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Local Impacts of a Global Crisis

Food Price Transmission and Poverty Impacts 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 differential local food price increases on various household groups. Taking the recent global food crisis as an example, we find that prices for domestic staples within all regional markets are highly correlated with prices for imported rice. However, price transmission between pairs of regional markets is limited; it is complete for local rice and maize only when more rigorous cointegration analysis is applied. Our findings also show the important role of seasonality in the determination of market integration and price transmission. The welfare effect for households as consumers appears relatively modest at the aggregate national level due to relatively diverse consumption patterns. 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 the urban poor—are the hardest hit by high food prices. The negative effect of the food crisis is particularly strong in the north of Ghana. Different consumption patterns, in which grains account for a larger share of the consumption basket in the north compared to the rest of the country, together with much lower initial per capita income levels, are the main explanations for this regional variation in the price effect.

1. INTRODUCTION

From 2007 onward, world food prices surged rapidly, leading to an acute food crisis in 2008. This food price escalation has raised serious concerns about adverse impacts on the poor in developing countries. While there is a possibility for agricultural producers to benefit from higher food prices, the supply response of many small farmers in developing countries is constrained by a number of conditions outside the farming sector. These include the rising costs of purchased inputs such as fertilizer, as well as long-existing problems such as access to credit and markets. Moreover, many farmers, and particularly poor farmers, are net buyers of staple food. Hence, the harm to farmers as consumers is likely to outweigh the benefit they gain from higher producer prices (von Braun 2007; World Bank 2007).

However, the impacts of a global food crisis are often country specific and depend critically on the country's food deficit or surplus situation in international trade, the food consumption patterns of different households groups in the country, and the degree of price transmission from global to local markets. Several recent papers have attempted to analyze the consequences of the 2007–2008 food crisis in developing countries at the national level. Ivanic and Martin (2008) apply a partial equilibrium model to nine countries' household survey data and try to assess the poverty impacts of the food crisis by shocking domestic prices in these countries. They find that the national poverty rate is likely to increase by 4.5 percent on average and that the results critically depend on the households' net buyer or net seller status. Ataman Aksoy and Isik-Dikmelik (2008) more carefully examine the net food buyer or seller positions of households for the same set of countries. They find that although many poor households are net buyers, 50 percent of poor households are net buyers at the margin, that is, the share of purchased food in their total consumption is small. This finding indicates that the estimation by Ivanic and Martin (2008) is likely to exaggerate the poverty impact of the food price rise in the studied countries. In a similar analysis, Wodon et al. (2008) focus on 12 West African countries. The authors impose a 50 percent price increase on selected food items, and the results suggest that the food price increase might raise poverty rates between 2.5 and 4.4 percentage points. A different method is used by Dessus, Herrera, and de Hoyos (2008), who focus on the potential impact of the food crisis on urban poverty using a sample of 73 countries. They estimate the cost involved to compensate the negative income impact of higher food prices and find that more compensation is needed for those households that were poor before the price shock, while the negative impact is modest for the households that do not belong to the poverty population group. The policy implication for responding to the food crisis is to scale up existing transfer systems rather than designing new programs to cover more people.

While most of these studies have certain policy implications for dealing with the food crisis, many of them have focused on aggregate effects at the national level and largely neglected subnational price transmission and its effects. A "stylized" fact is that international prices are not completely transmitted to a developing country's domestic market, particularly not to more remote parts of the country. In addition, production and consumption disparities commonly exist at the subnational level and across different household groups in a country. While analyses on price transmission do exist, most of them were conducted before the 2007–2008 food crisis. Conforti (2004), for example, provides some historical evidence on price transmission in 14 developing countries. He finds high degrees of transmission for maize and wheat in Mexico and for maize and rice in Ghana, but a low degree of transmission in Uganda. Abdulai (2000) confirms these findings for maize in Ghana and finds high levels of integration between three regional markets. Baffes and Gardner (2003) conduct an analysis similar to Conforti's for a sample of 31 country/commodity pairs and also find substantial differences in price transmission between different countries. More recent analysis by IFPRI researchers shows that the maize price increase in Tanzania's domestic market reflects about 81 percent of the change in the international market between 2003 and 2008. In the case of Indonesia's Jakarta market, the change in maize prices is even negative, and increases in the Surabaya market are only about 32 percent of the international change (Benson et al. 2008).

In addition to helping researchers and policymakers understand price transmission across countries, data on subnational-level transmission illuminate the regional income disparities that persist within many developing countries. For example, the poverty rate is 62.7 percent in northern Ghana, while it is 28.5 percent at the national level (GSS 2007). Similarly, the poverty rate of 60.8 percent in northern Uganda is in stark contrast to the rate of 31.1 percent for the country as a whole (UBOS 2006). These differences in household income levels across subnational regions are often accompanied by differences in production and consumption patterns and transportation costs between the regions. Moreover, food consumption patterns are also influenced by many factors other than the level of income, such as consumption traditions and agro-ecological conditions. With imperfect substitution between local and imported food products, this heterogeneity in consumption patterns across regions further affects price transmission among subnational regions and hence the possible impacts of external shocks from the world market on poor households. Generally speaking, the more autarkic a region is, and the lower the level of substitution between imported and local food products, the less likely it is that the local price of a good will be affected by changes in the respective world price.

This paper aims to fill this gap in the literature on the recent food price crisis by providing a subnational perspective for Ghana. In Section 2, we analyze price developments within Ghana before and during the food crisis. Section 3 quantitatively measures the price transmission between international and domestic markets and among different regional markets for major food staples using a cointegration model. Based on the findings in Sections 2 and 3, Section 4 analyzes the impacts of region-specific price changes on different household groups within each region, using a household model calibrated to the most recent data available for the country (Ghana Living Standard Survey, GLSSV, 2005/06). Section 5 offers conclusions.

2. GLOBAL CHANGES AND LOCAL MARKET IMPACTS IN GHANA

The consequences of high food prices vary widely within countries, due to differences in price transmission to regional markets as well as heterogeneity in production and consumption structures across subnational regions and between different food products. A country's import or export intensity for different food products is an important indicator showing to what extent global prices might transmit into domestic markets. If a country does not trade its food products with other countries, local prices for these products are unlikely to be affected by rising world prices. In the case of Ghana, food crop exports barely occur in formal trade; cross-border trade in certain food crops is reported but is hard to measure.[1] Therefore, we focus on the import dependence of Ghana across different food products in Table 1, together with relevant production and trade data of these food items. The data we use have been provided by the Ghana Statistical Service (GSS) and are simple averages for the years 2004–2006. As shown in Table 1, the major imported food products in Ghana are wheat and rice, while the country is largely self-sufficient in terms of the other major staple crops. Between 2004 and 2006, wheat consumption was 100 percent dependent on imports, and rice imports accounted for 65 percent of domestic consumption on average. On the other side, international trade captured by the country's customs statistics is negligible in the cases of maize, yam, and cassava, the three major staples consumed by both rural and urban consumers.

Table 1. Import dependence, production, consumption, and trade for major staples (average of 2004–2006)

Food Items	Domestic Production	Exports	Imports	Domestic Consumption	% Import Dependence
Maize	1,335	0	6	1,340	0.43
Rice	266	0	492	759	65
Wheat	0	1	324	323	100
Millet	152	0	0	152	0.01
Sorghum	294	0	0	294	0.00
Yam	4,229	12	0	4,218	0.00
Cassava	11,062	1	0	11,060	0.00

Source: Authors' calculations based on data obtained from the Trade Statistics Division of the Ghana Statistical Service (GSS).
Note: Production, consumption, and trade are in 1,000 metric tons. Data are simple averages.

Price transmission is also highly related to hoarding behavior and government stock/export policies, particularly in the short run. However, these factors can be largely ignored in Ghana. Ghana 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,[2] which made the government further hesitant to use state-owned stocks as a measure to safeguard against external shocks. The strong dependence on direct imports of wheat and rice

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[1] Cross-border informal trade is generally not captured by a country's customs data. While the volume of informal trade is believed to be quite large in some markets, particularly in northern Ghana, which often serves as a central market in the region, these trade flows are largely limited to neighboring countries in West Africa such as Niger, Burkina Faso, Togo, and Nigeria. Thus, informal trade may have only limited effects on the transmission of the food crisis to domestic markets in Ghana.
[2] 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.

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 (Figure 1).

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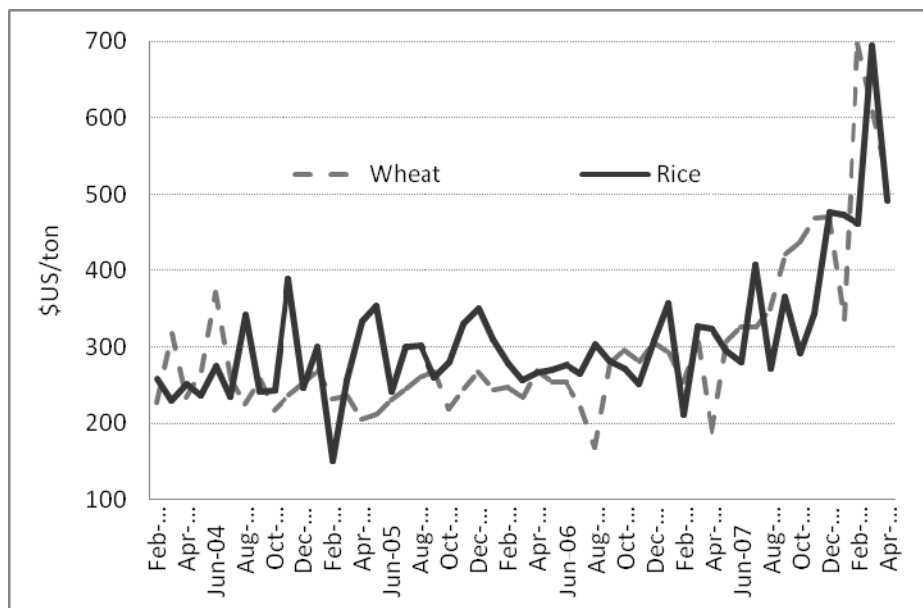
Source: Ministry of Food and Agriculture (MOFA).

Domestic Market Structure in Ghana

Ghana as a country is highly dependent on imports of wheat and rice for domestic consumption, yet price transmission within the country and hence the impact of international prices on local market prices may still vary at the subnational level due to differences in the production structures[3] and consumption patterns across regions (see Figure A.1 in the appendix for the geographical locations of major markets in the country). Production of rice in Ghana is concentrated in three regions, two of which are located in the north: Northern and Upper East, where the per capita rice production is 2.9 and 5.1 times the national average, respectively (Table 2). This makes the Tamale market, located in the north, the only major supply market for rice for the whole country, while the other five wholesale markets can be classified as consumer markets. Given that two-thirds of rice consumed domestically is imported, and rice production is highly unevenly distributed within the country, it can be expected that domestic rice market prices are highly sensitive to changes in the international price, with the possible exception of the Tamale market, which is located in the major rice supply region of the country and mainly serves as a market for local rice. We will further analyze this in the next subsection.

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3 Shively 1995 notes the importance of the levels of local production in achieveing low price variability in Ghana.

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Table 2. Per capita staple production across regions (normalized by the national average)

Region	Market	Maize	Rice	Cassava	Yam
Western		0.6	0.8	0.8	0.2
Central	Mankesim	1.4	0.1	1.5	0.1
Greater Accra	Accra	0.1	0.1	0.0	0.0
Volta		0.7	1.8	1.5	0.8
Eastern		2.1	0.8	2.4	1.6
Ashanti	Kumasi	0.9	0.2	0.8	0.4
Brong Ahafo	Techiman	2.0	0.4	2.3	4.0
Northern	Tamale	1.1	2.9	0.4	2.0
Upper East		0.2	5.1	0.0	0.0
Upper West	Wa	1.5	0.6	0.0	2.5
National (in 100 kg)		79	17	597	225

Source: Ministry of Food and Agriculture (MOFA).

Trends in Domestic Prices

Large variations can be observed among different food crops across different regional markets. Moreover, food price movements have certain seasonal patterns, which may complicate the comparison of price changes between regions and among crops. In order to better understand the differential linkages of domestic and international prices for both internationally tradable and nontradable products, we focus first on rice again. Figure 2 depicts the rice price trends for imported and local rice in two major markets, Accra, as Ghana's largest consumer market for both imported and local rice, and Tamale, as the supply market for local rice. As shown in Figure 2, the movement of prices for local rice generally follows the change in the price for imported rice. While local rice has quality and taste characteristics that are distinct from those of imported rice and is hence not perfectly substitutable with the imported rice (with is relatively cheaper), the markup margin associated with it together with trade and transport costs was quite constant in both markets before the food crisis. Moreover, the difference between the two markets' prices for imported rice is relatively smaller than the difference between their prices for local rice. However, a different pattern in price movements can be observed during 2007 and 2008 when the world rice price significantly increased (Figure 2). While the price for local rice in the Accra market rose to the level of imported rice in May–July 2007, a lean season in the country, its movement became quite 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. A certain time lag in the response of local rice prices to surging international rice prices in early 2008 might explain this. The most recent data for the prices of local rice are available for May 2008, and, hence, they may not fully capture the local response to the sudden and huge jump in world rice prices that occurred primarily in early 2008.

Figure 2. Rice price movement in the Accra and Tamale markets
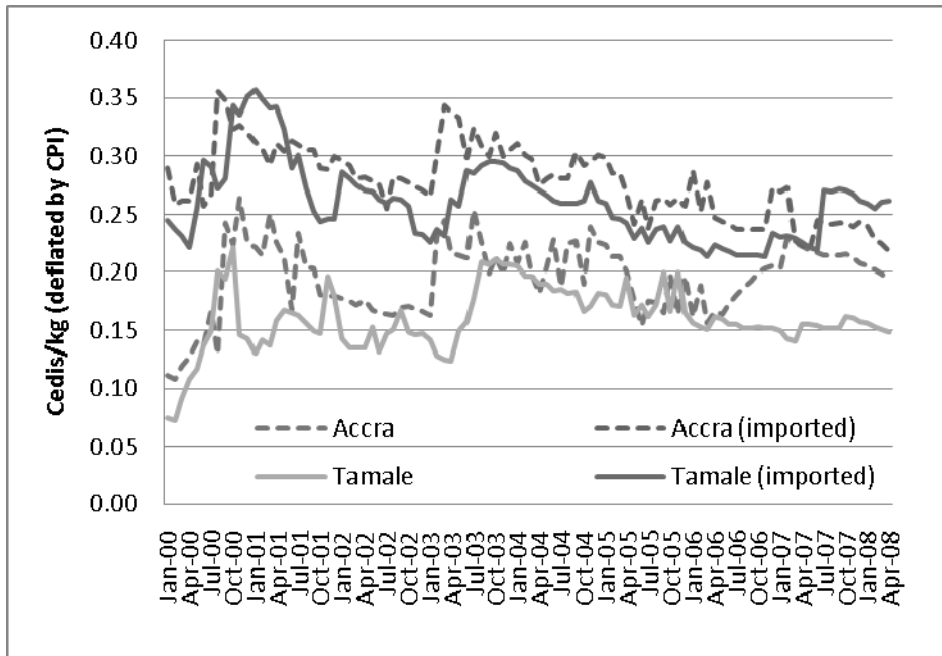
Source: Authors' calculations using data obtained from Ghana Statstical Service (GSS) (2008).

As discussed above, Ghana is largely self-sufficient in the major staples except for rice and wheat. Changes in the prices of these staples therefore may primarily be driven by domestic market forces, that is, by domestic supply and demand for these products. However, substitution in consumption between rice and local staples such as maize, cassava, and yam may cause domestic prices for nontradable products to rise when the world prices for imported food products increase. We use time series data for all these products in the Accra market to informally examine whether a certain co-movement of prices between imported rice and other products in the country exists.

The trends depicted in Figure 3 show that prices for all staple products have generally moved together in recent history, with a short exceptional period in 2006, particularly for maize. However, after the maize price decline in 2006, a year in which maize and rice prices moved in opposite directions, the maize price started to increase again in 2007 and 2008, moving in the same direction as rice prices. Prices for cassava and sorghum follow a similar trend to that of rice prices in late 2007 and 2008, while yam prices started to increase only in 2008. These general trends can also be observed in other markets, and, hence, we do not report them here.

Figure 3. Price movement for major crops in the Accra market
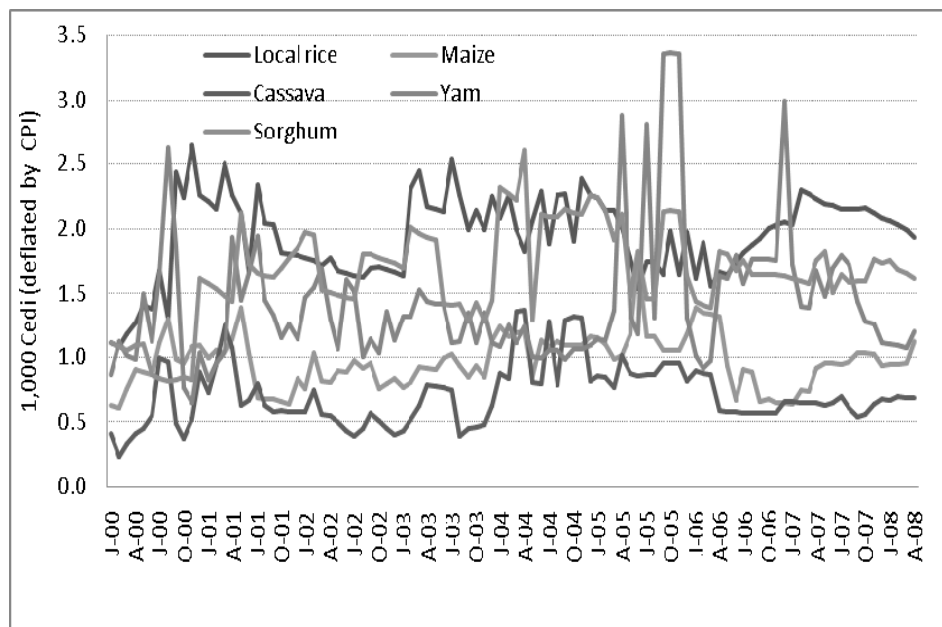
Source: Authors' calculations using data obtained from the Ghana Statstical Service (GSS) (2008).

Structure of Food Consumption

Consumption patterns vary across different income groups and regions within a country, particularly in low-income countries, where food often accounts for a large share of household spending. In contrast to many South and Southeast Asian countries, where rice as a single product 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 2005/06) show that grain and root/tuber consumption together account for about 28 percent 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, sorghum, wheat) 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 percent) of total spending in rural areas.

At the regional level, however, household food consumption structures vary, both in rural and urban areas. Among Ghana's four agro-ecological zones, households (particularly rural households) in the Coastal, Forest, and Southern Savannah zones consume more roots and tubers as staples, while among both rural and urban households in the Northern Savannah zone (which includes three regions: Northern, Upper East, and Upper West), the share of grain consumption is much higher than the share of roots/tubers (Table 3, second part). Moreover, poor households generally spend more of their income on food, particularly on staples. With more than 60 percent of households in the Northern Savannah zone (hereafter referred to as "the north") living below the national poverty line, northern households spend a much higher proportion of their income on food than do the households in the rest of the country (Table 3, 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 Section 4 we quantitatively measure this impact using a household model.

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Table 3. Household expenditure structure across agro-ecological zones

	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

Source: Authors' calculations using data from GLSSV 2005/06.

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 own-production and purchased staples[4] separately in Table 4, together with the share of other food and food in total expenditure by 10 income groups in both rural and urban areas. The households are first grouped according to their per capita income level into 10 population decile groups (at the national level) and then further identified by rural or urban location.

Staples, either own 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 Section 4.

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[4] 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 4. Consumption share by income groups

| | Staples | | | |
	Own Production	Purchased	Other Food	Food in Total Spending
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

Source: Authors' calculations using data from GLSSV 2005/06.
Note: The national poverty rate is 28 percent in the survey, which indicates that most households are poor in the first three groups and extremely poor in the first two groups.

3. ANALYZING PRICE TRANSMISSION IN GHANA

The descriptive analysis in the previous section has provided useful data and information that can serve as the basis for more rigorous analysis. We start by conducting a correlation analysis between world market prices of rice and prices for local staple crops (local rice, maize, cassava, and yam) all adjusted for food inflation in Ghana within each of the six wholesale markets in order to test whether local staple products are sensitive to the price of imported rice, the main imported food product in the country. We then use standard cointegration analysis to test whether the price transmission, if it exists, occurred uniformly in the different local markets. Surprisingly, the value of the partial correlation coefficient is much higher between world prices of rice and prices of local food staples in markets located in the poorest regions. Wa and the Tamale are located in the poor northern regions of Ghana and their staple food prices have the highest significant positive correlation with world prices of rice (Table 5). Moreover, this value is highest in the Wa market, which is also located in the Upper West region; the poorest of the three northern. However, the correlation value is also relatively high between the world price of rice and maize. We find a high and significant correlation for these two products' prices in the market located in the country's major maize consumption areas (Accra, Wa, and Mankesim). While both cassava and yam are traded within the country, their trade patterns are rather seasonal. Consistent with these trading patterns, the prices for these two products are less correlated with the price for world market price of rice

Table 5. Pairwise correlation coefficient between real prices of imported rice and local products

	Local Rice	Maize	Cassava	Yam
Accra	0.119	0.4092*	-0.050	-0.085
Sunyani	0.2455*	0.185	-0.175	0.013
Tamale	0.2083*	0.1933*	0.2345*	-0.001
Kumasi	0.4821*	-0.129	-0.269*	0.059
Mankesim	0.141	0.3589*	-0.128	-0.030
Wa	0.4206*	0.4042*	0.2148*	0.5163*

Source: Authors' calculations using monthly market data for January 2000 to September 2008 obtained from the Ghana Statistical Service (GSS) (2008).
Note: * Significance at 5% level

We now turn our attention to the price relationship across markets in the country by conducting a cointegration analysis. We test the order of integration of each price series and the cointegration of each major staple food commodity between every pair of markets and also simultaneously across all major markets in Ghana. Following a general vector error correction specification, we also test price transmission of cointegrated prices between major food markets in Ghana. Most price transmission analyses are based on the "law of one price" theory, 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[5]:

$$P_{i1} = P_{i2} + T_{i21}$$

(3.1)

---

[5] Existing methods of testing price transmission include the law of one price in Richardson (1978) and the Ravallion model (Ravallion 1986). Ravallion estimates a dynamic model that accounts for the possible cointegration of prices in an error correction setting. However, the model does not allow for the interaction between all prices, and it estimates different cointegrated equations separately. Therefore, the methodology misses an important layer of information that stems from the likely interaction between prices of the same commodity in different cointegration equations.

where P_{i1} and P_{i2} are the prices of commodity i in two spatially distinct markets 1 and 2, T_{i21} is a multiplicative 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 is still widely used in price transmission analyses, including those of Ravallion (1986), Barret 2001, Baulch 1997 and Asche, Jaffry, and Hartmann (2007).

As prices typically exhibit unit roots, we test the level of integration of each price series using the Augmented Dickey-Fuller (ADF) test. Given that we found that all our price series are of order one, I(1), first differences of the unrestricted vevtor autoregressive (VAR) Granger 1981 of some finite order p would be an appropriate starting point based on the notions of general-to-specific modeling (Hendry 1995). Accordingly, the following equation holds:

$$y_t = \mu + A_1 y_{t-1} + A_2 y_{t-2} + ... + A_p y_{t-p}$$

(3.2)

However, Granger (1983) notes that cointegrated systems have an error correction representation that would be missing if the first differences were modeled in equation (3.2). Hence, we further derive our error correction mechanism from Engle and Granger (1987) as:

$$\Delta P_t = \mu + \Pi P_{t-1} + \sum_{k=1}^{q-1} \Gamma_k \Delta P_{t-k} + \varepsilon_t$$

(3.3)

where Π is a matrix such that $\Pi = \alpha\beta'$. In addition, we use a multivariate specification of the vector error correction mechanism (VECM). In this way, we include cointegrated price pairs of the same commodity in different market pairs. This multivariate specification allows both short- and long-run changes in the price of a commodity in one market to potentially translate into changes in the price for the same commodity in the other markets.

To understand equation (3.3) and thereby demonstrate the interpretation of price transmission and the speed of adjustment toward equilibrium after a deviation, we consider a system with only a pair of prices: the price of a commodity in region a, P^a, and in region b, P^b. Assuming that these prices are integrated of order one; that is I(1) and cointegrate, then equation(3.3) represents this cointegrated system in matrix notation as follows:

$$\begin{bmatrix} \Delta p_t^a \\ \Delta p_t^b \end{bmatrix} = \underbrace{\begin{bmatrix} \alpha_1 \\ \alpha_2 \end{bmatrix}}_{A'} \underbrace{\begin{bmatrix} \beta_1 & \beta_2 \end{bmatrix}}_{B'} \begin{bmatrix} p_{t-1}^a \\ p_{t-1}^b \end{bmatrix} + \sum_{i=1}^{q-1} \Gamma_i \Delta P_{t-i} + u_t$$

(3.4)

where q is the lag length[6] of the underlying VAR. Usually, β_1 is normalized to 1, while a realization of $\beta_2 = -1$ indicates complete price transmission. α_1 and α_2 indicate the respective rates at which P^a and P^b adjust after disequilibria. In the two-price system shown in (3.4), we have one cointegration equation and need a minimum of only one restriction in the cointegration space. However, in a general multivariate system with r cointegrating equations, at least r^2 restrictions are required (Johansen 1995). In our analysis there are two cointegrating equations in each of the models we present, which means that we must impose at least four restrictions for each model. A causality test based on Granger (1969a) is also conducted (see the appendix for further discussion).

More specifically, in this study, as all price series were found to be I(1), cointegration tests have been conducted for individual staple food products (local rice, maize, cassava, and yam) in each pair of local markets (six markets in total). We first found no evidence of cointegration in any market pair for cassava and yam, indicating that prices for these two products may be locally determined. For both local rice and maize, we found evidence of two sets of cointegrated prices in the local markets. Based on these two cointegrated price sets we further tested for cointegration in a larger dimension, due to the choice of a

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[6] In choosing the lag length, we paid particular attention to Hannan-Quin and Schwartz criteria, as they are consistent, particularly in large samples (Paulson 1984; Tsay 1984; Lutkepohl 2005).

higher VECM dimension using the framework developed by Johansen (1988, 1991, 1995). Moreover, the critical issues in VECM are the cointegrating vector and speed of adjustment parameters, which are key for characterizing the extent of price transmissions and the disequilibrium behavior of prices, respectively. As these hinge critically on cointegrated prices, cointegration test results are reported in Table 6a.

The results reveal potential price transmission across local markets for rice and maize, while the markets for cassava and yam remain highly localized. These results are consistent with the simple correlation analysis discussed above. The first part of Table 6a reports the cointegration test for maize in the three local markets, while the second part of the table reports the results for local rice in the other three markets.

Table 6a. Johansen cointegration tests

| **Markets: Accra, Mankesim, and Techiman (Maize)** | | |
| **Trend: Constant** | | |
Maximum rank	Eigenvalue	Trace statistic
0	.	34.3503
1	0.22813	16.2243
2	0.16631	3.4920**
3	0.04866	
Markets: Accra, Tamale, and Wa (Local Rice)		
Trend: Constant		
Maximum rank	Eigenvalue	Trace statistic
0	.	39.8648
1	0.21886	15.4124
2	0.11733	3.0565**
3	0.0304	
Markets: World Prices, Mankesim, and Wa (Imported Rice)		
Trend: Constant		
Maximum rank	Eigenvalue	Trace statistic
0	.	48.5661
1	0.284	15.8301
2	0.1329	1.8550*
3	0.0188	

Note: ** Significance at 5% level

The ranks (0–3) in Table 6a represent the different null hypotheses: no cointegration (with rank 0), one or fewer cointegration equations (with rank 1), two or fewer cointegration equations (with rank 2), and so on. Johansen's test procedure is used, in which the trace statistic, the key result of this test, is computed from the eigenvalue. The trace statistic is compared with a 5% critical value that is not reported in the table. The hypotheses of no cointegration and one or fewer cointegration equations are both rejected, while the hypothesis of two or fewer cointegration equations is not rejected, implying two sets of cointegration equations for local rice and maize.

The results of the VECM for the prices of maize and local rice in the three respective markets are reported in Table 6b. In assessing model stability, Lagrange multiplier (LM) tests were conducted for residual autocorrelation, which shows that the null hypothesis of no autocorrelation cannot be rejected in both models for local rice and maize.

Table 6b: Vector error correction mechanism (VECM) results

MODEL 1: Results for cointegrated maize prices

	1st cointegration equation (Techiman & Accra)			2nd cointegration equation (Mankesim & Techiman)		
	Techiman(α)	Accra(α)	β	Mankesim(α)	Techiman(α)	β
Estimated value	0.285**	-0.123	-.940***	-0.751***	-0.151	-.575***
95% lower CL			-1.245			-0.778
95% upper CL			-0.635			-0.372
P value for null (β = -1)			0.773			0.038

MODEL 2: Results for cointegrated local rice prices

	1st cointegration equation (Tamale & Accra)			2nd cointegration equation (Wa & Accra)		
	Tamale(α)	Accra(α)	β	Wa (α)	Accra(α)	β
Estimated value	-0.267***	0.014	-.868***	-0.352***	0.281**	-.754***
95% lower CL			-1.081			-0.929
95% upper CL			-0.653			-0.58
P value for null (β = -1)			0.264			0.037

MODEL 3: Results for cointegrated imported rice prices

	1st cointegration equation (world prices & Accra)			2nd cointegration equation (world prices & Wa)		
	World prices(α)	Mankesim(α)	β	World prices(α)	Wa(α)	β
Estimated value	-0.0196	-0.3029***	-0.847***	0.033	-0.3902***	-.568***
95% lower CL			-1.0677			-0.7279
95% upper CL			-0.6256			-0.4077
P value for null (β = -1)			0.212			0.001

Notes: CL stands for confidence limit. The 95% confidence interval is characterized or defined by a lower and upper confidence limit.
*** Significance at 1% level
** Significance at 5% level

In Table 6b, complete price transmission is characterized by $\beta = -1$ in the VECM, in line with the explanation following equation (3.4). We observe here that the estimated beta values for the first cointegration equations in both models are close to -1. -1 lies in their respective 95% confidence interval, suggesting complete price transmission. We confirm this by imposing appropriate restrictions[7] in the cointegration space along the lines of Johanson's (1995) overidentifying restrictions. The P value for null ($\beta = -1$) in Table 6b reports the P value of the likelihood ratio test for our restrictions. P values greater than 0.05 are evidence that we are unable to reject the null hypothesis that $\beta = -1$ at a 5% level of significance, and so price transmission is complete. Following a similar scheme, we also tested for complete price transmission in the market pairs in the second cointegration equations for both models. As reported in Table 6b, the estimated beta values in the second cointegration equations are not as close to -1 as those in the first cointegration equations. Also, -1 does not lie in their respective 95% confidence intervals, suggesting incomplete price transmission. We confirm this with a likelihood ratio test, as with the first cointegration equations. The P values for the null hypothesis that $\beta = -1$ is rejected at a 5% level of significance, as the P values are less than 0.05.

The alphas depict speed of adjustment in restoring equilibrium after disequilibria. For the first cointegration equation of the maize price model (Table 6b), Accra maize prices adjust by reducing 12.3% of the amount of disequilibria, while Techiman maize prices increase by 28.5% of the disequilibrium amount. In the second cointegration equation for the same model, the adjustment rates are reductions of 75% and 15.1% in Mankesim and Techiman, respectively. In the local rice model, the adjustment rates are a 26.7% decrease in Tamale prices and a 1.4% increase in Accra prices for the first cointegration equation. For the second, the adjustment rates are a 35.2% reduction in Wa prices and a 28.1% increases in Accra prices. The short-run dynamics here show that short-run price impacts are highest in producing markets.

We also considered seasonality in our tests. By controlling for seasonality, we observed that for the first six months of the year before the harvest season, average monthly maize prices are 4.2 percent higher than those in the second half of the year in the Accra market, 3.1 percent higher in the Mankesim market, and 18.0 percent higher in the Techiman market. Thus, seasonality has a much larger impact in Techiman, a major supply market, than in Accra and Mankesim, the two major consumer markets.

Table 7. Tests for Granger causality between market prices

Causality Hypothesis	Test Value	P Value
Accra ⟶ Techiman	5.722	0.017
Techiman ⟶ Accra	4.059	0.044
Mankesim ⟶ Techiman	8.836	0.003
Techiman ⟶ Mankesim	0.103	0.749
Accra ⟶ Tamale	1.294	0.255
Tamale ⟶ Accra	7.929	0.005
Accra ⟶ Wa	7.491	0.006
Wa ⟶ Accra	8.296	0.004

Source: Authors' own calculations.

Note: ⟶ depicts Granger noncausality; all follow $\chi^2_{(1)}$ distribution.

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[7] Notice that the price series were arranged to ensure that the restrictions were consistent with the identified cointegrated price pairs.

In Table 7 the hypothesis in the first column is that Accra prices do not Granger-cause Techiman prices to change. The test statistic of 5.722 is then compared with the one degree of freedom critical value corresponding to a 5% level of significance. P values less than 0.05 show that the test value of 5.722 is less than the respective critical value not shown in the table, and so we reject the hypothesis that Accra prices do not Granger-cause Techiman prices—implying that Accra prices Granger-cause Techiman prices. For P values higher than 0.05 (e.g., in the case of Accra and Tamale), we fail to reject the noncausality hypothesis.

The findings of the series of econometric tests conducted in this section confirm the heterogeneity of price transmission in Ghana, and hence the different extents to which world food prices are passed on to local markets. We have shown that price transmission is high for grain products, both in the short and long run, while for root crops such as cassava and yam no evidence of price transmission is found across different regional markets. In the next section, we develop a simple household model, based on the analysis in Sections 2 and 3, to show how these locally diverse price changes affect different household groups in Ghana.

4. ANALYZING HOUSEHOLD-LEVEL IMPACTS OF FOOD | PRICE CHANGES IN GHANA

Rising world food prices are expected to hit the poor as consumers directly and immediately, since staple food forms the most important part of their daily diet. However, if households in a country have a broad and diverse diet structure and calorie intake, they may temporarily switch away from those grain products for which world prices have risen significantly to others such as roots and tubers, given that market supply for those alternative staples exists. In this case, domestic prices for commodities that are not internationally traded, such as cassava and yam in Ghana, are expected to rise through substitution effects. To assess how consumers, particularly poor consumers, will be immediately and directly affected by rising world food prices, we develop a partial equilibrium model that considers household demand for food products only. In the model, household demand for each food product is a function of prices and income:

$$c_i = \prod_j p_j^{\varepsilon_{i,j}} Y^{\varepsilon_i^I}$$

(4.1)

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 2005/06). 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:

$$U(c_1, c_2, \dots c_N) = \prod_j (c_j - \gamma_j)^{\beta_j}$$

(4.2)

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

(4.3)

In equations (4.2) and (4.3), $U(\cdot)$ 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 equations (4.2) – (4.3). 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 equation (4.1) such that the price (both own and cross prices elasticities) and income effect on the demand can be explicitly measured.

We incorporate 28 food commodities in order to capture the substitution effect between commodities. These commodities include maize, rice, sorghum, other grains (including wheat), a few pulses and oilseed products or product groups, plantains, fruits, vegetables, and several livestock products or product groups. The average income elasticities for all crops by income quintile groups and rural and urban locations are reported in Table A.1 in the appendix.

To further capture the differential effects of price shocks on household demand by region and income groups, we group all GLSSV sample households according to region, agro-ecological zone, and population decile in rural and urban areas. 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 corresponding 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.[8]

The actual changes in the regional prices between April 2007 and April 2008 are reported in Table 8. We focus on six staple crops and the impacts on poor households for our discussion.

Table 8. Percent increases in prices for major food commodities in Ghana from April 2007 to April 2008

	Maize	Rice	Sorghum & Millet	Other Grains	Cassava	Yams
Western	55.6	20.0	0.00	88.3	38.2	17.5
Central	55.6	20.0	0.00	88.3	38.2	17.5
Greater Accra	33.4	12.5	20.0	88.3	0.00	0.00
Volta	19.5	13.0	18.2	88.3	0.00	15.4
Eastern	19.5	13.0	18.2	88.3	0.00	15.4
Ashanti	19.5	29.3	0.0	88.3	16.7	5.8
Brong Ahafo	19.5	13.0	18.2	88.3	0.00	15.4
Northern	55.7	29.5	47.4	88.3	0.00	0.0
Upper East	44.9	6.3	44.7	88.3	0.00	71.8
Upper West	44.9	6.3	44.7	88.3	0.00	71.8

Source: Authors' calculations based on data obtained from Ghana Statstical Service (GSS) (2008).

Tables 9 and 10 report the negative effects of rising domestic food prices on real consumption of grain and root products by the 10 income groups across the four agro-ecological zones. At the national level and weighted by base-year prices, total staple consumption (including both own-production and purchased staples) falls by 7.1 percent for rural and 9.3 percent for urban households. 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 percent, which is comparable to the estimates of Wodon et al. (2008), in which a 7.7 percent decline in the consumption of select items is found for Ghana.

Our results show that urban consumers are more negatively affected than are rural consumers in terms of declines in staple consumption. This can be explained by the fact that the share of purchased food in total staples consumed by urban households is much higher than for rural households. As shown in Section 2, purchased products account for 85 percent of grains and roots consumed by urban households, but only 41 percent for rural households. Because of this, rural households' consumption is less price sensitive than is urban households' consumption, 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.

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[8] 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 9. Percentage change in grain and root consumption—rural households

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	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

Source: Household simulation model results.
Note: D1 represents the first decile, with the lowest level of income, and D10 represents the decile with the highest level of income.

Table 10. Percentage change in grain and root consumption—urban households

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	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

Source: Household simulation model results.
Note: D1 represents the first decile, with the lowest level of income, and D10 represents the decile with the highest level of income.

Tables 9 and 10 also show that food consumption falls more for poor households and that poor urban consumers are hit hardest by price increases. At the national level, staple consumption declines by 20 percent for the poorest urban households in the first two decile groups (Table 9, the last row), while it declines by 9.2 and 7.4 percent, respectively, for the rural households in the same two decile groups.

At the subnational level, the poorest urban households in the Forest zone are most negatively affected, as their staple consumption falls by 30.5 percent, followed by the poor urban households in the Coastal zone (group 2) and in the Northern Savannah zone (groups 1–3), with a decline of more than 20 percent. In rural areas, almost all households in the Northern Savannah zone are badly hurt by the rising prices, as the declines in their staple consumption are almost the same (between 8 percent and 11.4 percent, but most are around 9 percent). This result is consistent with what we expected and explained in Section 2. As almost 70 percent 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.

These results suggest that the 20 percent of the national population with the lowest incomes are most seriously affected by the food crisis, while most rural households in the north will be seriously hit too. According to the GSS (2007) and based on GLSSV data, the national poverty rate was 28.5 percent in 2005/06 in Ghana, with rates of 39.2 percent in the rural areas and 10.8 percent in the urban areas. Thus, in addition to those households that we categorize in the first two decile groups for our analysis, the majority of rural households in the third decile population group also fall below the national poverty line. The average effect of rising food prices on the households in the third decile group is smaller than the effect on the poorest 20 percent of the population, as they register a 14.3 percent and 6.8 percent decline in food consumption for urban and rural households, respectively (see the last row of column 3 in Tables 9 and 10). This trend, however, does not include the households in the Northern Savannah zone, which we have already discussed above.

In addition to the negative effect on those whose income is already below the poverty line, 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 due to the food price increase. While more in-depth analysis on the potential increase in the number of poor is important for assessing the economywide 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 hurt the most when food prices rise, and their capacity to cope with the food crisis by themselves is most limited. These people therefore need immediate and properly designed government response programs.

5. CONCLUSIONS

This paper has taken a local perspective on global food price shocks by analyzing price transmission between 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 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 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 found that prices for domestic staples are highly correlated with the price for imported rice within each regional market, particularly in the case of local rice and maize prices. However, complete price transmission across a pair of regional markets is found in the case of local rice and maize only when a more rigorous cointegration method is applied. This finding indicates that market integration and hence price transmission is highly heterogeneous for different food crops and different regional markets. The seasonality factor is found to play an important role in the determination of market integration and price transmission. Even for those commodities with complete price transmission, we found strong price volatility, particularly in the producer markets for the respective commodity.

The welfare effect for households as consumers is relatively modest at the national aggregated level and is comparable to the effect identified by recent studies in the literature (e.g., Wodon et al. 2008). The modest impact 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 diversity in the welfare effect both 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 poor urban households, are the hardest hit by high food prices. At the regional level, the negative effect of the food crisis is particularly severe in northern Ghana. Different consumption patterns, in which grains account for a larger share of the consumption basket in the north compared to the rest of the country, together with much lower initial per capita income levels in the north, are the main explanations for this regional variation in the price effect.

APPENDIX: A TECHNICAL NOTE ON THE COINTEGRATION ANALYSIS AND GRANGER CAUSALITY TEST

Granger causality is one of the basic tools used to assess the extent of price interaction in food markets in the literature. Granger (1969a) defines this concept of causality based on the intuitive idea that if a variable x affects another variable z, the former should help in improving predictions of the latter. Thus, a variable x_t is said to Granger-cause another variable z_t if the variance of the forecast mean square error (MSE) of the 1-step forecast, z_{t+1}, is strictly minimized in the presence of x_t. In testing for Granger causality, we observe that equation (3.4) in Section 3 of the paper can be expressed as

$$\begin{bmatrix} \Delta p_t^a \\ \Delta p_t^b \end{bmatrix} = \begin{bmatrix} \Pi_{11} & \Pi_{12} \\ \Pi_{21} & \Pi_{22} \end{bmatrix} \begin{bmatrix} p_{t-1}^a \\ p_{t-1}^b \end{bmatrix} + \sum_{i=1}^{q-1} \begin{bmatrix} \gamma_{11,i} & \gamma_{12,i} \\ \gamma_{21,i} & \gamma_{22,i} \end{bmatrix} \begin{bmatrix} \Delta P_{t-i}^a \\ \Delta P_{t-i}^b \end{bmatrix} + u_t$$

(A2)

In (A2), that ΔP_t^b does not Granger-cause ΔP_t^a is characterized by $\Pi_{12} = 0$ and $\gamma_{12,i} = 0$ for all $i = 1,...,q-1$. Similarly, that ΔP_t^a does not Granger-cause ΔP_t^b is characterized by $\Pi_{21} = 0$ and $\gamma_{21,i} = 0$ for all $i = 1,...,q-1$. Hence we characterize Granger causality by imposing linear restrictions to establish evidence against the above conditions. However, as we have fitted models of dimensions greater than 2, 1-step noncausality in such models does not imply h-step noncausality for h > 1. To avoid this complexity, we check causality in each set of cointegrated prices separately.9

Figure A.1. Map of Ghana's major markets

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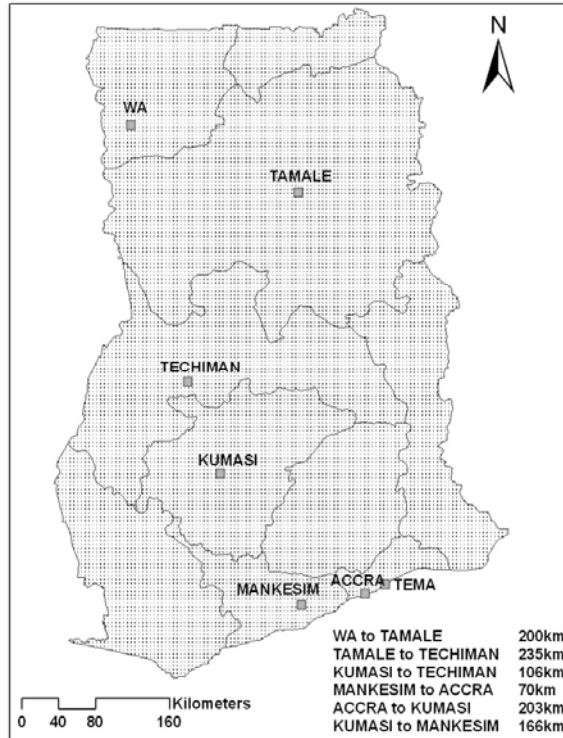
[9] Thus, in our models, we model each cointegrated set separately only for the purpose of characterizing Granger causality.

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Table A.1 Rural and urban income elasticities

Rural income elasticity

	cmaiz	crice	csorg	cogrn	ccass	cyams	ccyam	croot	ccpea	csbea	cpoil	cgnut	conut	cfrud	cvegd	cplan	cocro	cchik	ceggs	cbeef	cgoat	coliv	cfish	csupr	cdair	cmeat	cforf	clocf
DEC1	0.27	0.83	0.53	0.83	0.50	0.50	0.50	0.50	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	2.89	2.89	1.12	1.12	1.12	1.13	1.66	0.67	1.06	1.7	0.7
DEC2	0.27	0.83	0.53	0.83	0.50	0.50	0.50	0.50	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	2.89	2.89	1.12	1.12	1.12	1.13	1.66	0.67	1.06	1.7	0.7
DEC3	0.37	0.65	0.70	0.65	0.43	0.43	0.43	0.43	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	1.62	1.62	0.88	0.88	0.88	1.03	1.27	0.59	0.90	1.3	0.6
DEC4	0.37	0.65	0.70	0.65	0.43	0.43	0.43	0.43	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	1.62	1.62	0.88	0.88	0.88	1.03	1.27	0.59	0.90	1.3	0.6
DEC5	0.45	0.64	0.75	0.64	0.43	0.43	0.43	0.43	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	1.40	1.40	0.76	0.76	0.76	1.02	1.08	0.55	0.81	1.1	0.6
DEC6	0.45	0.64	0.75	0.64	0.43	0.43	0.43	0.43	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	1.40	1.40	0.76	0.76	0.76	1.02	1.08	0.55	0.81	1.1	0.6
DEC7	0.44	0.58	1.13	0.58	0.43	0.43	0.43	0.43	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	1.11	1.11	0.65	0.65	0.65	0.99	0.89	0.53	0.81	0.9	0.5
DEC8	0.44	0.58	1.13	0.58	0.43	0.43	0.43	0.43	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	1.11	1.11	0.65	0.65	0.65	0.99	0.89	0.53	0.81	0.9	0.5
DEC9	0.50	0.62	0.97	0.62	0.51	0.51	0.51	0.51	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.82	0.82	0.66	0.66	0.66	1.00	0.75	0.56	0.76	0.7	0.6
DEC10	0.50	0.62	0.97	0.62	0.51	0.51	0.51	0.51	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	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

	cmaiz	crice	csorg	cogrn	ccass	cyams	ccyam	croot	ccpea	csbea	cpoil	cgnut	conut	cfrud	cvegd	cplan	cocro	cchik	ceggs	cbeef	cgoat	coliv	cfish	csupr	cdair	cmeat	cforf	clocf
DEC1	0.80	1.78	0.17	1.78	2.03	2.03	2.03	2.03	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	2.89	2.89	1.43	1.43	1.43	1.61	1.25	1.20	0.94	1.2	1.2
DEC2	0.80	1.78	0.17	1.78	2.03	2.03	2.03	2.03	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	2.89	2.89	1.43	1.43	1.43	1.61	1.25	1.20	0.94	1.2	1.2
DEC3	0.85	1.22	0.39	1.22	1.05	1.05	1.05	1.05	1.19	1.19	1.19	1.19	1.19	1.19	1.19	1.19	1.19	1.97	1.97	0.98	0.98	0.98	1.25	1.13	1.06	0.90	1.1	1.1
DEC4	0.85	1.22	0.39	1.22	1.05	1.05	1.05	1.05	1.19	1.19	1.19	1.19	1.19	1.19	1.19	1.19	1.19	1.97	1.97	0.98	0.98	0.98	1.25	1.13	1.06	0.90	1.1	1.1
DEC5	0.77	0.90	0.68	0.90	0.96	0.96	0.96	0.96	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.46	1.46	0.86	0.86	0.86	1.40	1.04	0.92	0.90	1.0	0.9
DEC6	0.77	0.90	0.68	0.90	0.96	0.96	0.96	0.96	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.46	1.46	0.86	0.86	0.86	1.40	1.04	0.92	0.90	1.0	0.9
DEC7	0.71	0.83	0.51	0.83	0.82	0.82	0.82	0.82	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.10	1.10	0.75	0.75	0.75	1.65	0.92	0.79	0.88	0.9	0.8
DEC8	0.71	0.83	0.51	0.83	0.82	0.82	0.82	0.82	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.10	1.10	0.75	0.75	0.75	1.65	0.92	0.79	0.88	0.9	0.8
DEC9	0.48	0.51	0.27	0.51	0.59	0.59	0.59	0.59	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	0.95	0.95	0.60	0.60	0.60	2.23	0.64	0.58	0.91	0.6	0.6
DEC10	0.48	0.51	0.27	0.51	0.59	0.59	0.59	0.59	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	0.95	0.95	0.60	0.60	0.60	2.23	0.64	0.58	0.91	0.6	0.6

Source: Authors' estimates using data from GLSSV.

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