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MARKET INTEGRATION AND THE RESPONSE OF LOCAL PRICES TO POLICY CHANGES

by

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1 Introduction

A fundamental question that remains unanswered in most countries undergoing economic reform is to what extent local markets respond to structural and macroeconomic policy changes. The objective of this paper is to explore this question theoretically and empirically, and to assess the respective roles of spatial integration and arbitrage costs in explaining price changes following from economic reforms in Ghana. A dynamic model of price formation is introduced in section 2, which measures spatial integration and arbitrage costs and uses it to gauge the response of local agricultural prices to policy changes in Ghana. In section 3, the implications of the model for the long term adjustment of local prices are investigated. The model is then applied in section 4 to examine the adjustment of the time path of local prices in three main markets in Ghana.

2 Adjustment, spatial integration, and the time-path of local prices

In analogy to the analysis of market integration, the first step in modeling maize price formation in local markets is to express local market prices as a function of the price in a given central, reference market. Denoting the local and central markets by the superscripts L and C, respectively, the price in the local market can be written as[1]:

$$(1) \qquad P_t^L = \alpha_0^L + \alpha_1^L \, time + \beta^L \, P_t^C + \mu_t^L .$$

With price measured in levels, the intercept in equation (1) denotes fixed costs of marketing and the coefficient on the central market price measures a proportional markup, i.e. an arbitrage cost, from the central to local market.[2] Although equation (1) is instructive, it is incomplete. In order to investigate the speed with which new price information is incorporated into future prices one requires a more fully specified dynamic model. Following the approach by RAVALLION (1986), using j to indicate lags and X to denote a matrix that includes an intercept, a time trend, seasonal dummies, and other variables, expansion of equation (1) yields:

$$(2) \qquad P_t^L = \sum_{j=1}^{n} \alpha_j \, P_{t-j}^L + \sum_{j=0}^{n} \beta_j \, P_{t-j}^C + \gamma X_t + \varepsilon_t .$$

Interpretation of equation (2) is as follows. If $\beta_j=0 \; \forall j$ then the local market is segmented from the central market. In contrast, if $\beta_0 = 1$ then price changes are immediately transmitted from the central market to the local market. Furthermore, if the central and regional markets are

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1 See Badiane and Shively

2 Cointegration tests examine whether the prices in equation (1) move together, that is, whether the differential represented by μ is stationary.

integrated in the long run, then $\sum a + \sum \beta = 1$, and the number of lags required to ensure this equality provides evidence of integration that is less immediate than instantaneous price transmittal. Standard F- and t-tests applied to estimated coefficients of equation (2) can be used to investigate hypotheses regarding short-run or long-run integration.[3]

Given an initial shock to the central-market price, the dynamics of the adjustment process involve a series of interim multipliers as initial shocks fluctuate, converge, and stabilize. In the context of the model introduced above, the cumulative effect after *j* periods of a central-market price shock on the price in an outlying market can be computed as:

$$(3) \qquad \beta_j^{C,L} = \sum_{h=0}^{j} \frac{\partial E[P_{t+h}^L]}{\partial P_t^C} .$$

Complete adjustment of the process is given by the long-run dynamic multiplier:

$$(4) \qquad \beta^{C,L} = \lim_{j\to\infty} \beta_j^{C,L} .$$

The *speed* of price transmission can be calculated by computing the time γ that it takes for the intermediate multipliers to convergence to within a certain range of the long-run multiplier. The convergence rule is to find γ such that $|\beta\gamma / \beta\text{-}1| < \varepsilon$ and $|\beta_k / \beta\text{-}1| < \varepsilon$ for every $j > \gamma$, where ε is a tolerance limit and β_k is the estimated multiplier after *j* periods.

The model of market integration can be linked to the process of local price formation. We do this in order to model the adjustment of local market prices to a policy change that initially affects the central market. As an illustration, figure 1 shows the process of price adjustment. In line with the observed changes in Ghana, the central price is shown here to decline following reform in period t_a. The model of spatial integration predicts that this price change will be transmitted to the local market between time t_a and time t_{a+1}, a period that may range from a few weeks to a few months.

Derivation of the long-run multiplier that links b to a in figure 1 assumes the existence of arbitrage between the central and local markets. It can, therefore, be understood as reflecting the process of price adjustment in the local and central markets to changing supply and demand conditions in these markets. The estimated long run multipliers should, consequently, bear some relationship to the local price formation process beyond the short run process captured by the spatial integration analysis. Moreover, because arbitrage costs play a key role in both the speed of adjustment and the actual degree of market connectedness, changes in arbitrage costs can be expected to lead to different patterns of price response for different local-market/central-market pairings.

Accordingly, a model of local price formation is derived below, which is based on the following reasoning. If β_j^{CL} is the estimated value of the long run multiplier between the central market and a given local market after *j* periods, then the time path of prices in the local market can be expressed as $P_t^L\,(\beta_j^{CL}, \Delta T^L, P_{ta}^{\ L}, P_{ta}^{\ L}{}_{+1})$, where ΔT^L stands for the change in costs of spatial arbitrage; $P_{ta}^{\ L}$ is the pre-reform price level in the local market at time period t_a; and

[3] See Badiane and Shively (1997).

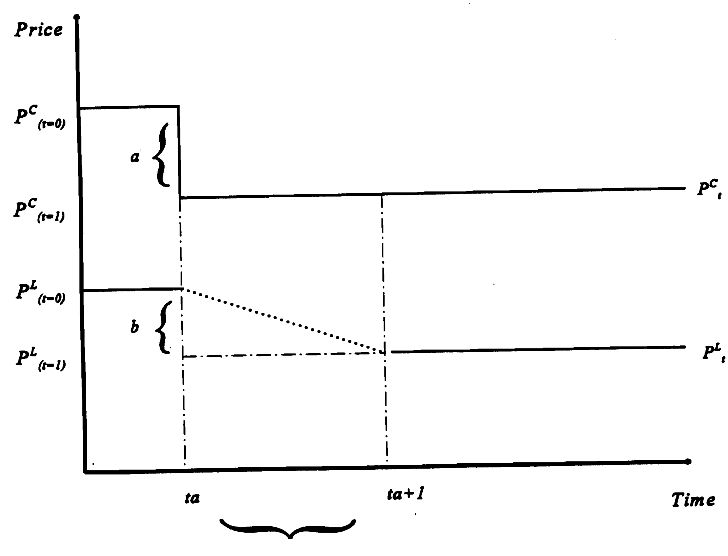
P^L_{ta+1} is the price level after the shock has fully reached the local market at time period t_{a+1} (see Fig. 1).

At any given point in time, the contemporaneous relationship between the local and central market prices, P^L and P^C, respectively, can be written as:

$$(5) \qquad P^L_t = P^C_t - T^L_t$$

Our goal is to derive an expression for local prices that uses both the central-market price and a measure of arbitrage costs. To proceed, recall that equation (4) defines the dynamic long-run equilibrium relationship between the price in a given local market and the price in the central market. It expresses the cumulative adjustment of the local price to changes in the central-market price in previous periods. Approximating derivatives by first differences, and defining as one period the h units of time required for the long run multiplier to converge to its long run value, equation (3) can be rewritten as:

Figure 1: Dynamics of local price adjustment
($a = \Delta P^C_{ta}$; $b = \Delta P^L_{ta+1}$; γ = speed of transmission)



$$(6) \qquad \Delta P^L_{t+1} = \beta^L \Delta P^C_t$$

Writing out and rearranging slightly, equation (6) can be solved as a second-order linear difference equation to obtain the following expression for the time path of local prices:[4]

$$P_t^L = \zeta_t \, P^L_{(t=0)} + \varsigma_t \, P^L_{(t=1)} + \varphi_t \, \Delta T^L$$

(7)

$$where \ \zeta_t = \frac{\beta - \beta^t}{\beta - 1} \ ; \ \varsigma_t = \frac{\beta^t - 1}{\beta - 1} \ ; \ and \ \varphi_t = (\frac{\beta}{\beta - 1})t \ .$$

Equation (7) expresses the local-market price at time t as a function of the initial (pre-reform) price, the long-run multiplier, and the change in arbitrage costs ΔT. It says that the price level at any time t depends on: i) its value in the distant past; ii) how well markets are connected; and iii) the cost of spatial arbitrage. In other words, changes in the degree of market integration or the cost of marketing not only affects local prices contemporaneously, but also affect the evolution of these prices over time.[5]

We turn now to an analysis of the role of the marketing system in transmitting the effects of policy reforms. We assume that a policy change first affects prices in the central market since these are more closely linked to production changes influenced by reform. The central market leads other markets in the price discovery process, and depending on the degree of integration between central and local markets, the effect of a policy change passes from the central market to outlying markets. Accordingly, the first step in modeling the transmission process is to model the effect of reforms on the central-market price.[6] To do this, note from the previous section that $P^L_{(t=0)}$ in equation (7) can be computed as:

(8) $$P^L_{(t=0)} = P^C_{(t=0)} - T_{(t=0)}$$

In contrast, $P^L_{(t=1)}$ must be modeled to reflect the effect of changes in policies and their transmission to local markets *following* adjustments in the central market. For example, assume that a one-time shock in the central market is induced by a policy change, and that local markets have finished adjusting to this shock. Defining as one period the time it takes for the long-run multiplier to converge to its equilibrium value, the post-adjustment price in the local market is:

(9) $$P^L_{(t=1)} = \beta[(P^C_{(t=1)} - P_{(t=0)})^C] + P^L_{(t=0)} \ .$$

Recall that $T_{(t=0)}$ is the cost of spatial arbitrage before the introduction of reforms, and that $P^C_{(t=0)}$ and $P^L_{(t=0)}$ are the pre-reform price levels observed in the central and local markets. Inputting the observed values into equation (9) and using the identity given by equation (8) provides the values of $P^L_{(t=0)}$ and $P^L_{(t=1)}$ that are required to compute the local time path described by equation (7). Equation (7) thus allows us to estimate the time path of prices in the local market that follows a shock in the central market. In the next section we report empirical estimates of this time path.

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4 See Badiane and Nuppenau (1996).

5 Differentiating equation (14) with respect to β gives the impact of improvements in the degree of market integration on the time path of local prices (see Badiane 1996,; pp. 14-15).

6 Badiane (1996) and Badiane and Nuppenau (1996) discuss ways to model these effects.

3 Estimating the time path of local prices

Historically, both direct and indirect government interventions depressed maize prices in Ghana while reducing price variability (STRYKER 1991). Ghana's 1983 Economic Recovery Program (ERP) reduced or eliminated many interventions, but despite the earlier bias against the sector, evidence reported elsewhere suggests that these policy reforms were accompanied by a decline in real maize prices (ALDERMAN and SHIVELY 1996). In part this decline in prices may be linked to improvements in the transport sector and a decline in marketing costs that followed the introduction of reforms (JEBUNI and SEINI 1992; STRYKER 1991). Furthermore, currency devaluation was a centerpiece of Ghana's structural adjustment program, and between April 1983 and October 1985, the Cedi fell from 2.75 per dollar to 60 per dollar.

Three types of data are needed to estimate the impact the above changes on the time path of local prices. The first type of data are series of local prices, which yield the level of pre-reform prices in the central and local markets, and also provide the basis for the estimation of the long run multipliers. The second type of data are the actual changes in arbitrage costs. The last type of data are the estimates of long-run multipliers between given local markets and the central market. The price data used in the subsequent analysis are real monthly wholesale maize prices from 1983 to 1993 in three major maize markets in Ghana: Bolgatanga, near the Burkina Faso border in the Upper East; Makola, the southern, capital city market; and Techiman, in the maize growing region of Brong-Ahafo. The changes in the differences between the Bolgatanga and Makola prices, on the one hand, and Techiman prices, on the other, are used as proxies for the change in arbitrage costs. For the long-run multipliers, estimates based on the above price series that have been computed in BADIANE and SHIVELY (1997) are used.

The estimated multipliers are 0.265 and 0.538, respectively, between Bolgatanga and Techiman and between Makola and Techiman. Dynamic multiplier estimates with respect to local prices are 0.687 and 0.519 for Bolgatanga and Makola, respectively[7]. These indicate that for Bolgatanga, local-market price history is more important than central-market price history for price determination, but that the opposite holds for Makola. For both markets, the multipliers place more weight on local price histories *vis-à-vis* central-market prices. The results are also consistent with hypotheses of long-run integration, with the sum of price parameters reaching 0.95 for Bolgatanga and 1.06 for Makola. For instance, Timmer's Index of Market Connectedness (IMC) is 2.6 for Bolgatanga, and slightly less than 1 for Makola. These values reflect the fact that the Bolgatanga market is relatively less integrated with the Techiman market than is the Makola market.

The values for the long-run dynamic multipliers of 0.27 and 0.54 for Bolgatanga and Makola, respectively, are used to compute equation (7) to obtain the time paths of local prices in the two markets. The estimated time required to fully transmit a price shock, that is the period from t_a to t_{a+1}, is about four months in each market. The period of 4 months is, consequently, used as a time unit, meaning that 4 month-averages of prices and arbitrage costs have to be used in the simulations presented below. In other words, $P^L_{(t=0)}$ and $P^C_{(t=0)}$ are the four-month averages of local (Bolgatanga and Makola) prices and central market (Techiman) prices at the time of reforms. We use the devaluation of April 1983 as our benchmark for the reform period. Thus, $P^L_{(t=0)}$ and $P^C_{(t=0)}$ represent the observed average prices in the third four-month period of 1983, with May 1983 to August 1983 corresponding to t_a[8]. Based on the estimated speed of

[7] See Badiane and Shively, 1997.

[8] The third four-month period of 1983 has been chose as starting period instead of the second because of apparent inconsistencies in the prices reported for the latter period.

transmission of four months, the first four-month period of 1984 is used as t_{a+1}. The local price used for $P^L_{(t=1)}$, computed with the help of equation (9), also corresponds to that period.

The observed changes in spatial price spreads between Techiman, on the one hand, and Bolgatanga and Makola, on the other, are used as proxies for the changes in arbitrage costs, again using the same four-month time unit. Given that equation (7) is a non-homogenous second-order difference equation, implying a constant DT, the average change in spatial price spreads between the individual four-month periods is used in the computations. During the period for which equation (7) is computed and which goes from the second four-month period of 1984 (II/84) to the second four-month period of 1993 (II/93), the average change in arbitrage cost between Techiman and Bolgatanga was -0.5 Cedis per four month-period. Between Techiman and Makola the corresponding figure was -0.4 Cedis.

Computed time paths of prices are presented in figures 2 and 3 for Bolgatanga and Makola, respectively. As explained previously, local price data enter into the computations for each market in the form of prevailing pre-reform price levels, $P^L_{(t=0)}$. These are calculated as the observed average price in t_a (III/1983). For Techiman, two initial values are entered. The first is the pre-reform price level, $P^C_{(t=0)}$, calculated as the average four-month price in III/83. The second is the price level immediately after the introduction of reforms, i.e. $P^C_{(t=1)}$, for which the four-month price average in t_{a+1} (I/1984) is used.

The bottom line in figure 2 shows the evolution of observed prices in Bolgatanga. The straight line is the *ex post* prediction of these prices. The predictions are computed using equations (7), (8), and (9), the pre-reform prices, the long run multiplier between Bolgatanga and Techiman (0.27), the observed decline in arbitrage costs between the two markets (-0.50), and Techiman prices observed immediately prior to and after the 1983 devaluation. The prediction indicates that the price decline in Techiman contributed to the fall in prices in Bolgatanga.[9] However, given the relatively weak link between Techiman and Bolgatanga, the contribution of Techiman price changes to Bolgatanga price changes was small. These results are in line with findings from the spatial integration model, which indicated that Bolgatanga prices are determined primarily by their own past values and local factors underlying them. In fact, based on the relatively low level of interconnectedness between Techiman and Bolgatanga one would expect that only a small amount of any price change in the former would be transmitted to the latter. To the extent that the weak connection between these markets is a reflection of a low level of arbitrage between them, one might also expect changes in arbitrage costs to have limited impact on the evolution of Bolgatanga prices.

The importance of spatial integration for price transmission is confirmed by the results for the better connected Makola market (figure 3). The straight line represents the predicted time path for Makola; the other line represents observed prices. Recall that the value of the long run multiplier for Makola is 0.54 - double that for Bolgatanga. As a result, the predicted price change in Makola is much greater than in Bolgatanga, despite the fact that the observed reduction in arbitrage costs between Techiman and Makola (-0.40) was smaller than that observed between Techiman and Bolgatanga (-0.50).

To show the importance of market connectedness for the response of local prices to changes in Techiman prices and arbitrage costs, equation (7) is solved again for Makola, using a lower value of 0.25 for the long-run multiplier and the same change in arbitrage costs. The result is plotted as the top line in figure 3. Contrasting the two predicted time paths in the graph, one

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9 Prices in Techiman fell from 53.17 to 40.54 Cedis between III/83 and I/84 while arbitrage costs between the two markets fell by an average of 0.5 Cedis every four-month period between III/84 and II/93.

sees that poor market integration helps to explain the limited impact of a decline in Techiman prices and arbitrage costs on prices in Bolgatanga. One sees for example, how similar the new predicted time path is to the one in figure 2.

Finally, two additional versions of equation (7) are computed using the data from the better integrated Makola market, to gauge the sensitivity of local prices changes to changes in the costs of arbitrage. In the first version, the average decline in arbitrage costs in each period between Techiman and Makola is reduced by half to -0.2. In the second version, the average arbitrage costs between Techiman and Makola are increased by 0.5 Cedis in each period. In both cases, the same long-run multiplier is used as the original prediction. The top line in Figure 5 indicates the predicted time path with increasing arbitrage cost. The middle line is the price path with the lower decrease in arbitrage costs. The increase in arbitrage costs has a large impact on the time path of local prices, despite the decline in Techiman prices. As one would expect, the increase in arbitrage costs dampens the impact of the fall in Techiman prices. In fact, prices in Makola not only decline less as a result of higher arbitrage costs, but they also begin to increase just after a few periods. This clearly illustrates that price and arbitrage cost changes in a central market can have unexpected and offsetting impacts when one accounts for the dynamic implications of arbitrage cost changes for long-run market integration.

5 Conclusions and prospects for future work

We have shown that the price-adjustment process in a local market is determined by the degree of interdependence between that market and the central market in which a price-shock originates, as well as the intertemporal dynamics of the price-adjustment process as influenced by arbitrage costs. Our results were formalized analytically using a dynamic model of price formation and further analyzed with a simulation model.

We explored empirically the implications of our model for the time-path of price adjustments, as determined directly and indirectly through the marketing sector. Using data from wholesale maize markets in Ghana we found that reductions in local prices following the introduction of economic reforms in 1983 could be traced to both local and central market forces and changes in arbitrage costs, but that differences in the degree of market integration between central and outlying markets had important implications for adjustment of prices in those outlying markets.

Our empirical analysis focused on three important markets in Ghana over the period 1980-1993. We found that the Techiman market - in the maize growing region of Ghana - was well connected to the Makola market during the study period, in the sense that central-market price history was more important for explaining price changes in Makola than was local-market price history. This finding is not surprising, given Makola's proximity to Techiman, and the fact that Makola is located in Accra and therefore exhibits a high intensity of trading activity. Market connectedness was less pronounced between Techiman and Bolgatanga, a market that lies at Ghana's northern border with Burkina Faso. In Bolgatanga, local-market price history was the predominant determinant of prices. Our findings indicated that wholesale maize prices fell in these markets following devaluation and inception of economic reforms, as did arbitrage costs between Techiman and the two outlying markets.

The current model does not indicate the extent to which observed reductions in arbitrage costs translate into higher farm prices, nor the extent to which consumers have benefitted from price changes. To gain greater insight into the welfare effects of the patterns described here, future work should attempt to supplement this analysis with microeconomic studies of household, farm, and trader behavior.

Figure 2. Actual and predicted price time paths
Bolgatanga market

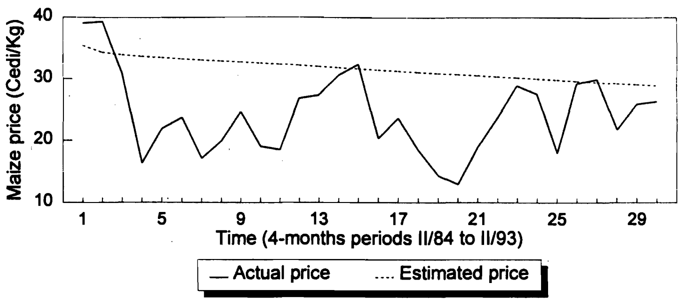


Figure 3. Integration and adjustment of local prices
Makola market

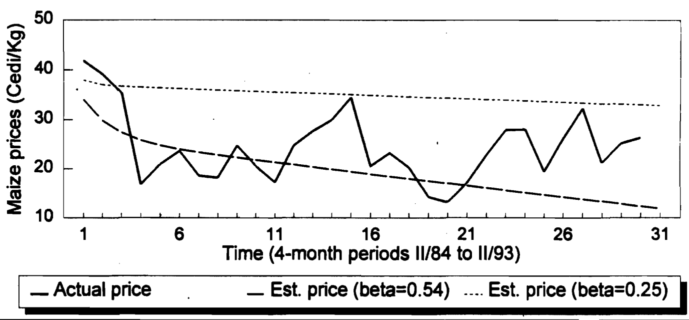
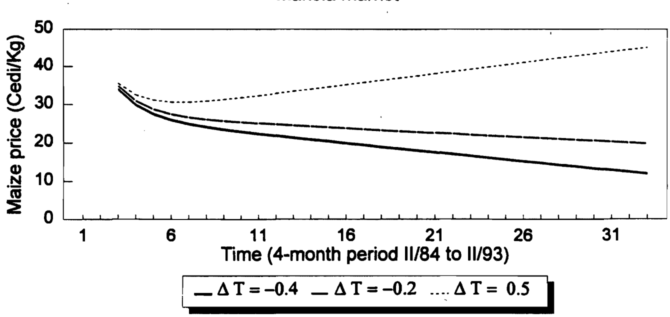


Figure 4. Arbitrage costs and adjustment of local prices
Makola market



6 Abstract

The present paper uses the example of Ghana to analyze the impact of spatial integration and arbitrage costs on the adjustment of local agricultural prices to policy changes. A dynamic model is applied to explore the implications for the time-path of price adjustments of the performance and response by the marketing sector to policy changes. The paper shows that the price-adjustment process in a local market is determined by the degree of interdependence between that market and the central market in which a price-shock originates. Using data from wholesale maize markets in Ghana, it finds that reductions in local prices following the introduction of economic reforms in 1983 can be traced to both local and central market forces, but that differences in the degree of market integration have important implications for long-run changes in arbitrage costs and the evolution of prices in outlying markets.

Zusammenfassung

Der Beitrag untersucht die Beziehung zwischen dem Integrationsniveau von lokalen Märkten und der Anpassung von Produktpreisen auf diesen Märkten an die durch agrarmarktpolitische Reformen verursachten politischen Veränderungen. Ein dynamisches Preisbildungsmodell wird angewandt, um die Implikationen der Leistungsfähigkeit des Vermarktungssektors und der Reaktion innerhalb des Vermarktungssystems für den Preisanpassungsprozeß herauszuarbeiten. Die Untersuchung zeigt anhand von Datenbeispielen aus Ghana, daß die Anpassung der lokalen Preise bestimmt wird durch a) das Ausmaß der Interdependenz zwischen den jeweiligen lokalen Märkten und dem zentralen Markt, aus dem der ursprüngliche Preisschock hervorgeht und b) die Veränderung der Arbitragekosten zwischen Zentral- und Lokalmärkten.

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