MAIZE MARKETS IN MOZAMBIQUE: TESTING FOR MARKET INTEGRATION

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Abstract

The issue of market integration lies at the heart of many contemporary debates concerning market liberalization, price policy, and government agency reforms in developing country food markets, Mozambique being one of the poorest. Without spatial integration of markets, price signals will not be transmitted from deficit to surplus areas, prices will be more volatile, agricultural producers will fail to specialize according to long-term comparative advantage, and the gains from trade will not be realized. The objective of this article is to indicate the extent of market integration between major Mozambican maize markets. Recognizing the statistical dangers and inaccuracies of using measures of price correlation to test for market integration, a new methodology for testing the state of food market integration is employed in this study, namely the parity bounds model, (PBM) as developed by Baulch (1997). This method provides a more reliable procedure for testing violations of spatial arbitrage conditions than conventional methods, because it compares time series of observed price differentials with transfer costs and explicitly recognizes that spatial arbitrage conditions are represented by inequality constraints. The results point to a failure of spatial arbitrage conditions between the Maputo and Chimoio markets about 23% of the time over the period

1. INTRODUCTION

The issue of market integration lies at the heart of many contemporary debates concerning market liberalization, price policy, and government agency reforms in developing country food markets, Mozambique being one of the poorest. Without spatial integration of markets, price signals will not be transmitted from deficit to surplus areas, prices will be more volatile, agricultural producers will fail to specialize according to long-term comparative advantage, and the gains from trade will not be realized (Baulch, 1997).

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As early as Adam Smith, David Ricardo, von Thunen, and many others, the importance of trade and integration of markets has been emphasized, by indicating potential gains from letting prices dictate production and hence specialization between regions, which in turn leads to the better use of resources. Prices thus become the instrument through which the "invisible hand" guides the efficient exchange of goods and services, resulting in "more efficient production", which finally is the main source of welfare gains. Usually the abundant resource phenomenon permits a country to be the low cost producer. However, a high degree of availability of information is needed to reflect the comparative resource costs between markets. Effective transportation systems are also a prerequisite for trade.

Lack of adequate infrastructures and strong and diversified production systems have limited the integration process in Mozambique. The primary problem is that a legacy of structural, institutional and political impediments together with inadequate economic policies have inhibited the free movement of information, capital, investment, goods and services. This legacy has bequeathed a dearth of economic activity in Mozambique, leading to underdevelopment, poverty, and generally low standards of living.

In order to spur economic growth and development, Mozambique embarked on an Economic and Social Rehabilitation Programme (ESRP) in 1987. The Programme relies heavily on market mechanisms to allocate resources and generate economic growth (Arndt, Jensen & Tarp, 2000). Given the important role currently awarded to market mechanisms, the importance of the agricultural sector and the spread out nature of the country, the level of integration of markets is of strong interest. The objective of this article is to indicate the extent of market integration between major Mozambican maize markets.

The remainder of the article is structured as follows. Section II provides brief background information on maize markets in Mozambique, whereas Section III discusses the PBM model and the data to this study. Section IV entails the analysis as well as the conclusion to the analysis.

2. MAIZE MARKETS

2.1 Production and the production centre

It is widely recognized that the agricultural sector will have to play a key role in any poverty reducing development strategy for Mozambique. Maize is the principal marketed crop in the country, consisting almost entirely of white, open-flint varieties, with no yellow maize production. Based upon rain-fed production systems, total white maize production in any given year depends upon the timing and quantity of rains. There is typically only one cropping season per year. In the late 1980s and early 1990s, war limited the production of maize. Roads and even footpaths to distant fields were dangerous for farmers to travel, so only the fields close to villages could be cultivated. Transportation problems also limited the delivery of inputs and consumer goods. Finally, many rural stores were destroyed during the war and traders were prevented from purchasing surplus production. After the drought (1991-1992), many farmers relied upon seeds distributed by relief agencies and are continuing to use the later generations of those seeds, even though some were hybrids (Donovan, 1996).

Maize production varies by region due to rainfall patterns and soil types. The central and northern provinces are the largest producers. Chimoio, located in the Manica Province in the centre region, was chosen as the production area for this study. It is situated in the heart of the Zambezi corridor, which is one of the most productive agricultural regions.

2.2 Consumption and the consumption centre

On the consumption side, maize is equally important. In a 1992/3 survey of income and expenditure for urban households, 30 percent of average monthly total household expenditure went towards bread and cereals, about half of which were expenditures on maize products (Republic of Mozambique, CNP/DNE 1994). Thus, 15 percent of average monthly household expenditures in the urban zones were on maize.

Maputo is, by far, the major consumption area, with a strong demand-pull for white maize. The population of Maputo is estimated at over one million people with only low-potential agricultural land nearby. Maputo markets are active in maize trading, with both white and yellow maize products available to consumers. The Chimoio region is the nearest major production area to Maputo, but it is still 1150 km away, at least 18 hours driving time along paved roads.

Until recently, the main marketing outlets for producers were itinerant informal traders, particularly in the south and centre. Urban consumers relied upon informal and formal marketplaces for their purchases. The formal sector, when it operated in white maize markets, dealt with other formal sector commercial agents or the public sector. The lack of rural stores in many areas of the centre and south limited the effectiveness of traditional trading systems.

Itinerant traders did not generally sell to formal wholesalers because higher prices could be obtained in the urban markets (Donovan, 1996).

2.3 Spatial integration and transport costs

Spatial price relationships generally refer to the factors that cause prices in one area to change in relation to those in another (Dessalegn *et al*, 1998). These variables may be shifts in demand or supply or changes in the pattern of trade costs. It is, however, postulated that, under competitive market structures, spatial price relationships are largely determined by transfer costs. These mainly consist of transportation, handling, fixed costs, and unmeasured transaction costs (e.g. the costs of time spent in identifying and negotiating transactions, risks associated with opportunistic behaviour of trading partners, contract monitoring, enforcement, etc). The principle is that under competitive market conditions and in the absence of trade barriers, the price differential that could prevail between trading areas is less than or equal to transfer costs (Tomek & Robinson, 1981).

The basis for this assumption is that, if regional price differences exceed transfer costs, buyers would be motivated to buy and transport grain from low price areas to those with high price. This will eventually cause prices in the supplying areas to increase and those in the importing areas to decrease to a level at which price differences no longer exceed transfer costs (Tomek & Robinson, 1981). However, the comparison of costs and actual margins is difficult because of the unmeasured and perhaps immeasurable "transaction cost" portion of marketing costs, that is, the transaction and risk costs mentioned above. Nevertheless, some insights are possible simply by comparing observed price spreads with the measurable component of spatial transfer costs (Dessalegn *et al*, 1998).

In addition, due to the seasonality of maize production, prices are normally expected to be low during the harvest season and to rise afterwards up to the next harvest as a function of costs of storage. Under competitive situations, the seasonal price differences should be equal to the storage costs incurred between the time of harvest and the subsequent points in the year. Thus, it is assumed that maize is allocated throughout the year by the relationship of current and expected prices to storage costs including direct costs of warehouse rent, labour, interest on capital invested in inventories, risk and normal profit. If seasonal price differences are over and above storage costs and normal profit, this may also indicate the existence of some degree of inefficiency in storage (Tomek & Robinson, 1981).

There exists another angle to the picture of price differentials that bears mentioning. Especially in the early 1990s, prices were distorted by food aid being delivered to the major consumption areas. This has in some instances even caused a reversed flow of maize, from consumption to production areas. Nevertheless, despite the influence on the pattern of prices, one would expect functioning markets to maintain spatial arbitrage conditions.

3. THE MODEL

If goods can move freely between markets and markets are competitive, then price differentials across spatially dispersed markets for a homogeneous good should not exceed transfer costs. These are called the spatial arbitrage conditions. Testing for market integration amounts to determining if there are violations of these spatial arbitrage conditions. Many previous studies have been devoted to this cause, but nearly all of them approach the issue of market integration indirectly (see, for example, the seminal work of Jones (1974)). Rather than examining transportation systems, interviewing traders, tracking shipments and looking for unrealised arbitrage opportunities, most researchers have used time series econometrics to search for correlations in observed food prices across spatially distinct markets (Baulch, 1997). Thus, most of these tests rely on price data alone and fail to recognize the pivotal role played by transfer costs. In particular, when transfer costs between two markets are large, price differentials might frequently be insufficient to compensate for transfer costs. In these instances, prices in the two markets need not be linked for substantial periods of time.

Recognizing the statistical dangers and inaccuracies of using measures of price correlation to test for market integration, a rather new methodology for testing the state of food market integration will be employed in this study, namely the parity bounds model, (PBM) as developed by Baulch (1997). This method provides a more reliable procedure for testing violations of spatial arbitrage conditions than conventional methods, because it compares time series of observed price differentials with transfer costs. In the PBM, available information on transfer costs as well as commodity prices are used to assess the efficiency of inter-market arbitrage.

The PBM model allows for transfer costs to vary, makes no implicit assumptions concerning the nature of marketing margins, and may be estimated using time series that are incomplete, as is often the case with food price series in developing countries. The extent of market integration will be assessed by distinguishing among three possible trade regimes: regime 1, in which spatial price differentials equal transfer costs; regime 2, in which price differentials are less than transfer costs; and regime 3, in which price differentials exceed transfer costs. The PBM has been shown to detect violations of the spatial arbitrage conditions with a high degree of accuracy when estimated with sample sizes that are typical of the short food prices series in most developing countries (Baulch, 1997).

3.1 The mechanics of the PBM model

Two markets are said to be spatially integrated if, when trade takes place between them, price in the importing market equals the price in the exporting market plus the transfer cost of the product between the two markets (Baulch, 1997). Put differently, markets are said to be integrated, where trade occurs when

$$P_t^i + K_t^{ij} = P_t^j \tag{1}$$

where

P_t^i = price of product in the export market at time t,
P_t^j = price of product in the import market at time t, and
K_t^{ij} = transfer cost between market i and j and time t.

This is regime 1.

No trade occurs in regime 2 where

$$P_t^i + K_t^{ij} > P_t^j \,. \tag{2}$$

Equation (1) and (2) are known as the spatial arbitrage conditions, and both are consistent with food market integration. When transfer costs equal the inter-market price differential (or spread) and there are no impediments to trade between markets, trade will cause prices in the two markets to move on a one-for-one basis and the spatial arbitrage conditions will be binding. When costs exceed the inter-market spread, trade will not occur, and the spatial arbitrage conditions will not be binding. When spreads exceed transfer costs, the spatial arbitrage conditions are violated, whether or not trade occurs. Violation of the spatial arbitrage conditions indicates that there are impediments to trade between markets and should be viewed as *prima facie* evidence of a lack of market integration. When production and consumption are specialized – so that production of food occurs in different geographical locations from where it is consumed – only regime 1 is consistent with market integration. But when production and consumption are non-specialized – as is usually the case in developing country food markets – both regimes 1 and 2 are consistent with the spatial arbitrage conditions and market integration. In either case, regime 3 is inconsistent with integration, so that the higher the incidence of regime 3, the lower the extent of market integration (Baulch, 1997).

The markets to be analysed in Mozambique, lie somewhere in between the classification mentioned above. Chimoio is a major production area for maize. However consumption also takes place in that market. Maputo on the other hand is mainly a consumption area, and no or very little production occurs. Therefore only the incidence of regime 3 will give an indication to what extent markets are integrated.

3.2 Data

The Ministry of Agriculture in Mozambique has compiled comprehensive time series data on maize prices in Mozambique. Weekly observations of white maize prices from April 1993 to August 1998 form the core data for the study. Transportation costs per ton by land (e.g. the measurable component of transfer costs) have been estimated by the Mozambican National Institute of Statistics. This transport cost number was multiplied by the appropriate distance measure between the markets under investigation, namely Maputo and Chimoio and converted to nominal terms using the Maputo consumer price index to meticais[3] per kilogram.

Figure 1 sketches the price differentials between the maize markets of Maputo and Chimoio, together with the transport costs. As expected, the transport costs lie below an imaginary mean value for the price differentials reflecting the other components of transfer costs discussed earlier.

As indicated above, one would like to obtain time series data on transfer costs through continuous monitoring of trading conditions, including some rigorous method of estimating the difficult to observe components of inter-market price spreads such as a risk premium. However, this is prohibitively expensive and simply does not occur in practice. The PBM model is designed to establish probable limits on transfer costs using only a limited number of estimates (often, and in this case only one) of transfer costs (Baulch, 1997).

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[3] *The Mozambican national currency is the Metical (plural meticais); currently about 20 000:1 to the USD*

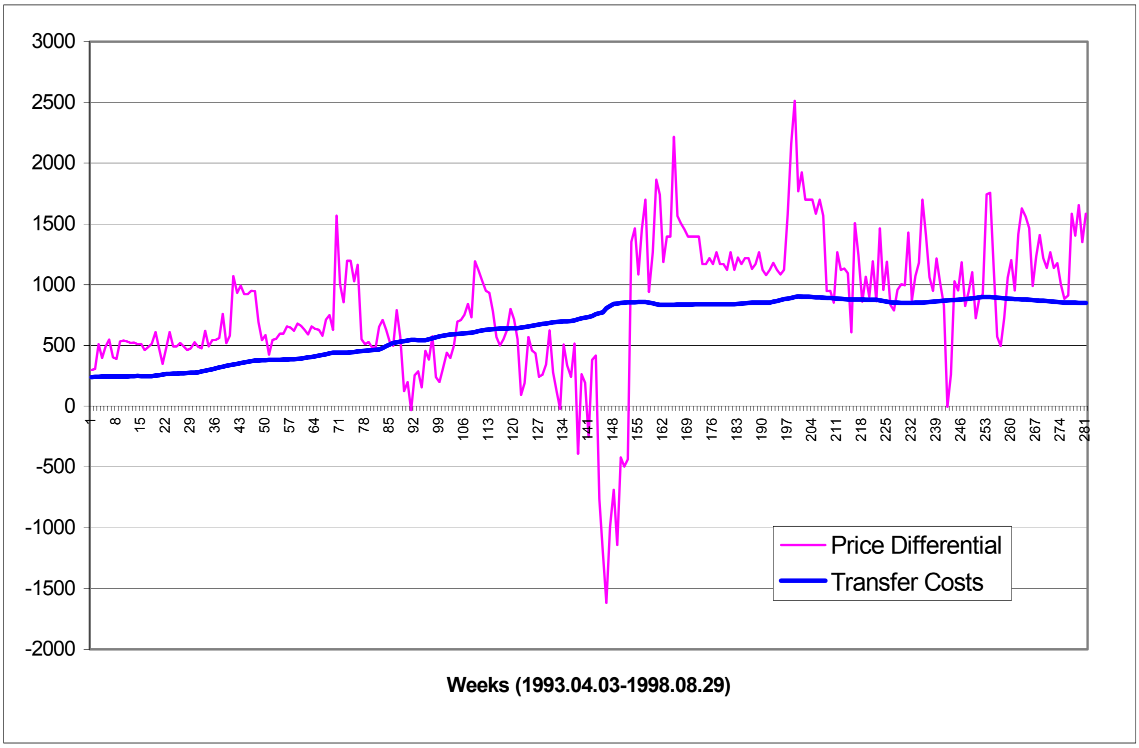

Figure 1: Price differentials between Maputo and Chimoio and transfer costs in meticais/kg

To capture the unobserved elements of transfer costs, transport costs were inflated by 32%. The inflation factor reflects the judgment of the authors. Substantial information exists to support high transfer costs (see Arndt, Jensen, Robinson & Tarp, 2000). In addition, due to the poor state of road infrastructure, an additional amount of 150 meticais was added to the transfer costs in the case of transport from Chimoio to Maputo for shipments prior to 1997. Figure 2 shows the adapted transfer costs. Note that price differentials are now represented in absolute values.

3.3 Transfer costs in meticais/kg

The data in Figure 2 indicates that, from observation 1 to 80, which corresponds roughly with the periods from 1993-94, price differentials and transfer costs display a high degree of correlation. Food aid dominated maize markets in this period. From 1995, markets were marked by an increasing role for domestically produced maize. By 1998, maize imports (inclusive of food aid) had been reduced to negligible levels. During this period, departures of price differentials from transport cost levels became more pronounced.

3.4 Maximum likelihood estimation

Kmenta (1997) defines maximum likelihood estimators in the following way:

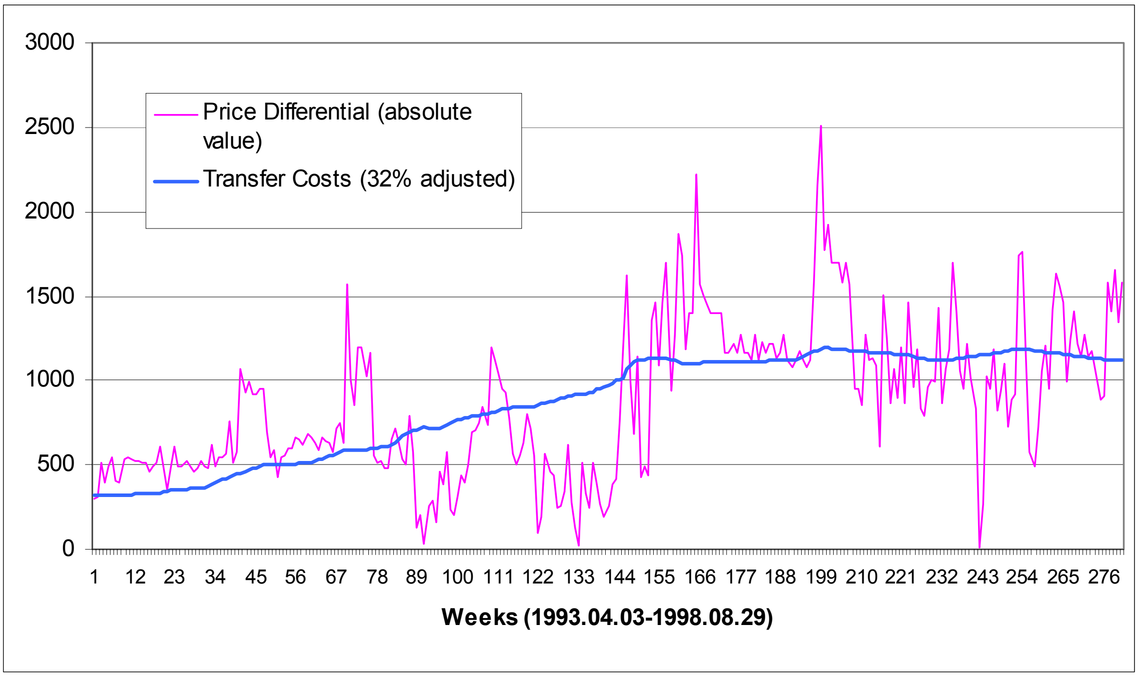

Figure 2: Price differentials in absolute value terms and adjusted

> "If a random variable X has a probability distribution f(x) characterized by parameters 21, 22, …, 2k and if we observe a sample x1, x2, …., xn, then the maximum likelihood estimators of 21, 22, …, 2k are those values of these parameters that would generate the observed sample most often" (p. 176).

Obtaining the maximum likelihood estimators involves specifying a likelihood function and finding those values of the parameters that give this function its maximum value. A necessary condition for a function to be at a maximum is that at this point its first derivative is equal to zero. If there are more than one unknown parameters, then one has to resort to partial derivatives. The following function represents a maximum likelihood function with a multivariate normal error, with mean vector **0** and variance matrix $\sigma^2\mathbf{I}$:

$$p(y) = \frac{1}{(2\pi\sigma^2)^{n/2}} \exp\left[-\frac{1}{2\sigma^2}(y - X\beta)'(y - X\beta)\right]. \qquad (3)$$

A similar maximum likelihood function is used for the PBM model, with some modifications.

3.4 Specifics of the PBM model

The PBM model seeks to determine the probability that an observation will fall into one of the three regimes discussed above. This requires establishing, in essence, upper and lower parity bounds for the spatial arbitrage conditions between the designated Mozambican markets. Specifically, the deviation of the inter-market price spread from the extrapolated transfer costs in any period is decomposed into three components. A symmetric error term with mean zero (e_t) applies to transfer costs. Two additional error terms are truncated from above zero (u_t and v_t), and are subtracted or added according to whether price differentials are inside or outside the parity bounds. The first error term (e_t) allows transfer costs to vary between periods, in response to (for example) seasonality or changing capacity utilization in the transportation sector. The second error term (u_t) captures the extent to which price differentials fall short of the parity bounds when there is no incentive to trade (regime 2), and the third error term (v_t) measures by how much price differentials exceed transfer costs when the spatial arbitrage conditions are violated (regime 3).

The PBM model makes use of results derived by Weinstein (1964) for the density of a normal plus half normal distribution, and follows Sexton, Kling and Carman (1991), to specify the following likelihood function:

$$L = \prod_{t=1}^{T} [\lambda_1 f_t^1 + \lambda_2 f_t^2 + (1 - \lambda_1 - \lambda_2) f_t^3] \qquad (4)$$

where

regime 1 (at the parity bounds) is

$$f_t^1 = \frac{1}{\sigma_e} \Theta\left[\frac{Y_t - K_t}{\sigma_e}\right],$$

regime 2 (inside the parity bounds) is

$$f_t^2 = \left[\frac{2}{(\sigma_e^2 + \sigma_u^2)^{1/2}}\right] \Theta\left[\frac{Y_t - K_t}{(\sigma_e^2 + \sigma_u^2)^{1/2}}\right] * \left\{1 - \Phi\left[\frac{-(Y_t - K_t)\sigma_u / \sigma_e}{(\sigma_e^2 + \sigma_u^2)^{1/2}}\right]\right\},$$

and regime 3 (outside the parity bounds) is

$$f_t^3 = \left[\frac{2}{(\sigma_e^2 + \sigma_v^2)^{1/2}}\right]\Theta\left[\frac{Y_t - K_t}{(\sigma_e^2 + \sigma_v^2)^{1/2}}\right] * \left\{1 - \Phi\left[\frac{(Y_t - K_t)\sigma_v / \sigma_e}{(\sigma_e^2 + \sigma_v^2)^{1/2}}\right]\right\}.$$

Here λ_1 and λ_2 denote the probabilities for regimes 1 and 2 and Y_t represents the natural logarithm of the absolute value of the price spread between markets *i* and *j* in period *t* (i.e., $Y_t = \ln\{|P_t^i - P_t^j|\}$); σ_e, σ_u, and σ_v are the standard deviations of the three error terms e_t, u_t, and v_t described above; K_t is the logarithm of nominal transfer costs in period *t*, while $\Theta(\cdot)$ and $\Phi(\cdot)$ denote the standard normal density and cumulative distribution functions. To obtain probability estimates for the three regimes of the PBM, the logarithm of this function may be maximized numerically with respect to λ_1, λ_2, σ_e, σ_u, and σ_v using a suitable algorithm. For this study, CONOPT solver from GAMS was employed (Brooke, Kendrick & Meeraus, 1992). Furthermore, for simplification the coefficient for regime 3, (1-λ_1-λ_2), is denoted by λ_3.

4. ANALYSIS AND CONCLUSION

4.1 Empirical analysis

The results of the PBM model for Maputo and Chimoio are shown in Table 1. The estimate of λ_1 shows that price differentials are at their parity bounds in 74.87% of the observations. Similarly, the estimate for λ_2 indicates that price spreads are inside the parity bounds in another 2.56% of the observations. Since the probability estimates for the three regimes must sum to one, price differentials must be outside their parity bounds in 22.58% (λ_3) of the observations.

Table 1: Results from the PBM model, Maputo-Chimoio

Parameter	Parameter Estimate	Standard Error	T-Statistic
λ_1	0.7487*	0.0478	13.57
λ_2	0.0256	0.0362	2.18
λ_3	0.2257*	-	-
σ_e	0.2445*	0.0029	11.53
σ_u	0.2327	0.4872	3.28
σ_v	1.3550*	0.5313	2.16

**Indicates significantly different from zero with at least a 95% confidence interval.*

The parameter λ_3 thus indicates how frequently the spatial arbitrage conditions are violated and may be interpreted as an index of market efficiency, in which values close to zero indicate that the spatial arbitrage is usually efficient. Maximum likelihood tests were performed for the three λ's, which were tested to be all significantly different from zero at the 95% level, which verifies the robustness of the results.

4.2 Conclusion

The results of the maximum likelihood estimation of the PBM suggest that, as was evident from Graph 3, there were periods where the markets were not integrated at all, and that markets were not always functioning according to the law-of-one-price. Note that the probability for λ_3 is rather high, indicating that there were serious factors, preventing markets from functioning efficiently. These could stem from periodic episodes of bad communication and/or road conditions connecting the two markets. Market failure resulting from imperfect competition is another possibility.

While the results do not indicate the degree of market integration that one would like to attain, the results do indicate that the Maputo and Chimoio markets have been linked nearly three quarters of the time. The hope is expressed that Mozambican maize markets in future will operate more efficiently through the installation of better communication technology and transportation facilities and roads.

Finally, the PBM model provides the food price analyst with a more reliable procedure of testing for market integration. Nevertheless, an extended study would also need to employ a considerable amount of investigative fieldwork in order to fully understand and then draw robust policy implications from the results.

NOTE

This article makes use only of a single transportation cost estimate, which is an average for 1996 and 1997, as supplied by the Mozambican National Institute of Statistics (Instituto Nacional de Estatistica, 1997). If we assume therefore that the immeasurable part of transfer costs is relatively stable over the length of the observation period, fluctuations in the spread between market price differentials and transfer costs can thus be linked to influences and barriers other than normal market forces, and hence distortions.

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