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Abstract

How does an increase in food prices at the border impact poverty in Uganda given the strong spatial heterogeneity of the country and its limited domestic transportation and communication networks? Recently, a number of studies on the impact of international food prices on poverty in developing countries have been published. However, the role of spatial price transmission in this context remains largely unexplored. This paper targets that niche. We assess the spatial variability and transmission of prices through the analysis of time series and household data using descriptive statistics and regression methods. Subsequently, we apply the findings in a simulation experiment to determine the first-order poverty impacts of a hypothetical 50% increase in border prices for food under the assumption of imperfect spatial price transmission. The poverty results show impacts substantially different from those of a perfect price transmission scenario and also display strong regional differentiation.

1 Introduction

The sharp rise in food prices witnessed in the 2006 to 2008 period[1] raised international concerns about the consequences for global poverty. It involves an inherent trade-off. The cost of food imports increases but the income from food exports increases at the same time. The same effect occurs on the household level. On the one hand, increased import prices for food raise the cost of living. On the other hand, by common assumption, the food price increase is accompanied by higher prices for the produce of the poor thereby increasing their income. As a consequence, the net impact on poverty is qualitatively

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[1]Between 2006 and 2008, the monthly global Food Price Index peaked at 180% and the Cereals Price Index at 255% compared to the respective January 2006 indices (FAO, accessed online on 5 November 2009, `http://www.fao.org/fileadmin/templates/worldfood/Reports_and_docs/Food_price_indices_data.xls`.).

ambiguous. Furthermore, the impact differs from household to household depending on a multitude of factors and thus the outcome is difficult to assess *a priori*. Most studies that examine the poverty impact of border price increases jump ahead and focus on the induced structural change and the resulting impacts on domestic prices, wages, and employment. But the missing step, which is crucial to induce this structural change, concerns the extent to which border prices are actually passed through to domestic economic actors. The price signals perceived by these actors might be amplified or weakened and consequently also their economic reactions. This is a particularly important issue for developing countries which are characterized by poorly functioning and missing markets due, for instance, to poor transportation, communications, and institutional infrastructure. These market imperfections may not be equal across actors or space.

In this paper, we look at the transmission of border price changes and spatial price variability in Uganda, and their effect on poverty outcomes, when world crop prices increase. We employ two datasets. The first consists of a time series of retail prices for six major local markets in Uganda and over a number of different commodities. The second data set is the Ugandan National Household Survey 2002/2003 which includes detailed expenditure and unit value data for 9711 households.

Two main approaches in the latest studies on poverty effects of border price shocks can be distinguished. The first looks at longer run effects and is based on computable general equilibrium (CGE) models linked to micro household data sets (see, e.g., Boysen and Matthews (2007) for a review). These studies usually find rather mild poverty effects due to their inherent assumptions of well functioning market mechanisms. The other approach is based on partial equilibrium models and focuses on short-run effects, the first-order effects of rising food prices on poverty which assume no reactions of the actors to the economic changes. Ivanic and Martin (2008), Wodon et al. (2008), and Joseph and Wodon (2008) are some recent examples of the latter approach. Both approaches are similar in that their results usually are derived under the strong assumption of perfect price transmission, thus relying on perfectly functioning markets and the assumption that price signals are transmitted perfectly across all sectors, regions, and production levels of the economy. In the first approach, economic agents react to these price signals with a reallocation of resources such that the overall outcome is again efficient. Thus, the shock is carried by and spread over the entire domestic economy. If, by contrast, prices are transmitted imperfectly across space, then the shocks differ in strength spatially and might even remain confined to certain areas thus implying that reactions to the shocks also vary with space. Only a few studies consider imperfect spatial price transmission when analyzing poverty impacts. Examples include Nicita (2004, 2007) examining the implications of imperfect domestic spatial price transmission in Mexico and Ethiopia, respectively, or Krivonos and Olarreaga (2006) who look at imperfect transmission of international to domestic prices for Brazil.

For Uganda, international prices are already considerably changed at the border due to its landlocked location. In particular, transport costs represent a substantial part of the final retail price for agricultural goods and staple foods which are of high volume and weight per unit price. This is exacerbated by poor road, railway, and inland water transport infrastructure within Uganda but also within Kenya and Tanzania, which provide the two main transport corridors to the sea ports of Mombasa and Dar es Salaam. Railway lines through both countries to Uganda exist but their quality of service is considered to be poor and cargo loss and delivery delays are frequent. Road transportation is usually more reliable but also much more expensive. Part of the distance can also be bridged via ship across Lake Victoria. Transportation between the ocean and the Ugandan border usually requires weeks. Thus, Uganda's world market access depends, *inter alia*, on transport infrastructure conditions in the neighboring countries and, also, on oil prices. Air transport is less important for heavy and bulky goods. A considerable share of Uganda's international trade consists, in fact, of trade with its neighbors with Uganda mainly acting as a food exporter.

The main transport infrastructure within Uganda is also rather sparse, consisting of two railway lines, both starting from the southeastern border with Kenya, one heading northwest through Gulu and one westward through Kampala. This is complemented by a few major road routes. However, large parts of the country, especially in the north, remain isolated in this respect. For these reasons, Uganda is a particularly interesting case study for the analysis of spatial price transmission.

This paper is positioned within the strand of studies looking at first-order poverty effects of rising food prices but aims particularly at examining the implications of imperfect domestic price transmission for poverty outcomes. In particular, we look at spatial price variability and spatial price transmission within Uganda and their effects on poverty in the case of a hypothetical 50% rise in border prices for food. We find marked differences in poverty impacts between perfect and imperfect spatial price transmission scenarios.

The paper is organized as follows: Section 2 reviews the theory underlying spatial price transmission and the empirical evidence on price transmission in Uganda. An introduction to the data used and the poverty measures applied throughout the study is given in Section 3. Section 4 reports the descriptive and inferential analysis of the data sets while Section 5 reports the results for a simulation experiment of a rise in border food prices and analyses the results. The final Section 6 summarizes and qualifies the analysis and the results.

2 Theoretical Basis

The theoretical basis for this analysis is given by the notion of spatial equilibrium.[2] In equilibrium, prices of spatially separated markets should exhibit a common single price, once transaction costs are taken into account (*Law of One Price*, LOP). If markets work efficiently, then arbitrageurs ensure that the price difference between two spatially separated markets i and j is not larger than the transaction costs c_{ij}^T required to move the good from i to j, with i being the market with the lower price. Thus, the *spatial arbitrage condition*

$$p_j - p_i \leq c_{ij}^T \tag{1}$$

holds in equilibrium. If two markets trade directly, the condition becomes an equality. Since this is an equilibrium condition, prices can deviate from each other in the short-run but should return to equilibrium in the long-run. Markets are said to be spatially efficient when all opportunities for making profits through arbitrage are exhausted.

Note, this definition of spatial market equilibrium is in line with situations where $|p_j - p_i| < c_{ij}^T$. In this case, transaction costs are too high, trade is unprofitable and prices in the two regions might float independently in a certain band. Thus, a spatial equilibrium does not require markets to be integrated. The term *market integration* describes the degree to which price movements of one region are transmitted to another region and is measured by the expectation of the *price transmission* ratio

$$R_{ij} = \frac{\partial p_j / \partial \epsilon_i}{\partial p_i / \partial \epsilon_i} \tag{2}$$

where ϵ_i is a shock on market i and $R_{ij} = 1$ indicates perfect price transmission. Note, in this definition the price transmission ratio will necessarily be below one if (parts of) the transfer costs are absolute rather than proportional to the price. As price transmission is not necessarily immediate it makes sense to relax the notion of market integration and differentiate between short- and long-run market integration. For a detailed discussion of these terms see Fackler and Goodwin (2001).

The integration of domestic with international markets likely varies across goods. Export goods with only little domestic consumption should be strongly integrated with the world market. But depending on the level of the value-added chain one looks at, even here price changes need not transmit perfectly because of market inefficiencies. For instance, Fafchamps et al. (2003) find that changes in international coffee prices transmit quite strongly to those in the higher levels of the coffee value-added chain in Uganda but only weakly to coffee growers. Purely imported products should also be strongly inte-

[2]The terminology and definitions are based on Fackler and Goodwin (2001).

grated. But in the more general case, goods will be partly imported or exported and partly domestically consumed. Again, goods will not be traded if $|p_j - p_i| < c_{ij}^T$. The nature of agricultural products, e.g., non-movable, low price per weight, bulky, heavy, or perishable, can make their transfer costs so high that no trade emerges and domestic markets are decoupled from the international market. A good might be traded only during certain periods / seasons, e.g., it might be non-traded during harvest and post-harvest periods but imported during the pre-harvest period as, for instance, Moser et al. (2008) found for rice in Madagascar. Trade flows between regions might even reverse in different seasons. Generally, the more heterogeneous the products the less prices will transmit because of the increased role of preference and quality considerations.

Markets can also, however, have a complementary or substitutional relationship so that these markets are integrated even though the goods are not the same, e.g., different types of cereals. Thus, prices of other markets create additional noise in the data. Also, Moser et al. (2008) find that market integration might differ with spatial scale, i.e., national, regional, and sub-regional level, and that, in the case of Madagascar, integration is quite complete on the sub-regional level but rather low on the national level.

Rapsomanikis et al. (2003), in reference to Prakash (1998) and Balcombe and Morrison (2002), summarize the different dimensions of price transmission into three components. (1) The degree of co-movement and adjustment refers to how much of the price change in one market is transferred to the price in the other market. (2) The dynamics and speed of adjustment refer to the mechanisms themselves through which prices are transmitted and their speed. (3) The asymmetry of response refers to the fact that the price transmission from one region to the other does not necessarily need to be the same in the opposite direction, neither in size nor in speed.

By and large, prices are determined dynamically within a complex, interdependent system and research on spatial price discovery, determinants, and transmission is relatively recent. The analysis of price transmission is particularly complicated by the absence of regional trade data so that usually only price data are available. Moreover, many components of transfer costs are non-observable, such as data on risks or bribes. Among the many and frequent causes of reduced price transmission are institutional price setting or marketing controls, longer-term contractual arrangements, and storage, to name a few.

Given these impediments to price transmission, the literature highlights the importance of a transfer cost component of prices which is non-proportional to the origin's price. There is much ongoing research trying to isolate this non-proportional price component developing several versions of threshold error correction models and parity bounds models. For recent detailed discussions and reviews of corresponding studies, see Abdulai (2007) and Rapsomanikis et al. (2003).

2.1 Price Transmission Evidence for Uganda

The following studies present some evidence of the degree of spatial price transmission for Uganda, either from the world market to the Ugandan market or amongst domestic markets.

Rapsomanikis et al. (2003) analyze the integration of and price transmission between the Ugandan national coffee market and the world market using producer prices and the composite indicator price (CIP) of the International Coffee Organization (ICO). They apply the Johansen cointegration test which indicates the existence of one cointegrating relationship and thus that the international and Ugandan markets are integrated. A subsequent Granger causality test confirms that the CIP Granger-causes the domestic producer price. The error correction coefficient of the estimated vector error correction model suggests that domestic producer prices fully adjust to shocks in the CIP after 5 months. The short-term adjustment coefficient indicates that 58% of the CIP shock is passed through to domestic producer prices instantaneously.

Conforti (2004) also looks at international to domestic price transmission in Uganda for various products. Using a bivariate error correction model (ECM), he finds long-run equilibrium relationships with the world price for producer prices for wheat and sorghum and the import unit value of milk powder but finds no such relationship for other commodities. He remarks that he did not have the price data for important agricultural products like coffee, tea, or cotton. The possible reasons stated for this low degree of price transmission are the general low tradability of the products examined and the relative self-sufficiency of Uganda in terms of food.

Rashid (2004) focuses on the evolution of domestic maize market integration following the liberalization of Ugandan agricultural markets including removal of parastatals in the early 1990's. He analyzes weekly wholesale price data for 8 district markets[3] over the periods from 1993, week 1 to 1994, week 40 and from 1999, week 40 to 2001, week 30 using a dynamic cointegration moving average model. He finds that the majority of the district markets are integrated and that integration with Kampala improved from the first to the second period and that the largest maize producing districts dominate long-run price formation. The time series for Masaka and Mbarara are stationary in period one but are found to be integrated with the other markets in period two. However, the nothern districts of Gulu and Arua are not integrated, something the author attributes to the prolonged state of insurgency in northern Uganda.

Kuteesa (2005) analyzes price discovery in domestic maize and beans markets in Uganda utilizing a vector autoregression model and a directed acyclic graphs approach on weekly wholesale prices of maize and beans for 16 markets from 2000, week 1 to

[3] These are Kampala, Jinja, Masaka, Gulu, Arua, Mbarara, Hoima, and Mbale.

2003, week 52. She finds that maize markets are rather integrated and react quickly to each other so that after 23 weeks all markets have reacted. By contrast, beans markets only react in the medium-run to each other and even in the long-run, three markets do not react. The reactions to price shocks in the beans markets are generally lower than those in the maize markets. Price discovery for maize originates mainly from Mbale and Iganga which are high production areas and where Mbale is the main root of price determination. Even Gulu reacts to price shocks elsewhere in the long-run. For beans, prices of most markets are discovered in Jinja but some also in Tororo. Arua and Gulu respond only little to shocks elsewhere. Surprisingly, the Kampala market seems rather unimportant for the price determination of both maize and beans markets.

The study by Atingi-Ego et al. (2008) looks at the transmission from world to border prices and from border to producer prices for the export crops maize, bananas, beans, cotton, tea, and tobacco. Unit export prices are used as proxies for border prices. The monthly time series for the years 2000 to 2004 data are analyzed using error correction models. They find cotton, tea, and tobacco exporter prices to be integrated with the world market. However, those products display no evidence for domestic price transmission from exporters to producers. For maize, beans, and bananas they find neither price transmission from world to border nor from border to producer prices.

Benson et al. (2008) analyze graphically the relationship of world and average Ugandan prices for several staple foods during the 2007 and 2008 food price spike. They suggest that domestic prices only for rice and wheat are affected directly by international market prices. Other staple prices are affected indirectly through increased regional demand for Ugandan food exports. The authors conclude that prices from the global food markets are not transmitted very effectively to Ugandan domestic prices. The overall weak transmission of staple food prices is attributed to high transaction costs and to the diversity of the basket of staples consumed in Uganda. The basket consists largely of domestically grown crops which are little traded on international markets.

In summary, the literature presents ample empirical evidence for the case of Uganda regarding imperfect price transmission from the world market to the Ugandan market and between Ugandan regional markets. In the following sections, we assess the spatial variability and transmission of food commodity prices across Ugandan regions and use the results to examine the implications of imperfect spatial price transmission for poverty analysis in a simulation of an increase in food prices at the border.

3 Data and Poverty Measures

This study utilizes two data sets. The first data set consists of price time series for six Ugandan markets and 11 staple foods for the months from July 1997 to July 2006 published by the Ministry of Agriculture, Uganda.[4] Series which are only available for one market are discarded. This data is utilized for the actual analysis of spatial price transmission in Uganda.

The data used for the analysis of spatial variability of prices and for the simulation of income and poverty consequences of an increase of international prices for food is the Uganda National Household Survey 2002/2003.[5] It comprises 9711 households and a detailed household expenditure section which includes values and quantities for a large number of food commodities. Unfortunately, on the income side this survey only contains a single figure for annual income from crop farming in the welfare indicators section of the survey so that this does not allow detailed analysis of different crops. We regard this crop farming income figure as being more uncertain than the extensive expenditure data. The details on how this dataset was prepared for analysis can be found in Boysen and Matthews (2008).

For measuring poverty, we employ an absolute poverty line and the measures P_α introduced by Foster, Greer and Thorbecke (1984). Setting the parameter α in the following formula to 0, 1, or 2 computes the poverty headcount, gap, or severity index, respectively.

$$P_\alpha = \frac{1}{N} \cdot \sum_{i=1}^{N} \left(\frac{z - y_i}{z} \right)^\alpha \cdot I_i$$

with N: population size, z: poverty line, y_i: income of individual i, and $I_i = \begin{cases} 1 & \text{if } y_i < z \text{ and} \\ 0 & \text{otherwise.} \end{cases}$

The poverty headcount index P_0 measures the percentage of people falling below the poverty line. The poverty gap P_1 measures the extent to which poor people undercut the poverty line as a percentage of the poverty line on average. The poverty severity index P_2 squares that shortfall percentage of each person before averaging and thus gives more weight to more severely affected people.

For poverty lines we use separate rural and urban lines which have been recovered from the adjusted household survey data in order to reproduce the poverty headcounts reported in the UNHS Report on the Socio-Economic Survey (UBoS, 2003, Table 6.3.2 (a)). In particular, we find poverty lines of 192,707 UGS and 218,516 UGS for the 41.7% of rural and 12.2% of urban poverty headcounts, respectively. The UBoS poverty lines are based on the *cost of basic needs approach*, which accounts for the cost of meeting physical calorie needs and allows for vital non-food expenditure, such as clothing and cooking fuels, valued using the average consumption basket of the poorest 50% of the

[4] Accessed online on 20 August 2008, `http://www.agriculture.go.ug/docs/FoodPriceData.xls`.

[5] Uganda Bureau of Statistics, Entebbe, Uganda, 2003.

population.[6] The rural and urban poverty lines account for the differences in prices and consumption baskets for the respective subpopulations. For the income measure we use per capita income.

4 Descriptive Analysis

Overall, given the above definition of poverty and the derived poverty lines, 37.7% of the population is living in poverty. Of the poor population only 4.5% live in urban but 94.5% in rural areas. Put differently, 13.8% of the Ugandan population is living in urban and 86.2% in rural areas. 12.2% of the urban population and 41.7% of the rural population are classified as poor.

The poor spend 56.9% (53% in urban and 57.1% in rural areas) of their discretionary expenditure on food, i.e., expenditures excluding income taxes and food excluding beverages and tobacco. But the dependency on markets and hence on market prices is rather different. Overall, the poor source 43.4% of their food expenditures from markets. In urban areas this proportion is 69% in contrast to only 42.3% in rural areas. Although both of these values are quite high, the direct effects of changes in market prices will be much larger in urban than in rural areas (ignoring indirect opportunity cost-driven effects).

Due to data limitations on the income side, we henceforth restrict the discussion to crops which we use as synonymous with food. Under our definition, crops comprise all plant products including coffee and tea. Since the UNHS surveys only a single figure on income from crop farming, we cannot separate out different crops on the income side.[7] On the expenditure side, we decided to leave out tobacco as it is an important expenditure but its retail price is usually not related to its producer price due to regulation and taxes.

4.1 Dependency on Markets for Food

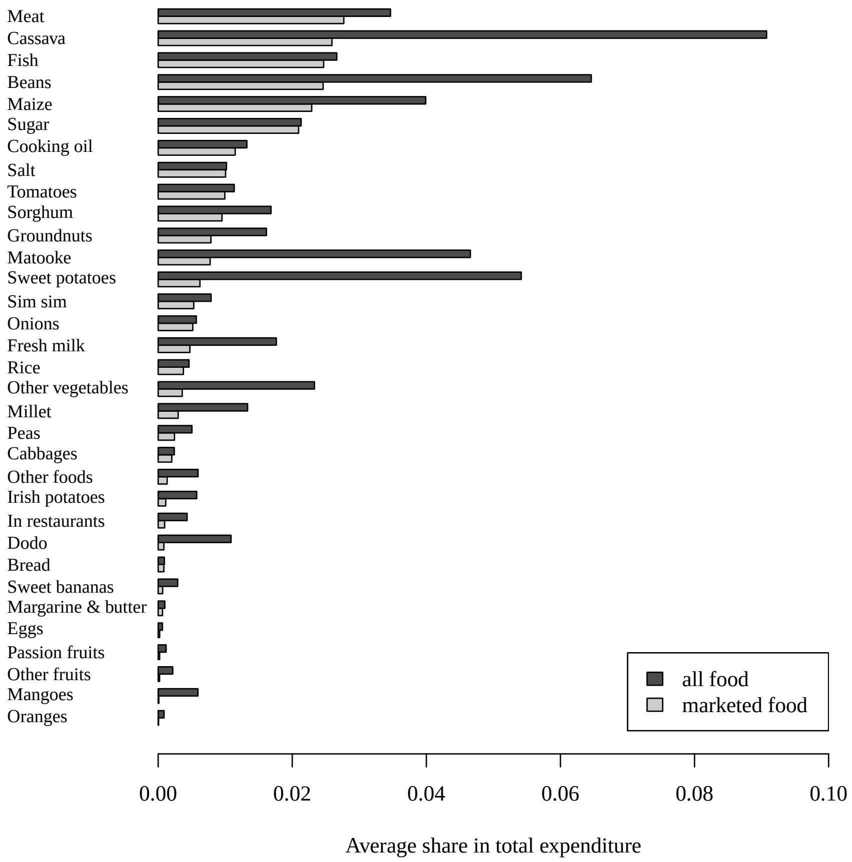
Since this study focuses on poverty, it is important to determine which products are important for the poor population in Uganda. Figure 1 shows the shares of their expenditures that the poor spend on different food items per capita on average, ordered by the share of marketed expenditures. It is important to differentiate between market and non-market expenditures because only the marketed expenditures are initially affected by price changes. 31.7% of total expenditures are spent on staple foods (cassava, beans, maize, sorghum, matooke, sweet potatoes, rice) and 10.1% are actually spent in markets on these foods. Thus, barely a third of those expenditures are marketed on average but this varies considerably, e.g., between urban (60.3%) and rural (30.5%) areas. The most widespread

[6] See UBoS (2003, Appendix II(A), 2).

[7] This UNHS, in particular, also includes no data on livestock incomes.

staples are cassava, beans, sweet potatoes, matooke, and maize but only cassava, beans, and maize are sourced to a substantial degree from markets whereas only maize is regularly purchased on markets at a share of over 50%. The poor population relies strongly, or even completely, on markets for the important foods meat, fish, sugar, cooking oil, and salt.

Figure 1: Poors' food expenditure shares by item



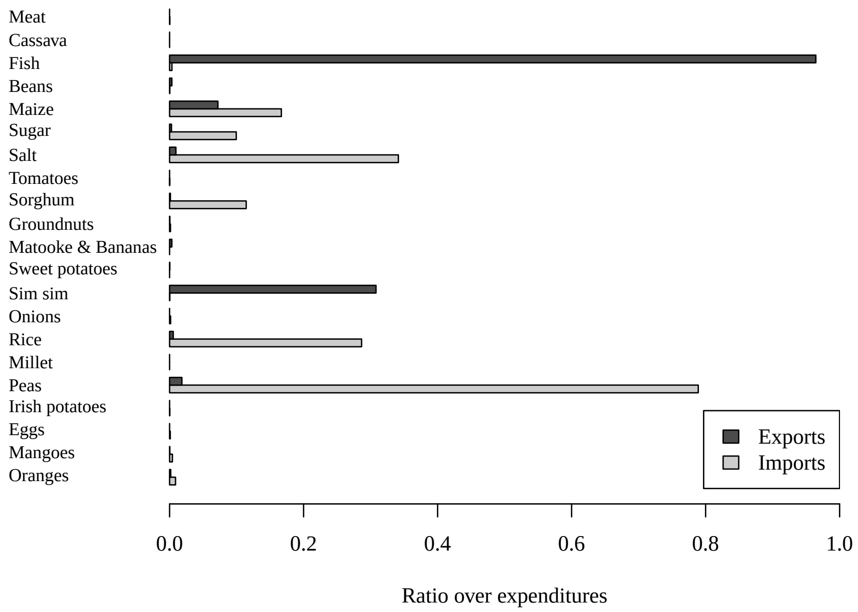
Average share in total expenditure on food, excluding beverages and tobacco, per capita over the poor population only. The bars for marketed food show only the share of the food bought on markets as opposed to auto- or free consumption. Source: Own computation from UNHS 2002/2003 data.

One would expect strong price transmission from international to Ugandan markets wherever there are also strong trade links. Figure 2 presents the ratio of Ugandan total imports and exports over total Ugandan expenditures on food items in 2002/2003.[8] In the foods sector, there are few substantially traded food items which are also important for the poor.[9] The more important ones with substantial trade are fish, maize, sugar, salt, sorghum, and the less important sim sim, rice, and peas. All of these also have a

[8]The import and export data is taken from the UNCTAD Trains database, United Nations Conference on Trade and Development, Geneva, Switzerland. Accessed online via WITS, World Bank, on 6 October 2008.

[9]Coffee and tea are not part of the diet of the poor population and thus missing.

Figure 2: Total import and export values over total household expenditures by food item



The bars show Ugandan import and export values over total Ugandan household expenditures for individual food items. Trade values are simple averages of 2002 and 2003 data. Source: Own computation from UNHS 2002/2003 and UNCTAD Trains data.

relatively high marketed to total food expenditure ratio. Maize, sorghum, and rice appear to be the only staple foods imported to a significant extent. Thus, prices of main staples like cassava, beans, and matooke can only be affected indirectly via substitution effects. Fish is one of the main export industries of Uganda and is also a substantial part of the poor's food expenditures. But quality differences might make the poor's fish prices less responsive to world market prices as the exports consist mainly of high quality fillets. The equally important expenditure component meat is not traded at all but might have a substitutional relationship with fish.

Taken together, Figures 1 and 2 suggest that direct price links from international markets to the poor's market food expenditure basket are rather insignificant.

Table 1 shows the distribution of people's status as net food buyers or sellers and suggests who and in which regions depends more on producer or on retail prices or is rather independent of food price movements. Firstly, one can observe that across all quintiles and regions there is a substantially larger share of net buyers than sellers. The share of net buyers generally tends to increase with income level while the picture for sellers is not as clear. The share of net sellers decreases continuously in all regions except the Northern region where the highest prevalence of sellers is in the middle three income quintiles.[10] The share of even net positions decreases with rising income level. There are

[10]The Northern region has a poverty headcount index of 66%. Thus, large parts of the middle deciles

more net buyers in urban than in rural regions and more net sellers in rural than in urban regions. The poorest two quintiles in the Eastern and Northern regions feature more net buyers and less net sellers than the Central and Western regions thus making them more dependent on food retail prices. These are also the regions where the majority of the poor live (63%). Kampala is a purely urban area with virtually only net buyers.

4.2 Domestic Price Variability

Another important indication of the level of price transmission within Uganda concerns spatial price distribution. To facilitate comparisons, all unit values have to be measured in the same units. Many of the 85 different measures used in the UNHS are multiples of kilograms or liters and thus easily scaled to one kilogram or liter. But other measures are less specific, like, for instance, "Bunch (Big)", "Bunch (Medium)", or "Crate". In the absence of UNHS-specific conversion factors, we estimate such factors using a regression approach inspired by Capéau and Dercon (2006). While doing so, we also estimate conversion factors to convert different variants or qualities of a commodity to a base variant, for instance, maize flour to maize grains, in order to get a more manageable set of items.

We start from the identity equation for the unit value, $p_u = v_u/q_u = c_u \cdot p^{kg}$, where the unit value of an item i measured in units u is given by the total value v_u of item i divided by the total quantity q_u of item i measured in units u. The measures u should have a fixed relation and thus the unit value p_u should equal some conversion factor c_u times the kilogram price p^{kg}.[11] As household surveys include measurement errors, e.g., caused by differing measurement devices, the conversion factors cannot simply be calculated. Even when prices are measured in the same units, other sources of price variations are quality and seasonal, regional, and preference variations.[12] Different variants of a commodity are converted to a base variant using the variety conversion factor m_j and seasonal variation is accounted for by the seasonal factor k_s. We assume the price equation for a specific item and unit as being $p_u = c_u \cdot m_j \cdot k_s \cdot p^{kg}$ and settle for the following regression equation:[13]

$$\log p_{h,u,j,r,s} = \sum_{u \in \{U \setminus kg\}} \beta_u u_{h,u} + \sum_{j \in J} \beta_j j_{h,j} + \sum_{r \in R} \beta_r r_{h,r} + \sum_{s \in S} \beta_s s_{h,s} + \epsilon_{h,j} \qquad (3)$$

are poor.

[11] The conversion factor for kilogram to liter unit values corresponds to the reciprocal of the density of the item.

[12] Deaton (1997, p. 288) emphasizes that unit values are not prices since value is divided by a mixture of items of different quality. If the choice of quality is also related to income, there is a potential selection bias such that higher income areas will show higher unit values because of the quality difference.

[13] All units given in multiples of kilograms and liters have been scaled to one kg and one liter, respectively, beforehand. All units given in definite ranges of kilograms or liters, e.g., "1 to 2 kgs", have been assigned the mean value.

Table 1: Net crop balance across regions and income quintiles

		Of total		Quintile 1			Quintile 2			Quintile 3			Quintile 4			Quintile 5		
Region		% pop.	% poor	sell	even	buy	sell	even	buy	sell	even	buy	sell	even	buy	sell	even	buy
Central	rural	21.6	13.6	38.8	16.2	45.0	36.2	14.1	49.5	23.8	11.4	64.8	22.0	9.4	68.6	13.7	5.6	80.3
	urban	2.9	0.7	14.9		85.1	16.5	2.4	81.1	6.9	4.8	88.3	3.3	1.4	95.3	2.9	0.9	96.2
	total	24.5	14.4	38.5	15.9	45.6	35.1	13.5	51.2	22.6	10.9	66.4	20.1	8.6	71.3	11.1	4.5	84.2
Eastern	rural	25.3	31.4	18.3	18.7	62.9	21.5	16.9	61.6	18.7	8.5	72.8	17.6	8.5	73.9	18.1	7.0	74.8
	urban	2.1	0.9	10.4	1.8	87.8	12.0	1.6	86.3	6.1	1.9	92.0	1.4	1.3	97.3	3.9	1.2	94.9
	total	27.4	32.3	18.2	18.5	63.3	21.2	16.4	62.4	18.2	8.2	73.6	15.8	7.8	76.4	13.9	5.3	80.8
Northern	rural	16.8	29.5	22.5	10.8	66.6	31.7	6.8	61.5	32.4	6.5	61.1	31.9	5.6	62.5	18.3	1.7	80.0
	urban	1.4	1.5	15.3	0.1	84.5	1.1	0.2	98.7	1.1	0.1	98.7	0.8	1.0	98.2	2.1	1.1	96.9
	total	18.2	31.0	22.2	10.4	67.1	29.9	6.4	63.6	29.1	5.8	65.1	27.3	4.9	67.7	13.8	1.5	84.6
Western	rural	22.6	20.9	37.1	13.0	49.9	31.7	9.5	58.8	29.1	10.6	60.2	23.5	9.3	67.2	21.6	3.8	74.6
	urban	2.2	1.0	5.1	5.2	89.7	13.3	9.1	77.6	9.2	5.9	84.9	9.2	3.0	87.8	6.4	1.0	92.6
	total	24.7	21.9	36.1	12.7	51.1	31.0	9.5	59.6	28.1	10.4	61.5	22.1	8.7	69.2	18.3	3.2	78.5
Kampala	urban	5.1	0.3			100.0			100.0			100.0	2.0		98.0		0.6	99.4

The "Of total" columns report the share of the total population and the share of the total poor population living in that area, respectively. The "Quintile" column sets denote net sellers, people with balanced positions, and net buyers of crops. People within a net crop position of +/- 5% of their total crop consumption are deemed balanced. Source: Own computation based UNHS 2002/2003 data.

with observation index h (household), unit type $u \in U$, item variant $j \in J$, region $r \in R$, season $s \in S$, and $\beta_{.}$ the corresponding coefficients. This equation is estimated for each item individually using OLS.[14]

We use only the four Ugandan regions plus Kampala instead of the more detailed district level of 56 districts. A check of the estimated unit conversion coefficients β_u for rather homogeneous goods, e.g., rice or beans from liters to kg, against conversion factors found on the internet confirms that the estimates are rather accurate. Moreover, the ordering of conversion factors for ordinal measures appears sensible and the conversion factors for different variants of an item reflect the level of product refinement. The estimated regional unit values and seasonal multiplication factors are shown in Table 2. A comparison of the estimated unit values with the regional price data from the Ugandan Ministry of Agriculture for the third quarter 2002 in Kampala indicates that the estimations are rather accurate with stronger deviations where units are rather unspecific, as, for instance, for matooke which is mainly measured in bunches. Also, the seasonal multipliers seem plausible where significant.

The estimated unit values (acknowledging the aforementioned difference between prices and unit values, we henceforth use both terms synonymously for unit values) exhibit a strong regional variation where the prices in Kampala generally belong to the highest (highest prices for 11 of 16 items), but which also features the lowest price averages for Sugar and Tomatoes. It is also interesting to note that there is no single item where the Central Region has the lowest prices. The max/min column illustrates that average prices vary considerably (up to factor 2.56, for sorghum) across space and much more across regions than over seasons (up to factor 1.48, for matooke).

4.3 Domestic Market Integration

Figure 3 pictures the commodity price time series data set from the Ministry of Agriculture, Uganda. Initial inspection of the local commodity price time series suggests that most of the Ugandan markets are rather integrated. Most markets' curves tend to follow the major common movements although there are differences in the strengths of reactions. Note, these are all relatively large cities of at least 68,000 inhabitants (census 2002) spread across the country but which are also relatively well connected, i.e., they are favorably situated on one of the few main roads and four of them also on the two main lines of the sparse railway network. Disregarding the world series, Gulu often sticks out as an extreme, being either the cheapest or the most expensive city. It is, however, the only city located in the north of the country, whereas the others are located along the entire

[14] Capéau and Dercon (2006) separate out regional conversion factors whereas we focus on a national conversion factor.

Table 2: Variation of unit values of foods by region and season

	Central	Eastern	Northern	Western	Kampala	max/min	Jul-Sep	Oct-Dec	Jan-Mar
Meat	1,864	1,971	1,746	1,843	2,249	1.29	1.01	1.06	1.07
	(986.26)***	(1,049.91)***	(767.91)***	(1,025.00)***	(469.09)***		(1.58)	(6.91)***	(7.04)***
Cassava	310	204	177	224	340	1.93	0.93	1.07	1.02
	(179.05)***	(208.08)***	(175.71)***	(186.52)***	(87.59)***		(-2.54)*	(2.43)*	(0.80)
Fish	903	868	775	1,052	1,178	1.52	0.99	0.93	0.95
	(57.73)***	(57.29)***	(55.17)***	(57.14)***	(53.18)***		(-0.23)	(-2.26)*	(-1.57)
Beans	547	506	460	454	656	1.45	0.97	1.03	1.06
	(374.76)***	(417.91)***	(330.96)***	(392.60)***	(194.40)***		(-2.15)*	(1.98)*	(3.19)**
Maize	482	439	435	438	541	1.24	0.98	1.11	1.15
	(496.46)***	(496.12)***	(320.92)***	(462.53)***	(212.63)***		(-1.21)	(7.97)***	(8.68)***
Sugar	1,231	1,220	1,310	1,272	1,210	1.08	1.00	0.98	0.98
	(2,104.13)***	(2,058.42)***	(1,478.89)***	(1,930.85)***	(878.80)***		(-0.38)	(-4.18)***	(-4.46)***
Cooking oil	1,042	944	985	1,139	1,156	1.22	0.96	1.04	1.07
	(109.48)***	(107.57)***	(107.34)***	(112.02)***	(102.05)***		(-2.65)**	(2.92)**	(4.30)***
Salt	596	493	558	569	632	1.28	0.94	0.93	0.94
	(547.16)***	(543.56)***	(406.22)***	(541.62)***	(212.57)***		(-4.83)***	(-5.52)***	(-4.47)***
Tomatoes	360	350	354	549	537	1.57	0.92	1.04	0.92
	(95.53)***	(95.84)***	(91.98)***	(105.00)***	(88.05)***		(-4.23)***	(2.26)*	(-4.13)***
Sorghum	613	240	296	379	548	2.56	0.97	1.23	1.09
	(18.71)***	(110.58)***	(101.79)***	(78.36)***	(13.06)***		(-0.52)	(3.60)***	(1.73)˙
Groundnuts	1,245	909	519	1,126	1,240	2.40	0.96	1.03	1.02
	(387.18)***	(338.66)***	(203.22)***	(349.69)***	(192.39)***		(-1.81)˙	(1.41)	(0.71)
Matooke	90	109	74	69	134	1.94	0.94	1.32	1.32
	(11.81)***	(12.29)***	(11.13)***	(11.08)***	(12.83)***		(-2.08)*	(9.00)***	(7.81)***
Sweet potatoes	153	111	68	118	170	2.50	1.07	1.02	0.97
	(90.23)***	(85.45)***	(71.11)***	(105.09)***	(56.37)***		(1.53)	(0.56)	(-0.87)
Sim sim	879	824	614	912	822	1.49	1.04	1.16	1.06
	(44.94)***	(133.24)***	(130.61)***	(67.03)***	(30.62)***		(0.91)	(3.91)***	(1.71)˙
Rice	945	830	930	952	956	1.15	0.97	0.99	0.97
	(767.22)***	(802.87)***	(538.21)***	(718.46)***	(415.68)***		(-2.68)**	(-1.50)	(-2.47)*
Millet	617	424	339	487	642	1.89	0.94	1.02	1.02
	(137.56)***	(145.76)***	(95.36)***	(182.77)***	(71.93)***		(-1.37)	(0.51)	(0.44)

The first five columns show the estimated unit values for the four Ugandan regions plus Kampala. Column max/min lists the ratios of maximum over minimum price. The last three columns show the estimated seasonal multipliers with April to June being the base season. All values are given as exponents of the log estimates. The brackets mark the t-values of the particular regression coefficient. Each commodity row describes an individual regression. All values are in UGS. Source: Own computation based UNHS 2002/2003 data.

east-west axis more or less close to the southern border. Kampala is usually one of the most expensive markets, except for cassava flour, where it is amongst the cheapest.

The world market prices are taken from IMF statistics[15] and are not exactly the same commodities.[16] Those prices reflect spot market quotes and do not take into account the cost of delivering the goods to Uganda, such as transport, insurance, taxes. Also, world prices for maize refer to grains as opposed to Ugandan prices which refer to flour.

Next, we examine if these major markets are integrated with the Kampala market and how quickly these adjust to price shocks originating from Kampala. For this, we estimate bivariate error correction models, following the Engle-Granger two-step procedure (see, e.g., Enders, 2004, ch. 6).

All time series for all markets and goods appear to be difference stationary $I(1)$ variables as determined by Augmented Dickey-Fuller (ADF) tests on the variables in levels and first differences (results not shown). We then estimate the long-run relationships between Kampala and each of the regional markets with the following equation by OLS:

$$y_t = \beta_0 + \beta_1 z_t + e_t \tag{4}$$

The resulting estimated error term $\hat{e}_t$ is stationary only if y and z are cointegrated with z being the particular Kampala price series and y that of the other regional markets. Thus, we perform a Dickey-Fuller test on $\hat{e}_t$. The values of the test statistics with their p-values in brackets are reported in Table 3, column ADF. The p-values are based on MacKinnon (1991).[17] The hypothesis of no cointegration is rejected for all variables at the 5% significance level, with only Gulu being a borderline case for maize flour. We can conclude that the Kampala market is somehow cointegrated with all the other five markets.

Now we estimate the ECM using

$$\Delta y_t = \alpha_1 + \alpha_y(y_{t-1} - \beta_1 z_{t-1}) + \alpha_{11}\Delta y_{t-1} + \alpha_{12}\Delta z_{t-1} + \sum_{m=1}^{12} \gamma_{y,m} M_t + \epsilon_{y,t} \tag{5}$$

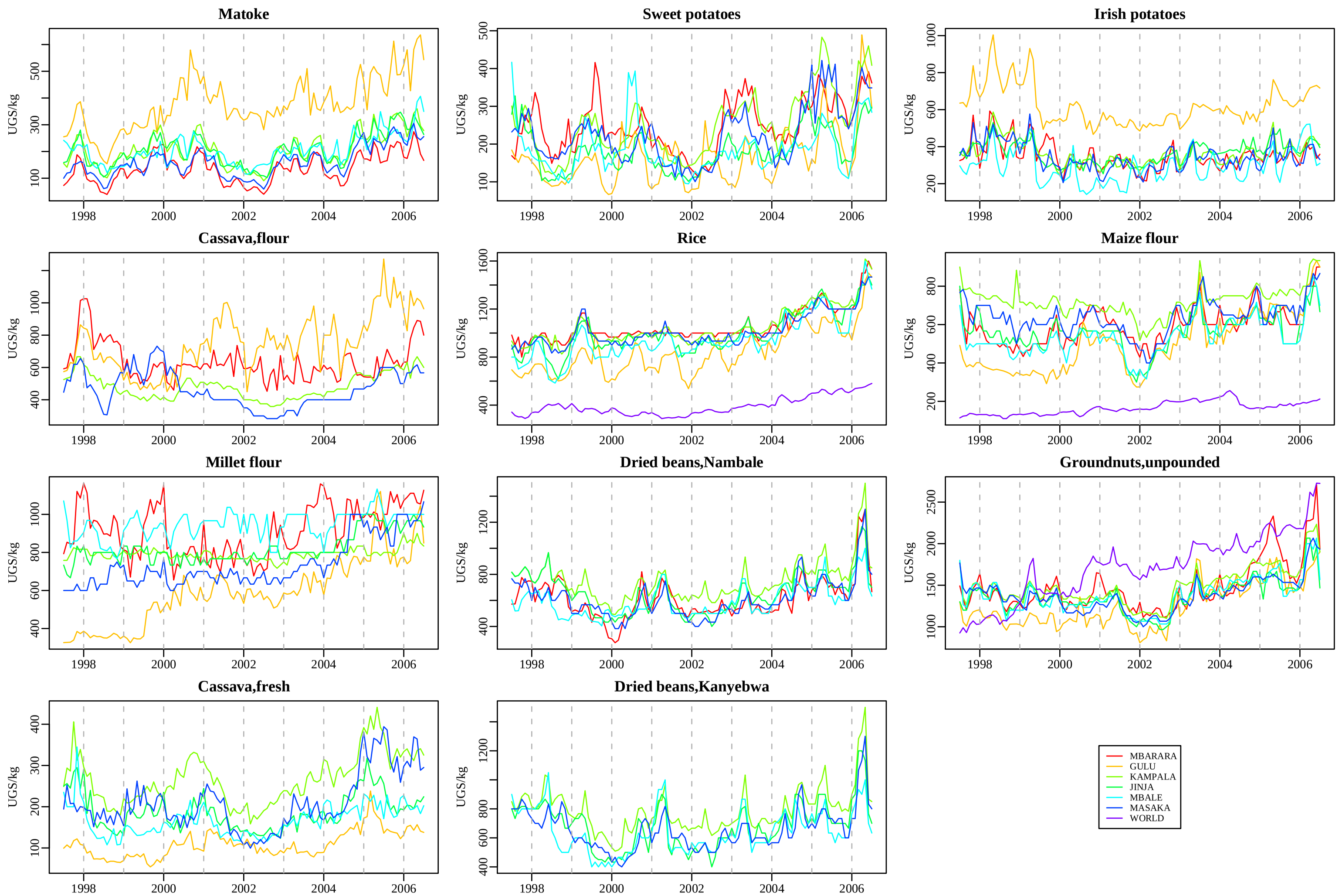
where M_t are dummy variables for calendar months with the corresponding index m and coefficients $\gamma_{y,m}$ to account for seasonality. $\epsilon_{y,t}$ accounts for unexplained error. The

[15] Accessed online on 12 September 2008, `http://www.imf.org/external/np/res/commod/externaldata.csv`. The prices are converted from USD to UGS using an exchange rate from the International Financial Statistics (IMF), accessed online on 19 September 2008, `http://www.imfstatistics.org/imf/`, series "principal exchange rate, monthly average".

[16] The series used are: "Rice, 5 percent broken milled white rice, Thailand nominal price quote, US$ per metric tonne", "Maize (corn), U.S. No.2 Yellow, FOB Gulf of Mexico, U.S. price, US$ per metric tonne", "Groundnuts (peanuts), 40/50 (40 to 50 count per ounce), cif Argentina, US$ per metric tonne".

[17] The p-value computation is conducted through the R package `fUnitRoots` (R Development Core Team, 2008) which implements the MacKinnon method.

Figure 3: Retail market price variation across time and regions by item



Note, the origin and scale of the ordinate vary between items and thus price fluctuations are not directly comparable. Source: Own computation presentation based on data from the Ministry of Agriculture, Uganda.

Engle-Granger procedure re-uses the error term series $\hat{e}_t$ estimated by Equation (4) in the first step and substitute that – lagged by one time unit – for the term $(y_{t-1} - \beta_1 z_{t-1})$ in Equation (5).

The results are shown again in Table 3.[18] We are mainly interested in the α_y coefficients as these indicate that market price y corrects for deviations from the long-run price in Kampala z. If so, the α_y coefficient should appear negative and significant. This is largely the case. All regional markets for sweet potatoes, Irish potatoes, rice and groundnuts respond to price changes in Kampala. However, every region is unresponsive to Kampala price changes in two to three of the other markets without any noticeable regularities. Moreover, the α_y coefficients indicate the *speed of adjustment* to the long-run equilibrium. Looking only at the coefficients significant at the 5% level, there seems a tendency for the markets south of Kampala, Masaka and Mbarara, to react faster than the northern ones. For instance, Masaka's markets for the two bean variants correct for 93% and 82% of the deviation from the long-run equilibrium price with Kampala in the first month. On average, Masaka's markets correct for 51% of the gap to the long-run equilibrium and thus adapt to over 90% in the fourth month. The opposite extreme is Gulu, the northernmost market, which adjusts the slowest with a mean of 25% per month corresponding to a 90% adaptation after about eight months. The speed of adjustment decreases monotonically with increasing distance to the north and to the south of Kampala, as expected. Only Jinja's speed of adjustment falls out of alignment with 30% although it is rather close to Kampala and well connected.

By and large, these Ugandan markets seem to be integrated with the Kampala market so that shocks to Kampala market prices will be transmitted sooner or later. But these numbers fall short of answering the question of how the majority of the poor living in rural areas is affected. The six markets considered are larger cities and exceptionally well connected by major roads and, in four cases, also by national railway lines. However, the level of market integration might drop rapidly with distance from these centers and the sparse national transportation network.

[18] The estimated coefficients for the seasonal dummies are not shown.

Table 3: Error correction model estimates on regional market prices

	Region	ADF	α_1	α_y	α_{11}	α_{12}	R^2
Matoke	Gulu	-3.07	-18.62	-0.21	0.79	-0.32	0.26
		(0.00)**	(-1.07)	(-2.67)**	(2.86)**	(-3.30)**	
	Mbale	-4.72	-25.98	-0.40	0.08	-0.02	0.31
		(0.00)***	(-2.76)**	(-3.75)***	(0.56)	(-0.17)	
	Jinja	-5.85	-28.20	-0.35	0.07	-0.15	0.50
		(0.00)***	(-3.78)***	(-2.12)*	(0.48)	(-1.05)	
	Masaka	-5.97	-7.98	-0.17	0.13	-0.08	0.47
		(0.00)***	(-1.27)	(-1.49)	(1.20)	(-0.61)	
	Mbarara	-4.23	-28.36	-0.31	0.16	-0.21	0.58
		(0.00)***	(-4.34)***	(-1.87)$^{\cdot}$	(1.04)	(-1.35)	
Sweet potatoes	Gulu	-5.37	-9.57	-0.32	0.22	0.09	0.45
		(0.00)***	(-0.80)	(-3.68)***	(1.90)$^{\cdot}$	(0.81)	
	Mbale	-4.40	0.37	-0.26	0.24	-0.01	0.25
		(0.00)***	(0.03)	(-3.19)**	(2.13)*	(-0.11)	
	Jinja	-5.45	-6.83	-0.39	0.31	-0.05	0.34
		(0.00)***	(-0.87)	(-4.68)***	(3.60)***	(-0.55)	
	Masaka	-4.52	13.05	-0.47	-0.04	-0.11	0.26
		(0.00)***	(1.12)	(-4.62)***	(-0.30)	(-0.99)	
	Mbarara	-5.02	-10.53	-0.43	-0.11	0.11	0.21
		(0.00)***	(-0.91)	(-5.35)***	(-0.88)	(1.16)	
Irish potatoes	Gulu	-5.97	2.71	-0.34	-0.14	0.12	0.23
		(0.00)***	(0.14)	(-3.44)***	(-0.68)	(1.01)	
	Mbale	-5.30	4.89	-0.37	-0.13	0.15	0.55
		(0.00)***	(0.29)	(-3.88)***	(-0.78)	(1.34)	
	Jinja	-4.77	-5.34	-0.26	0.05	-0.17	0.22
		(0.00)***	(-0.44)	(-2.59)*	(0.39)	(-1.56)	
	Masaka	-5.60	-27.58	-0.51	0.16	-0.30	0.49
		(0.00)***	(-1.62)	(-3.79)***	(0.88)	(-2.76)**	
	Mbarara	-6.15	-35.18	-0.54	-0.13	-0.00	0.50
		(0.00)***	(-1.80)$^{\cdot}$	(-4.55)***	(-0.73)	(-0.02)	
Cassava, flour	Gulu	-3.04	14.20	-0.18	0.90	-0.15	0.17
		(0.00)**	(0.46)	(-2.85)**	(2.57)*	(-1.57)	
	Masaka	-2.11	-7.34	-0.07	0.04	-0.02	-0.01
		(0.03)*	(-0.50)	(-1.53)	(0.26)	(-0.17)	
	Mbarara	-3.97	-16.96	-0.35	0.18	-0.07	0.18
		(0.00)***	(-0.69)	(-4.05)***	(0.63)	(-0.65)	

Table 3: Error correction model estimates on regional market prices

	Region	ADF	α_1	α_y	α_{11}	α_{12}	R^2
Rice	Gulu	-5.21	-0.16	-0.23	0.04	0.06	0.26
		(0.00)***	(-0.01)	(-2.22)*	(0.26)	(0.52)	
	Mbale	-4.03	61.62	-0.25	0.24	0.17	0.38
		(0.00)***	(3.47)***	(-2.70)**	(1.75)$^{\cdot}$	(1.49)	
	Jinja	-4.76	48.71	-0.26	-0.02	0.08	0.38
		(0.00)***	(3.13)**	(-2.86)**	(-0.18)	(0.74)	
	Masaka	-5.68	-9.69	-0.54	0.03	0.15	0.29
		(0.00)***	(-0.73)	(-4.84)***	(0.28)	(1.47)	
	Mbarara	-4.32	18.10	-0.39	0.31	-0.14	0.32
		(0.00)***	(1.23)	(-2.99)**	(2.63)**	(-1.25)	
Maize flour	Gulu	-1.92	23.14	0.01	0.09	-0.24	0.10
		(0.05)$^{\cdot}$	(1.24)	(0.32)	(0.62)	(-2.07)*	
	Mbale	-3.34	-36.52	-0.12	0.11	0.13	0.14
		(0.00)**	(-2.38)*	(-1.61)	(1.01)	(1.15)	
	Jinja	-4.37	-3.17	-0.22	-0.01	0.05	0.11
		(0.00)***	(-0.19)	(-2.32)*	(-0.12)	(0.43)	
	Masaka	-5.30	-13.30	-0.35	0.15	0.05	0.16
		(0.00)***	(-0.85)	(-3.36)**	(1.25)	(0.44)	
	Mbarara	-2.92	-31.19	-0.13	0.13	-0.01	0.10
		(0.00)**	(-1.70)$^{\cdot}$	(-1.69)$^{\cdot}$	(0.96)	(-0.11)	
Millet flour	Gulu	-2.11	-4.98	-0.06	-0.21	0.05	0.08
		(0.03)*	(-0.25)	(-1.81)$^{\cdot}$	(-0.72)	(0.49)	
	Mbale	-4.44	8.28	-0.30	-0.13	0.06	0.17
		(0.00)***	(0.49)	(-3.70)***	(-0.52)	(0.56)	
	Jinja	-3.19	18.14	-0.15	0.03	-0.17	0.19
		(0.00)**	(1.50)	(-2.75)**	(0.17)	(-1.69)$^{\cdot}$	
	Masaka	-2.35	-0.03	-0.03	0.02	-0.23	0.07
		(0.02)*	(-0.00)	(-0.66)	(0.11)	(-2.18)*	
	Mbarara	-4.09	38.40	-0.27	-0.41	-0.19	0.25
		(0.00)***	(1.41)	(-3.41)***	(-0.99)	(-1.89)$^{\cdot}$	
Dried beans, Nambale	Mbale	-4.20	39.45	-0.12	-0.02	-0.08	0.35
		(0.00)***	(1.98)$^{\cdot}$	(-1.21)	(-0.19)	(-0.61)	
	Jinja	-3.50	23.52	-0.06	-0.14	0.19	0.28
		(0.00)***	(1.07)	(-0.53)	(-1.02)	(1.14)	
	Masaka	-5.21	-16.84	-0.93	-0.23	0.13	0.36
		(0.00)***	(-0.72)	(-5.64)***	(-1.44)	(0.91)	
	Mbarara	-5.49	4.55	-0.64	0.11	-0.05	0.39
		(0.00)***	(0.17)	(-4.33)***	(0.75)	(-0.40)	

Table 3: Error correction model estimates on regional market prices

	Region	ADF	α_1	α_y	α_{11}	α_{12}	R^2
Groundnuts, unpounded	Gulu	-4.24	-65.90	-0.24	0.28	-0.26	0.35
		(0.00)***	(-1.89)˙	(-2.54)*	(1.89)˙	(-2.34)*	
	Mbale	-5.52	16.59	-0.41	0.13	-0.06	0.26
		(0.00)***	(0.50)	(-2.06)*	(0.59)	(-0.33)	
	Jinja	-5.34	-16.05	-0.46	0.09	0.01	0.28
		(0.00)***	(-0.49)	(-2.70)**	(0.58)	(0.09)	
	Masaka	-4.16	-25.84	-0.29	0.22	-0.05	0.33
		(0.00)***	(-1.28)	(-3.03)**	(1.94)˙	(-0.46)	
	Mbarara	-4.08	73.30	-0.30	0.07	0.00	0.22
		(0.00)***	(1.68)˙	(-3.21)**	(0.37)	(0.02)	
Cassava, fresh	Gulu	-3.11	2.77	-0.09	0.01	-0.34	0.19
		(0.00)**	(0.58)	(-1.35)	(0.23)	(-3.23)**	
	Mbale	-5.94	20.40	-0.59	0.35	0.02	0.50
		(0.00)***	(3.10)**	(-5.55)***	(4.19)***	(0.21)	
	Jinja	-4.59	15.09	-0.34	0.12	-0.24	0.28
		(0.00)***	(1.96)˙	(-3.50)***	(1.30)	(-2.37)*	
	Masaka	-3.49	6.35	-0.20	0.04	-0.21	0.20
		(0.00)***	(0.65)	(-2.83)**	(0.29)	(-2.11)*	
Dried beans, Kanyebwa	Mbale	-4.32	54.56	-0.17	0.04	-0.12	0.31
		(0.00)***	(1.99)*	(-1.76)˙	(0.28)	(-0.95)	
	Jinja	-5.24	63.28	-0.07	0.02	0.08	0.41
		(0.00)***	(2.67)**	(-0.46)	(0.13)	(0.50)	
	Masaka	-5.59	-2.80	-0.82	-0.02	0.02	0.45
		(0.00)***	(-0.12)	(-5.44)***	(-0.14)	(0.16)	

ADF denotes the augmented Dickey-Fuller test statistic on the residuals of the long-run equation (4), the α coefficients correspond to equation (5), and R^2 is the adjusted R^2. The brackets mark MacKinnon p-values for the ADF column and t-values of the regression coefficients otherwise. Source: Own computation based on Ministry of Agriculture, Uganda data.

4.4 Price Transmission Elasticity

To derive a more detailed picture of the poverty impacts of an increase in border prices for food, we estimate short-run price elasticities for these six markets, inspired by Nicita (2007). The regression estimates one "general" price transmission elasticity across all products for each region, based on the bundle provided in the data set. Here, we make the strong assumption that border price changes start spreading from Kampala. This is a rough simplification but considering the infrastructure links and population-density of that region it might not be too unreasonable. Furthermore, we assume the same transmission for all goods and across time. For rather homogenous goods such as staple foods this might be defensible. The regression equation is given in below.

$$\Delta p_{irt} = \beta_r \Delta p_{iKt} R_r + \gamma_r R_r + \epsilon_{irt} \quad (6)$$

with $\Delta p_{irt} = \log p_{irt} - \log p_{irt-1}$.[19] The differenced price Δp_{irt} of item i in region r at time t depends on the price change of the same item at the same time in Kampala Δp_{iKt} interacted with a regional dummy. The coefficient β_r will pick up the short-run price transmission elasticity. The extra regional dummy R_r is supposed to pick up effects fixed by region. The equation is estimated by OLS.

Table 4 shows the results. Only the interaction effect of the Kampala price with the region dummies are significant. The estimated coefficients can be interpreted as price transmission elasticities. All the southern cities, i.e., four of the five markets besides Kampala, seem to experience a similar degree of price transmission in the short-run. The result for Mbarara is surprising since it is the furthest away from Kampala amongst those four markets and still experiences the strongest price transmission. 76.5% of a price increase is transmitted to Mbarara in the short-run. Gulu, located rather isolated in the north, in a region permanently afflicted by insecurities, has the lowest transmission elasticity with 41.3%.

Table 4: Domestic short-run price transmission

	Estimate	Std. Error	t value	Pr(>|t|)
γ_{Gulu}	0.004	0.004	1.139	0.255
γ_{Jinja}	-0.000	0.003	-0.045	0.964
γ_{Masaka}	0.002	0.003	0.541	0.588
γ_{Mbale}	-0.001	0.003	-0.309	0.757
$\gamma_{Mbarara}$	0.002	0.004	0.543	0.587
β_{Gulu}	0.413	0.041	10.065	0.000
β_{Jinja}	0.518	0.036	14.518	0.000
β_{Masaka}	0.557	0.035	15.850	0.000
β_{Mbale}	0.527	0.036	14.774	0.000
$\beta_{Mbarara}$	0.765	0.040	19.008	0.000

An OLS regression to determine general short-run price transmission elasticities for each region from the given product bundle. Regression summary statistics: Residual standard error: 0.113 on 5282 degrees of freedom. Multiple R-Squared: 0.178. Adjusted R-squared: 0.177. F-statistic: 115 on 10 and 5282 DF. p-value: <2e-16. Source: Own computation.

[19] It can be shown that $\log y_t - \log y_{t-1} \approx \frac{y_t - y_{t-1}}{y_{t-1}}$ in the domain $|y_t / y_{t-1}| < 1$ and thus can be interpreted as a percentage change (see, e.g, Brandt and Williams, 2007, pp. 49).

5 A Simulation of Rising Border Food Prices

Next, we use the estimated price transmission elasticities to simulate a hypothetical 50% increase of border prices for food, which is equivalent to a 50% increase of prices in Kampala under our assumption.[20] We associate each household with its nearest city amongst the six from the above regressions and the corresponding price transmission elasticity. Thus, we assume perfect price transmission from the nearest city to the households. The simulation explores the first-order effects of the price increase on real income. Individual households' food expenditure baskets are inflated with the assumed price increase multiplied by the appropriate price transmission elasticity. Only purchased food is subjected to the price increase leaving consumption of goods received for free or consumption of own produce unaffected. Thus, subsistence households will naturally experience lower increases in their cost of living. The income side is treated equivalently. The crop income is multiplied by the price increase and the appropriate price transmission elasticity. Taxes are subtracted from the income before the real income is calculated. Due to the lack of producer price time series data, on the income side we assume that the spatial price transmission elasticities estimated for retail prices also apply to producer prices. The imperfect spatial price transmission scenario is contrasted with a perfect transmission scenario where all spatial price transmission elasticities are set to one. In addition, we consider two cases separately. *Case one* assumes that only food consumption prices increase leaving crop farming sales prices unchanged. The idea behind this is that there is higher uncertainty on the producer side about the vertical price transmission elasticity down to the farm gate. Evidence for low vertical producer price transmission elasticities for, e.g., coffee is reported by Fafchamps et al. (2003) and Atingi-Ego et al. (2008). Thus, case one looks at the cost of living effect in isolation and assumes a vertical price transmission elasticity of one on the food consumer but of zero on the food producer side. *Case two* considers identical price increases for both consumption and sales of food, and correspondingly vertical price transmission elasticities of one on both sides.

The results of the case one experiment are presented in Table 5. Rural and urban poverty headcounts P_0 increase by 3% if imperfect price transmission is accepted but 4% to 5% if prices are completely passed through. Note, here and in the following discussion on changes of poverty and inequality measures, the percentage sign denotes percentage *point* changes. But the poverty depth P_1 and severity P_2 indices are substantially higher in rural than in urban areas for both scenarios. Inequality, measured by the Gini index, changes only minimally in rural areas, but changes by 0.9% and 1.4% in urban areas in the cases of partial and full price transmission, respectively. Real incomes change much less

[20] Note that this is not equivalent to a 50% increase in international food prices. The Uganda country study by Benson et al. (2008) indicates a rather weak transmission from international to Ugandan prices for staple foods.

Table 5: First-order poverty impacts if only consumer prices are affected by the price increase

	Before		Partial transm.		Full transm.	
	rural	urban	rural	urban	rural	urban
Poverty			% point change			
P_0	41.7	12.2	2.8	3.2	4.7	4.3
P_1	13.0	3.4	1.4	0.9	2.4	1.4
P_2	5.7	1.4	0.7	0.4	1.4	0.6
Gini	42.8	54.3	-0.0	0.9	0.3	1.4
Real income						
Decile	Mean income		% change			
1	82,684	78,496	-4.7	-6.7	-8.6	-12.4
2	125,086	124,774	-4.2	-6.7	-7.3	-11.7
3	155,942	157,940	-4.3	-7.6	-7.3	-12.5
4	186,465	187,491	-4.5	-8.8	-7.4	-13.0
5	220,883	223,411	-4.7	-8.6	-7.4	-12.2
6	262,850	262,060	-4.6	-9.8	-7.0	-13.3
7	315,944	315,335	-4.8	-8.7	-7.3	-12.1
8	403,604	402,679	-5.1	-9.4	-7.4	-12.2
9	572,068	586,518	-5.1	-9.7	-7.2	-11.4
10	1,489,480	1,988,556	-4.9	-8.1	-6.7	-9.1

Case 1. We assume a 50% increase shock to food prices in Kampala. Only the consumer prices increase while producer prices are kept fix. This implies a vertical price transmission elasticity of zero on the producer side and of one on the consumer side. The poverty figures use rural and urban poverty lines, respectively. Totals are in UGS of 2003. Source: Own computation.

for the rural than for the urban population in both scenarios. Yet, rural areas experience a percentage point increase in poverty headcount of similar size as urban areas. The cause becomes clear from Figure 4. The figure shows the real per capita income level by population percentile. The rural income curve is much flatter around the intersection with the poverty line than the urban one so that a much smaller turn downward of the rural income curve is sufficient to create similar poverty effects percentage-wise as in urban areas. Generally, taking imperfect price transmission into account attenuates the negative cost of living effects affecting the poor.

Table 6 reports results for case two, i.e., for the same scenarios but now the same price increase and transmission elasticities are assumed to apply to both consumer and farm gate crop prices. The higher income from increased prices for crops offsets most of the negative effects on the expenditure side for the rural population. However, the improvement is only minor for the urban population. But within the rural areas, the

Table 6: First-order poverty impacts if both prices for food expenditures and crop farming sales increase

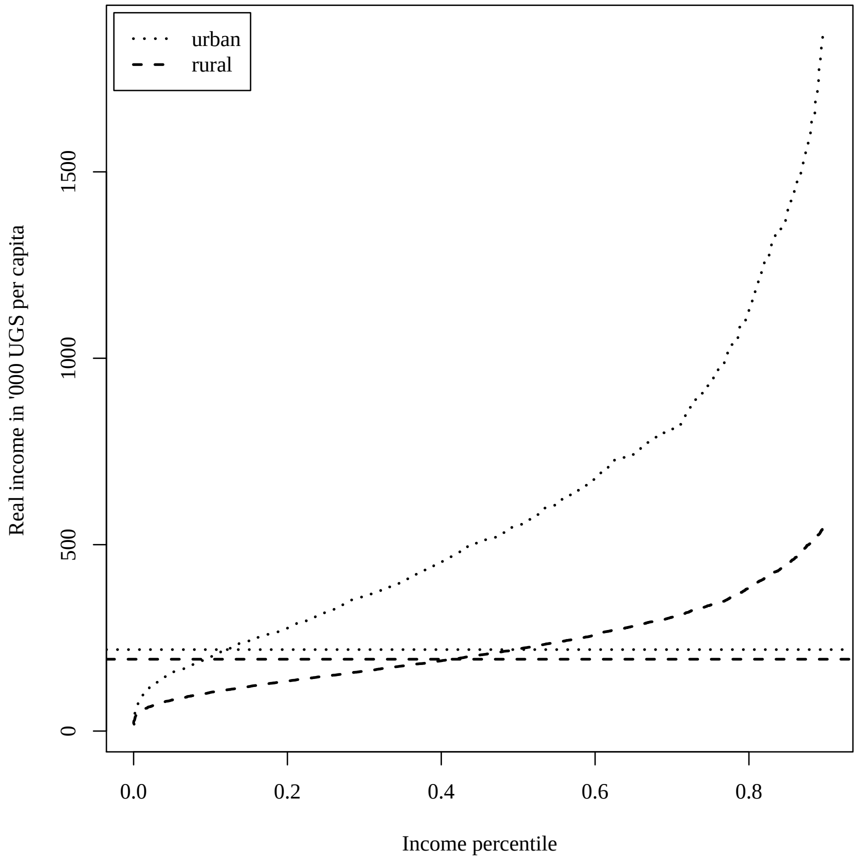
	Before		Partial transm.		Full transm.	
	rural	urban	rural	urban	rural	urban
Poverty			% point change			
P_0	41.7	12.2	0.9	2.7	1.6	3.6
P_1	13.0	3.4	0.6	0.7	1.1	1.2
P_2	5.7	1.4	0.3	0.3	0.7	0.6
Gini	42.8	54.3	-0.2	0.8	-0.0	1.3
Real income						
Decile	Mean income		% change			
1	82,684	78,496	-2.5	-6.0	-4.7	-10.9
2	125,086	124,774	-1.7	-5.5	-3.1	-9.5
3	155,942	157,940	-1.2	-6.7	-1.7	-10.9
4	186,465	187,491	-1.7	-7.6	-2.6	-11.3
5	220,883	223,411	-2.0	-7.4	-2.8	-10.5
6	262,850	262,060	-1.8	-9.0	-2.7	-12.2
7	315,944	315,335	-2.4	-8.3	-3.6	-11.4
8	403,604	402,679	-2.6	-8.7	-3.5	-11.3
9	572,068	586,518	-3.0	-9.3	-3.9	-10.9
10	1,489,480	1,988,556	-3.0	-7.8	-3.8	-8.7

Case 2. We assume a 50% increase shock to food prices in Kampala. Both, consumer prices and crop farmers' sales prices increase. We assume perfect vertical price transmission for both prices. The poverty figures use rural and urban poverty lines, respectively. Totals are in UGS of 2003. Source: Own computation.

poorest decile is hit relatively hard compared to those in the deciles just above. By contrast to the previous case of only increased food consumption prices in Table 5, especially in rural areas the increases of poverty depth and severity indices are much smaller and this time of similar size as those of the urban areas.

The next two tables shift the focus to the regional differences in poverty impacts. In Table 7, the "% poor" column highlights that 63% of the poor live in the Northern and Eastern regions even though these account for only 36% of the total population. The Northern region also has the highest poverty headcount index of 64% followed by the Eastern region with 44%. The Central (P_0=22%) and Western (P_0=33%) regions have much lower poverty prevalence. In particular, Kampala has a low poverty headcount index of only 2.5%. The regional details confirm that, in general, the urban areas have much lower poverty prevalence than the corresponding rural areas. Considering the full price

Figure 4: Per capita income distribution over percentiles



The curves show the per capita real income per percentile of the poorest population for the rural and urban populations individually. The horizontal lines mark the respective poverty lines. Source: Own computation from UNHS 2002/2003 data.

transmission scenario first, the Northern region suffers the largest increase in poverty headcount while Kampala and the Central region the lowest. It is surprising that the magnitude of change in percentage point terms is very similar for all regions, apart from Kampala, given that they have very different headcount levels to begin with. Turning to the imperfect price transmission scenario, the Northern region suddenly fares comparatively the best.[21]

Table 8 is identical to the previous table except for the last set of columns that contrast case one – inflated consumer food prices only – with case two , where the producer farmgate prices are inflated also. Both cases feature imperfect price transmission. Here, the Northern together with the Central region experience the lowest rise in poverty headcount, at least in rural areas. This includes also the Northern region's urban area for which P_0 increases by now 2%. Looking at the totals, basically all regions' poverty increases drop

[21]The impacts for Kampala remain unchanged since Kampala has by construction a price transmission elasticity of one.

Table 7: Poverty impacts of a consumer price increase of food by region

Region		Of total		Before			Partial transm.			Full transm.		
		% pop.	% poor	P_0	P_1	P_2	ΔP_0	ΔP_1	ΔP_2	ΔP_0	ΔP_1	ΔP_2
Central	rural	21.6	13.6	23.8	5.5	1.9	2.7	0.9	0.4	3.8	1.3	0.6
	urban	2.9	0.7	9.5	1.9	0.5	3.6	0.9	0.3	4.0	1.1	0.4
	total	24.5	14.4	22.1	5.1	1.7	2.8	0.9	0.4	3.8	1.3	0.6
Eastern	rural	25.3	31.4	46.8	14.2	6.0	2.7	1.3	0.7	4.9	2.5	1.3
	urban	2.1	0.9	16.1	4.5	2.0	3.0	0.9	0.4	5.1	1.9	0.8
	total	27.4	32.3	44.4	13.4	5.7	2.8	1.3	0.7	4.9	2.5	1.3
Northern	rural	16.8	29.5	66.3	25.2	12.6	1.8	1.9	1.2	5.0	4.2	2.9
	urban	1.4	1.5	39.1	13.3	6.2	4.0	1.8	1.0	8.3	4.2	2.5
	total	18.2	31.0	64.1	24.2	12.1	2.0	1.9	1.2	5.2	4.2	2.8
Western	rural	22.6	20.9	34.9	9.7	3.8	3.8	1.5	0.7	5.0	2.0	1.0
	urban	2.2	1.0	17.4	4.8	1.9	3.4	1.2	0.6	4.8	1.7	0.8
	total	24.7	21.9	33.4	9.2	3.6	3.8	1.5	0.7	5.0	2.0	1.0
Kampala	urban	5.1	0.3	2.5	0.4	0.1	2.7	0.4	0.1	2.7	0.4	0.1

Case 1. We assume a 50% increase shock to food prices in Kampala and that only prices for food expenditures are affected. The “Of total” columns report the share of the total population and the share of the total poor population living in that area, respectively. The last two sets of columns ΔP_α report percentage point changes from the “Before” set. The poverty figures use rural and urban poverty lines, respectively. Totals are in UGS of 2003. Source: Own computation.

below the level of increase of Kampala (3%) and are of the order of 0.5% to 2%. The corresponding increases in urban areas only are of the order of 2% to 3%. Thus, under the assumptions of imperfect price transmission and an equivalent increase of farm-gate producer prices, Kampala suffers the highest poverty increases. This is qualified somewhat when looking at the poverty depth measure P_1 which shows that the total percentage shortfall of income below the poverty line still increased the least in Kampala and the Central and Western regions. The already numerous poor in the other regions experience a deeper drop below the poverty line.

6 Summary and Conclusions

How will the poverty impact of a hypothetical increase of border food prices change once spatial heterogeneity of price transmission is taken into account? How quickly do regional food markets adapt after such a price shock? What is the spatial variability of prices? What is the likely impact on poverty considering peoples’ status as net food buyers or sellers and given the shares of food consumption they actually source from markets? How is this pattern distributed across space?

Table 8: Poverty impacts of a food prices increase by region under imperfect price transmission

Region		Of total		Before			Exp.			Exp. and inc.		
		% pop.	% poor	P_0	P_1	P_2	ΔP_0	ΔP_1	ΔP_2	ΔP_0	ΔP_1	ΔP_2
Central	rural	21.6	13.6	23.8	5.5	1.9	2.7	0.9	0.4	0.2	0.4	0.2
	urban	2.9	0.7	9.5	1.9	0.5	3.6	0.9	0.3	2.6	0.7	0.3
	total	24.5	14.4	22.1	5.1	1.7	2.8	0.9	0.4	0.5	0.4	0.2
Eastern	rural	25.3	31.4	46.8	14.2	6.0	2.7	1.3	0.7	1.0	0.7	0.4
	urban	2.1	0.9	16.1	4.5	2.0	3.0	0.9	0.4	2.2	0.8	0.4
	total	27.4	32.3	44.4	13.4	5.7	2.8	1.3	0.7	1.1	0.7	0.4
Northern	rural	16.8	29.5	66.3	25.2	12.6	1.8	1.9	1.2	0.2	0.9	0.7
	urban	1.4	1.5	39.1	13.3	6.2	4.0	1.8	1.0	3.2	1.6	0.9
	total	18.2	31.0	64.1	24.2	12.1	2.0	1.9	1.2	0.5	1.0	0.7
Western	rural	22.6	20.9	34.9	9.7	3.8	3.8	1.5	0.7	1.8	0.5	0.2
	urban	2.2	1.0	17.4	4.8	1.9	3.4	1.2	0.6	2.7	1.0	0.5
	total	24.7	21.9	33.4	9.2	3.6	3.8	1.5	0.7	1.9	0.5	0.2
Kampala	urban	5.1	0.3	2.5	0.4	0.1	2.7	0.4	0.1	2.7	0.4	0.1

Comparison of case 1 and 2 under imperfect price transmission. We assume a 50% increase shock to food prices in Kampala. The "Of total" columns report the share of the total population and the share of the total poor population living in that area, respectively. Columns "Exp." show the effects when only the consumption prices are increased. Columns "Exp. and inc." reflect the effects when consumption and crop farming income prices are increased. Imperfect price transmission is assumed in both cases. The last two sets of columns ΔP_α report percentage point changes from the "Before" set. The poverty figures use rural and urban poverty lines, respectively. Totals are in UGS of 2003. Source: Own computation.

We address these issues by analyzing time series data for six local Ugandan markets and several staple foods and by analyzing data from the Uganda National Household Survey 2002/2003 (UNHS) and subsequently employ these results in a simulation of a hypothetical 50% rise in Ugandan border prices for food.

A descriptive analysis of the expenditure side shows that the poor in rural areas source about a third of their food from markets but those in urban areas twice as much. Moreover, there is a strong heterogeneity in the shares of people being net sellers or buyers of food across geographic areas and income quintiles. A regression analysis of the unit value data of the UNHS adds evidence for strong spatial heterogeneity in Uganda as it indicates regional differences in food item unit values of up to a factor of 2.6. Conducting a dynamic analysis of price data for six local markets using an error correction model, we find that all the five remaining markets are integrated with the Kampala market for most items, with the exception of only a few item-location pairs. The most remote market turned out also to be the market that adjusts the slowest to Kampala price shocks requiring on average about eight months to return to equilibrium with Kampala.

For the simulation, we estimate aggregate elasticities for each of the prices in the five local markets with respect to price changes in Kampala. Assuming a perfect price transmission for all households from their nearest of those markets to which they live, we simulate a hypothetical 50% rise in border prices for food which starts to spread from Kampala. We calculate the first-order impacts on each household's cost-of-living as well as on its crop farming income and contrast the resulting poverty implications with those from a simulation under perfect spatial price transmission. We examine two cases. In case one, only prices of food expenditures increase which isolates the cost of living effect. In case two, both prices of food expenditures and food sales increase thus there are cost of living and income effects.

In the former case, it is remarkable that the magnitude of the percentage point increase of the poverty headcount index in rural and urban areas is of the same magnitude although the urban households source a much larger share of their food from markets. This is explained by the difference in the income distribution curves. The income distribution curve of rural households is substantially flatter around the intersection with the poverty line than that one of the urban households so that a much smaller decrease in the income of rural households causes an equivalently large effect on the poverty headcount. Accounting for spatial heterogeneity in price transmission reduces the estimated negative effects on poverty substantially in both cases, with and without the crop farming income side.

There are very strong regional differences in poverty prevalence to begin with. The Northern and Eastern regions are obvious as negative extremes and the Kampala area as a positive one. Again, imperfect price transmission attenuates the poverty increase in all cases. In the expenditure only case (case 1), the regional impacts differ by a factor of 2. The urban population tends to see larger increases in poverty headcount across regions than the rural. This is not the case for the poverty depth and severity measures which tend to increase relatively more in rural areas. Once the expenditure and income sides are considered (case 2) under imperfect price transmission, the negative poverty headcount impacts in rural areas are reduced strongly to percentage point change levels of 0.5% in the Central and Northern regions and also more than halved in the other regions. However, urban impacts remain much higher throughout.

In summary, results from an analysis of the poverty impacts of rising border food prices turn out rather differently when accounting for spatial heterogeneity in price transmission compared to a perfect price transmission assumption. The Northern region, for example, appears as the most hit region under perfect price transmission but once imperfect transmission is accounted for, it experiences the least severe headcount increase among all regions. The poverty depth increase, however, remains the highest although it also more than halves.

The approach to estimating price transmission taken here is methodologically very rough due to the limited availability of price time series but also due to many difficulties in filtering out the price transmission effects mentioned in the introduction. This remains an unresolved topic in the literature. However, our analysis conveys an impression of the relevance of imperfect price transmission for poverty impact simulation of Uganda.

Furthermore, the marked differences in poverty impacts between perfect and imperfect spatial price transmission scenarios suggest that ignoring the spatial dimension of price transmission can lead to strongly exaggerated conclusions about poverty impacts of global food price shocks. For instance, a figure of 105 million additional people in poverty due to the 2008 food price spike is cited frequently in policy discussions based on the Ivanic and Martin (2008) study. This study is based on perfect transmission of global prices shocks within countries. By the existence of imperfect spatial price transmission, it is plausible that this figure would turn out to be significantly lower.

When considering the results, one should also keep in mind that these are only short-run simulations examining first-round impacts and thus do not model the reactions of households to the changed economic circumstances. On the expenditure side, substitution may reduce negative impacts while on the income side higher prices may open up new opportunities and increase income. Higher agricultural production might also increase wages. There are strong doubts especially on the income side that higher border prices will actually transmit to a large extent through the value-added chain to the farm-gate (vertical price transmission) as shown, for instance, by Fafchamps et al. (2003) for Uganda coffee growers. Thus, such first-order impacts can be regarded as a worst-case scenario on the expenditure side. On the crop farming income side, however, vertical price transmission is likely far below one. Results from simulations including price effects on the income side should be considered with corresponding caution. The crop farming income effects are likely substantially lower.

References

Abdulai, A. (2007). Spatial and Vertical price transmission in food staples market chains in Eastern and Southern Africa: What is the evidence?, *Paper presented at the FAO Trade and Markets Division Workshop on Staple Food Trade and Market Policy Options for Promoting Development in Eastern and Southern Africa, Rome, March 1-2, 2007*.

Atingi-Ego, M., Opolot, J. and Santa Drale, A. (2008). Can the benefits of developed country agricultural trade reforms trickle down to the rural agricultural households in least developed countries: Analysis via price transmission in selected agricultural markets in Uganda, *IIIS Discussion Paper Series No. 159*, Institute for International Integration Studies, Trinity College Dublin.

Balcombe, K. G. and Morrison, J. (2002). Commodity price transmission: A critical review of techniques and an application to selected export commodities, *Report to the food and agriculture organization of the united nations*.

Benson, T., Mugarura, S. and Wanda, K. (2008). Impacts in Uganda of rising global food prices: The role of diversified staples and limited price transmission, *Agricultural Economics* **39**(s1): 513–524.

Boysen, O. and Matthews, A. (2007). The impact of developed country agricultural trade liberalization on poverty: A survey, Mimeo.

Boysen, O. and Matthews, A. (2008). Poverty impacts of an economic partnership agreement between Uganda and the EU, *IIIS Discussion Paper Series No. 261*, Institute for International Integration Studies, Trinity College Dublin.

Brandt, P. T. and Williams, J. T. (2007). *Multiple Time Series Models*, Vol. 148 of *Quantitative Applications in the Social Sciences*, Sage.

Capéau, B. and Dercon, S. (2006). Prices, unit values and local measurement units in rural surveys: an econometric approach with an application to poverty measurement in Ethiopia, *Journal of African Economies* **15**(2): 181–211.

Conforti, P. (2004). Price transmission in selected agricultural markets, *Commodity and trade policy research working paper no. 7*, Food and Agricultural Organization (FAO), Rome.

Deaton, A. (1997). *The Analysis of Household Surveys: A Microeconometric Approach to Development Policy*, John Hopkins University Press for the World Bank, Washington D.C., Baltimore and London.

Enders, W. (2004). *Applied Econometric Time Series*, second edn, John Wiley and Sons, New York.

Fackler, P. L. and Goodwin, B. K. (2001). Spatial price analysis, *in* B. L. Gardner and G. C. Rausser (eds), *Handbook of Agricultural Economics*, Vol. 1 of *Handbook of Agricultural Economics*, Elsevier, chapter 17, pp. 971–1024.

Fafchamps, M., Hill, R. and Kaudha, A. (2003). The transmission of international commodity prices to domestic producers, *Development and Comp Systems 0409038*, EconWPA.

Foster, J., Greer, J. and Thorbecke, E. (1984). A class of decomposable poverty measures, *Econometrica* **52**(3): 761–66.

Ivanic, M. and Martin, W. (2008). Implications of higher global food prices for poverty in low-income countries, *Policy Research Working Paper Series 4594*, The World Bank.

Joseph, G. and Wodon, Q. (2008). Assessing the potential impact on poverty of rising cereals prices : the case of Mali, *Policy Research Working Paper Series 4744*, The World Bank, Washington, D.C.

Krivonos, E. and Olarreaga, M. (2006). Sugar prices, labor income, and poverty in Brazil, *Policy Research Working Paper Series 3874*, The World Bank, Washington D.C.

Kuteesa, A. (2005). *Price discovery in the wholesale markets for maize and beans in Uganda*, Master's thesis, Texas A&M University.

MacKinnon, J. G. (1991). Critical values for cointegration tests, *in* R. F. Engle and C. W. J. Granger (eds), *Long-run Economic Relationships: Readings in Cointegration*, Oxford University Press, Oxford, pp. 267–276.

Moser, C., Barrett, C. B. and Minten, B. (2008). Spatial integration at multiple scales: Rice markets in madagascar, *August 2008 revision*, Western Michigan University.

Nicita, A. (2004). Who benefited from trade liberalization in Mexico? measuring the effects on household welfare, *Policy Research Working Paper Series 3265*, The World Bank.

Nicita, A. (2007). Ethiopia, *in* B. M. Hoekman and M. Olarreaga (eds), *Global Trade and Poor Nationas: The Poverty Impacts and Policy Implications of Liberalization*, Brookings Institution Press, Yale Center for the Study of Globalization, and Groupe d'Economie Mondiale, pp. 53–76.

Prakash, A. (1998). *The transmission of signals in a decentralised commodity marketing system: the case of the UK pork market.*, PhD thesis, University of London.

R Development Core Team (2008). *R: A Language and Environment for Statistical Computing*, R Foundation for Statistical Computing, Vienna, Austria.

Rapsomanikis, G., Hallam, D. and Conforti, P. (2003). Market integration and price transmission in selected food and cash crop markets of developing countries: Review and applications, *Commodity Market Review 2003-2004*, Food and Agriculture Organization of the United Nations, Rome.

Rashid, S. (2004). Spatial integration of maize markets in post-liberalized Uganda, *MTID discussion papers 71*, International Food Policy Research Institute (IFPRI).

UBoS (2003). *Uganda National Household Survey 2002/2003 - Report on the Socio-Economic Survey*, Uganda Bureau of Statistics, Entebbe, Uganda.

Wodon, Q., Tsimpo, C., Backiny-Yetna, P., Joseph, G., Adoho, F. and Coulombe, H. (2008). Potential impact of higher food prices on poverty : summary estimates for a dozen west and central African countries, *Policy Research Working Paper Series 4745*, The World Bank, Washington, D.C.

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