

## MAIZE MARKETS AND STORAGE IN MOZAMBIQUE

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Abstract:

We apply a mixed complementarity approach to analyze spatial and temporal equilibrium in the maize market in Mozambique when interest rates differ between urban and rural zones. Results indicate that differentials in interest rates significantly impact marketing patterns. Benefits from reductions in rural interest rates accrue primarily to rural households.

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## **MAIZE MARKETS AND RURAL STORAGE IN MOZAMBIQUE:**

### **A SPATIAL AND TEMPORAL ANALYSIS**

#### **1. Introduction**

For many agricultural commodities, three facts dominate the process of marketing. First, agricultural commodities tend to be produced a considerable distance from centers of consumption. Second, agricultural commodities are often harvested within a distinct and short interval of time. Third, consumption tends to be relatively evenly spaced in time. These three facts are particularly relevant for maize marketing in Mozambique. The distance by road between Lichinga, the capital of Niassa province-- a major maize producing province in the north-- to Maputo, the national capital and major consumption center, exceeds 2800 kilometers. Trucking is the only viable transport option.

While dispersion of production through space requires transport to bring maize to consumption centers, concentration of the harvest period in time requires storage to allow for a relatively smooth consumption pattern over time. Storage of maize implies opportunity forgone in terms of consumption or sale to a third party. This opportunity cost of holding maize from one period to the next rather than selling it in the current period is best represented by the opportunity cost of capital. Recently in Mozambique, real interest rates have been extremely high and dualistic. Moll (1996) calculates that, in 1994, real interest rates to small borrowers, including formal sector borrowers, were in excess of 100% on a yearly basis. At the same time, they were low to negative for some favored large borrowers. For traders operating in rural areas, credit constraints remain severe; and significant interest rate differentials between formal and informal sector borrowers exist (Miller, 1996; Coulter, 1996; Strachan, 1994; and Donovan, 1996).

Recent developments in the theory of spatial and temporal price determination for agricultural commodities illustrate that transport costs and interest rates *interact* in important ways in the determination of marketing patterns over space and time (Benirschka and Binkley, 1995). In developing countries such as Mozambique, where interest rates and transport costs tend to be high, these interactions can be expected to have significant impacts on grain marketing patterns. They are frequently modeled using an optimization approach of the form suggested by Takayama and Judge (1971) and applied examples are numerous. Recent applications include Nuppenau and Masters (1993); Arndt (1993); Mwanauomo, Masters, and Preckel (1997); Bivings (1997); and Brennan, Williams, and Wright (1997).

Here, focus is on storage and transport patterns with explicit accounting for dualistic interest rate structures between the formal and informal sectors. Under the Takayama and Judge optimization approach, interest rates are imposed via the discount rate. Accounting for dualistic interest rate structures (i.e., multiple discount rates across space) is hard. Instead, we rely on a mixed complementarity problem (MCP) approach to a spatial and temporal equilibrium model of the maize market in Mozambique. The MCP approach captures the interactions between transport costs and interest rates, which may differ according to location, in a manner which is simple to program and solve.

The remainder of this paper is organized as follows. Section two provides background information on Mozambique and introduces the model, data, and underlying assumptions. The third section presents the alternative simulations attempted and contains a discussion of model results. A final section concludes and suggests topics for future research.

## **2. Background and Model**

### 2.1 Background

Mozambique is one of the poorest countries in the world. The economy inherited deep structural problems upon independence from Portugal in 1975. These were severely aggravated by a failed socialist experiment and civil war. The combination of war and inefficient socialist policies paved the way to complete economic collapse in 1986. In early 1987, a stabilization and structural adjustment program (ERP) was launched. However, ongoing civil war severely limited the scope and impact of the initial reform measures under the ERP. Meanwhile, war continued to devastate the agricultural sector. By the cessation of hostilities in 1992, Mozambique faced massive reconstruction needs. In addition, implementation of the ERP, particularly at the microeconomic level, had barely begun.

Since the cessation of hostilities in 1992, economic growth has returned with the economy registering real GDP growth of about 7% in 1995 (National Institute of Statistics, 1997). In addition, the major elements of the ERP are now in place. By 1996, international and domestic trade in maize was almost completely free of legislative barriers and taxation. In this environment, spatial maize price arbitrage appears to have been active at least in south and central Mozambique. Despite these improvements, the reconstruction/development agenda remains massive. For example, means for delivering formal credit to smallholders are practically non-existent (Donovan, 1996). Consequently, rural inhabitants face severe credit constraints.

### 2.2 Model and Data

The model contains ten regions, corresponding to the ten provinces in Mozambique, with each region containing an urban and a rural zone. Thus, a total of 20 locations in space are present in the model. The time span considered is 12 months. The beginning time period is

March, corresponding to the beginning of the maize harvest season. Production occurs exclusively in rural zones. Transport is possible between urban and rural zones in the same region and between urban zones of different regions. This implies that production must first incur costs to enter the marketing system (represented as the urban zone) and then additional fixed and variable costs to be distributed to other regions. Storage is permitted in all locations. International trade occurs in the urban zone of the three regions containing major international ports: Maputo, Beira (in Sofala province), and Nacala (in Nampula province).<sup>1</sup> Demand and supply functions are linear; consequently, the non-linear programming manifestation of the model (when interest rates are constant across space) is a quadratic program and the MCP manifestation of the model is a linear complementarity problem. The model is solved using GAMS/PATH (Brooke, Kendrick, and Meeraus, 1992; and Dirkse and Ferris, 1996).

Economic collapse and war have not been kind to data gathering systems. As one might expect, data quality is often exceedingly poor and large information holes persist. Nevertheless, enormous efforts have been made to collect and analyze data since the cessation of hostilities in 1992. For the benchmark period, which starts with the 1996 harvest, data is available on production of maize by province, unit road transport costs, distances between regions, retail prices of maize in urban zones by province, and international trade. As is often the case, demand patterns (let alone the elasticity of demand) are less well known. A per capita consumption level of 57 kg per annum is employed, along with statistics on population, to develop benchmark demand functions (Bardalez, 1997; and Famine Early Warning System, 1997).

We follow Nuppenau and Masters and assume an elasticity of demand of -0.3. Linear supply functions are benchmarked in order to recreate production patterns in the 1996-97

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<sup>1</sup>International trade of maize with neighboring countries, other than South Africa, is not modeled explicitly, as the magnitudes are not known.

marketing year assuming an elasticity of supply of 0.6 for the more favorable northern regions plus Manica and an elasticity 0.3 for the drier southern regions. A substantial gap (78\$/tonne) exists between prices received for exports and prices paid for imports. A complete listing of data and assumptions is available from the authors upon request.

### **3. Simulations and Results**

The alternative simulations performed are presented in Table 1. These simulations vary rural and urban interest and storage loss rates. A summary of results for the alternative cases is shown in Table 2. In the following paragraphs, the base and the intuition behind results in case 1 are described. Welfare analysis comprises the remainder of this section.

#### 3.1 The Base Case and Case 1

In the base case, production quantities and prices reflect benchmark values. The base case reasonably matches observed supply prices and demand prices for the first two thirds of the marketing year. As in the 1996-97 marketing season, exports of maize are very small and imports fill the gap between supply and demand. All imports in the model base case scenario arrive through the port of Maputo, which is consistent with actual import patterns. More than half of the total commodity volume stored in the month of May is located in rural zones. Note that, regarding storage, the rural zone is conceived of as on-farm storage while the urban zone is conceived of as more efficient (lower interest and storage loss rates) off-farm storage. Transport costs between rural and urban zones (and interest charges on transport costs) are sufficiently high to deter movement of most maize to more efficient off-farm storage sites. Transport of this sort occurs primarily in the southern provinces where maize prices, and consequently opportunity costs of capital, are relatively high. This accords with empirical observation and results in a relatively high value for total transport cost.

Case 1 lowers interest rates and storage losses in rural zones such that values for these parameters are equalized between zones. As one might expect, the impact of lower interest and storage loss rates in rural zones is almost uniformly positive. Average consumption prices decline and consumption increases accordingly. At the same time, average harvest prices increase and supply responds accordingly. The reduction in the rate of growth of prices affords this simultaneous benefit on the demand and supply side. Due to reduced interest and storage loss rates, those wishing to stock maize are willing to pay more at harvest; and growth in prices throughout the marketing year is reduced. This reduction in the rate of growth in prices lowers average demand prices even though the initial base for price increases, harvest prices, are higher.

Impacts on prices are strongest, in relative terms, in rural areas with surplus production which are distant from consumption centers. In these areas, maize prices are low; consequently, the opportunity cost of storage is low and the option of transporting maize to a more efficient storage site is least attractive due to the high relative price of transport costs. In the rural zone of Niassa, hungry season (February) maize prices are 16% lower in case 1 compared with the base case. In contrast, hungry season prices in rural Inhambane, a deficit located near Maputo (the major consumption center), register only a minute decline.

The only welfare decreasing impact in case 1 is a mild increase in the average urban price paid for maize. As Table 2 illustrates, the increase in urban prices is confined to the southern provinces. The increase in average prices in Maputo is a particularly strong driver of this result since Maputo is both a relatively high priced region and by far the largest center of urban consumption. Maputo depends primarily upon imports from the rest of the world for maize supplies. In both the base case and case 1, imports to Maputo begin in September. The import price, which is constant across the scenarios, anchors prices for earlier periods. Lower storage

costs imply that prices do not need to fall as far below the import parity price level in the immediate post-harvest periods in order to compensate for the costs of storage. Consequently, average maize prices in southern urban regions rise. Finally, as predicted by theory, maize storage occurs completely in rural zones. As shown in Table 2, this reduces total transport costs as maize is never transported from rural to urban zones, stored, and then transported back.

### 3.2 Welfare Analysis

The presence of differential interest rates between urban and rural zones complicates welfare analysis. Interpretation of the nature of the interest rate differential influences results. If the interest rate differential represents real costs associated with delivering credit to rural borrowers, then transportation to lower cost storage in urban zones saves real resources as long as the total savings on storage exceed the total cost of transport. However, the interest rate differentials might also reflect market distortions such as interest rate subsidies, imperfect competition in credit delivery to rural areas, and/or simple market inefficiency. In this case, transport to avoid high cost rural storage could be inefficient.

All of these credit market distortions are arguably present in Mozambique. One of the major stocking organizations, *Instituto de Cereais de Moçambique* (ICM), is owned by the state and enjoys good relationships with the banking system. A case could be made that ICM benefits from implicit interest rate subsidies. In addition, smallholders tend to be highly dispersed and rural agents dispensing credit very few, creating conditions conducive to the exercise of market power in credit delivery. Finally, information on rural markets is scarce. Investors could easily content themselves with urban markets, where returns are quite adequate, even if risk/reward ratios for delivering credit to rural areas are very favorable. Accounting for distortions in credit delivery would imply that the market overstates the ratio of cost of rural storage to cost of urban



storage. In addition, the market price of road transport quite likely understates the total cost of road transport. Overstatement of rural storage costs and understatement of transport costs would imply efficiency gains associated with any shock which increased volumes of rural storage and reduced transport volumes. As shown above, reductions in rural interest and storage loss rates engenders both of these effects.

In the welfare analysis, interest rate differentials and transport costs are assumed to fully reflect real resource costs. Thus, the welfare measure most favorable to urban storage is chosen. Welfare is calculated from the Takayama and Judge measure which would have prevailed if an iterative non-linear programming optimization scheme had been employed (Rutherford, 1995). Once the equilibrium has been derived via the MCP formulation, it is straightforward to derive this welfare measure.

In case 2, interest and storage loss rates are reduced relative to the base case by 25% and 33% respectively for both rural and urban zones. The total welfare gain and the source of the welfare gain between case 1 and case 2 form an interesting comparison. In case 2, agents have access to urban interest and storage loss rates which are 25% and 33% lower, respectively, than in case 1. Rural interest and storage loss rates are 12.5% and 33% higher in case 2 as compared with case 1. Even though very efficient storage, relative to case 1, is available in the urban zones, the welfare increase is higher in case 1 compared with case 2. The primary contributor to the difference is transport cost. Case 1 obtains a higher welfare gain from reduced transport cost than case 2. This occurs because, in order to profit from urban storage, transport cost must be incurred. As a result, while case 2 reaps large welfare gains from less costly storage, these gains are heavily offset by higher transport cost.

In case 3, urban interest and storage loss rates are reduced by the same proportions as rural rates in case 1. As in the preceding two cases, average consumption prices fall and harvest prices rise. However, welfare gains are more than 40% greater in case 1 compared with case 3. Two factors drive this difference. First, the same proportionate decline in interest and storage loss rates leads to a larger absolute decline in rural rates since rural rates started at higher levels. Second, as in case 2, maize must be transported from rural zones to urban zones in order to profit from lower interest and storage loss rates in urban zones. Total transport costs increase by 18% relative to the base case. The increase in transport costs offsets about two thirds of the benefits of lower urban interest rates.

These results indicate that establishing a relatively few, but very efficient, grain storage locales while ignoring rural storage technology and credit constraints might not be the best policy. Often, efforts are made to support more formalized storage depots-- presumably at the expense of programs to develop and extend more efficient on-farm storage. As in case 3, this policy could serve mainly to increase transport volumes, with transport costs (and accrued interest on these transport costs) largely offsetting the increases in urban zone storage efficiency. In general, these policies are inconsistent with the inherent advantages of storage on or near farm. The presence of the distortions mentioned above would further bolster the case for efforts to enhance the viability of rural storage.

The results have distributional consequences as well. Table 2 contains producer and consumer surplus measures with the consumer surplus measure divided into rural and urban zones. Elimination of the interest rate differential between urban and rural zones (case 1) benefits rural zones exclusively in the form of increased producer and consumer surplus. Producers are particularly large gainers. Urban zones actually experience a mild decline in consumer surplus.

In contrast, when only urban interest and storage loss rates decline (case 3), rural consumers benefit relatively little. This indicates that the benefits of reduced rural interest and storage loss rates tend to accrue to rural household rather than get passed on to urban households in the form of lower maize prices.

The intuition behind these welfare results is as follows. With friction free credit markets and reasonably efficient rural storage technologies, the bulk of storage would tend to take place on-farm or near farm in rural zones. In the presence of impediments to delivering credit to rural zones, substantial storage can occur in urban zones in order to take advantage of lower costs of credit. To compensate for these credit impediments, rural producers must sell at a lower price in order to either cover high rural storage costs or the costs of transport to lower cost storage sites. In the periods immediately following harvest, rural zones will tend to rely on local stocks; consequently, price increases must be sufficiently high to cover the costs associated with inefficient rural storage. As the marketing season progresses, the rapid rate of price increase in rural zones may push rural prices sufficiently high to cover costs of transport back from urban zones. Only then do rural household begin to enjoy the benefits of moderate price increases associated with urban storage. Consequently, rural consumers reap a relatively small share of the benefits from lower urban interest and storage loss rates. Given this disparity of impacts of dualistic interest rate structures between urban and rural zones, it is not surprising that rural households reap the lionshare of the benefits from reduced interest rate differentials.

### **3. Conclusions and Suggestions for Future Research**

A mixed complementarity problem approach was applied to a spatial/temporal equilibrium model of maize markets in Mozambique. Relative to traditional optimization approaches, the MCP approach permits examination of the impact of dualistic interest rate

structures on maize marketing patterns in a manner which is simple to program and solve. Empirical results indicate that divergences in interest rates and storage loss rates across space have significant impacts on marketing patterns. Reductions in these divergences improve welfare, and these welfare gains tend to accrue primarily to rural inhabitants-- a group that is poor. These results suggest that efforts to improve the efficiency of rural storage should be given priority as opposed to the creation of large, formal sector grain collection centers.

In terms of future research, these results highlight the need to study rural credit markets, storage technology, and access to market information. In addition, detailed examination of actual marketing patterns would help in refining analytical approaches and strengthening the empirical basis for parameter values employed. Finally, the role of risk in influencing storage behavior and marketing patterns needs to be examined.

Table 1: List of simulations.

Case	Interest Rates		Storage Loss Rates	
	(% Monthly)		(% Monthly)	
	Urban	Rural	Urban	Rural
Base	2.00	3.00	0.50	1.00
Case 1	2.00	2.00	0.50	0.50
Case 2	1.50	2.25	0.33	0.67
Case 3	1.33	3.00	0.25	1.00

Table 2: Selected simulation results.

		Base	Case 1	Case 2	Case 3
Avg. Price <sup>1</sup>	Mt/Kg	1,829	1,803	1,799	1,815
Avg. Harvest Price	Mt/Kg	1,340	1,377	1,369	1,369
Avg. Rural Price	Mt/Kg	1,782	1,746	1,746	1,769
Avg. Urban Price	Mt/Kg	1,980	1,986	1,967	1,960
Avg. Urban Price South	Mt/Kg	2,216	2,227	2,215	2,210
Avg. Urban Price North	Mt/Kg	1,539	1,536	1,509	1,499
Total Production	Tonne	947,000	957,374	956,063	956,659
Total Demand	Tonne	938,573	949,116	947,591	942,714
Total Exports	Tonne	33,876	39,695	34,477	35,492
Total Imports	Tonne	66,222	62,413	58,052	52,011
Urban Storage May	Tonne	340,367	0	279,623	491,838
Rural Storage May	Tonne	398,815	748,587	470,059	255,745
Transport Cost	Mt 10 <sup>9</sup>	166.0	149.8	159.5	196.4
Welfare Change from Base	Mt 10 <sup>9</sup>	0.0	52.8	49.9	37.4
- Producer Surplus	Mt 10 <sup>9</sup>	0.0	31.6	24.3	25.1
- Consumer Surplus Rural	Mt 10 <sup>9</sup>	0.0	22.6	23.3	8.6
Urban	Mt 10 <sup>9</sup>	0.0	-1.3	2.3	3.7

<sup>1</sup>Average prices are calculated by taking a consumption weighted average across all time periods for the relevant regions.

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