.43	(0.37)
Cooking Oil (Birr/Kg)	1.65	(1.00)
Wheat (Birr/Kg)	1.66	(0.31)
Beans (Birr/Kg)	1.80	(0.42)
Sorghum (Birr/Kg)	1.46	(0.40)
Potatoes (Birr/Kg)	1.45	(0.71)
Onions (Birr/Kg)	1.86	(0.71)
Cabbage (Birr/Kg)	0.86	(0.66)
Milk (Birr/Liter)	1.96	(0.82)
Tella (Birr/Liter)	0.67	(0.25)
Sugar (Birr/Kg)	5.71	(1.98)
Income		
Income (Birr)	498.52	(2633.17)
Nonzero Income (Birr)	773.00	(3246.47)
Budget Shares		
Budget Share of Maize	0.17	(2.66)
Budget Share of Coffee	0.06	(0.69)
Budget Share of Barley	0.21	(1.59)
Budget Share of Cooking Oil	0.00	(0.01)
Budget Share of Wheat	0.04	(0.48)
Budget Share of Beans	0.02	(0.50)
Budget Share of Sorghum	0.12	(1.01)

Note: Income (i.e., the sum of off-farm income, all crop revenues, and livestock sales) was different from zero for only 5625 observations, so budget shares are computed for that sub-sample.

Table 4: Variance-Covariance Matrix of Commodity Prices

	Maize	Coffee	Barley	Cooking Oil	Wheat	Beans	Sorghum
Maize	**0.119**						
Coffee	0.354	**24.483**					
Barley	0.022	0.413	**0.135**				
Cooking Oil	0.092	0.150	-0.009	**0.999**			
Wheat	0.024	0.277	0.044	-0.045	**0.098**		
Beans	0.043	0.466	-0.023	0.090	0.049	**0.177**	
Sorghum	0.039	0.306	0.057	-0.046	0.056	-0.003	**0.164**

Table 5: Marketable Surplus Equations for Seven Commodities Over Four Rounds (continued on next page)

	(1)		(2)		(3)	
Dependent Variable:	**Maize Marketable Surplus**		**Coffee Marketable Surplus**		**Barley Marketable Surplus**	
Coefficients	**Coefficient**	**(Std. Err.)**	**Coffee**	**(Std. Err.)**	**Barley**	**(Std. Err.)**
Maize Price	**189.319*** **	**(3.018)**	-8.074***	(0.202)	-71.000***	(2.770)
Coffee Price	56.681***	(3.385)	**-1.891*** **	**(0.218)**	81.732***	(0.160)
Barley Price	36.990***	(2.949)	4.959***	(0.114)	**62.720*** **	**(0.280)**
Cooking Oil Price	-263.941***	(1.260)	-7.066***	(0.049)	-31.836***	(2.008)
Wheat Price	1128.603***	(10.002)	5.272***	(0.435)	-104.801***	(4.581)
Beans Price	409.257***	(1.018)	4.992***	(0.049)	56.911***	(1.210)
Sorghum Price	-435.434***	(2.199)	-1.536***	(0.159)	30.801***	(0.065)
Potatoes Price	322.917***	(1.224)	2.341***	(0.071)	-2.906***	(0.310)
Onions Price	-490.630***	(0.637)	2.178***	(0.015)	16.153***	(0.143)
Cabbage Price	-16.669***	(1.739)	3.141***	(0.102)	11.634***	(1.529)
Milk Price	138.942***	(1.131)	-3.119***	(0.065)	36.346***	(1.783)
Tella Price	426.326***	(1.903)	-1.303***	(0.143)	-83.445***	(0.066)
Sugar Price	-122.945***	(0.660)	-6.126***	(0.000)	-156.141***	(0.020)
Soap Price	-326.135***	(1.449)	-3.620***	(0.094)	25.393***	(0.187)
Income	1.943*	(1.078)	0.119*	(0.064)	-1.055	(0.763)
Intercept	538.643***	(9.440)	20.728***	(0.644)	96.530***	(0.908)
N	8722		8722		8722	
p-value (All Coefficients)	0.00		0.00		0.00	
R^2	0.23		0.22		0.28	
Household FEs	Yes		Yes		Yes	
Woreda-Round FEs	Yes		Yes		Yes	

Note: *, **, and *** denote significance at the 90, 95, and 99 percent levels. Bolded coefficients and standard errors are for own-price.

Table 5 (continued): Marketable Surplus Equations for Seven Commodities Over Four Rounds

	(4)		(5)		(6)		(7)	
Dependent Variable:	**Cooking Oil Marketable Surplus**		**Wheat Marketable Surplus**		**Beans Marketable Surplus**		**Sorghum Marketable Surplus**	
Variable	**Coefficient**	**(Std. Err.)**	**Coefficient**	**(Std. Err.)**	**Coefficient**	**(Std. Err.)**	**Coefficient**	**(Std. Err.)**
Maize Price	-9.606***	(0.157)	41.469***	(1.725)	-22.529***	(0.849)	-139.863***	(2.754)
Coffee Price	17.251***	(0.158)	-2.040	(1.553)	8.404***	(0.859)	160.801***	(2.142)
Barley Price	4.122***	(0.098)	-41.248***	(0.928)	11.684***	(0.549)	320.284***	(3.949)
Cooking Oil Price	**10.970*****	**(0.043)**	30.357***	(0.290)	-0.774***	(0.239)	71.284***	(0.603)
Wheat Price	21.537***	(0.375)	**69.374*****	**(3.836)**	-1.869	(2.069)	-652.280***	(10.494)
Beans Price	-1.682***	(0.007)	-68.754***	(0.182)	**9.222*****	**(0.032)**	570.179***	(2.024)
Sorghum Price	-5.775***	(0.105)	5.235***	(1.114)	-11.717***	(0.570)	**354.159*****	**(0.103)**
Potatoes Price	0.234***	(0.059)	16.142***	(0.612)	-6.543***	(0.321)	121.370***	(0.385)
Onions Price	4.145***	(0.030)	11.201***	(0.251)	11.874***	(0.169)	29.341***	(0.263)
Cabbage Price	3.327***	(0.079)	-22.882***	(0.893)	7.618***	(0.428)	90.097***	(1.013)
Milk Price	13.344***	(0.044)	1.013**	(0.401)	-4.981***	(0.230)	80.960***	(0.356)
Tella Price	-18.794***	(0.104)	18.221***	(1.051)	-13.980***	(0.562)	96.090***	(2.179)
Sugar Price	-5.635***	(0.005)	83.282***	(0.099)	-47.898***	(0.018)	-201.706***	(0.404)
Soap Price	-5.555***	(0.065)	-15.340***	(0.702)	12.516***	(0.357)	-60.716***	(0.805)
Income	0.113**	(0.048)	0.797	(0.507)	-0.108	(0.264)	1.414	(0.864)
Intercept	-58.878***	(0.474)	-43.209***	(4.503)	23.168***	(2.589)	-171.849***	(5.941)
N	8722		8722		8722		8722	
p-value (All Coefficients)	0.00		0.00		0.05		0.00	
R^2	0.21		0.28		0.21		0.31	
Household FEs	Yes		Yes		Yes		Yes	
Woreda-Round FEs	Yes		Yes		Yes		Yes	

Note: *, **, and *** denote significance at the 90, 95, and 99 percent levels. Bolded coefficients and standard errors are for own-price.

Table 6a: Matrix of Price Risk Aversion for *R* = 2

	Maize	Coffee	Barley	Cooking Oil	Wheat	Beans	Sorghum
Maize	**187.484****	0.282***	2.831	0.482	0.523	0.069	9.294**
	(93.165)	(0.102)	(2.829)	(0.343)	(0.362)	(0.049)	(4.566)
Coffee	0.090	**0.365***	0.133	0.077***	0.038**	0.135**	0.328
	(0.068)	**(0.188)**	(0.130)	(0.018)	(0.018)	(0.067)	(0.257)
Barley	-0.008	0.021	**26.609*****	0.107*	14.709	-1.968	-6.808
	(0.007)	(0.014)	**(8.576)**	(0.059)	(16.827)	(1.959)	(4.793)
Cooking Oil	0.818**	0.103**	0.457	**0.363*****	0.240**	0.287**	0.178
	(0.377)	(0.028)	(0.433)	**(0.090)**	(0.094)	(0.137)	(0.130)
Wheat	-1.512	0.038**	0.040**	0.087	**13.279**	0.061**	-0.015
	(2.134)	(0.018)	(0.019)	(0.073)	**(9.271)**	(0.025)	(0.049)
Beans	0.095	0.123***	0.159*	0.331	0.235*	**35.431**	0.396
	(0.060)	(0.044)	(0.089)	(0.238)	(0.128)	**(30.118)**	(0.319)
Sorghum	0.432	0.122	10.268	0.005	0.190	-42.318	**70.856****
	(0.289)	(0.090)	(10.270)	(0.004)	(0.185)	(37.318)	**(28.744)**

Note: Standard errors are in parentheses, and *, **, and *** denote significance at the 90, 95, and 99 percent levels. Bolded coefficients are own-price risk aversion coefficients.

Table 6b: Tests of Symmetry of the Matrix of Price Risk Aversion for *R* = 2

Sub-Matrix	**Test Statistic**	***p*-value**
A_3 (Maize, …, Barley)	$F(3, 8719) = 1.70$	0.17
A_4 (Maize, …, Cooking Oil)	$F(6, 8716) = 1.42$	0.20
A_5 (Maize, …, Wheat)	$F(10, 8712) = 1.12$	0.34
A_6 (Maize, …, Beans)	$F(15, 8707) = 1.00$	0.46
A_7 (Maize, …, Sorghum)	$F(21, 8701) = 1.27$	0.17
Joint Significance (All Coefficients)	$F(49, 8721) = 2.52$	0.00
Joint Significance (Diagonal Coefficients)	$F(7, 8721) = 6.18$	0.00
Joint Significance (Off-Diagonal Coefficients)	$F(42, 8721) = 2.36$	0.00

Table 7a: WTP as Proportion of Household Income for Upper Triangular Matrix

	R = 1		*R* = 2		*R* = 3	
Commodity	**WTP**	**(Std. Err)**	**WTP**	**(Std. Err)**	**WTP**	**(Std. Err)**
Maize	0.091**	(0.039)	0.207**	(0.081)	0.324***	(0.123)
Coffee	0.010***	(0.003)	0.023***	(0.005)	0.036***	(0.008)
Barley	0.046***	(0.015)	0.097***	(0.029)	0.149***	(0.043)
Cooking Oil	0.006***	(0.002)	0.006***	(0.002)	0.007***	(0.002)
Wheat	-0.014***	(0.003)	-0.010***	(0.004)	-0.005	(0.004)
Beans	-0.003	(0.002)	0.003	(0.004)	0.010	(0.006)
Sorghum	-0.006	(0.005)	0.016**	(0.008)	0.038***	(0.011)
All Commodities	**0.129*** **	**(0.042)**	**0.342*** **	**(0.086)**	**0.555*** **	**(0.131)**

Note: Standard errors are in parentheses, and *, **, and *** denote significance at the 90, 95, and 99 percent levels.

Table 7b: WTP as Proportion of Household Income for Lower Triangular Matrix

	R = 1		*R* = 2		*R* = 3	
Commodity	***R* = 1**	**(Std. Err)**	***R* = 2**	**(Std. Err)**	***R* = 3**	**(Std. Err)**
Maize	0.103***	(0.039)	0.220***	(0.081)	0.336***	(0.123)
Coffee	0.011**	(0.004)	0.024***	(0.007)	0.037***	(0.009)
Barley	0.037**	(0.015)	0.088***	(0.029)	0.139***	(0.043)
Cooking Oil	-0.006***	(0.001)	-0.006***	(0.001)	-0.006***	(0.001)
Wheat	0.025***	(0.002)	0.029***	(0.003)	0.033***	(0.003)
Beans	0.007***	(0.002)	0.013***	(0.004)	0.019***	(0.006)
Sorghum	0.001	(0.004)	0.023***	(0.007)	0.046***	(0.011)
All Commodities	**0.153*** **	**(0.042)**	**0.365*** **	**(0.087)**	**0.578*** **	**(0.131)**

Note: Standard errors are in parentheses, and *, **, and *** denote significance at the 90, 95, and 99 percent levels.

Table 7c: WTP as Proportion of Household Income Ignoring Covariances

	R = 1		*R* = 2		*R* = 3	
Commodity	***R* = 1**	**(Std. Err)**	***R* = 2**	**(Std. Err)**	***R* = 3**	**(Std. Err)**
Maize	0.093**	(0.039)	0.209***	(0.081)	0.326***	(0.123)
Coffee	0.016***	(0.003)	0.029***	(0.006)	0.042***	(0.008)
Barley	0.045***	(0.015)	0.096***	(0.029)	0.146***	(0.043)
Cooking Oil	-0.010***	(0.001)	-0.010***	(0.001)	-0.010***	(0.001)
Wheat	-0.001	(0.001)	0.002	(0.002)	0.005**	(0.002)
Beans	0.005***	(0.002)	0.011***	(0.004)	0.017***	(0.006)
Sorghum	-0.019***	(0.004)	0.003	(0.007)	0.025**	(0.011)
All Commodities	**0.129*** **	**(0.042)**	**0.340*** **	**(0.086)**	**0.551*** **	**(0.131)**

Note: These measures are derived following Finkelshtain and Chalfant (1997). Standard errors are in parentheses, and *, **, and *** denote significance at the 90, 95, and 99 percent levels.

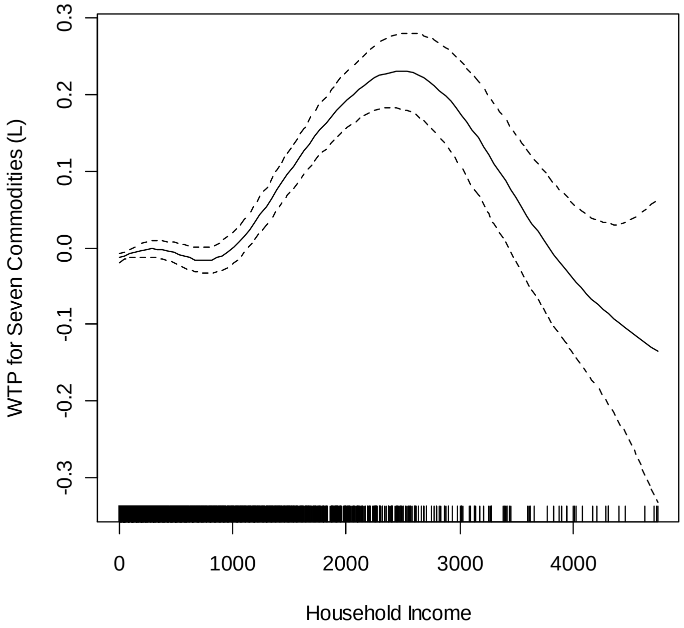

Figure 1: Nonparametric regression of WTP derived from lower triangular matrix of A on household income with 95 percent confidence band.

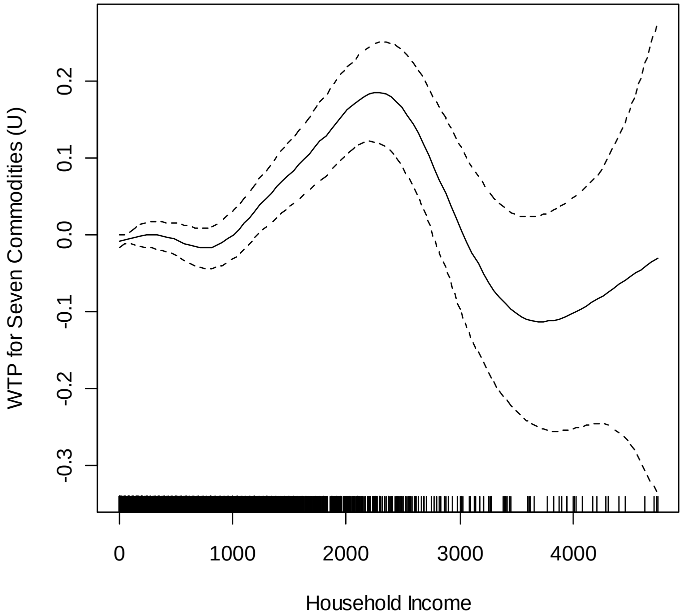

Figure 2: Nonparametric regression of WTP derived from upper triangular matrix of A on household income with 95 percent confidence band.

Discussion

- Households are price risk-averse for all commodities except wheat and beans.

- Households are often price risk-averse over co-movements in the prices of goods, as expected.

- There is scope for policies aimed at compensating households for the price fluctuations they face. For $R = 2$, households would be willing to pay 35 percent of their income on average.

- Symmetry of A is never be rejected, but Slutsky symmetry is rejected.

- Although the test has low power, symmetry of A cannot be rejected no matter how large the commodity space considered.

- The symmetry result is not due to lack of significance of the coefficients themselves.

- The symmetry result is robust to changes in R.

Conclusion

- This paper stemmed from the realization that a whole vector of prices goes into $V(p, y)$ and that economists had so far not considered the implications of V_{pp} empirically.

- The unitary AHM framework allow deriving V_{pp}, and then A, which (mostly) relies on observables.

- The main implications of the theory are that (i) A is symmetric; (ii) A is linked to the Slutksy matrix; and (iii) a test of the symmetry of A is a weaker test of rationality than a test of Slutsky symmetry.

- In terms of policy, WTPs to stabilize the price of individual commodities and of a subset of all commodities are derived analytically and estimated.

- This means that it is possible to talk about "price stabilization" without stabilizing prices, i.e., without introducing considerable distortions in the economy.

- Price stabilization, however, is a regressive policy: the gains are concentrated among the households in the upper half of the income distribution.

- In terms of future research, it would be important to reproduce these results using data from an industrialized country.

- It would be even more important to use individual-level data, adopt a collective household modeling framework, and, following Browning and Chiappori (1998), conduct symmetry tests for one-, two-, ..., N-person households.