Time Path of Price Adjustment in Domestic Markets of Non-tradable Staples to Changes in World Market Prices

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ABSTRACT

The paper presents a model to analyze the adjustment of prices of non-traded food staples to changes in global food prices via the response of traded commodities in domestic markets. It shows that the impact on local prices of shocks originating in global markets lasts much longer than suggested by findings in the traditional literature on market integration. Furthermore, unlike the conventional analysis which focuses on estimating a single parameter indicating the degree of market interconnectedness, the model used here allows us to trace the future impact of shocks on local prices over time and thus helps policy makers to anticipate changes and better plan response strategies. It combines the methodology developed by Gonzales-Rivera and Helfand (2001) and Granger and Gonzalo (1995) on market cointegration with the model developed by Badiane and Shively (1998) for the estimation of the time path of price adjustments to market shocks. It is then applied to monthly price data over a 12-year period from all major regions of Niger, a landlocked country that is extremely vulnerable to volatility in staple foods markets. The results suggests that it takes much longer for the impact of shocks on local prices to stabilize. They also show that the impact of shocks originating from global markets can be more pronounced across markets for non-traded staples, such as local maize and sorghum, compared to traded food commodities such as rice. Furthermore, it appears from the findings that prices the two non-traded staples tend to be “stickier” as their rate of increase decelerates much more slowly than for rice.

Keywords: Prices, Markets, Niger

1. Introduction

Anticipating the extent and speed to which domestic commodity prices will adjust to shocks can give policymakers enough time to respond to price spikes and mitigate their impact on consumer purchasing power. Although some important food staples consumed in Africa are not internationally traded, they are affected by changes in global prices via the response in domestic markets for tradable foods. For example, Minot (2011) found that during the 2007-08 food price crisis, the rise in staple prices in 11 African countries was about 75% of the proportional rise in world prices; however, his analysis of longer-term trends showed that only 13 of the 62 African food prices examined exhibited a long-term relationship with world prices. There is clearly a need to better understand how tradable international commodity price spikes are transmitted not only to domestic tradable commodity markets but also to non-tradable ones. The latter link seems to be ignored in the literature, although non-tradable commodities can be far more important for the food security of the poor and vulnerable.

This paper develops a tool to analyze the impact of price shocks originating in global markets on prices for non-tradable staples and to trace the time path of price adjustment beyond the initial shock. This approach combines techniques and concepts from Gonzales-Rivera and Helfand (2001), Granger and Gonzalo (1995) and Badiane and Shively (1998). Two main advantages over traditional price transmission analysis should be highlighted. First, this method allows ex ante examination of the trajectory of the impact of global price shocks, and thus gives policy planners more time to prepare response strategies. Second, it can be applied to examine the response of prices for local food staples to changes in the prices of traded commodities.

The model is applied to data from Niger, a Sahelian country with recurring food insecurity issues. Niger has undergone recurrent food crises in the last decade, and was ranked last of the 186 ranked countries in the United Nations Development Programme 2012 Human Development Index (UNDP, 2013). Shin (2010) showed that the spatial autocorrelation of millet prices in Niger varied over time, decreasing markedly at the height of the 2005 food crisis but recovering quickly thereafter. Aker (2010) also analyzed changes over time in Niger's grain markets, and found that price dispersion declined by 10 to 16% due to the introduction of mobile phone service in the early 2000s. Our study will add to the understanding of the opertation of staple foods markets in Niger.

2. Background and Methodology

The recent wave of high international commodity prices has increased interest in understanding how prices in domestic food markets react to changes in global food markets, despite the fact that the issue of spatial market integration has been extensively studied in the literature (see for example Ravallion, 1986; Alexander and Wyeth, 1994; Badiane and Shively, 1998; Rashid, 2004; Van Campenhout, 2007). Most of those studies have focused on individual tradable commodities. A smaller number of studies examine intercommodity price transmission across separate market locations (Alderman, 1993; Rashid, 2011). The traditional market integration analysis estimates ex-post a single parameter as a measure of price interconnectedness. It does not address the time path adjustment of local prices. Policymakers need to understand both the extent and the trajectory of adjustment to shocks in order to design effective response strategies; for example, very different interventions would be needed if an entire price shock were transmitted within a month versus 12 months. To the best of our knowledge, no previous studies have tried simultaneously to capture the impact of a given international commodity price change on local prices and to trace their dynamic paths. The aim of this study is to fill this gap. A second contribution of this analysis is to add to knowledge on market integration in Niger, an often food-insecure country whose agricultural markets have not been extensively studied.

The model developed here combines the methodology proposed by Gonzales-Rivera and Helfand (2001) and Granger and Gonzalo (1995) for analyzing the cointegration of markets with that developed by Badiane and Shively (1998) for estimating the time path of price adjustments from central to peripheral markets. First, we define the "market" for a given product as a set of locations where the prices for this commodity share a unique common factor. We identify this common factor and determine which location serves as the central market for each product (maize, millet, rice and sorghum), based on the relative importance of each location in determining the common factor. Price series between the central markets of each commodity are used to assess cross-commodity price transmission between tradable and non-tradable products. Badiane and Shively's approach is then used for each staple food to quantify the trajectory of horizontal price transmission between the central and peripheral markets. The inter- and intra-commodity price response models are then combined to project the future trajectory of the adjustment of prices in local markets for non-traded staples (millet, sorghum, and local maize) to a price shock in rice markets, the main tradable food commodity.

2.1 Identification of markets and central market locations

Following Gonzalez-Rivera and Helfand (2001), a number of n locations can be considered as a market for one commodity if the price series in those locations are integrated, I(1), and cointegrated with (n-1) rank of cointegration. To identify the group of locations that comprises the market for each commodity, we determine the rank of cointegration for different combinations of market locations using the test proposed by Johansen (1992), and select the set of locations for which the (n-1) rank of cointegration condition is met (see Rashid (2011) for more details). The corresponding vector error correction model can be written as follows:

$$\Delta P_t = \gamma\alpha' P_{t-1} + \sum_{i=1}^{q-1} \Gamma_i \Delta P_{t-i} + \epsilon_t \quad (1)$$

Where Δ denotes the differential operator, P_t is the price vector and ϵ the error term.

Since the rank of cointegration equals (n-1), the theory of the common factor (Gonzalo & Granger, 1995) argues that one and only one common factor exists for P_t. This common factor, denoted f_t, is a linear combination of the price series in the considered locations. It is expressed as:

$$f_t = \gamma'_{\perp} P_t \quad (2)$$

Where $\gamma'_{\perp}$ is obtained from equation (1) such that $\gamma'_{\perp}\gamma = 0$.

The estimation of the common factor shows the importance of each location, through $\gamma'_{\perp}$, in shaping the long-run behavior of the product's price (Gonzalez-Rivera & Helfand, 2001). The higher the coefficient for a location in (2), the more powerful we expect its impact to be on the product's price in all locations. For each product, we will consider the location with the highest estimated coefficient to be the central market for that product.

2.2 Response of prices for non-tradable staples to changes in prices of tradable foods

After identifying the central market for each product, we use this information to evaluate cross-product price transmission between rice, the tradable commodity, and the other, non-tradable products via a bivariate analysis. To test whether a change in the price of rice in the international market affects the prices of local staples, we use an autoregressive distributed lag (ADL) between the central market for a selected product (maize, millet or sorghum) and the central market for rice.

$$P_t^l = \sum_{i=1}^{p} \alpha_i P_{t-i}^l + \sum_{k=0}^{q} \beta_k P_{t-k}^r + \gamma X_t + \varepsilon_t \quad (3)$$

Where P_t^l denotes the price for commodity l (maize, millet or sorghum), P_t^r is the price of rice, i and k denote lags, and X is a matrix of deterministic variables that includes an intercept and a time trend. The lag selections are made using the information criteria (AIC, BIC). If all coefficients of P_t^r

are null, we conclude that a change in the price of rice has no impact on the price P_t^l. To assess how a change in the price of rice affects the price of maize, millet or sorghum, we derive the intercommodity long-run multiplier from (3). We first compute the intermediate multiplier after j periods:

$$\mu^j = \sum_{h=0}^{j} \frac{\partial E(P_{t+h}^l)}{\partial P_t^r} \qquad (4)$$

The intermediate multiplier converges to the intercommodity long-run multiplier, which can be used to calculate the total effect of a price change in the rice central market on commodity l in its central market after the adjustment process is completed:

$$\mu = \lim_{j\to\infty} \mu^j \qquad (5)$$

2.3. The time path of price adjustment across locations for non-traded food staples and its determinants

Once we have determined the effect of a price shock in the rice central market on the prices of staples in their central markets, we analyze how the change in price for each staple is transmitted from its central market to peripheral markets. We do this by applying equation (3) to prices in the central market P^{lA} and prices in each of the peripheral markets P^{lB}(in the places of rice prices and other staple prices). We obtain an intra-commodity long-run multiplier expressed as in equation (4).

In reality, the ripple effects of price shocks in local markets extends much beyond the period of time it takes for the long-run multiplier to converge. As we will see later, future local prices are affected by the magnitude of the shock itself, that is, the difference between the price prior to the shock and the price after the shock has been transmitted (see equation 9). To show the relationship, first rewrite equation (4), approximating derivatives by first differences and defining as one period the time it takes for the multiplier to converge, as:

$$\Delta P_{t+1}^{lA} = \mu \Delta P_t^{lB} \qquad (6)$$

Next, for each staple food, express the concurrent relationship between the price in the central market and the price in any peripheral market, at any given time, as:

$$P_t^{lA} = P_t^{lB} - T_t \qquad (7)$$

Then inserting the values for P_t^{lB} from (7) into equation (6) yields:

$$P_{t+2}^{lA} = (1+\mu)P_{t+1}^{lA} - \mu P_t^{lA} + \mu \Delta T_t \qquad (8)$$

Assuming ΔT_t to be constant, equation (8) can be solved as[1]:

$$P_t^{lA} = \varsigma_t P_{(t=0)}^{lA} + \varrho_t P_{(t=1)}^{lA} + \varphi_t \Delta T_t \qquad (9)$$

Where $\varsigma_t = \frac{\mu-\mu^t}{\mu-1}$; $\varrho_t = \frac{\mu^t-1}{\mu-1}$ and $\varphi_t = \left(\frac{\mu}{\mu-1}\right) t$

Equation (9) can be used to project the time path of price adjustment in local staple markets. It also shows the variables that determine the pace and trajectory of price adjustment. Besides the

[1] See Badiane & Shively, 1998.

intra-commodity long-run multiplier, which affects the time path of price adjustment through the parameters ς_t, ϱ_t, and φ_t, the other variables that determine the adjustment trajectory are the level of the price before the shock $P^{lA}_{(t=0)}$, the price immediately after the shock ($P^{lA}_{(t=1)}$), and the changes in the cost of transport or arbitrage (ΔT_t). Government policies can thus influence the intensity of the price response in two ways: (i) through measures that limit the initial change in local prices from $P^{lA}_{(t=0)}$ to $P^{lA}_{(t=1)}$, such as subsidies, or (ii) measures that affect the cost of arbitrage. These may include restrictions of commodity flows and fees, legal and illegal, that are levied on such flows, both of which raise arbitrage cost ΔT_t, or measures to lower the cost of transport, which have the opposite effect on ΔT_t. In the long run, measures that affect the degree of market integration and thus the long-run multiplier μ also have an impact on the trajectory of price adjustment.

3. Data and estimation results

Monthly price data from January 2000 to December 2012 on rice, millet, sorghum and maize from the country's seven regions and the capital district, Niamey, are used. Because we choose to include only series which have a unit root, we consider six of the eight locations in our analysis: Agadez, Dosso, Maradi, Niamey, Tahoua and Tillaberi.

A central point in our approach is the determination of a market area for each commodity. We start with a group of six locations (Agadez, Dosso, Maradi, Niamey, Tahoua, Tillaberi) for each of our four considered commodities (maize, millet, rice and sorghum), and define the market by selecting the set of n locations such that the rank of cointegration between their price series is (n-1). We identify a different market area for each commodity. For maize, all six locations are selected. The market for millet includes Agadez, Dosso, Maradi, Tahoua and Tillaberi and that for rice Agadez, Maradi, Niamey and Tahoua. The market for sorghum includes Dosso, Maradi, Tahoua and Tillaberi. Since the selected locations for each commodity hold (*n-1*) rank of cointegration, they share a unique common factor. The estimation of that common factor (equation 2) gives:

$$f_t\_Maize = 0.24*Aga+0.517*Dos -0.291*Mar-0.375*Nia +0.67*Tah+0.044*Til$$

$$f_t\_Millet = -0.203*Aga + 0.672*Dos + 0.300*Mar - 0.554*Tah +0.332*Til$$

$$f_t\_Rice = 0.467*Aga+ 0.729*Mar+0.146*Nia + 0.477*Tah$$

$$f_t\_Sorghum = 0.090*Dos+ 0.943*Mar +0.001*Tah+ 0.319*Til$$

These estimations show the role of each location in shaping the common factor for a specific product. The most influential locations, as shown by the largest coefficients, are Tahoua for maize, Dosso for Millet, and Maradi for rice and sorghum. Therefore, those cities are considered to be the central market for the corresponding commodity.

As indicated above, we first calculate the connectedness between prices in the leading rice market and prices in each of the leading markets for staple food commodities (equations 4 and 5). The results show no relationship between rice and millet prices. In contrast, long-run multipliers of 0.354 and 0.359 are estimated between rice and maize prices, and rice and sorghum prices, respectively. The next step is the estimation of the same long-run multipliers and speed of convergence between prices in the central and the peripheral markets for each of the staple foods. We find that most of the peripheral markets are highly integrated with their respective central market, with long-run multipliers around than 0.7 or higher (see Table 1). The speed of convergence is the period of time it takes for the transmission of the price shock to peripheral markets to reach the magnitude indicated by the estimated long-run multiplier. Estimates presented in parentheses in the table suggest convergence speeds of around 6 months for most markets.

Finally, we estimate the time path of price adjustment across local markets for non-traded food staples to changes in the price of the traded commodity, rice, beyond the initial shock (equation 9). In addition to the long-run multipliers in the table below, we also need the prices prior to the shock and after the shock has been transmitted, that is, $P^{lA}_{(t=0)}$ and $P^{lA}_{(t=1)}$. For that purpose, we assume a rise of 48.625 FCFA in the price of rice, which corresponds to the variation observed in Maradi during the global food price crisis between July and October 2007. Based on the estimated long-run multipliers, this increase in the rice price raises prices in the central market of maize (Tahoua) and sorghum (Maradi) by 17.21 FCFA and 17.45 FCFA respectively, that is, from 132.357 FCFA and 67.069 FCFA prior to the shock ($P^{lA}_{(t=0)}$) to 149.567 FCFA and 84.519 after the shock ($P^{lA}_{(t=1)}$).

Table 1: *Intra-commodity long-run multiplier and speed of convergence (in parentheses)*

Products	*Central markets*	*Agadez*	*Dosso*	*Maradi*	*Tahoua*	*Tillaberi*	*Niamey*
Maize	Tahoua	0.967 (9)	0.916 (6)	0.976 (6)		0.477 (12)	0.939 (5)
Rice	Maradi	0.688 (6)			0.768 (6)		0.972 (13)
Sorghum	Maradi		0.825 (3)		0.850 (9)	0.936 (9)	

The final parameter that we need to compute the time path of the price adjustment in local staple food markets is the change in arbitrage costs (ΔT_t). We first estimate Equation (9) assuming that the cost of arbitrage is constant, or $\Delta T_t = 0$. We next run two scenarios assuming alternatively a rise in arbitrage costs of 0.5 FCFA and a decrease of 0.5 FCFA per period. The purpose here is to illustrate the impact of government interventions that may exacerbate or mitigate the magnitude of shocks by raising costs of arbitrage in local markets. A good example of an intervention that may increase arbitrage costs is the decision to restrict operations by private traders or restrict the movement of food staples in the wake of crises.

Figures 1a-1c show the simulated time path of adjustment in prices for maize and sorghum in local markets across Niger resulting from changes in the global price for rice, transmitted via price changes in the Maradi rice market. As can be seen from all three graphs, the effect of the shock resulting from global rice prices on the prices of local non-traded staples such as maize and sorghum extend beyond the first period, which corresponds to the time it takes for the long-run multiplier that is estimated in the conventional market integration analysis to converge. Without changes in arbitrage costs (the middle line), it takes 2 to 3 periods for the impact on prices to stabilize. The tables in the annex show the evolution of price changes through the first three periods for various markets. It is interesting to observe from the figures that, with the exception of the capital city area of Niamey, the rise in prices for the two non- traded staples (sorghum and local maize) exceeds in all markets the increase in the price of rice, the traded commodity. More importantly, these prices tend to be "stickier," as the increase in the price of rice decelerates much faster. For example, the rate of increase in the price of sorghum in Tahoua of 14% in the first period falls to 10% and 8% in the second and third period. In the case of rice, the rates of price increase in the same market are 11%, 8%, and 6% for the three periods.

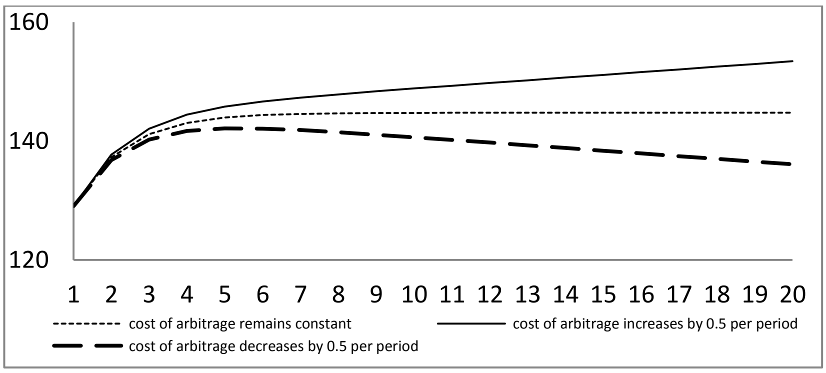

Figure 1.a*: Time path of maize prices in FCFA per Kg for Tillabery*

Source : Author's simulations

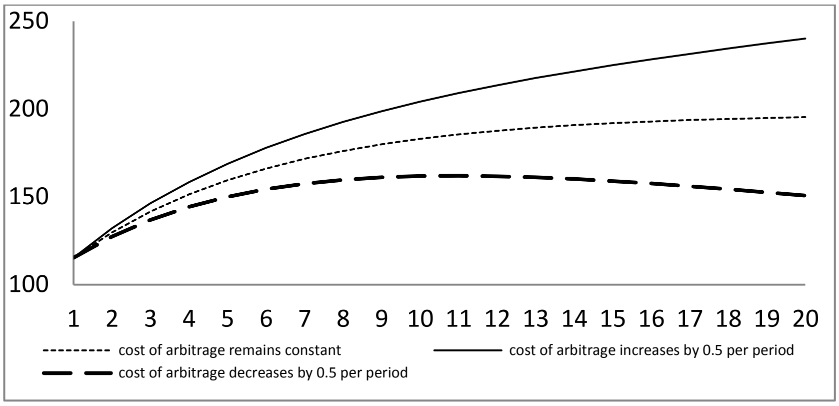

Figure 1.b*: Time path of sorghum prices in FCFA per Kg for Dosso*
Source : Author's simulations

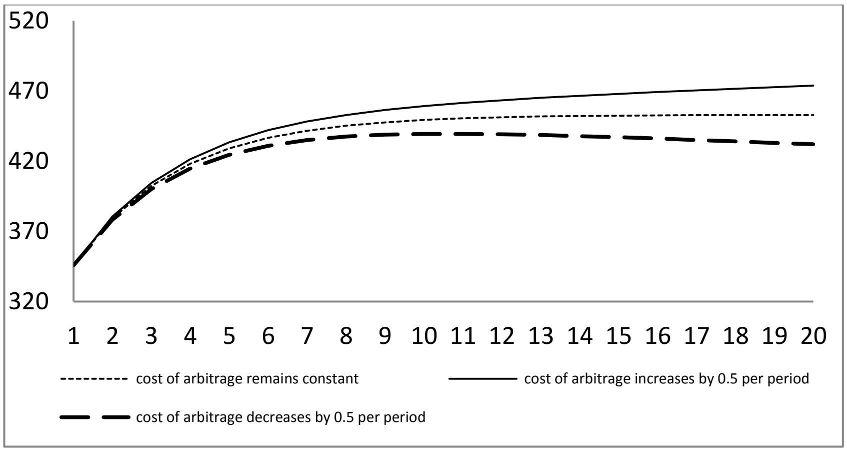

Figure 1.c*: Time path of rice prices in FCFA per Kg for Agadez*
Source : Author's simulations

4. Conclusion

As indicated by the results discussed above, the model presented here makes three contributions. First, it analyses the impact of changes in global food prices on the prices of non-traded food staples. Second, it shows that the response of local prices to shocks originating in other markets lasts longer than suggested by findings from the traditional market integration analysis. Rather than simply analyzing the mechanism of correction after a shock, the model captures the changes in prices when the effect of the shock is completely absorbed. Thirdly, it provides a base for simulating not just the extent of price adjustment in local markets but also the time path of adjustment. While the simulation cannot predict the exact value of future prices, it can provide a general indication about the evolution of prices. This is by far more valuable information for policymakers than just a parameter quantifying the degree of market interconnectedness. The simulated trajectory of future price adjustment can be used by policymakers to better anticipate the behavior of commodity prices across locations and through time. This in turn allows them to prepare more effective response strategies to global price shocks.

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ANNEXES

Annex 1: *Simulated prices changes for maize*

	AGADEZ	*DOSSO*	*MARADI*	*TILLABRI*	*NIAMEY*
Period 1	10%	14%	15%	6%	14%
Period 2	8%	12%	13%	3%	11%
Period 3	8%	9%	11%	1%	10%

Annex 2: *Simulated prices changes for sorghum*

	DOSSO	*TAHOUA*	*TILLABRI*
Period 1	13%	14%	13%
Period 2	9%	10%	11%
Period 3	7%	8%	9%

Annex 3: *Simulated prices changes for rice*

	AGADEZ	*TAHOUA*	*NIAMEY*
Period 1	10%	11%	16%
Period 2	6%	8%	13%
Period 3	4%	6%	11%