Relative prices of food and return volatility of agricultural commodities: Evidence from some latin american economies

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The main question

- Is there empirical evidence of a link between volatility of major agricultural commodities and *consumer welfare*?

Problems:

- Consumer welfare is notoriously difficult to measure due to income effects associated with price changes.
- It is not uncommon in developing countries for consumers to be producers of agricultural commodities.
- Models for the dynamic evolution of conditional volatility are often based on restrictive stochastic models

A related question

- Is there empirical evidence of a link between volatility of major agricultural commodities and *relative prices* of certain defined food groups?

A clarification

- There is empirical evidence of a positive correlation between changes in **prices** of agricultural commodities and changes in relative prices of certain food groups.
- The question being asked here is whether or not the **volatility** of price changes has an impact in relative prices of certain food groups.

How to measure relative prices of food groups?

- Let there be N goods and services. A consumption basket in time period $t = 0, 1, \cdots, T$ and its price are denoted by

$$q_t' = \begin{pmatrix} q_{t1} & \cdots & q_{tN} \end{pmatrix}, p_t' = \begin{pmatrix} p_{t1} & \cdots & p_{tN} \end{pmatrix}.$$

  The share of expenditures on element F of the basket is

$$s_{tF} = \frac{p_{tF}\, q_{tF}}{p_t' q_t}$$

The Laspeyres index

- The Laspeyres index from time period $t-1$ to time period t is

$$L(p_t, p_{t-1}, q_{t-1}) = \sum_{n=1}^{N} \frac{p_{tn}}{p_{t-1,n}} s_{t-1,n} \text{ for } t = 1, \cdots, T$$

- The relative share of the price index change associated with element F of the basket is

$$Y_{tF} = \frac{\frac{p_{tF}}{p_{t-1,F}} s_{t-1,F}}{L(p_t, p_{t-1}, q_{t-1})} \in (0,1) \text{ for } t = 1, \cdots, T.$$

- If Y_{tF} is close to 1 at time t, the element F in the consumption basket accounts for a large share of price index variability.

A model of conditional volatility

Let $r_t = \log \frac{P_t}{P_{t-1}}$ and assume that

$$r_t = m_0 + \sum_{j=1}^{L} m_j(r_{t-j}) + \left(h_0 + \sum_{j=1}^{L} h_j(r_{t-j}) \right)^{1/2} \varepsilon_t \tag{1}$$

where

- $L \in \mathbb{N}$, $\varepsilon_t \sim IID(0, 1)$
- $E(m_j(r_{t-j})) = E(h_j(r_{t-j})) = 0$ for all j, $h_0 > 0$

Estimation of m_j and h_j for $j = 0, 1, \cdots, L$ is conducted as proposed in Martins-Filho et al. (2013) using daily returns.

A general stochastic model

We consider the estimation of

$$E(Y_{tF}|h^{1/2}(r_{t-1},\cdots,r_{t-L}),W_t) = g^{-1}(m(h^{1/2}(r_{t-1},\cdots,r_{t-L}),W_t))$$

for $t = L+1,\cdots,T$, where

- $W_t \in \mathbb{R}^K$ is a collection of suitably defined conditioning variables
- g is a strictly monotonic *link* function $g(x) : [0,1] \rightarrow \mathbb{R}$
- m is a smooth function $g(x) : \mathbb{R}^{K+1} \rightarrow \mathbb{R}$

The fact that $Y_{tF} \in (0,1)$ has important implications for stochastic modeling.

Beta regression

The Beta density is given by

$$\pi(y; p, q) = \frac{\Gamma(p+q)}{\Gamma(p)\Gamma(q)y^{p-1}(1-y)^{q-1}} \text{ for } p, q > 0,\ 0 < y < 1.$$

If $\mu = \frac{p}{p+q}$ and $\phi = p + q$

$$E(y) = \mu,\ V(y) = \frac{\mu(1-\mu)}{1+\phi}.$$

We consider a conditional Beta density where μ is such that

$$g(\mu_t) = \alpha\, h^{1/2}(r_{t-1}, \cdots, r_{t-L}) + \sum_{j=1}^{K} W_{tj}\beta_j = X_t \begin{pmatrix} \alpha \\ \beta \end{pmatrix} = X_t\theta$$

and

$$g(\mu) = \log\frac{\mu}{1-\mu}.$$

Maximum likelihood estimation

The log-likelihood function based on a sample of size T is,

$$\ell(\alpha, \beta, \phi) = \sum_{t=1}^{T} \ell_t(\mu_t, \phi)$$

with score vectors given by

$$\begin{aligned}
\ell_{\alpha,\beta}(\alpha, \beta, \phi) &= \phi X' D(Y^* - \mu^*) \\
\ell_{\phi}(\alpha, \beta, \phi) &= \sum_{t=1}^{T} (\mu_t(Y^*_{tF} - \mu^*_t) + log(1 - Y_{tF}) - \psi((1 - \mu_t)\phi) \\
&\quad + \psi(\phi))
\end{aligned}$$

where Y^* has t^{th} element $Y^*_t = log \frac{Y_{tF}}{1-Y_{tF}}$, μ^* has t^{th} element $\mu^*_t = log \frac{\mu_t}{1-\mu_t}$, $\psi(\cdot)$ is the digamma function,

$$D = diag\{1/g'(\mu_t)\}_{t=1}^{T},\ X' = \begin{pmatrix} X'_1 & \cdots & X'_T \end{pmatrix}$$

The impact of changes in covariate values

- It is easy to show that

$$\frac{\partial}{\partial v_t} E(Y_{tF}|v_t, W_t) = \alpha \frac{exp\left(\alpha\, v_t + \sum_{j=1}^{K} W_{tj}\beta_j\right)}{1 + exp\left(\alpha\, v_t + \sum_{j=1}^{K} W_{tj}\beta_j\right)}$$

  where $v_t = h^{1/2}(r_{t-1}, \cdots, r_{t-L})$.
- The lefthand side should be interpreted as the impact that changes in commodity volatility have on the share of aggregate price changes associated with basket item(s) F.
- Such impact changes with t.

Data

- Latin american countries: Costa Rica, El Salvador, Guatemala, Honduras, Ecuador, Peru, Mexico, Nicaragua, Panama, Dominican Republic
- The length of the time series for each country is different
- Food groups: 1. Bread and Cereals, 2. Meat, 3. Dairy products and eggs, 4. Other food items
- Covariates
  1. Monthly index of economic activity: a Laspeyres index
  2. Imports
  3. Oil prices
  4. Measures of monthly volatility (average, median, interquartile range of daily volatility)

Table: Economic Activity

Country	Breads	Meat	Dairy	Other Food
Ecuador 1	+			
2	+			
El Salvador 1	-	-	+	+
2	-	-	+	+
Guatemala 1	+			
2	+			
Honduras 1	-	-	-	-
2	-	-	-	-
Nicaragua 1				
2				
Panama 1	+	+	+	+
2	+		+	+
Peru 1	-		-	-
2	-		-	-

Table: Imports

Country	Breads	Meat	Dairy	Other Food
Ecuador 1		+	+	+
2	+	+	+	+
El Salvador 1	+	-		+
2		-		+
Guatemala 1	+		-	-
2	+		-	-
Honduras 1	+	+	+	+
2		+	+	+
Nicaragua 1	+			+
2	+	+		+
Panama 1				-
2				-
Peru 1	+	+	+	+
2	+	+	+	+

Table: Impact of Wheat Volatility on Breads and Cereals: * indicates significant at the 0.95 level

Country	Coefficient sign
Ecuador 1	$\theta_7 < 0$, $\theta_8^* > 0$
2	$\theta_7 < 0$, $\theta_8^* > 0$
El Salvador 1	$\theta_7 > 0$, $\theta_8^* > 0$
2	$\theta_7^* < 0$, $\theta_8^* > 0$
Guatemala 1	$\theta_7 < 0$, $\theta_8 > 0$
2	$\theta_7^* < 0$, $\theta_8^* > 0$
Honduras 1	$\theta_7^* > 0$, $\theta_8 > 0$
2	$\theta_7^* > 0$, $\theta_8^* > 0$
Nicaragua 1	$\theta_7 > 0$, $\theta_8^* > 0$
2	$\theta_7 < 0$, $\theta_8 > 0$
Panama 1	$\theta_7 > 0$, $\theta_8 < 0$
2	$\theta_7^* > 0$, $\theta_8 > 0$
Peru 1	$\theta_7 < 0$, $\theta_8^* > 0$
2	$\theta_7 < 0$, $\theta_8^* > 0$

Model: Y_{Ft} - Breads and Cereals,

$$X_t = \begin{pmatrix} EconAc & Imp & roil & volcorn \\ volsoy & volrice & volcbot & volkcbt \end{pmatrix}$$

Table: El Salvador

Parameter	Estimate	t-Statistic	Marginal impact
ϕ	5.4175179e+03	8.8879436e+00	
θ_0	-2.1058891e+00	-4.3698465e+01	-1.9660802e-01
θ_1	-1.2249664e-03	-3.5698240e+00	-1.1436415e-04
θ_2	1.0725985e-04	2.2854983e+00	1.0013892e-05
θ_3	2.6834286e-02	5.2875246e-01	2.5052771e-03
θ_4	4.5457471e-01	3.2355020e-01	4.2439573e-02
θ_5	3.9607611e+00	1.7053255e+00	3.6978082e-01
θ_6	-6.1587276e+00	-5.4004882e+00	-5.7498528e-01
θ_7	3.6475944e+00	1.1918150e+00	3.4054325e-01
θ_8	4.6638978e+00	1.7920549e+00	4.3542640e-01

Pseudo-R^2 0.53 n=158

Model: Y_{Ft} - Breads and Cereals,

$$X_t = (\begin{array}{cccc} EconAc & Imp & roil & Lvolcorn \\ Lvolsoy & Lvolrice & Lvolcbot & Lvolkcbt \end{array})$$

Table: El Salvador

Parameter	Estimate	t-Statistic	Marginal impact
ϕ	5.4971816e+03	8.8879472e+00	
θ_0	-2.1150775e+00	-4.2295926e+01	-1.9746576e-01
θ_1	-1.0915932e-03	-3.1781488e+00	-1.0191224e-04
θ_2	8.2287472e-05	1.7162125e+00	7.6824409e-06
θ_3	2.9731758e-02	5.9813175e-01	2.7757867e-03
θ_4	1.1981307e+00	8.5164620e-01	1.1185868e-01
θ_5	2.7575252e+00	1.2040419e+00	2.5744532e-01
θ_6	-5.9155797e+00	-5.2472361e+00	-5.5228445e-01
θ_7	-8.4706345e-01	-2.3662760e-01	-7.9082692e-02
θ_8	8.9420304e+00	3.4872605e+00	8.3483692e-01

Pseudo-R^2 0.84 n=158

Model: Y_{Ft} - Breads and Cereals,

$$X_t = \begin{pmatrix} EconAc & Imp & roil & volcorn \\ volsoy & volrice & volcbot & volkcbt \end{pmatrix}$$

Table: Guatemala

Parameter	Estimate	t-Statistic	Marginal impact
ϕ	1.7169728e+03	6.5952009e+00	
θ_0	-3.1144181e+00	-2.2200854e+01	-3.3719763e-01
θ_1	3.6099175e-03	2.2634221e+00	3.9084528e-04
θ_2	7.4616688e-04	8.6971877e+00	8.0787387e-05
θ_3	2.0019588e-01	1.6149464e+00	2.1675180e-02
θ_4	-6.6993282e+00	-1.5239044e+00	-7.2533536e-01
θ_5	1.0891397e+01	2.4565925e+00	1.1792101e+00
θ_6	-1.1742169e+01	-3.2729591e+00	-1.2713231e+00
θ_7	-7.2937477e+00	-8.5429016e-01	-7.8969308e-01
θ_8	1.3061335e+01	1.2745466e+00	1.4141489e+00

Pseudo-R^2 0.94 n=87

Model: Y_{Ft} - Breads and Cereals,

$$X_t = (EconAc \quad Imp \quad roil \quad Lvolcorn \quad Lvolsoy \quad Lvolrice \quad Lvolcbot \quad Lvolkcbt)$$

Table: Guatemala

Parameter	Estimate	t-Statistic	Marginal impact
ϕ	1.9344963e+03	6.5952266e+00	
θ_0	-3.1446363e+00	-2.2953654e+01	-3.4046599e-01
θ_1	3.0371523e-03	1.9401008e+00	3.2882882e-04
θ_2	8.5329152e-04	9.8748830e+00	9.2384846e-05
θ_3	2.1924706e-01	1.8921667e+00	2.3737615e-02
θ_4	-7.8565930e+00	-1.8933265e+00	-8.5062386e-01
θ_5	1.0618852e+01	2.5663397e+00	1.1496903e+00
θ_6	-4.5568277e+00	-1.2849233e+00	-4.9336225e-01
θ_7	-3.0255493e+01	-3.7944617e+00	-3.2757258e+00
θ_8	1.9123974e+01	1.9129604e+00	2.0705297e+00

Pseudo-R^2 0.95 n=87

Model: Y_{Ft} - Breads and Cereals,

$$X_t = \begin{pmatrix} EconAc & Imp & roil & volcorn \\ volsoy & volrice & volcbot & volkcbt \end{pmatrix}$$

Table: Honduras

Parameter	Estimate	t-Statistic	Marginal impact
ϕ	1.6070724e+04	6.9278833e+00	
θ_0	-2.4801223e+00	-5.4023049e+01	-2.4801223e+00
θ_1	-4.5700356e-03	-8.2841426e+00	-2.5666318e-04
θ_2	6.1187060e-04	7.1886738e+00	3.4363989e-05
θ_3	-1.7189877e-02	-3.5593859e-01	-9.6542106e-04
θ_4	-1.3099926e+00	-7.6354957e-01	-7.3572043e-02
θ_5	-4.0799069e+00	-2.0809212e+00	-2.2913648e-01
θ_6	2.6122018e+00	2.1661969e+00	1.4670696e-01
θ_7	9.2651068e+00	2.8726307e+00	5.2034863e-01
θ_8	4.9457396e-01	1.1278328e-01	2.7776354e-02

Pseudo-R^2 0.78 $n = 96$

Model: Y_{Ft} - Breads and Cereals,

$$X_t = (EconAc \quad Imp \quad roil \quad Lvolcorn \quad Lvolsoy \quad Lvolrice \quad Lvolcbot \quad Lvolkcbt)$$

Table: Honduras

Parameter	Estimate	t-Statistic	Marginal impact
ϕ	1.4103094e+04	6.9278387e+00	
θ_0	-2.4861492e+00	-4.7065065e+01	-1.3962761e-01
θ_1	-4.6771299e-03	-7.5630219e+00	-2.6267791e-04
θ_2	6.4725493e-04	6.9350586e+00	3.6351261e-05
θ_3	-3.9731987e-02	-7.7744443e-01	-2.2314358e-03
θ_4	-7.5051825e-01	-4.0474104e-01	-4.2150756e-02
θ_5	-2.5590965e+00	-1.2205010e+00	-1.4372449e-01
θ_6	2.3909685e+00	1.8151177e+00	1.3428205e-01
θ_7	9.4019861e+00	2.1113136e+00	5.2803623e-01
θ_8	2.7155886e+00	5.2257676e-01	1.5251343e-01

Pseudo-R^2 0.75 $n = 96$

Model: Y_{Ft} - Breads and Cereals,

$$X_t = (EconAc \quad Imp \quad roil \quad volcorn \\ volsoy \quad volrice \quad volcbot \quad volkcbt)$$

Table: Nicaragua

Parameter	Estimate	t-Statistic	Marginal impact
ϕ	1.7216915e+04	6.6330779e+00	
θ_0	-2.8381193e+00	-8.6084449e+01	-1.9994182e-01
θ_1	3.8062084e-04	1.8292384e+00	2.6814244e-05
θ_2	7.1638524e-04	1.1482739e+01	5.0468410e-05
θ_3	2.1194529e-02	4.5006392e-01	1.4931271e-03
θ_4	-2.4331101e+00	-1.4989056e+00	-1.7140945e-01
θ_5	4.4250330e+00	2.6104689e+00	3.1173783e-01
θ_6	-1.0704606e+00	-8.2514252e-01	-7.5412561e-02
θ_7	1.4496067e-01	4.6387961e-02	1.0212291e-02
θ_8	9.3557301e+00	2.4707224e+00	6.5909904e-01

Pseudo-R^2 0.93 $n = 88$

Model: Y_{Ft} - Breads and Cereals,

$$X_t = (EconAc \quad Imp \quad roil \quad Lvolcorn \quad Lvolsoy \quad Lvolrice \quad Lvolcbot \quad Lvolkcbt)$$

Table: Nicaragua

Parameter	Estimate	t-Statistic	Marginal impact
ϕ	1.5426402e+04	6.6330580e+00	
θ_0	-2.8482778e+00	-8.2048240e+01	-2.0065773e-01
θ_1	3.7132220e-04	1.6891897e+00	2.6159200e-05
θ_2	7.8201515e-04	1.1566348e+01	5.5092021e-05
θ_3	4.4330109e-02	9.0198173e-01	3.1230026e-03
θ_4	-2.5793887e+00	-1.5070366e+00	-1.8171481e-01
θ_5	4.5108313e+00	2.5863822e+00	3.1778261e-01
θ_6	4.4931652e-01	3.1867475e-01	3.1653806e-02
θ_7	-2.5347556e+00	-7.8568942e-01	-1.7857046e-01
θ_8	4.4354508e+00	1.0431897e+00	3.1247214e-01

Pseudo-R^2 0.92 $n = 88$

Model: Y_{Ft} - Breads and Cereals,

$$X_t = \begin{pmatrix} EconAc & Imp & roil & volcorn \\ volsoy & volrice & volcbot & volkcbt \end{pmatrix}$$

Table: Panama

Parameter	Estimate	t-Statistic	Marginal impact
ϕ	1.8538451e+04	6.2845152e+00	
θ_0	-3.5692882e+00	-5.4489454e+01	-1.5838184e-01
θ_1	2.7120370e-03	4.8621890e+00	1.2034259e-04
θ_2	4.5766928e-05	7.0767095e-01	2.0308391e-06
θ_3	-2.8247263e-02	-6.1850854e-01	-1.2534302e-03
θ_4	8.2985021e-01	3.4148554e-01	3.6823365e-02
θ_5	5.2890696e+00	2.9812481e+00	2.3469457e-01
θ_6	3.9037800e+00	2.4210672e+00	1.7322441e-01
θ_7	2.9847876e+00	7.3369770e-01	1.3244549e-01
θ_8	-1.6964357e+00	-3.4775664e-01	-7.5276802e-02

Pseudo-R^2 0.90 n=79

Model: Y_{Ft} - Breads and Cereals,

$$X_t = (EconAc \quad Imp \quad roil \quad Lvolcorn \quad Lvolsoy \quad Lvolrice \quad Lvolcbot \quad Lvolkcbt)$$

Table: Panama

Parameter	Estimate	t-Statistic	Marginal impact
ϕ	2.2730263e+04	6.2845866e+00	
θ_0	-3.5610518e+00	-5.8998929e+01	-1.5801632e-01
θ_1	2.5643620e-03	5.0049113e+00	1.1378971e-04
θ_2	5.1524237e-05	8.6899411e-01	2.2863105e-06
θ_3	1.6993894e-02	4.2123411e-01	7.5407849e-04
θ_4	3.8410105e+00	1.7993276e+00	1.7043906e-01
θ_5	2.9267845e+00	1.7845089e+00	1.2987166e-01
θ_6	3.7962244e+00	2.5088509e+00	1.6845175e-01
θ_7	7.2748081e+00	2.0231171e+00	3.2280867e-01
θ_8	3.7854001e-02	8.9219155e-03	1.6797144e-03

Pseudo-R^2 0.92 n=79

Model: Y_{Ft} - Meat,

$$X_t = \begin{pmatrix} EconAc & Imp & roil & volcorn \\ volsoy & volrice & volcbot & volkcbt \end{pmatrix}$$

Table: El Salvador

Parameter	Estimate	t-Statistic	Marginal impact
ϕ	1.2356701e+04	8.8872642e+00	
θ_0	-2.8443036e+00	-6.0859471e+01	-1.1691487e-01
θ_1	-9.2103003e-04	-2.7607626e+00	-3.7858865e-05
θ_2	-2.9435129e-04	-6.3749124e+00	-1.2099286e-05
θ_3	1.2207874e-02	2.4901439e-01	5.0180367e-04
θ_4	-2.2791506e-01	-1.6771250e-01	-9.3684301e-03
θ_5	-4.8703277e+00	-2.0985897e+00	-2.0019442e-01
θ_6	-5.2278916e+00	-4.7191795e+00	-2.1489206e-01
θ_7	6.0138489e+00	2.0177614e+00	2.4719877e-01
θ_8	5.3416257e+00	2.1568755e+00	2.1956709e-01

Pseudo-R^2 0.84 n=158

Model: Y_{Ft} - Meat,

$$X_t = (EconAc \quad Imp \quad roil \quad Lvolcorn \quad Lvolsoy \quad Lvolrice \quad Lvolcbot \quad Lvolkcbt)$$

Table: El Salvador

Parameter	Estimate	t-Statistic	Marginal impact
ϕ	1.2060611e+04	8.8872414e+00	
θ_0	-2.8065697e+00	-5.6926362e+01	-1.1536384e-01
θ_1	-1.0919615e-03	-3.2045347e+00	-4.4884997e-05
θ_2	-2.8496555e-04	-5.9211345e+00	-1.1713488e-05
θ_3	-4.2851002e-03	-8.7368766e-02	-1.7613873e-04
θ_4	-6.9941779e-01	-5.0139192e-01	-2.8749517e-02
θ_5	-6.4686221e+00	-2.7779604e+00	-2.6589223e-01
θ_6	-5.0776189e+00	-4.5581687e+00	-2.0871515e-01
θ_7	4.1376872e+00	1.1785544e+00	1.7007933e-01
θ_8	4.6936766e+00	1.8724710e+00	1.9293323e-01

Pseudo-R^2 0.84 n=158

Model: Y_{Ft} - Meat,

$$X_t = \begin{pmatrix} EconAc & Imp & roil & volcorn \\ volsoy & volrice & volcbot & volkcbt \end{pmatrix}$$

Table: Guatemala

Parameter	Estimate	t-Statistic	Marginal impact
ϕ	9.8850398e+04	6.5954216e+00	
θ_0	-2.4850933e+00	-1.0885193e+02	-1.7060924e-01
θ_1	-3.5542165e-04	-1.3507995e+00	-2.4400781e-05
θ_2	-9.9999615e-05	-7.1092075e+00	-6.8652788e-06
θ_3	-3.9201334e-02	-1.9851693e+00	-2.6912913e-03
θ_4	1.8279507e-01	2.7286295e-01	1.2549440e-02
θ_5	1.8770846e-02	2.5869720e-02	1.2886759e-03
θ_6	4.7034284e-01	8.5578714e-01	3.2290471e-02
θ_7	1.4001665e+00	9.6802158e-01	9.6125706e-02
θ_8	-2.7976839e+00	-1.6390227e+00	-1.9206954e-01

Pseudo-R^2 0.94 n=87

Model: Y_{Ft} - Meat,

$$X_t = \begin{pmatrix} EconAc & Imp & roil & Lvolcorn \\ Lvolsoy & Lvolrice & Lvolcbot & Lvolkcbt \end{pmatrix}$$

Table: Guatemala

Parameter	Estimate	t-Statistic	Marginal impact
ϕ	1.1221546e+05	6.5954253e+00	
θ_0	-2.4988269e+00	-1.1409981e+02	-1.7155209e-01
θ_1	-1.7410488e-04	-6.8581290e-01	-1.1952831e-05
θ_2	-1.1110252e-04	-7.9309352e+00	-7.6275268e-06
θ_3	-3.1272814e-02	-1.7057797e+00	-2.1469741e-03
θ_4	1.0493405e+00	1.6601006e+00	7.2040425e-02
θ_5	3.3316441e-01	4.9176392e-01	2.2872753e-02
θ_6	-4.5568277e+00	-1.2849233e+00	-4.9336225e-01
θ_7	-1.3212298e-01	-2.4523904e-01	-9.0706457e-03
θ_8	4.5915100e+00	3.4750575e+00	3.1522117e-01

Pseudo-R^2 0.95 n=87

Model: Y_{Ft} - Meat,

$$X_t = \begin{pmatrix} EconAc & Imp & roil & volcorn \\ volsoy & volrice & volcbot & volkcbt \end{pmatrix}$$

Table: Honduras

Parameter	Estimate	t-Statistic	Marginal impact
ϕ	4.2949241e+04	6.9280964e+00	
θ_0	-2.5086568e+00	-9.1587042e+01	-1.4881959e-01
θ_1	-2.2917038e-03	-6.9673303e+00	-1.3594941e-04
θ_2	1.3250691e-04	2.6006137e+00	7.8606305e-06
θ_3	-4.2246311e-02	-1.4747301e+00	-2.5061534e-03
θ_4	1.7350482e+00	1.6983170e+00	1.0292726e-01
θ_5	-4.7390143e+00	-4.0398777e+00	-2.8112979e-01
θ_6	-5.6843931e-01	-7.8991160e-01	-3.3721195e-02
θ_7	6.9203739e+00	3.5472521e+00	4.1053332e-01
θ_8	-8.2482057e+00	-3.1248930e+00	-4.8930352e-01

Pseudo-R^2 0.89 $n = 96$

Model: Y_{Ft} - Meat,

$$X_t = (EconAc \quad Imp \quad roil \quad Lvolcorn \quad Lvolsoy \quad Lvolrice \quad Lvolcbot \quad Lvolkcbt)$$

Table: Honduras

Parameter	Estimate	t-Statistic	Marginal impact
ϕ	4.0786422e+04	6.9280907e+00	
θ_0	-2.5337996e+00	-8.3767831e+01	-1.5031112e-01
θ_1	-2.0816675e-03	-5.8561789e+00	-1.2348955e-04
θ_2	9.9692336e-05	1.8481577e+00	5.9139906e-06
θ_3	-7.1750304e-02	-2.4610113e+00	-4.2564017e-03
θ_4	1.4496288e+00	1.3645609e+00	8.5995486e-02
θ_5	-3.6331322e+00	-3.0063027e+00	-2.1552619e-01
θ_6	-9.8855431e-01	-1.3048655e+00	-5.8643434e-02
θ_7	8.8814315e+00	3.4797619e+00	5.2686800e-01
θ_8	-3.4222840e+00	-1.1378797e+00	-2.0301816e-01

Pseudo-R^2 0.82 $n = 96$

Model: Y_{Ft} - Meat,

$$X_t = (\begin{matrix} EconAc & Imp & roil & volcorn \\ volsoy & volrice & volcbot & volkcbt \end{matrix})$$

Table: Nicaragua

Parameter	Estimate	t-Statistic	Marginal impact
ϕ	2.4887673e+04	6.6331321e+00	
θ_0	-2.5849987e+00	-9.3923210e+01	-1.8196477e-01
θ_1	-3.3763168e-05	-1.9361887e-01	-2.3766771e-06
θ_2	9.3840829e-05	1.7835792e+00	6.6056996e-06
θ_3	-5.1721109e-02	-1.3305371e+00	-3.6407832e-03
θ_4	1.9110545e+00	1.4371527e+00	1.3452409e-01
θ_5	-1.8924546e+00	-1.3269345e+00	-1.3321479e-01
θ_6	-1.6111228e+00	-1.4993847e+00	-1.1341111e-01
θ_7	-1.8885179e-01	-7.0596441e-02	-1.3293768e-02
θ_8	-1.9268657e+00	-6.0371840e-01	-1.3563708e-01

Pseudo-R^2 0.93 $n = 88$

Model: Y_{Ft} - Meat,

$$X_t = (\begin{matrix} EconAc & Imp & roil & Lvolcorn \\ Lvolsoy & Lvolrice & Lvolcbot & Lvolkcbt \end{matrix})$$

Table: Nicaragua

Parameter	Estimate	t-Statistic	Marginal impact
ϕ	2.4455416e+04	6.6331300e+00	
θ_0	-2.5906311e+00	-9.3671329e+01	-1.8236125e-01
θ_1	-4.3689392e-05	-2.4803481e-01	-3.0754098e-06
θ_2	1.1209054e-04	2.0711490e+00	7.8903440e-06
θ_3	-6.3188550e-02	-1.6324917e+00	-4.4480062e-03
θ_4	9.0533068e-01	6.7513180e-01	6.3728579e-02
θ_5	-2.0921485e+00	-1.4888826e+00	-1.4727177e-01
θ_6	-3.7778020e-01	-3.4243219e-01	-2.6592930e-02
θ_7	-3.7453585e+00	-1.4327553e+00	-2.6364551e-01
θ_8	1.5728008e+00	4.6243533e-01	1.1071354e-01

Pseudo-R^2 0.92 $n = 88$

Model: Y_{Ft} - Meat,

$$X_t = \begin{pmatrix} EconAc & Imp & roil & volcorn \\ volsoy & volrice & volcbot & volkcbt \end{pmatrix}$$

Table: Panama

Parameter	Estimate	t-Statistic	Marginal impact
ϕ	3.6024571e+04	6.2848532e+00	
θ_0	-2.5208484e+00	-7.0988023e+01	-2.0499812e-01
θ_1	7.3563172e-04	2.4218639e+00	5.9822366e-05
θ_2	-9.4521459e-06	-2.6587303e-01	-7.6865871e-07
θ_3	1.2229043e-02	4.9363040e-01	9.9447900e-04
θ_4	-2.6478621e+00	-2.0075779e+00	-2.1532700e-01
θ_5	2.8865752e+00	3.0019662e+00	2.3473941e-01
θ_6	-3.6265511e+00	-4.1435749e+00	-2.9491505e-01
θ_7	-1.3620192e-02	-6.1003145e-03	-1.1076087e-03
θ_8	-1.7403212e+00	-6.5366926e-01	-1.4152480e-01

Pseudo-R^2 0.78 n=79

Model: Y_{Ft} - Meat,

$$X_t = (EconAc \quad Imp \quad roil \quad Lvolcorn \quad Lvolsoy \quad Lvolrice \quad Lvolcbot \quad Lvolkcbt)$$

Table: Panama

Parameter	Estimate	t-Statistic	Marginal impact
ϕ	3.5514661e+04	6.2848525e+00	
θ_0	-2.4830199e+00	-6.7714384e+01	-2.0192186e-01
θ_1	3.8825277e-04	1.2435401e+00	3.1573135e-05
θ_2	1.6597791e-05	4.5657596e-01	1.3497503e-06
θ_3	2.9713719e-02	1.2146173e+00	2.4163518e-03
θ_4	-1.2170063e+00	-9.4078846e-01	-9.8968271e-02
θ_5	3.6239703e+00	3.6752753e+00	2.9470518e-01
θ_6	-4.1984856e+00	-4.5776341e+00	-3.4142539e-01
θ_7	-1.3114725e+00	-5.8815310e-01	-1.0665036e-01
θ_8	1.4673116e-01	5.6485698e-02	1.1932337e-02

Pseudo-R^2 0.77 n=79

Future research

- We are working on the asymptotic properties of a semiparametric estimator for the model

  $$E(Y_{tF}|h^{1/2}(r_{t-1},\cdots,r_{t-L}),W_t) = g^{-1}(\theta h^{1/2}(r_{t-1},\cdots,r_{t-L})+m(W_t))$$

  Implementation of this model and estimator will be hindered by the small time series.
- Different food groupings might give stronger results
- Volatility sequence is stochastic and dependent!