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Local impacts of a global crisis: Food price transmission, consumer welfare and poverty in Ghana

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ABSTRACT

This paper takes a local perspective on global food price shocks by analyzing food price transmission between regional markets in Ghana. It also assesses the impacts of food price increases on various household groups. Taking the 2007–2008 global food crisis as an example, we show that prices for domestic grain products are highly correlated with world market prices. This is true both for products for which Ghana is highly import-dependent (e.g., rice) and the products for which Ghana is self-sufficient (e.g., maize). The econometric results also show that price transmission is high between regional producer markets and markets located in the country's largest cities, and the distance between producer and consumer markets and the size of consumer markets matter in explaining the price transmission. The welfare analysis for households as consumers shows that the effect of world food prices appears relatively modest for the country as a whole due to relatively diverse consumption patterns within country. However, the national average hides important regional differences, both between regions and within different income groups. We find that the poorest of the poor—particularly those living in the urban areas—are hardest hit by high food prices. The negative effect of the food crisis is particularly strong in northern Ghana. The main explanations for this regional variation in the price effect is the different consumption patterns and much lower per capita income levels in the North of Ghana compared to other regions in the country.

Introduction

Since 2007, world food prices have surged rapidly, leading to an acute global food crisis in 2008. This escalation of food prices has highlighted the increasing complexity of the causes and effects of food price shocks in a globalized world and raised serious concerns among policymakers about the adverse impacts of food prices on the poor in developing countries. Most analysts agree that a mix of rising oil prices, US dollar ($) depreciation, biofuel policies, market speculation, and temporarily imposed trade restrictions all contributed to the rapid surge in food prices [see Headey and Fan (2008) for a review]. Several cross-country studies also confirm that the net welfare effect of rising food prices on the world's poor has been negative, mainly due to the high share of net food buyers among the poor (Ivanic and Martin, 2008; Dessus et al., 2008; Aksoy and Isik-Dikmelik, 2008).

However, the impacts of surging food prices are often country specific and depend critically on macroeconomic conditions, the country's net international trade position, and the food production and consumption patterns of different households groups at the subnational level. In addition, the degree of price transmission within countries varies widely and is critical in determining local prices, particularly in more remote parts of a country (Conforti, 2004; Abdulai, 2000; Baffes and Gardner, 2003). Despite the importance of price transmission in determining household welfare effects, only few studies on the 2007–2008 global food crisis have included a rigorous price transmission analysis and subnational regional heterogeneity.[1] Taking price transmission into account is especially important in countries with big regional disparities. For example, the poverty rate is 62.7% in the North of Ghana, while it is 28.5% at the national level (GSS, 2007).

This paper aims to fill this gap in the literature by combining price threshold cointegration analysis with a regionalized household consumption model for Ghana. In the next section we first review major food trade, price, and consumption developments in Ghana before and during the 2007–2008 food crisis. In "Food price transmission in Ghana", we use the threshold cointegration model to measure the price transmission between international and domestic markets and among different regional markets for major food staples. Based on the findings in "Food markets and policies in Ghana" and "Food price transmission in Ghana", we analyze the impacts of region-specific price changes on different regional

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[1] Arndt et al. (2008) include a simple correlation analysis and find evidence for strong price transmission for Mozambique.

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household groups, using a consumption model calibrated to the most recent Ghana Living Standard Survey (GLSSV, 2005–2006). Last section offers conclusions.

Food markets and policies in Ghana

Food trade and policies

Similar to other countries in West Africa, different agro-ecological conditions characterize different crop and hence consumption patterns across regions in Ghana[2]. Such heterogeneous production and consumption patterns must be taken into consideration in understanding price transmission in the country. The Northern and Southern Savannah zones are the dominant sorghum and millet production areas, accounting for 60% of national production of these two crops. Local rice is also produced in these zones, accounting for 70% of national production. However, while sorghum and millet are local crops with little international trade, local rice can only meet 35% of domestic demand. On the other hand, maize is a crop broadly grown and consumed in the country. However, with the semi-humid weather in the southern part of the country, it is possible to have two seasons of maize in the Forest zone while there may be only one season in the Northern and Southern Savannah zones. Because this, more than 40% of maize is produced in the southern and middle belt of the Forest zone. For the country as a whole, Ghana is self-sufficient in maize production, while intra-country trade and informal cross-border trade (in West Africa) do exist. Root and tuber crops, primarily cassava, yam, cocoyam, can be produced in most places of the country, though different types of roots and tubers may concentrate in different locations. For example, cassava production is concentrated in the Northern and Southern Savannah zones (45%) and cocoyam in the Forest zone (60%). While some root crops (such as yam) are actively traded in the country, besides cross-border trade in West Africa, there is little international trade for such crops.

In summary, with its diversified agro-ecological conditions, Ghana is largely self-sufficient in major staple crops, yet it depends on imports of wheat and rice to meet domestic demand. About 65% of rice consumed domestically (100% of wheat) is imported, while as mentioned above, imports are negligible for the other major staple crops, such as maize, yam, and cassava (Table 1). Food crops are also negligible in formal exports, yet cross-border trade in certain food crops is reported but is hard to measure.[3]

Ghana is a relatively open economy with low tariff rates for most commodities. The maximum (ad valorem equivalent of specific tariff) tariff rate was 20% in 2007 (World Bank, 2008),[4] which is also the standard rate applied to major food items in Ghana. Moreover, in an attempt to lower domestic food prices, the Ghanaian government temporarily waived tariffs on imports of rice, wheat, yellow corn, and vegetable oil in May 2008, at the height of the food crisis.

In addition to tariff policies and import/export intensities, price transmission can be also highly related to hoarding behavior and government stock/export policies, particularly in the short term. However, these factors can be largely ignored in Ghana, as the country does not have significant public or private capacity to maintain large stocks to deal with unexpected international or domestic shocks. Since the failed attempt to manage its state grain stock system in the 1980s, the country has only once tried (in the case of maize) to build up a state stock as a consequence of an unexpected price shock in 2005–2006. However, the inadequate infrastructural conditions of the warehouses, high electricity costs, and poor management capacity resulted in a huge financial loss and loss of physical stock,[5] which made the government further hesitant to use state-owned stocks as a measure to safeguard against external shocks.

The strong dependence on imports of rice and wheat and the lack of storage capacity indicate that the country is vulnerable to world market price fluctuations, and the sharp rise in import prices for rice and wheat in recent years have confirmed this (Fig. 1).

Table 1
Import dependence, production, consumption, and trade for major staples (average of 2004–2006). *Source*: Authors' calculations based on data obtained from the Trade Statistics Division of the Ghana Statistical Service (GSS).

Food items	Domestic production	Exports	Imports	Domestic consumption	% Import dependence
Maize	1335	0	6	1340	0.43
Rice	266	0	492	759	65
Wheat	0	0	324	323	100
Millet	152	0	0	152	0.01
Sorghum	294	0	0	294	0.00
Yam	4229	12	0	4218	0.00
Cassava	11,062	1	0	11,060	0.00

Note: Production, consumption, and trade are in 1000 metric tons. Data are simple averages.

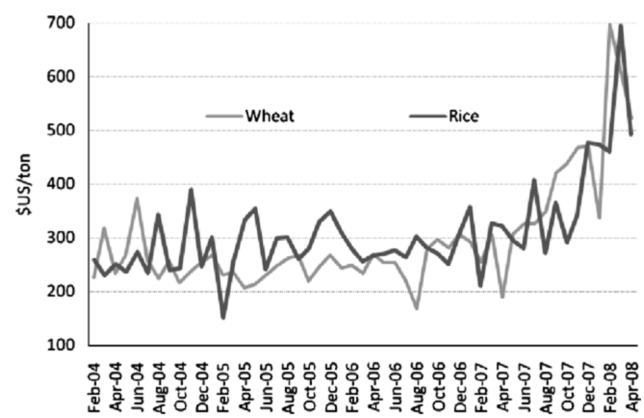

Fig. 1. Wheat and rice price developments (CIF prices, 2004–2008). *Source*: Ministry of Food and Agriculture (MOFA).

Food price trends

In this section we further explore how price for the major imported food item, rice, might affect prices for locally produced rice and for the nontraded staple products in Ghana. Fig. 2 depicts the price trends for imported and local rice in two major markets, Accra, Ghana's largest consumer market for both imported and local rice, and Tamale, one of the largest supply markets for local rice. It can be seen in Fig. 2, the movement of prices for local rice generally follows the change in the price for imported rice. While local rice

[2] The Coastal zone comprises the Coastal Savannah. The Forest zone covers the Rainforest and Deciduous Forest area. The Northern Savannah zone includes the Central Sudan Savannah, the Eastern Sudan Savannah, the Open Guinea Savannah. The Southern Savannah zone comprises the remaining sub-zones (see Fig. A2).

[3] Cross-border informal trade is generally not captured by a country's custom data. While the volume of informal trade is believed to be quite large in some markets, particularly in the North of Ghana, these trade flows are largely limited to neighboring countries in West Africa such as Niger, Burkina Faso, Togo, and Nigeria. Thus, informal trade may only have limited effects on the transmission of the food crisis to domestic markets in Ghana.

[4] Ghana applies few formal nontariff barriers. However, in several nontariff barrier indicators, Ghana is behind its peers. For example, logistical competence is noticeably lower, and inefficient customs and other border procedures are problematic. Relatively high domestic transportation costs also have a negative effect on the country's trade activities (IMF 2008).

[5] Information is based on a May 8, 2008, interview with Aggrey Fynn, the former director of Ghana's Agricultural Statistics Department in the Ministry of Food and Agriculture.

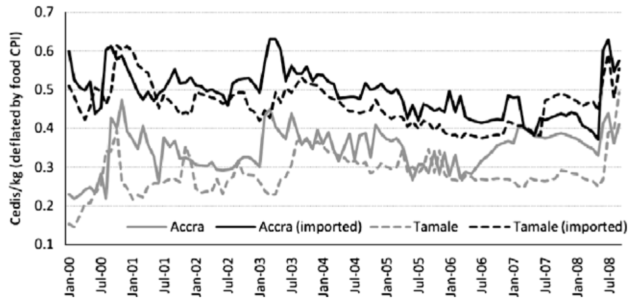

Fig. 2. Movement of the price of rice in the Accra and Tamale markets (2000–2008). *Source*: Authors' calculations using data obtained from Ghana Statstical Service (GSS).

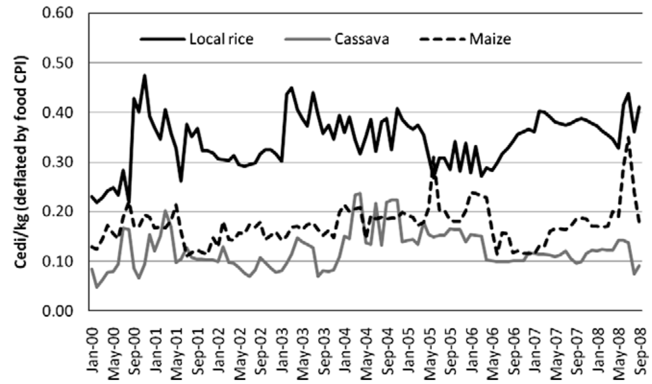

Fig. 3. Price movement for major crops in the Accra market. *Source*: Authors' calculations using data obtained from the Ghana Statstical Service (GSS).

differs from the imported rice in terms of quality and taste characteristics, and hence, is not perfectly substitutable with the imported rice, the markup margin associated with both local and imported rice, together with trade and transport costs, was quite constant in both markets before the food crisis. Moreover, the price difference between the two markets for imported rice is relatively smaller than the price difference between imported and local rice. Between 2000 and 2008, price differences between imported rice in Accra and Tamale ranged between 0.02 Ghanian cedis/kg and 0.09 Ghanian cedis/kg and the highest price gap was about 4.5 times of the lowest gap in this period. On the other hand, the price difference for local rice in the two markets was between 0.06 Ghanian cedis/kg and 0.35 Ghanian cedis/kg, almost six times the difference between the highest and lowest price gap. However, a different pattern in price movements was observed during 2007 and 2008 when the world price of rice increased significantly (Fig. 2). While the price for local rice in the Accra market rose to the level of imported rice from May to July 2007, a lean season in the country, its movement became relatively flat after that. In contrast, the gap between prices for local rice and for imported rice in the Tamale market widened during this period, compared to historical trends.

Yet, the effect on local prices also hinges on the question, in how far high world market prices for other (nontraded) food commodities spill over to local markets. Substitution in consumption between rice and local staples such as maize and cassava may cause domestic prices for nontradable products to rise when the world prices for imported food products increase. The trends depicted in Fig. 3 suggest that prices for all staple products had a tendency to move together in recent years, with the exception of 2006, particularly for maize. However, after the decline of the price of maize in 2006, a year in which maize and rice prices moved in opposite directions, the price of maize started to increase again in 2007 and 2008, moving in the same direction as the price of rice. Prices for cassava and sorghum followed a similar trend as that of rice prices in late 2007 and 2008, while yam prices started to increase only in 2008.

Food consumption patterns

Consumption patterns in Ghana vary substantially across different income groups and regions. In contrast to many South- and Southeast Asian countries, where rice often makes up the lion's share of staple food consumption, particularly for poor households, Ghana, like many other West African countries, has a much more diverse diet among both rural and urban households. Calculations from the recent household survey (GLSSV 2005–2006) show that grain and root/tuber consumption together account for about 28% of total food expenditure for an average Ghanaian. Spending on staple food (including the consumption of own production) is almost equally distributed between grain products (maize, rice, wheat, sorghum, millet) and roots and tubers (cassava, yam, cocoyam). This consumption pattern applies to both rural and urban households, while the share of grain and root staples together accounts for a much larger share (33%) of total spending in rural areas.

Across different regions in the country, however, household food consumption structures vary, both in rural and urban areas. Roots and tubers are more important as staples in three agro-ecological zones, Coast, Forest, and the Northern and Southern Savannah zones (particularly for rural households), while in the Northern Savannah zone, the share of grain consumption is much higher than the share of roots/tubers (Table 2, second part). Moreover, poor households generally spend more of their income on staples. With more than 60% of households in the Northern Savannah zone (hereafter referred to as "the North of Ghana") living below the national poverty line, Northern households spend a much higher proportion of their income on food than households in the rest of the country (Table 2, first part). These two factors together (i.e., more grain consumption and more spending on food in the North) indicate that poor Northern households are more vulnerable to rising world food prices, which have particularly surged for grain products. In "Welfare impacts of food price shocks" we quantitatively measure this impact using a household model.

While the poor consume proportionally more food as a share of their income, some households, particularly rural households, meet part of their food consumption by own production. The impact of rising food prices on the consumption levels of households whose consumption is primarily met by their own production is expected to be smaller than the impact on households relying on food purchases from markets. Therefore, we report the share of their own production and purchased staples[6] separately in Table 3, together with the share of other food and food in total expenditure by 10 income groups in both rural and urban areas.

Results show that staples, either self-produced or purchased from markets, account for a larger share of spending for poor households in the first two decile groups compared to other household groups. However, compared with rural households, shares of purchased staples are generally larger for urban households, particularly for urban poor households in the first two decile groups. These consumption patterns, which indicate that rising food prices may affect urban households more than rural households, will be further analyzed in "Welfare impacts of food price shocks".

[6] We consider only grains (including maize, rice, wheat, sorghum, and other grains that cannot be identified) and roots/tubers as staples and group other foods such as pulses, oilseeds, vegetables, fruits, and livestock products into an "other food" category in our analysis.

Table 2
Household expenditure structure across agro-ecological zones. *Source*: Authors' calculations using data from GLSSV 2005–2006.

	Total expenditure			Food expenditure			
	Food	Other	Total	Grains	Roots	Other food	Total food
Rural							
Coastal	62.0	38.0	100	12.9	14.8	72.2	100
Forest	57.5	42.5	100	11.3	17.3	71.4	100
S. Savannah	65.5	34.5	100	16.4	29.7	53.9	100
N. Savannah	70.3	29.7	100	26.8	12.0	61.2	100
Urban							
Coastal	41.1	58.9	100	9.4	8.1	82.5	100
Forest	47.5	52.5	100	11.2	11.7	77.1	100
S. Savannah	53.5	46.5	100	11.8	17.7	70.5	100
N. Savannah	51.4	48.6	100	24.2	9.4	66.4	100

Table 3
Food consumption share by income groups. *Source*: Authors' calculations using data from GLSSV 2005–2006.

	Staples		Other food	Food in total spending
	Own production	Purchased		
Rural				
The poorest	28.3	16.2	55.6	65.4
2nd	24.4	13.7	61.9	64.7
3rd	24.1	13.3	62.6	66.2
4th	21.5	14.3	64.2	64.4
5th	21.9	13.4	64.7	64.2
6th	18.9	14.2	66.9	64.2
7th	18.9	13.0	68.1	63.6
8th	18.3	13.2	68.5	60.5
9th	16.2	14.0	69.8	62.3
The richest	11.3	12.0	76.7	54.6
Urban				
The poorest	17.5	19.8	62.8	54.8
2nd	9.9	17.5	72.7	54.8
3rd	8.4	21.6	70.0	53.5
4th	6.8	22.0	71.2	54.7
5th	6.9	20.6	72.5	55.0
6th	4.1	21.0	74.9	53.6
7th	3.6	20.8	75.6	52.9
8th	2.8	19.5	77.7	51.5
9th	3.1	18.3	78.6	49.6
The richest	1.5	15.7	82.8	36.1

Note: The national poverty rate is 28% in the survey, which indicates that most households are poor in the first three groups and extremely poor in the first two groups.

Food price transmission in Ghana

Most price transmission analyses are based on the "law of one price," in which an equilibrium price among spatially separated markets exists as defined by Enke (1951), Samuelson (1952), and Takayama and Judge (1971). This price relationship can be defined as follows:

$$P_{i1} = P_{i2} + T_{i21} \tag{1}$$

where P_{i1} and P_{i2} are the prices of commodity i in two spatially distinct markets 1 and 2, T_{i21} is a markup factor including the cost of transporting a unit of the commodity from market 2 to market 1. All are in logarithmic form. This specification has been widely used in price transmission analyses, including those of Ravallion (1986), Barrett (2008), Baulch (1997) and Asche et al. (2007).

In standard error correction models as above, adjustment towards long-run equilibrium is linear and stable over time, i.e., it is always present and of the same strength under all circumstances. However, transaction costs, chiefly transportation costs, are unlikely to be stable overtime. Ignorance of such costs may inhibit price transmission, which is the major setback for the traditional cointegration method. Threshold cointegration, on the other hand, enables the cointegration relation between two variables to be inactive within a certain threshold, resulting in the variables not adjusting to deviations from equilibrium and adjustment taking place only when deviations become large and exceed the threshold. In other words, as long as the deviations from equilibrium are small, the variables evolve independently and become cointegrated once the disequilibrium is substantial.

To account for this shortcoming (accommodating transaction costs), Balke and Fomby (1997) were one of the early proponents of the concept of threshold cointegration. Unlike the original cointegration method, the threshold cointegration does not impose stationarity on the cointegrating error.[7] Examples also include Goodwin and Piggott (GP) (2001) who concluded that empirical models should consider threshold effects in order to adequately characterize spatially integrated markets; and Sephton (2003) who extended GP analysis and re-examined evidence of threshold cointegration in spatially separated markets. In summary, threshold cointegration allows the cointegrating price relation to change if the price series exhibits a different behavior beyond a threshold in the cointegrating error.

Empirical methodology

We first conducted unit root tests using the ADF tests and found that all our price series to be integrated of order 1 I(1). We also conducted Johanson and Juselius (1992) and the Engle and Granger (1987) cointegration tests after the unit root tests. We found that all bivariate price pairs to be tested in the threshold cointegration model below cointegrate by using the two methodologies. In the following we describe the threshold cointegration model used in this paper.

Let P_t be a 2-dimensional I(1) prices of a specific food in a pair of markets which is cointegrated with a 2×1 cointegrating vector β. Also, let $w_t(\beta) = \beta' P_t$ represent an error correction term. A 2 lag specification of this model can be represented as

$$\Delta P_t = A' P_{t-1}(\beta) + u_t$$

where,

$$P_{t-1}(\beta) = \begin{pmatrix} 1 \\ w_{t-1}(\beta) \\ \Delta P_{t-1} \\ \Delta P_{t-2} \end{pmatrix}$$

The error u_t is assumed to be independent, identically distributed and Gaussian with the covariance matrix $\sum = E(u_t U_t'$. In order to reduce the dimensionality of the system, one of the cointegrating vectors is usually normalized to 1. This specification is completely characterised by a maximum likelihood estimation with the assumption that u_t is independent, identically distributed, and Gaussian with respect to $(\beta, A, \sum)$ where β is $(1 - \beta_2)$ due to the normalization. Prices are said to transmit between these two spatial markets if β_2 is 1 or lies in the 95% confidence interval of β_2.

Threshold cointegration estimates the linear model as above and extends the linear model to accommodate a possible nonlinearity, the model allows different coefficients beyond a threshold. A two-regime threshold which we specify is represented as:

$$\Delta P_t = \begin{cases} A_1' P_{t-1}(\beta) + u_t & \text{if } w_{t-1}(\beta) \leqslant \gamma \\ A_2' P_{t-1}(\beta) + u_t & \text{if } w_{t-1}(\beta) > \gamma \end{cases}$$

where γ is the threshold parameter. The parameters $(A_1, A_2, \beta, \gamma, \sum)$ are estimated using maximum likelihood estimation under the

[7] Cointegrating error is the price differential that Roehner (2000) suggests is a function of transaction costs.

assumption of iid Gaussian errors. Following the Hansen and Seo (2002) methodology, γ, β are fixed whiles (A_1, A_2, $\sum$) are estimated in terms of γ, β. As the resulting concentrated likelihood function was not smooth (non differentiable), and so a grid search optimization method was used to estimate the values of (γ, β) that maximize the concentrated likelihood function. But for γ to exit, the following condition should not be a null set. $0 < P(w_{t-1} \leqslant \gamma) < 1$ and so the following condition was imposed: $\pi_0 \leqslant P(w_{t-1} \leqslant \gamma) \leqslant 1 - \pi_0$ where π_0 is the trimming factor and was set at 0.05 following Hansen and Seo (2002).

For inference on γ, Hansen and Seo (2002) proposed a Lagrange Multiplier based test statistic along the lines of the union-intersection principle of Davies (1987). A parametric residual bootstrap methods was used which required complete specification of the model under the null hypothesis. The linear cointegration specification was therefore assumed under the null. Given that the initial conditions were fixed, random draws from the linear estimation results were used to calculate the proposed test statistic SupLM. The reported bootstrap p-values are the percentage of stimulated statistics that exceeded the actual statistic. Hence low p-values are evidence against the linear model.

Estimation results

The lag lengths[8] of the underlying VARs of our models were found to be either 1 or 2. However, for each price pair, we tested threshold cointegration for lag specifications 1 and 2 for robustness. We also estimated the model for the case in which our cointegration parameter β was estimated[9] and also for the case in which we tested complete price transmission $\beta = 1$.

Table 4 below show local rice estimation results and bootstrap p-values for the presence of a threshold. The lag length of the underlying VAR in Table 4 is indicated under lag for all bivariate price pair. The bootstrap p-values however is estimated for lag specifications ($l = 1$ and $l = 2$ when β is estimated and also, when β is set at 1) the p-values show threshold effect is significant in at least three bivariate models for each lag specification. The results show that besides the (Accra/Wa) price pair, all estimated values of β are close to 1, indicating price transmission between the markets. Price transmission is highest between Accra and Kumasi (the two most populated cities) and Sunyani, Tamale, and Wa, which are the markets with the highest shares of local rice production in Ghana.

Tables 5 and 6 below show threshold estimation results for imported rice and maize respectively. In each of the two tables, threshold effects are significant in only one pair of markets (Tamale/Accra) for imported rice and one (Mankesim/world market prices) for maize.

Table 5 also shows that world market prices for maize and rice transmit well into some key consumer markets in Ghana namely Kumasi and Sunyani. Ghana is self-sufficient in maize production and virtually imports no maize (Table 4) except yellow corn for animal feed. Despite this, prices in Sunyani located in the largest maize production region, appear to trend well with world market maize prices.

Also, Table 6 shows high price transmission between Techiman, the largest production market (in the same region as Sunyani) and Accra and also Tamale. Thus, vicinity to production areas and the size of consumer markets appears to play a major role in the transmission of prices.

Table 4
Tests for threshold cointegration on local rice prices and estimated β values.

Markets		Threshold cointegration (p-values)				Estimated β at the chosen lag length lag β estimate	
		β estimated		$\beta = 1$			
		$l = 1$	$l = 2$	$l = 1$	$l = 2$		
Accra	Sunyani	0.382	0.333	0.415	0.337	1	1.036
Accra	Wa	0.096	0.037	0.364	0.043	1	1.710
Sunyani	Tamale	0.005	0.039	0.005	0.049	1	1.077
Sunyani	Kumasi	0.284	0.531	0.235	0.074	1	1.282
Tamale	Wa	0.004	0.014	0.011	0.025	1	0.850
Kumasi	Mankesim	0.702	0.928	0.321	0.540	1	0.624
Kumasi	Wa	0.862	0.962	0.919	0.957	1	0.708
Mankesim	Wa	0.341	0.157	0.086	0.192	1	1.183

Table 5
Threshold cointegration tests on imported rice prices and estimated β values.

Markets		Threshold cointegration (p-values)				Estimated β at the chosen lag length lag β estimate	
		β estimated		$\beta = 1$			
		$l = 1$	$l = 2$	$l = 1$	$l = 2$		
Wa	World	0.885	0.145	0.843	0.869	2	1.130
Kumasi	World	0.680	0.428	0.463	0.605	2	1.002
Tamale	World	0.655	0.191	0.152	0.578	2	0.402
Sunyani	World	0.520	0.644	0.063	0.168	2	1.166
Accra	World	0.592	0.782	0.556	0.192	2	1.365
Wa	Tamale	0.161	0.187	0.059	0.203	2	0.402
Wa	Sunyani	0.227	0.259	0.244	0.233	2	0.599
Wa	Accra	0.685	0.761	0.724	0.782	2	0.673
Mankesim	Sunyani	0.270	0.241	0.147	0.039	2	1.270
Kumasi	Tamale	0.389	0.235	0.841	0.794	1	0.997
Tamale	Accra	0.026	0.001	0.024	0.176	2	0.472

Table 6
Threshold cointegration tests on maize prices and estimated β values.

Markets		Threshold cointegration (p-values)				Estimated β at the chosen lag length lag β estimate	
		β estimated		$\beta = 1$			
		$l = 1$	$l = 2$	$l = 1$	$l = 2$		
Accra	Techiman	0.153	0.350	0.402	0.317	1	1.130
Techiman	Tamale	0.292	0.651	0.587	0.788	1	1.002
Techiman	Mankesim	0.780	0.828	0.635	0.853	1	0.402
Sunyani	World	0.117	0.392	0.966	0.852	1	1.166
Tamale	World	0.454	0.083	0.848	0.087	1	1.365
Mankesim	World	0.045	0.359	0.319	0.527	1	0.402

These results show that price transmission is highest between key production markets, markets located in large cities, and markets surrounded by production areas. We therefore conclude that the distance between markets and the size of markets play a key role in explaining price transmission in Ghana. The implication for policy interventions during the food price crises is that small populated towns and towns far from major staple productions areas need to be given particular attention. More generally, improving road networks and storage facilities will increase price transmission and thus improve incentives for producers in more remote locations to supply food to urban areas. Prices of imported rice generally transmit well to major local markets due to the high import intensity of rice and low substitutability with local crops.

Welfare impacts of food price shocks

The price transmission results of previous section are applied in this section for welfare impact analysis. It is expected that the

[8] In choosing VAR lag lengths, we paid particular attention to the Hannan Quin and Schwartz information criteria because they are consistent particularly in large samples (Paulson 1984; Tsay 1984; Lutkepohl, 2005).

[9] Where β is understood here as β_2 due to the normalisation.

Table 7
Percentage change in grain and root consumption—rural households. *Source*: household simulation model results.

	*D*1	*D*2	*D*3	*D*4	*D*5	*D*6	*D*7	*D*8	*D*9	*D*10	Total
Coastal	−6.9	−6.9	−6.5	−7.6	−7.9	−7.3	−6.9	−7.1	−8.9	−8.7	−7.8
Forest	−5.7	−6.4	−5.6	−5.6	−5.6	−5.4	−5.6	−5.8	−6.7	−7.8	−6.1
S. Savannah	−4.1	−2.7	−3.0	−3.3	−3.9	−3.2	−3.1	−3.5	−4.7	−4.3	−3.4
N. Savannah	−9.6	−9.1	−9.6	−9.5	−8.0	−9.6	−9.1	−9.2	−11.4	−8.0	−9.4
National	−9.2	−7.4	−6.8	−6.5	−6.5	−6.5	−6.3	−6.2	−8.1	−7.8	−7.1

Note: *D*1 represents the first decile, with the lowest level of income, and *D*10 represents the decile with the highest level of income.

Table 8
Percentage change in grain and root consumption—urban households. *Source*: household simulation model results.

	*D*1	*D*2	*D*3	*D*4	*D*5	*D*6	*D*7	*D*8	*D*9	*D*10	Total
Coastal	−15.6	−21.7	−12.7	−14.2	−10.7	−9.5	−9.1	−9.2	−6.0	−5.7	−7.7
Forest	−30.5	−19.0	−12.3	−13.3	−11.7	−11.1	−10.6	−10.6	−6.7	−7.2	−9.3
S. Savannah	−13.0	−14.2	−8.0	−6.8	−7.6	−8.6	−7.5	−8.3	−5.3	−5.4	−7.1
N. Savannah	−20.0	−21.7	−20.1	−19.5	−16.8	−14.6	−14.9	−15.9	−10.3	−12.1	−15.6
National	−19.8	−19.8	−14.3	−14.8	−12.0	−10.8	−10.6	−10.7	−6.7	−6.5	−9.3

Note: *D*1 represents the first decile, with the lowest level of income, and *D*10 represents the decile with the highest level of income.

areas identified as achieving higher transmission of grain prices will face prices more directly affected by the world prices. Such areas are mainly in the Forest and Southern Savannah agro-ecological zones of Ghana. Thus, we expect negative welfare impacts due to grain price increases to be the highest in these areas. However, with a diverse diet among Ghanaian households across zones, some households may temporarily switch away from those grain products for which world prices have risen significantly and have higher price transmission to other food such as roots and tubers that are primarily nontraded, given that market supply for these alternative staples exists. In this case, domestic prices for commodities that are not internationally traded, such as cassava, yam and cocoa yam in Ghana, might rise through substitution effects. To assess how consumers, particularly poor consumers, will be directly affected by rising world food prices, we develop a partial equilibrium model that considers consumer demand for food products. In the model, demand for each food product is a function of prices and income:

$$c_i = \Pi_j p_j^{\varepsilon_{i,j}} Y^{\varepsilon_i^I} \tag{2}$$

where $\varepsilon_{i,j}$ represents the price elasticity and ε_i^I the income elasticity. A two-stage approach is used to derive these elasticities. We first estimate the income elasticity for each individual food product using the most recent household survey available for Ghana (GLSSV 2005–2006). The income elasticities are estimated for different population groups by rural and urban location. We then calculate price elasticities by considering a demand system that is solved from a Stone–Geary (SG) utility function:

$$U(c_1, c_2, \ldots c_N) = \Pi_j (c_j - \gamma_j)^{\beta} \tag{3}$$

$$\text{Subject to } \sum_{i=1}^{N} p_i \cdot c_i = Y \tag{4}$$

In Eqs. (2) and (3), $U(\cdot)$ is the utility function, c_i is the total quantity of demand for good i, γ_i is the subsistence level of good i, β_i is the marginal budget share (not the average budget share) of good i, p_i is the price for i, and Y is the income. We chose the consumption of own production for good i as γ_i and solved a linear expenditure demand system from Eqs. (2) and (3). With this demand system, together with expenditure share data, the assumption that γ_i equals the home consumption data and estimated income elasticities, the price elasticity of demand can be calculated. We then apply these elasticities to Eq. (1) such that the price (both own and cross prices) and income effect on the demand for different food commodities can be explicitly measured. The average income elasticities for all crops by income quintile groups and rural and urban locations are reported in Table A1 in the Appendix A.

The shock imposed on the model is a one-time change in the domestic prices for maize, rice, wheat, sorghum, cassava, and yam that is based on the country's monthly price changes from April 2007 to April 2008 and defined at the regional level. That is, we applied the actual price increase in the six main markets for which information is available to the households in the corre-

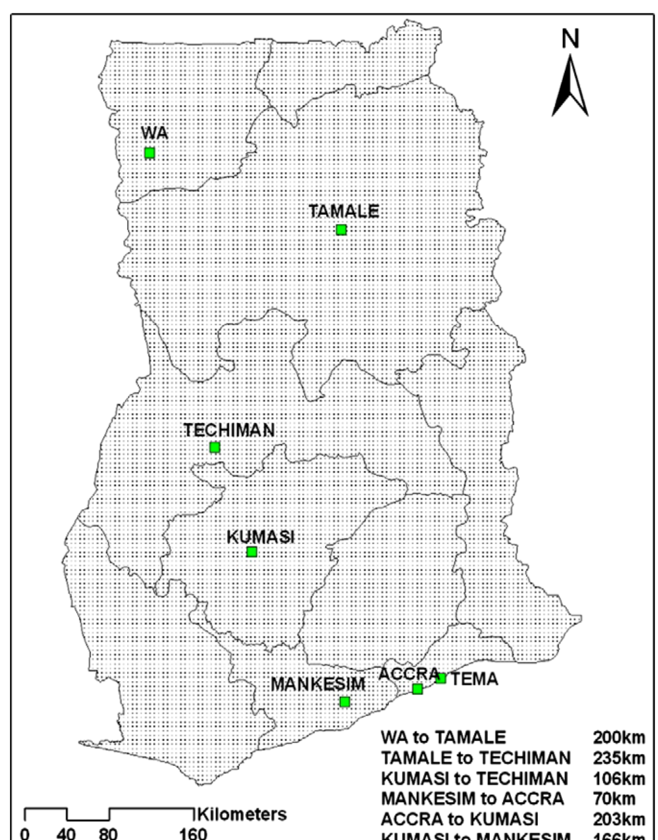

Fig. A1. Map of Ghana's major markets.

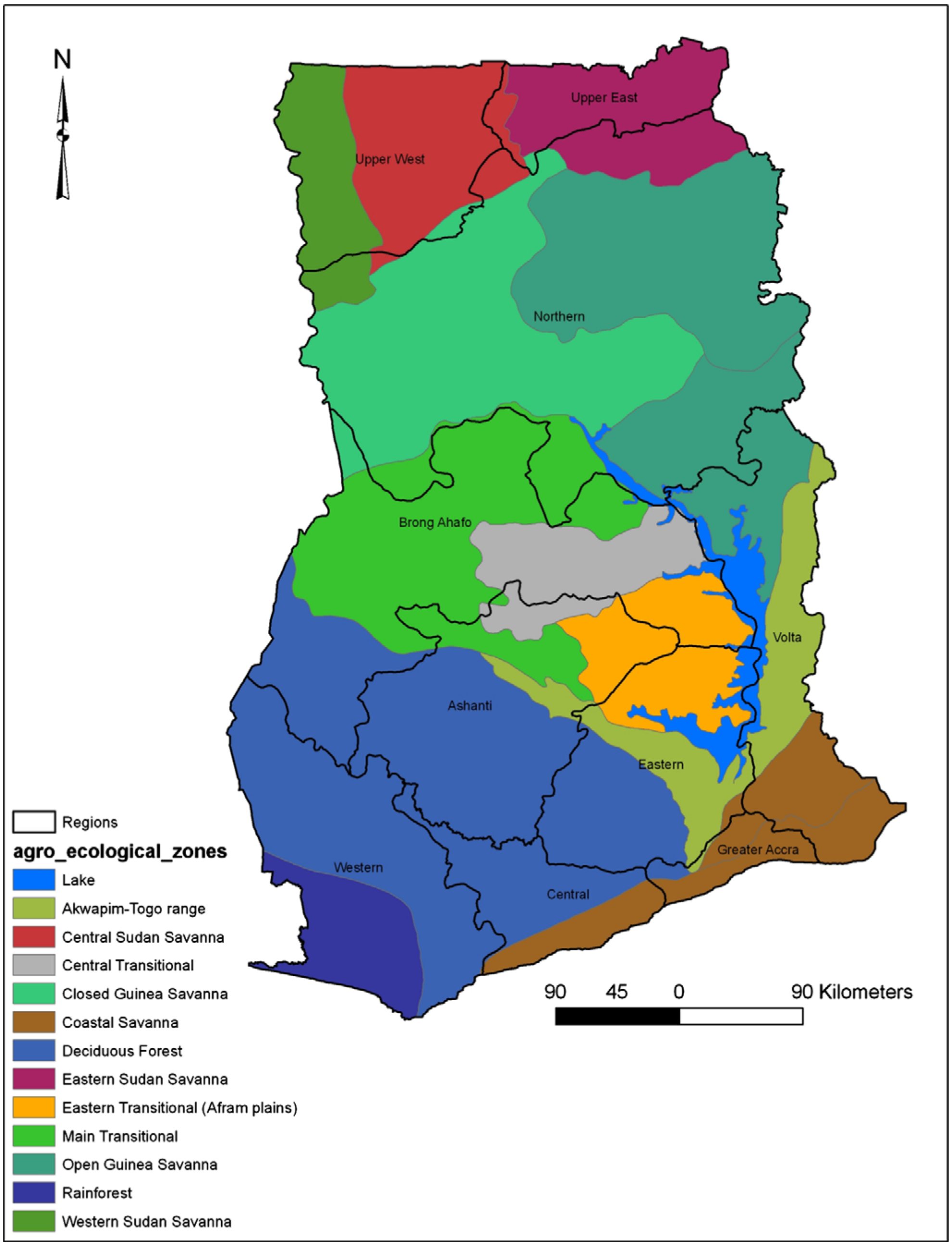

Fig. A2. Ghana's agro-ecological zones and administrative regions.

sponding regions. For the regions where market price information is not available, we use the changes in the prices of neighboring regions within the same agro-ecological zones as a proxy. We consider the effect on consumers only and omit the possible effect on rural households as food producers in the analysis because of data constraints.[10]

Results show that at the national level and weighted by base-year prices, total staple consumption (including both own production and purchased staples) falls by 7.1% for rural and 9.3% for urban households (Tables 7 and 8). This decline is due to the reduced consumption of purchased food, while consumption of own production food is assumed to remain unchanged. The total consumption effect at the national level is −7.9%.

Urban consumers are more negatively affected than rural consumers in terms of declines in staple consumption. This can be explained by the fact that urban households consume a higher share of purchased food in total staples than rural households do. As shown in "Food markets and policies in Ghana", purchased products account for 85% of grains and roots consumed by urban households, but only 41% for rural households. Because of this, rural households' consumption is less price sensitive than that of urban households', as rural households can rely on their own production for a large share of consumption, even when food purchases are reduced by a similar amount to urban households' reductions.

Food consumption falls more for poor households, and poor urban consumers are hit hardest by price increases. At the national

[10] The quality of production data by individual crops is poorer than that of consumption data. Therefore, we decided not to identify net sellers or buyers in the analysis. While supply response and income effect are important topics in analyzing the food price crisis, given that the focus of the paper is on short-term effects, such analysis is beyond the scope of this paper.

Table A1
Agricultural structural and regional contribution. *Source*: Authors' calculations using Ghana DCGE model results (Breisinger et al., 2008).

	Contribution to national total				
	Coast	Forest	S. Savannah	N. Savannah	Total
Cereals	**13.2**	**24.5**	**28.3**	**34.0**	**100.0**
Maize	22.2	32.9	30.6	14.3	100.0
Rice	13.4	43.9	5.0	37.7	100.0
Sorghum and millet	0.1	1.5	37.7	60.7	100.0
Roots	**3.8**	**31.8**	**32.6**	**31.8**	**100.0**
Cassava	4.1	25.2	45.3	25.4	100.0
Yams	2.8	32.3	25.2	39.6	100.0
Cocoyam	8.2	60.4	17.2	14.2	100.0
Other staples	**8.9**	**29.9**	**31.6**	**29.6**	**100.0**

level, staple consumption declines by 20% for the poorest urban households in the first two decile groups (Table 8, the last row), while it declines by 9.2 and 7.4%, respectively, for the rural households in the same two decile groups (Table 7, last row).

At the subnational level, the poorest urban households in the Forest zone are most negatively affected, as their staple consumption falls by 30.5%, followed by the poor urban households in the Coast zone (Group 2) and in the Northern and Southern Savannah (Groups 1–3), with a decline of more than 20%. In rural areas, almost all households in the Northern Savannah zone are badly hit by the rising prices, as the declines in their staple consumption are almost the same (between 8% and 11.4%, but most are around 9%). This result is consistent with what we expected and explained in "Food markets and policies in Ghana". As almost 70% of rural households in the Northern Savannah are living below the poverty line, and also as households in the north consume proportionally more grains than root products, they are more vulnerable to shocks and find it more difficult to adjust their consumption patterns by switching to the consumption of other staples.

In addition to the negative effect on those whose income is already below the poverty line,[11] due to the food price increase, some households that are not poor according to their current income may fall into poverty, and hence the number of poor in Ghana may increase. While more in-depth analysis on the potential increase in the number of poor is important for assessing the economy wide impacts of rising food prices, this paper focuses on the low-income groups. The important message of this analysis is that the poorest of the poor are hit the most when food prices rise, and their capacity to cope with the food crisis on their own is most limited.

Conclusions

This paper has taken a local perspective on global food price shocks by analyzing price transmission between global, national, and regional markets in Ghana. It has also used region-specific price changes of major traded and nontraded food commodities to assess the impacts of the 2007–2008 food crisis on different household groups.

Ghana is highly dependent on wheat and rice imports, for which world market prices have risen sharply during the 2007–2008 food crisis. In addition, the capacity to hedge against price fluctuations is limited in the country by the lack of physical storage facilities, both for the government and for the private sector. However, the country is largely self-sufficient in many other staple foods such as maize, cassava, and yam. Moreover, the domestic market structure for both production and consumption is heterogeneous across

[11] According to the GSS (2007) and based on GLSSV data, the national poverty rate was 28.5% in 2005/06 in Ghana, with rates of 39.2% in the rural areas and 10.8% in the urban areas.

Table A2
Rural and urban income elasticities. *Source*: Authors' estimates using data from GLSSV.

	Cmaiz	Crice	Csorg	Cogrn	Ccass	Cyams	Ccyam	Croot
Rural income elasticity								
DEC1	0.27	0.83	0.53	0.83	0.50	0.50	0.50	0.50
DEC2	0.27	0.83	0.53	0.83	0.50	0.50	0.50	0.50
DEC3	0.37	0.65	0.70	0.65	0.43	0.43	0.43	0.43
DEC4	0.37	0.65	0.70	0.65	0.43	0.43	0.43	0.43
DEC5	0.45	0.64	0.75	0.64	0.43	0.43	0.43	0.43
DEC56	0.45	0.64	0.75	0.64	0.43	0.43	0.43	0.43
DEC7	0.44	0.58	1.13	0.58	0.43	0.43	0.43	0.43
DEC8	0.44	0.58	1.13	0.58	0.43	0.43	0.43	0.43
DEC9	0.50	0.62	0.97	0.62	0.51	0.51	0.51	0.51
DEC10	0.50	0.62	0.97	0.62	0.51	0.51	0.51	0.51
Urban income elasticity								
DEC1	0.80	1.78	0.17	1.78	2.03	2.03	2.03	2.03
DEC2	0.80	1.78	0.17	1.78	2.03	2.03	2.03	2.03
DEC3	0.85	1.22	0.39	1.22	1.05	1.05	1.05	1.05
DEC4	0.85	1.22	0.39	1.22	1.05	1.05	1.05	1.05
DEC5	0.77	0.90	0.68	0.90	0.96	0.96	0.96	0.96
DEC56	0.77	0.90	0.68	0.90	0.96	0.96	0.96	0.96
DEC7	0.71	0.83	0.51	0.83	0.82	0.82	0.82	0.82
DEC8	0.71	0.83	0.51	0.83	0.82	0.82	0.82	0.82
DEC9	0.48	0.51	0.27	0.51	0.59	0.59	0.59	0.59
DEC10	0.48	0.51	0.27	0.51	0.59	0.59	0.59	0.59

	Ccpea	Csbea	Cpoil	Cgnut	Conut	Cfrud	Cvegd	Cplan	Ccro
Rural income elasticity									
DEC1	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77
DEC2	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77
DEC3	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70
DEC4	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70
DEC5	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65
DEC56	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65
DEC7	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
DEC8	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
DEC9	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59
DEC10	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59
Urban income elasticity									
DEC1	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
DEC2	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
DEC3	1.19	1.19	1.19	1.19	1.19	1.19	1.19	1.19	1.19
DEC4	1.19	1.19	1.19	1.19	1.19	1.19	1.19	1.19	1.19
DEC5	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30
DEC56	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30
DEC7	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23
DEC8	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23
DEC9	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23
DEC10	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23

	Cchik	Ceggs	Cbeef	Cgoat	Coliv	Cfish	Csupr	Cdair	Cmeat	Cforf	Clocf
Rural income elasticity											
DEC1	2.89	2.89	1.12	1.12	1.12	1.13	1.66	0.67	1.06	1.7	0.7
DEC2	2.89	2.89	1.12	1.12	1.12	1.13	1.66	0.67	1.06	1.7	0.7
DEC3	1.62	1.62	0.88	0.88	0.88	1.03	1.27	0.59	0.90	1.3	0.6
DEC4	1.62	1.62	0.88	0.88	0.88	1.03	1.27	0.59	0.90	1.3	0.6
DEC5	1.40	1.40	0.76	0.76	0.76	1.02	1.08	0.55	0.81	1.1	0.6
DEC56	1.40	1.40	0.76	0.76	0.76	1.02	1.08	0.55	0.81	1.1	0.6
DEC7	1.11	1.11	0.65	0.65	0.65	0.99	0.89	0.53	0.81	0.9	0.5
DEC8	1.11	1.11	0.65	0.65	0.65	0.99	0.89	0.53	0.81	0.9	0.5
DEC9	0.82	0.82	0.66	0.66	0.66	1.00	0.75	0.56	0.76	0.7	0.6
DEC10	0.82	0.82	0.66	0.66	0.66	1.00	0.75	0.56	0.76	0.7	0.6
Urban income elasticity											
DEC1	2.89	2.89	1.43	1.43	1.43	1.61	1.25	1.20	0.94	1.2	1.2
DEC2	2.89	2.89	1.43	1.43	1.43	1.61	1.25	1.20	0.94	1.2	1.2
DEC3	1.97	1.97	0.98	0.98	0.98	1.25	1.13	1.06	0.90	1.1	1.1
DEC4	1.97	1.97	0.98	0.98	0.98	1.25	1.13	1.06	0.90	1.1	1.1
DEC5	1.46	1.46	0.86	0.86	0.86	1.40	1.04	0.92	0.90	1.0	0.9
DEC56	1.46	1.46	0.86	0.86	0.86	1.40	1.04	0.92	0.90	1.0	0.9
DEC7	1.10	1.10	0.75	0.75	0.75	1.65	0.92	0.79	0.88	0.9	0.8
DEC8	1.10	1.10	0.75	0.75	0.75	1.65	0.92	0.79	0.88	0.9	0.8
DEC9	0.95	0.95	0.60	0.60	0.60	2.23	0.64	0.58	0.91	0.6	0.6
DEC10	0.95	0.95	0.60	0.60	0.60	2.23	0.64	0.58	0.91	0.6	0.6

regions. These factors, together with different consumption patterns across different income groups, indicate that rather heterogeneous and complicated local welfare effects occur from a world food price increase.

We have shown that the prices for domestic staples are highly correlated. This is particularly true for cereals, as Ghana is either highly import-dependent (rice) or self-sufficient (maize) in cereals. However, price transmission for different crops or markets differs, and the highest price transmission is found between major production markets and markets located in large cities, or between markets surrounded by production areas. We therefore conclude that distance between markets and the size of markets matter most in explaining price transmission in Ghana.

The welfare effect for households as consumers is relatively modest at the national aggregated level, which can be explained primarily by the relatively diverse consumption patterns, in which root crops account for a large share of staple foods. However, this national average hides important regional diversified welfare effects across regions and between different income groups. By disaggregating households into different income groups across regions, we find that the poorest of the poor, especially those living in the urban areas, are hardest hit by high food prices. At the regional level, the negative effect of the food crisis is particularly severe in the North of Ghana. The main explanations for this regional variation in the price effect are dependence on grain consumption, together with much lower initial per capita income levels in the North.

In conclusion, our analysis indicates that policy interventions during food price crises need to focus on small populated towns and towns far away from major staple productions areas. More generally, improving road networks and storage facilities will increase price transmissions and thus improve incentives for local producers to supply more food to consumers in the urban areas. The urban poor in all regions and the rural poor in the northern Ghana are the most vulnerable to food price shocks and thus need special support in times of crises, for which certain types of direct transfer schemes are required.

Appendix A

See Figs. A1 and A2 and Tables A1 and A2.

References

Abdulai, A., 2000. Spatial price transmission and asymmetry in the Ghanaian maize market. Journal of Development Economics 63, 327–349.

Aksoy, A.M., Isik-Dikmelik, A., 2008. Are Low Food Prices Pro-Poor? Net Food Buyers and Sellers in Low-Income Countries. World Bank, Washington, DC (Policy Research Working Paper No. 4642).

Arndt, C., Benfica, R., Maximiano, N., Nucifora, A.M.D., Thurlow, J., 2008. Higher fuel and food prices: impacts and responses for Mozambique. Agricultural Economics 39, 497–511.

Asche, F., Jaffry, S., Hartmann, J., 2007. Price transmission and market integration: vertical and horizontal price linkages for salmon. Applied Economics 39s1 (19), 2535–2545.

Baffes, J., Gardner, B., 2003. The transmission of world commodity prices to domestic markets under policy reforms in developing countries. Journal of Economic Policy Reform 6, 159–180.

Balke, N.S., Fomby, T.B., 1997. Threshold cointegration. International Economic Review 38, 627–645.

Barrett, C., 2008. Spatial market integration. In: Durlauf, S.N., Blume, L.E. (Eds.), New Palgrave Dictionary of Economics, second ed. Palgrave Macmillan, New York.

Baulch, B., 1997. Transfer costs, spatial arbitrage, and testing for food market integration. American Journal of Agricultural Economics 79, 477–487.

Conforti, P., 2004. Price transmission in selected agricultural markets. FAO Commodity and Trade Policy Research Working Paper No. 7. Food and Agriculture Organization (FAO), Rome.

Davies, R.B., 1987. Hypothesis testing when a nuisance parameter is present only under the alternative. Biometrica 74, 33–43.

Dessus, S., Herrera, S., de Hoyos, R., 2008. The impact of food inflation on urban poverty and its monetary cost: some back of the envelope calculations. Agricultural Economics 39s1, 417–429.

Engle, R.F., Granger, C.W.J., 1987. Cointegration and error correction: representation, estimation and testing. Econometrica 55, 251–276.

Enke, S., 1951. Equilibrium among spatially separated markets: solutions by electrical analogue. Econometrica 19, 40–47.

Ghana Statistical Service (GSS), 2007. Ghana Living Standard Survey Round 5 (GLSSV). Accra, Ghana: GSS.

Goodwin, B.K., Piggott, N.E., 2001. Spatial market integration in the presence of threshold effects. American Journal of Agricultural Economics 83 (2001), 301–317.

Hansen, B., Seo, B., 2002. Testing for two-regime threshold cointegration in vector error correction models. Journal of Econometrics 110, 393–418.

Headey, D., Fan, S., 2008. The anatomy of a crisis: the causes and consequences of surging food prices. Agricultural Economics 39s1, 375–391.

Ivanic, M., Martin, W., 2008. Implications of higher global food prices for poverty in low-income countries. Agricultural Economics 39, 405–416.

Johanson, S., Juselius, K., 1992. Testing structure hypothesis in a multivariate cointegration analysis of the PPP and UIP for UK. Journal of Econometrics 53, 211–244.

Lutkepohl, H., 2005. New introduction to multiple time series analysis. Springer-Verlag, Berlin.

Paulson, J., 1984. Order determination of multivariate autoregressive time series with unit roots. Journal of Time Series Analysis 5, 115–127.

Ravallion, M., 1986. Testing market integration. American Journal of Agricultural Economics 68, 102–109.

Roehner, B.M., 2000. The correlation length of commodity markets: 2. Theoretical framework. The European Physical Journal B13, 189–200.

Samuelson, P.A., 1952. Spatial price equilibrium and linear programming. American Economic Review 42, 560–580.

Sephton, P., 2003. Spatial market arbitrage and threshold cointegration. American Journal of Agricultural Economics 85 (4), 1041–1046.

Takayama, T., Judge, G., 1971. Spatial and Temporal Price Allocation Models. Amsterdam, North Holland.

Tsay, R.S., 1984. Order selection in nonstationary autoregressive models. Annals of Statistics 12, 1425–1433.

World Bank, 2008. World Trade Indicators 2008 Database. <http://www.worldbank.org/wti2008> (accessed of December 2008).