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Pass Through, Food Prices and Food Security

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ABSTRACT: This paper studies the impact of world food price movements on final consumption prices across countries with different levels of income. Using FAO world food price index data and ILO local consumer price index data we estimate the rate of pass through of world food prices onto final consumption prices. We find that the rate of pass through from world food prices to final consumption prices is about 30% in low and middle income countries and about 12% in high income countries. A larger rate of pass through in low income countries reflects a larger share of primary food in processed food and a smaller role for services margins. Indeed, the estimated rates of pass through are close to primary food shares in total food consumption in the different groups of countries from the national accounts in the GTAP database.
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1 Introduction

The commodity crisis of 2007/2008 and 2010/2011 underscores the vulnerability of the global food system to shocks from diverse sources: extreme weather events, disruption in energy and financial markets, increased demand for non-food products as well as export bans and other measures applied by various governments intent on shielding their constituents from spiking prices in international markets. These events have in turn prompted research on food price transmission and the underlying politics on food price volatility. Swinnen and Squicciarini (2012) has stressed that the political demands of developing countries and Non Government Organizations (NGOs) in this regard are actually inconsistent over time. There were consistent demands for changes in food policy in the Organisation for Economic Co-operation and Development (OECD) that led, predictably, to food price increases. These increases have themselves been criticized by the same combination of NGOs and developing countries thereafter.

In this paper, we examine another aspect of food price volatility – the extent to which world price movements actually impact on final consumption prices. Intensive studies can be found in the literatures addressing price pass-through especially after the abruptly world food price surges mentioned above. Mundlak and Larson (1992) point out that volatility of world agricultural prices are the main source of variation of domestic food prices. Nonetheless, the pass-through rates differ among countries and depend on various factors.

First of all, since international food prices are denominated in dollars, the movement of exchange rates leads to changes in domestic prices. Campa and Goldberg (2005)

exam the exchange rate pass-through for OECD countries, and reach a long run average elasticity of exchange rate for food import prices as high as 66%. However, the exchange rate pass-through is less complete for consumers. Abbott and de Battisti (2011) show that the depreciation of African currencies mute the border price changes, keep local prices high after the crisis and diminish the effect of declining world prices.

Secondly, the recent drastic policy reforms undertaken in many countries have either contributed or hindered the world food prices transmission to domestic markets. The impact is mixed. Baffes and Gardner (2003) test the co-integration of world food prices and domestic prices before and after trade liberalization in eight developing countries and found out that only three of them experience great pass-through. Dawe (2008) discover that the real rice prices in several Asian countries have only increase one third of the world rice price due to specific policies. Ferrucci et al (2008) compare the pass-through patterns of EU countries and conclude that Common Agricultrural Policy (CAP) contributes to a statistically and economically significant food price pass-through in the euro area. Imai et al (2008) claim that the transmission is incomplete presumably because of distortionary government interventions by studying the agricultural commodity price pass-through in India and China.

Further studies investigate the source of incomplete transmission of prices as a result of the margin effect. Due to distribution structure, retailing cost etc., the world price pass-through is more significant for domestic producers than consumers (e.g. Leiptag (2009) and Francois et al (2008)). Final consumption prices include not only the final commodities themselves, but require further service inputs (transport, distribution, food-

processing services) to change basic commodities into final, delivered consumption goods. Those margins drive a wedge between producer and consumer prices. Additionally, these margin activities are more expensive in high-income countries, yielding insulation from volatility of commodity prices at the final consumption level. IMF (2008) estimates that the pass-through rate in advanced economies have been decreasing along with the economic growth during the 70s to 90s. And emerging countries now have roughly three times higher pass-through rate than in advanced economies. As a result, the poor in developing countries, whose large share of income is spent on food staples, become extremely vulnerable to the volatility of world food prices (Ivanic and Martin (2008)).

In this paper, we address the long-term impact of price transmission on food security, thus to identify the vulnerable groups under the high volatility of world food prices. Yet Computable General Equilibrium (CGE) models typically ignore the bundling of margin services and commodities in consumption. We engage in a two-step exercise. The first step involves econometric analysis of price pass-through. Here, we work with commodity price data, consumption price data, and service price data to quantify the extent to which commodity prices are translated into final consumer price volatility. These estimates are used in a second-stage CGE exercise with the GTAP Framework, where we include adjustments based on our pass-through estimates. The rest part of the paper is organized as the following: Section 2 includes the econometric estimation of pass-through elasticity. The results are are compared with GTAP data. Conclusions and comments are offered in section 3.

2 Econometric Analysis of Food Price Pass-Through

2.1 Empirical Specification

The consumption of food Q_f in a country can be decomposed into a primary food component Q_{pf} of food traded internationally like wheat, meat and milk and additional local services in food consumption Q_{sf} not traded internationally such as shipping, local processing, storage, and distribution. Suppose Q_f is a homothetic function of Q_{pf} and Q_{sf}.[1] We can then write the price of food consumption P_f as a function of the price of primary food P_{pf} and the price of food services P_{sf}:

$$P_f = G\left(P_{pf}, P_{sf}\right) \tag{1}$$

Log differentiating equation (1) and applying Shephard's lemma, the relative change of the price of food consumption can be expressed as a function of the relative change of the price of primary food and food services:

$$\widehat{P_f} = \frac{P_{pf}Q_{pf}}{P_fQ_f}\widehat{P_{pf}} + \frac{P_{sf}Q_{sf}}{P_fQ_f}\widehat{P_{sf}} \tag{2}$$

So, from equation (2) the share of internationally traded food in total food consumption is equal to the elasticity of P_f with respect to P_{pf}. We can calculate this elasticity by estimating a pass through equation in logs of total food prices P_f on internationally traded

[1] In Appendix C the case with nonhomothetic preferences across primary food and food services is mapped out. The results are identical. We work with homothetic preferences in the main text for ease of exposition.

food prices P_{pf}.

Following the literature on pass through (Campa and Goldberg (2005), Nakamura and Zerom (2012)) we regress the first difference of the (log) price of total food consumption on the first difference of the (log) price of internationally traded food:

$$\Delta \log P_{f,it} = \sum_{k=0}^{K} \beta_{r,k} \Delta \log P_{pf,it-k} + \eta_i + \varepsilon_{it} \tag{3}$$

i is a country subscript, t is a time subscript, r a region subscript and η_i is a country fixed effect. The number of lags K is determined by the rule followed in Nakamura and Zerom (2012) that adding more lags does not change the long-run elasticity. The long run elasticity is equal to the sum of pass-through coefficients, $\sum_{k=0}^{K} \beta_{r,k}$. The price of total food consumption in country i, $P_{f,it}$, is measured with the food component in country i's CPI. The price of internationally traded food, $P_{pf,it-k}$, is measured with an international food price index converted into local currencies.[2]

We estimate different coefficients for different regions r, as the share of local food services is expected to vary across regions r. The price of these services tends to rise as countries grow richer for two reasons. First, the Harrod-Balassa-Samuelson effect (Baumol (1967) and Balassa (1964)) tends to raise the price of local services as countries get richer. With limited possibilities for substitution between primary food and food services, this will increase the share of food services. Second, consumers' demand for quality will rise as countries grow. This will mainly lead to more consumption of the local

[2]We abstract from markup adjustments of international and local wholesalers and local retailers in using the long run elasticity as a measure for the share of internationally traded food in total food consumption.

services component, as primary food traded on the international market consists mainly of homogeneous food items.

2.2 Data

The data cover 202 countries over the period 1990-2012. The price of total food consumption in country i, $P_{f,it}$, is calculated from the food component in country i's consumer price index (CPI) composed by the ILO (ILO (2013)). The price of internationally traded food, $P_{pf,it-k}$, is calculated from the world food price index (WFPI) composed by FAO (FAO (2013)). Both are available on a monthly basis. The WFPI is converted from dollars into local currencies using IMF and World Bank data on historical exchange rates (IMF (2013) and World Bank (2013)). When monthly exchange rates are not available, annual series are extrapolated. Income per capita data to define different income groups are from the World Bank (World Bank (2013)). The three income groups are low and lower middle income (less than $3000 per capita GDP at year 2000 prices), higher middle income ($3000-$9000) and high income (more than $9000).

2.3 Estimation Results compared with GTAP

Table 1 displays the results of the estimation of equation (3). Table A.1 in Appendix A shows that the H0 of a unit root cannot be rejected. This provides support for estimation in first differences. To check robustness of the estimation in first differences, we have also conducted a regression in levels including an AR(1) term. The results for the three income groups of the regression in levels are in the first three columns of table 1 and the

results of the regression in first differences in the last three columns. Following the rule by Nakamura and Zerom (2012) on the number of lags described in subsection 2.1, we included 15 lags.

The first two rows of table 2 show the long run elasticities following from the estimations in first differences and in levels. A clear pattern emerges: the long run elasticity is much larger in low/lower middle income and middle income countries than in high income countries. From the estimation in first differences the pass through is about 12% in high income countries and about 30% in low and middle income countries. Pass through rates are roughly equal in the lowest and middle income category.

From equation (2) the pass through rates provide an estimate for the share of internationally traded food in total food consumption. Therefore, we can compare the pass through rates with national accounts data on the share of internationally traded food in total food consumption. The third row of table 2 displays the share of primary food in consumer food prices in three different categories of countries from GTAP (Appendix B). The shares are close to the pass through rates for low and middle income countries. The share of primary food in the middle income countries is about 10% larger than the pass through rate. A possible explanation for this pattern is that the shares of the different food items in the local CPI P_f are different from the shares in the world food price index WFPI, P_{pf}. In Appendix D it is shown that the coefficients on P_{pf} will be upward biased if goods with a larger share in the local CPI than in the international WFPI display larger than average price increases. This might be in particular the case for middle income countries. To illustrate which share in the consumer food price index is picking

	regression in levels[1].			regression in differences[1].		
	low income	middle income	high income	low income	middle income	high income
$lnDFPI_t$	0.118***	0.138***	0.0279***			
	(0.0122)	(0.0116)	(0.00489)			
$lnDFPI_{t-1}$	0.136***	0.155***	0.0539***			
	(0.0122)	(0.0116)	(0.00486)			
$\Delta lnDFPI_t$				0.0149***	0.0130***	-0.00405
				(0.00320)	(0.00436)	(0.00296)
$\Delta lnDFPI_{t-1}$				0.0190***	0.0288***	0.00868***
				(0.00328)	(0.00437)	(0.00306)
$\Delta lnDFPI_{t-2}$				0.0441***	0.0329***	0.0154***
				(0.00485)	(0.00437)	(0.00305)
$\Delta lnDFPI_{t-3}$				0.0312***	0.0384***	0.0105***
				(0.00487)	(0.00439)	(0.00304)
$\Delta lnDFPI_{t-4}$				0.0282***	0.0258***	0.00279
				(0.00485)	(0.00437)	(0.00299)
$\Delta lnDFPI_{t-5}$				0.0157***	0.0214***	0.0123***
				(0.00487)	(0.00436)	(0.00298)
$\Delta lnDFPI_{t-6}$				0.0137***	0.0111**	0.00898***
				(0.00487)	(0.00434)	(0.00299)
$\Delta lnDFPI_{t-7}$				0.0158***	0.0184***	0.0108***
				(0.00486)	(0.00430)	(0.00298)
$\Delta lnDFPI_{t-8}$				0.0222***	0.0166***	0.00944***
				(0.00488)	(0.00431)	(0.00299)
$\Delta lnDFPI_{t-9}$				0.0115**	0.0148***	0.00760**
				(0.00489)	(0.00431)	(0.00300)
$\Delta lnDFPI_{t-10}$				0.0158***	0.00516	0.00497
				(0.00488)	(0.00435)	(0.00305)
$\Delta lnDFPI_{t-11}$				0.0159***	0.0189***	0.0123***
				(0.00488)	(0.00435)	(0.00304)
$\Delta lnDFPI_{t-12}$				0.0159***	0.00889**	0.000314
				(0.00489)	(0.00434)	(0.00304)
$\Delta lnDFPI_{t-13}$				0.0143***	0.0171***	0.00499
				(0.00487)	(0.00433)	(0.00305)
$\Delta lnDFPI_{t-14}$				0.0224***	0.0142***	0.00809***
				(0.00485)	(0.00433)	(0.00305)
$\Delta lnDFPI_{t-15}$				0.0155***	0.0121***	0.00985***
				(0.00488)	(0.00435)	(0.00297)
Observations	9,723	5,392	5,231	8,372	4,743	4,553
χ^2	293.84	626.12	137.6579	353.29	429.17	278.65
$Pr > \chi^2$	0.000	0.000	0.000	0.000)	0.000)	0.000
No of regions	76	39	38	70	38	36

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

1. FGLS AR(1) with heteroskedastic panel corrected standard errors.

Table 1: **World primary food prices and internal consumer food prices**

up as countries get richer, the fourth row of table 2 displays the share of margin services in consumer food prices. As countries get richer their primary food share falls and their share of margin services correspondingly rises.

	low income	middle income	high income
long-run passthrough regression in levels	0.254	0.293	0.082
long-run passthrough regression in differences	0.316	0.296	0.123
primary food share of consumer food price	0.280	0.192	0.115
margin service share of consumer food price	0.185	0.267	0.402

Table 2: **Long-run passthrough and cost shares**

3 Concluding Remarks

In this paper we investigate to which extent international food prices are transmitted into domestic markets due to different margin effect. By constructing country specific time trend for the econometric estimation in first differences, we are able to capture the long run pass-through elasticities in different country groups. Robust check confirms the estimation. Empirical results show that high margin value coupled with food commodities in rich economies moderate the price transmission while consumers from poor economies are more exposed to the volatility of international prices. Consequently, commodities

price surges during recent years have worsened the situation of food buyers, especially in less developed countries.

The estimation fits well with the calculation of margin share in GTAP database. Our next step will focus on the inclusion of margin effect in the consumption structure, where we simulate the final consumer price for long-term projections.

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Appendix A Unit-Root Test

Annex Table A.1: **Fisher-type unit-root test**

	Statistic	p-value
Inverse χ^2 (294) P	226.8330	0.9986
Inverse normal Z	13.8464	1.0000
Inverse logit t(724) L	13.8161	1.0000
Modified inv. χ^2 Pm	-2.7699	0.9972

Based on augmented Dickey-Fuller tests
Ho: All panels contain unit roots
Ha: At least one panel is stationary
No of panels = 154, Avg no of periods = 133.71

Appendix B GTAP Pass-Through

GTAP is a multi-regional CGE model which captures world economic activity in 57 different industries of 134 regions (Version 8 of the database, base year 2007), with perfect competition and constant returns to scale, bilateral trade is handled via the Armington assumption (Hertel and Tsigas (1997)). The underlying set ups of GTAP is similar to other CGE models. Standard GTAP model treats prices of food commodities and their attached margin cost separately. To calculate the pass-through in GTAP, the data are aggregated into 8 regions (table 3) and 6 industries (table 4) depending on the levels of countries' richness (World Bank (2013)). The share of margin cost is calculated according to the share of "Trade" in the final consumed goods. Multiplying this ratio with the share of primary food in producing processed food give us the pass-through rate in GTAP (table 2).

Annex Table B.1: Detailed region aggregation in GTAP		
Region Code	Region Details	Description
BRA	Brazil	Brazil
CHN	China	China
IND	India	India
JPN	Japan	Japan
USA	United States of America	USA
HIPC	Australia; New Zealand; Hong Kong; Korea; Taiwan; Singapore; Canada; Rest of North America; Austria; Belgium; Cyprus; Czech Republic; Denmark; Estonia; Finland; France; Germany; Greece; Hungary; Ireland; Italy; Luxembourg; Malta; Netherlands; Poland; Portugal; Slovakia; Slovenia; Spain; Sweden; United Kingdom; Switzerland; Norway; Rest of EFTA; Croatia; Bahrain; Israel; Kuwait; Oman; Qatar; Saudi Arabia; United Arab Emirates	High Income Countries
MIPC	Malaysia; Thailand; Mexico; Argentina; Chile; Colombia; Ecuador; Peru; Uruguay; Venezuela; Rest of South America; Costa Rica; Panama; Latvia; Lithuania; Bulgaria; Belarus; Romania; Russian Federation; Rest of Europe; Kazakhstan; Azerbaijan; Iran Islamic Republic of; Turkey; Tunisia; Rest of North Africa; Botswana; Namibia; South Africa	Middle Income Countries
LIPC	Rest of Oceania; Mongolia; Rest of East Asia; Cambodia; Indonesia; Lao People's Democratic Republic; Philippines; Viet Nam; Rest of Southeast Asia; Bangladesh; Nepal; Pakistan; Sri Lanka; Rest of South Asia; Bolivia; Paraguay; Guatemala; Honduras; Nicaragua; El Salvador; Rest of Central America; Caribbean; Albania; Ukraine; Rest of Eastern Europe; Kyrgyztan; Rest of Former Soviet Union; Armenia; Georgia; Rest of Western Asia; Egypt; Morocco; Benin; Burkina Faso; Cameroon; Cote d'Ivoire; Ghana; Guinea; Nigeria; Senegal; Togo; Rest of Western Africa; Central Africa; South Central Africa; Ethiopia; Kenya; Madagascar; Malawi; Mauritius; Mozambique; Rwanda; Tanzania; Uganda; Zambia; Zimbabwe; Rest of Eastern Africa; Rest of South African Customs; Rest of the World	Low Income Countries

Table 3:

	Annex Table B.2 Detailed sector aggregation in GTAP	
Sector Code	Sector Details	Description
PrimFood	Paddy rice; Wheat; Cereal grains nec; Vegetables, fruit, nuts; Oil seeds; Sugar cane, sugar beet; Plant-based fibers; Crops nec; Cattle,sheep,goats,horses; Animal products nec; Raw milk; Wool, silk-worm cocoons	Primary Food
Procfood	Meat: cattle,sheep,goats,horse; Meat products nec; Vegetable oils and fats; Dairy products; Processed rice; Sugar; Food products nec; Beverages and tobacco products	Processed Food
Mnfc	Forestry; Fishing; Coal; Oil; Gas; Minerals nec; Textiles; Wearing apparel; Leather products; Wood products; Paper products, publishing; Petroleum, coal products; Chemical,rubber,plastic prods; Mineral products nec; Ferrous metals; Metals nec; Metal products; Motor vehicles and parts; Transport equipment nec; Electronic equipment; Machinery and equipment nec; Manufactures nec; Electricity; Gas manufacture, distribution; Water; Construction.	Extraction, Textile, Manufacturing and Construction
Transport	Transport nec; Sea transport; Air transport	Transport
Trade	Trade	Trade
CommOthSer	Communication; Financial services nec; Insurance; Business services nec; Recreation and other services; PubAdmin/Defence/Health/Educat; Dwellings	Communication and Other Services

Table 4:

Appendix C Nonhomothetic Preferences

Suppose the demand across primary food and food services is non-homothetic. We can then write the average spending on total food consumption $\widetilde{P}_f$ (as a proxy for its price) as the minimum expenditure on total food $\widetilde{G}\left(P_{pf}, P_{sf}\right)$ divided by the consumption of primary food $\widetilde{Q}_f$:

$$\widetilde{P}_f = \frac{\widetilde{G}\left(P_{pf}, P_{sf}\right)}{\widetilde{Q}_f} \tag{C.1}$$

Log differentiating equation (C.1) and applying Shephard's lemma generates an expression for the relative change of $\widetilde{P}_f$:

$$\widehat{\widetilde{P}_f} = \frac{Q_{pf}P_{pf}}{\widetilde{P}_f\widetilde{Q}_f}\widehat{P_{pf}}$$

Hence, the elasticity of total food prices with respect to primary food prices generates an expression for the primary food share also with non-homothetic preferences.

Appendix D Differences in Food Shares

Suppose the food items are indexed by subscript j. The quantity, price and value shares of the different food items in the local CPI and WFPI are indicated by respectively $q_{f,ij}, P_{f,ij}, s_{f,ij}$ and $q_{pf,j}, P_{pf,ij}, s_{pf,ij}$. We have then:

$$\begin{aligned} Q_{f,i}P_{f,i} &= \sum_j p_{f,ij}q_{f,ij} \\ Q_{pf}P_{pf} &= \sum_j p_{pf,j}q_{pf,j} \end{aligned}$$

Log differentiating the price indexes gives:

$$\begin{aligned}\widehat{P_{f,i}} &= \sum_j s_{f,ij}\widehat{p_{f,ij}} \\ \widehat{P_{pf}} &= \sum_j s_{pf,j}\widehat{p_{f,j}}\end{aligned}$$

We want to get a measure for $s_{pf,i}$ which can be defined as:

$$\begin{aligned}s_{pf,i} &= \frac{\sum_j q_{pf,ij}P_{pf,ij}}{\sum_j q_{f,ij}P_{f,ij}} \\ &= \frac{\sum_j q_{pf,ij}P_{pf,ij}}{\sum_j q_{pf,ij}P_{pf,ij} + \sum_j q_{sf,ij}P_{sf,ij}}\end{aligned}$$

This can be gathered from the regression of log price changes of total food on log price changes of primary food (equation (1)):

$$\widehat{P_{f,i}} = \frac{Q_{pf,i}P_{pf,i}}{Q_{f,i}P_{f,i}}\widehat{P_{pf,i}} + \frac{P_{sf,i}Q_{sf,i}}{P_{f,i}Q_{f,i}}\widehat{P_{sf,i}}$$

But the price indexes in the data are calculated from the prices of the individual food items:

$$P_{f,i}\left(p_{f,i1},..,p_{f,iJ}\right) = G\left(P_{pf}\left(p_{pf,i1},..,p_{pf,iJ}\right), P_{sf}\left(p_{sf,i1},..,p_{sf,iJ}\right)\right)$$

Therefore, $\widehat{P_{f,i}}$ is measured with local shares $s_{f,ij}$ as follows:

$$\widehat{P_{f,i}} = \sum_j s_{f,ij}\widehat{p_{f,ij}}$$

And $\widehat{P_{pf,i}}$ should be measured with local shares $s_{pf,ij}$:

$$\widehat{P_{pf,i}} = \sum_j s_{pf,ij} \widehat{p_{pf,ij}}$$

But $\widehat{P_{pf,i}}$ is measured in reality with international shares $s_{pf,j}$:

$$\widehat{P_{pf}} = \sum_j s_{pf,j} \widehat{p_{pf,j}}$$

If the exchange rate conversions are correct we have $\widehat{p_{pf,ij}} = \widehat{p_{pf,j}}$. But the shares in the WFPI $s_{pf,j}$ might deviate from the shares in the local CPI $s_{pf,ij}$.

To make the exposition as easy as possible, suppose that we estimate the following relationship (omitting the lags) with an estimated $\overline{\beta}$:

$$\sum_j s_{f,ij} \widehat{p_{f,ij}} = \overline{\beta} \sum_j s_{pf,j} \widehat{p_{pf,j}}$$

Whereas we need the true β using the correct shares:

$$\sum_j s_{f,ij} \widehat{p_{f,ij}} = \beta \sum_j s_{pf,ij} \widehat{p_{pf,j}}$$

Suppose we would estimate with method of moments, we would get the following expression for the estimated $\overline{\beta}$ as a function of the true β:

$$\overline{\beta} = \frac{\sum_j s_{f,ij} \widehat{p_{f,ij}}}{\sum_j s_{pf,j} \widehat{p_{pf,j}}} = \beta \frac{\sum_j s_{pf,ij} \widehat{p_{pf,j}}}{\sum_j s_{pf,j} \widehat{p_{pf,j}}}$$

Hence, if price increases across goods correlate positively with the local relative international share, one overestimates the β. Or phrased differently, if goods with larger than average price increases have a larger local share $s_{pf,ij}$ than international share $s_{pf,j}$ the β will be upwardly biased. A way to check the possible impact of this bias is to run som simulations on how large of a bias one can expect for certain deviations of the spending shares.θ