Integration and Equilibrium in the Maize Markets in Southern Africa

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1. INTRODUCTION

For most countries in southern Africa, food security has traditionally been addressed through self-sufficiency, normally attained through widespread government involvement in the input and output markets for major food commodities. Food policies through the 1980's have been characterized by input subsidies for farmers, fixed, pan-seasonal and pan-territorial pricing systems in commodity markets, mainly implemented through parastatal marketing boards, as well as subsidies and price controls at the wholesale and retail levels. Most of these policies have since been abandoned for more market oriented policies, either under the Structural Adjustment Programs (SAPs), or domestic reforms, of the 1990's. During the same period, most countries in the region joined the multilateral trading system, the World Trade Organization (WTO), just in time for the Uruguay Round tariff reforms, and on a regional level, two regional free trade agreements were ratified, under the Southern Africa Development Community (SADC) and the Common Market for East and Southern Africa (COMESA), and bilateral preferential trading agreements continue to be negotiated. These policy shifts have left in their wake a region characterized by a blend of food policy, with greater openness and a market-led economy in some countries, while substantial government involvement persists in others. In this policy environment, food supply volatility, price instability and weak coordination of trade policy remain fundamental problems.

Improving intra-regional trade, through reduction of tariff and non-tariff measures has been widely advocated for as a critical piece in the food insecurity puzzle (SADC FANR 2003, World Bank DTIS, Mozambique 2004, Malawi 2002, Tschirley *et al* 2004, Mano 2003, Arlindo and Tschirley 2003, Moepeng 2003), and significant amount of work has already gone into monitoring cross-border trade movement of food grains in the region (WFP/FEWS 2004-2006, USAID 1995). However, it has also been shown that the extent to which benefits expected from greater market openness are realized depends significantly on how well integrated and efficient the markets are, both within and across borders (Ndlela 2002, Lewis 2002, Wobst 2002, Arndt 2005, World Bank 2002 and 2004). Integrated and / or efficient markets provide a mechanism for price signals to be transmitted between markets, curb price volatility, and ensure that prices deliver accurate incentives.

In the southern Africa region, research efforts have focused on analyzing integration of agricultural markets at an intra-country level (Abdula 2005, Tostão and Brorsen 2005, Alemu and Baucuana 2006, Penzhorn and Arndt 2002, Traub *et al* 2004, Mabaya 2003, Mutambatsere 2002, Barrett 1997). Limited work has gone into evaluating how well integrated or efficient the markets are at the regional level, to ascertain if in fact trade is a viable food security strategy given existing market systems. This paper analyzes bilateral integration and efficiency for distinct maize markets in a sample of four countries: Botswana, Malawi, Mozambique and South Africa, vis-à-vis current trade flows and existing marketing systems. The specific objectives are to: (1) evaluate the nature of price co-movements and trade relations among the sample markets, (2) establish the level of regional spatial integration, and (3) evaluate the level of market efficiency. Data on maize prices, trade volumes and transfer costs are analyzed using the Barrett-Li Model (BLM), supported by a comprehensive non-parametric description of market pairs.

2. MODEL TERMINOLOGY

Market integration traditionally has been used as a proxy for measuring market efficiency, initially employing time series price-based methods such as bivariate correlations, causality tests and co-integration analyses (also known as level I procedures, Barrett 1996). As the limitations of those methods became apparent, more sophisticated models emerged that incorporated transfer costs data, and later trade volumes, in analyzing market efficiency (called level II and level III methods respectively). With those developments, a crucial need to clearly define specific market outcomes arose.

In a survey of spatial price analyses, Fackler and Goodwin 2001 distinguish among several market linkage concepts for markets interlinked in space, form or time. The authors show that the 'integration' concept, have been 'loosely applied, such that the same word may involve distinctly different concepts in different studies' (Fackler and Goodwin 2001). Barrett 2001 proposes a clear distinction between the concepts of integration and efficiency, where integration is restricted to the flow-based notion of tradability, whereas efficiency is taken as a price-based concept that relates to the satisfaction of equilibrium conditions. Here, market efficiency holds under one of three conditions:

$$P_i \leq P_j + \tau_{ji} \quad \text{if } q_{ji} = 0 \qquad (1)$$

$$P_i = P_j + \tau_{ji} \quad \text{if } q_{ji} \in \left(0, \overline{q}_{ji}\right) \qquad (2)$$

$$P_i \geq P_j + \tau_{ji} \quad \text{if } q_{ji} = \overline{q}_{ji} \qquad (3)$$

where P_i and P_j are the prices in markets i and j, τ_{ji} is the cost of transferring the good from market j to market i, q_{ji} is the quantity traded and $\overline{q}_{ji}$ is the maximal possible trade volume (Barrett 2001, Takayama and Judge 1964, Samuelson 1952, Enke 1951). We adopt those definitions of integration and efficiency in this paper[1].

[1] Note that from the defined equilibrium conditions, trade (hence integration) is neither necessary nor sufficient for market efficiency.

3. *MODEL AND DATA*

The Barrett-Li model (Barrett and Li 2002) is used to establish direction specific integration and equilibrium for the four market pairs considered in this analysis: Gaborone-Gauteng, Gauteng-Maputo, Maputo-Mocuba and Mocuba-Blantyre. A level III method, the BLM is an extension of parity bounds (Baulch 1997) and switching regimes (Spiller and Haung 1986, Sexton, Kling and Carman 1991) procedures, employing time series price, exogenous transfer costs and trade flow data in evaluating market integration and efficiency. The BLM's main improvements from level II parity bounds and switching regime models are that first, the BLM provides a clear, testable distinction between market integration and competitive market equilibrium; and second, it makes use of direction specific trade data (with no restrictions on continuity or direction of trade flows between markets), useful in providing a holistic characterization of bilateral market behaviors. The BLM also can be employed to assess market integration and efficiency for commodities that are not entirely homogenous, since it takes into consideration seasonal or contemporaneous bidirectional trade.

To recap, market integration implies the transfer of excess demand from one market to another, manifest in the physical flow of commodities (tradability) and/or the transmission of price shocks from one market to another (contestability), whereas competitive equilibrium refers to the state in which the marginal profits from trade are completely arbitraged. Let P_{it} be the price in market i at time t, C_{jit} the observable costs of transferring commodities from market j to i at time t, $R_{jit} = P_{it} - P_{jt} - C_{jit}$ the marginal returns from arbitrage between markets j and i at time t, and T_{jit} the volume of trade from market j to i at time t. Six market regimes are identified:

Regime 1: $R_{jit} = 0$ and $T_{jit} > 0$, perfect integration with trade (4)

Regime 2: $R_{jit} = 0$ and $T_{jit} = 0$, perfect integration without trade (5)

Regime 3: $R_{jit} > 0$ and $T_{jit} > 0$, inefficient integration (6)

Regime 4: $R_{jit} > 0$ and $T_{jit} = 0$, segmented disequilibrium (7)

Regime 5: $R_{jit} < 0$ and $T_{jit} > 0$, inefficient integration (8)

Regime 6: $R_{jit} < 0$ and $T_{jit} = 0$, segmented equilibrium (9)

Competitive equilibrium prevails whenever the inter-market arbitrage condition holds with equality, or when transfer costs exceed price differentials so that no trade occurs:

$R_{jit} = 0$; or $R_{jit} < 0$ and $T_{jit} = 0$ (10)

Market integration holds whenever the inter-market arbitrage condition is binding or when positive trade is observed:

$R_{jit} = 0$; or $T_{jit} > 0$ (11)

A joint probability distribution can be estimated for T_{jit} and R_{jit}. Let λ_k be the estimated probability associated with regime *k*. Market equilibrium prevails with estimated probability $\lambda_1 + \lambda_2 + \lambda_6$, and integration with estimated probability $\lambda_1 + \lambda_2 + \lambda_3 + \lambda_5$. The maximum likelihood method is used to establish the probability of being in each regime. Following Baulch's logic for parity bounds models, we use available point estimates of transfer costs to establish a confidence interval (the lower and upper parity bounds) within which the deflated transfer costs are allowed to vary. This translates into an interval for R_{jit}. The deviation of returns to arbitrage in each time period from the null hypothesis of perfect integration (or zero returns to arbitrage) is captured by a systematic error term v_t, assumed to be normally distributed with mean α and variance σ_v^2, plus a positive error term u_t that is added when $R_{jit} > 0$ and subtracted when $R_{jit} < 0$. u_t is assumed to follow a half normal distribution with variance σ_u^2. A non-zero term α captures the random components of measurement error or the unobservable component of transfer costs

(Barrett and Li 2001). Following Weinstein 1964, on summing a normally and half-normally distributed variable, we can define the probability density functions for each regime as follows:

$$f_{jit}^1 = f_{jit}^2 = \frac{1}{\sigma_v}\varphi\left[\frac{R_{jit}-\alpha}{\sigma_v}\right] \tag{12}$$

$$f_{jit}^3 = f_{jit}^4 = \left[\frac{2}{\left(\sigma_u^2+\sigma_v^2\right)^{1/2}}\right]\varphi\left[\frac{R_{jit}-\alpha}{\left(\sigma_u^2+\sigma_v^2\right)^{1/2}}\right]\times\left[1-\Phi\left[\frac{-\left(R_{jit}-\alpha\right)\sigma_u/\sigma_v}{(\sigma_u^2+\sigma_v^2)^{1/2}}\right]\right] \tag{13}$$

$$f_{jit}^5 = f_{jit}^6 = \left[\frac{2}{\left(\sigma_u^2+\sigma_v^2\right)^{1/2}}\right]\varphi\left[\frac{R_{jit}-\alpha}{\left(\sigma_u^2+\sigma_v^2\right)^{1/2}}\right]\times\left[1-\Phi\left[\frac{\left(R_{jit}-\alpha\right)\sigma_u/\sigma_v}{(\sigma_u^2+\sigma_v^2)^{1/2}}\right]\right] \tag{14}$$

The maximum likelihood function for this parity bounds model is given by:

$$L = \prod_{t=1}^{T}\left(T_{jit}\times\left[\lambda_1 f_{jit}^1+\lambda_3 f_{jit}^3+\lambda_5 f_{jit}^5\right]+\left(1-T_{jit}\right)\times\left[\lambda_2 f_{jit}^2+\lambda_4 f_{jit}^4+\lambda_6 f_{jit}^6\right]\right) \tag{15}$$

where the parameters λ_1 to λ_6, α, σ_v and σ_u are estimated by optimizing In(L) with respect to each parameter. In this specification, T_{jit} is a dummy variable taking values 0 when trade occurs and 1 when trade does not occur, Φ[.] is the standard normal cumulative distribution function, and φ[.] the standard probability density function.

A few limitations of the BLM are worth mentioning. First, this procedure is fairly data intensive, and transfer costs and trade data of the required frequency are not always readily available. Transfer costs for example are extremely difficult to measure, comprising numerous components[2] including unobservable aspects such as risk and suck costs. Thus the accuracy with which transactions costs are measured also influences credibility of results. Second, this model

[2] Barrett identifies the following components: transport costs, costs associated with insurance, financing, hedging, contracting and satisfying technical barriers to trade such as complying with safety standards, exogenous transfer costs such as underwriting fees and testing charges, duties, and a whole host of unmeasurable transactions costs associated with doing business (opportunity costs of entrepreneurial time, search costs, risk, price and exchange rate variability etc) (Barrett 2001).

offers only static comparisons, and does not permit dynamic analysis of inter-temporal adjustments to deviations from long-run equilibrium (Barrett 2001). The model also suffers some of the limitations generally associated with switching regimes models: it assumes serial independence of price and transfer costs data, and regime probability estimates are sensitive to the underlying regime probability distribution assumptions (Barrett and Li 2001, Fackler and Goodwin 2001).

A sample of five markets in southern Africa is analyzed: Gaborone in Botswana, Gauteng in South Africa, Blantyre in Malawi, and Maputo and Mocuba in Mozambique (see figure 1). Maputo, a net maize buyer, is included as the central market for Mozambique's southern region, and Mocuba (a net seller) as the representative market for the northern region[3]. Generally, the choice of markets was based on centrality of each market in the countries under study, each representing one of the largest consumer and/or producer markets in each country. Market choice was also based on data availability, and on diversity of trade relations among the sample markets. For example, whereas the Botswana and South Africa markets are engaged in continuous trade with no tariffs, South Africa and southern Mozambique (Malawi and northern Mozambique) are characterized by mostly unidirectional continuous, protected trade; South Africa and Malawi by bidirectional discontinuous trade; and Botswana and Malawi/Mozambique by very little trade. Two markets are included for Mozambique to capture distinct trade relations between Mozambique and neighboring South Africa and Malawi. This set of markets thus

[3] The Northern region here comprises the four regions: Niassa, Cabo Delgado, Nampula and Zambezia, and the Southern region is made up of Maputo, Gaza and Inhambane.

makes up an interesting sample, in which some typical assumptions about market connectedness and efficiency can be tested.

Monthly time series data on maize retail prices from each of these markets P_{jt}, direction-specific transfer costs between market pairs C_{jit}, and direction-specific trade volumes T_{jit}, are used in this analysis. The complete set comprised data for the time period June 1994 to December 2004. Sources of these data are summarized in Table 1.

Table 1: Data and Sources

	SOURCE					
	Price	Trade flows	Hauling costs	Tariff Rates	Exchange Rates, Consumer Indices	Fuel Prices
Botswana	BAMB	WITS, CSO, FAOSTAT	Studies*	WITS, CSO	CSO, BoB	CSO
South Africa	NDA, SAFEX	WITS, FAOSTAT, TIPS	WB, SAGIS, Studies	WITS, DTI	STATS SA, Reserve Bank	DME
Mozambique	SIMA	WITS, FEWS, FAOSTAT	WB, SIMA, MoTI, Studies	WITS	INE	MoE

Abbreviations: Central Statistics Office (CSO), Bank of Botswana (BoB), World Bank (WB), Botswana Agricultural Marketing Board (BAMB), Food Early Warning System Network (FEWS NET), Food and Agriculture Organization's (FAO) online database FAOSTAT, World Integrated Trade Solution (WITS) – World Bank trade database, Trade and Industry Policy Strategies (TIPS), Department of Trade and Industry (DTI), National Department of Agriculture (NDA), South African Grain Information Services (SAGIS), South African Futures Exchange (SAFEX), National Department of Minerals and Energy (NDME), National Institute of Statistics (INE), Agricultural Marketing System under the Ministry of Agriculture (SIMA), Ministry of Trade and Industry (MoTI), Ministry of Energy (MoE).
**Studies* are outlined in-text.

All of the price statistics were reported in local currency, and were converted to their US$ equivalents using the appropriate exchange rate. These values were used as the 'normalized' price series without further inflation adjustments. Overall, the maize price series (US Dollar equivalents) for the sample markets are volatile, non-stationary processes, integrated of order 1. Higher price volatility is observed for Mocuba, Maputo and Blantyre, with Gauteng and Gaborone prices appearing to be the least volatile. Table 2 shows selected descriptive statistics for the market price data.

Table 2: Descriptive Statistics for Maize Prices, US$/ton

	Gauteng	Gaborone	Maputo	Mocuba	Blantyre
Mean	139.7368	177.6928	228.7836	124.7917	201.7333
Standard Error	1.776191	3.057913	6.505519	5.457079	6.160831
Median	143.5	183	218	111	184.5
Mode	149	181	225	111	112
Standard Deviation	24.48311	39.39846	75.30683	65.48494	82.65622
Mean Confidence Level (95%)	3.503706	6.037683	12.86766	10.78696	7.685807

Occasionally in the analyses, reference is made to the 'trade unit values' of maize, computed as the source/destination specific per unit value of the maize traded. As shown later, trade unit values sometimes differ from the market prices prevailing in either the source or destination markets, and may help explain perceived discrepancies in trade flows given the market price determined returns to arbitrage. Because trade unit values are national averages rather than market specific values, their use is restricted mainly to the discussion of results.

The transfer costs variable was challenging to construct, given incomplete and asymmetric data availability for the sample markets. The series was derived primarily from the per km hauling costs for road and rail transportation estimated in the World Bank's diagnostic trade integration studies for Malawi and Mozambique (2001), Tostão and Brorsen 2005, SADC freight studies by Vink *et al* 2002, Kandiero et at 2005, Erero and van Heerman 2005, the Food Agriculture and Natural Resources Policy Analysis Network (FANRPAN) 2003, and from SAGIS 2005. These sources provide several point estimates for the study period that, following Baulch 1997, are extrapolated to cover the study period. Data of varying degrees of completeness on fuel prices, distance between markets and transport cost indices are employed in the extrapolation process. Often, when such extrapolations are performed, conservative and extreme point estimates of the transfer costs variable are offered in the literature. In this analysis we adopt the average of extreme estimates where appropriate, allowing for the variability observed in the transport cost index and fuel costs to determine seasonal fluctuations of transfer costs. Data on tariff rates were used to estimate the tariff costs per unit traded between specific markets, and these were added to the hauling costs estimates.

In Mozambique the Value Added Tax (VAT) on imported maize grain is observed to be quite high, and is often considered trade restrictive (Tschirley *et al* 2005). In this analysis, since VAT is an internal tax that is often subject to exemption, we refer to it only in explaining observed trade flows, rather than as part of transfer costs. Costs such as handling, border inefficiency, and insurance costs could not be captured in the transfer costs estimates used here, however considering that maize is a non-perishable, low-value commodity, we might expect border losses due to spoilage, and insurance costs, to be relatively small. Note that transfer costs between any given market pair are not symmetric, since the fuel prices and consumer indices are market specific, and tariff rates differ between countries for specific time periods.

Trade statistics, though generally available from various sources for the study period, are almost exclusively available in annual form. For the sample countries, more frequent trade statistics are limited to some historic quarterly statistics for Botswana, a few recent monthly statistics for South Africa available from the Department of Trade and Industry, and for Malawi and Mozambique, monthly trade statistics for specific trade routes available from Food Early Warning System Network (FEWS NET)'s cross border trade monitoring studies. The major challenge in consolidating the trade flow variable was that the most comprehensive bilateral trade time series, available from WITS, is reported on an annual basis, whereas the monthly statistics such as those from FEWS NET were only available for recent years, often falling outside of the study period. Moreover, with the exception of FEWS NET data, trade statistics only tell country level bilateral flows, but do not identify exactly what markets the commodity originated from, or where it was destined. In this analysis, the trade dummy variable used in the

Barrett-Li analysis was derived from the annual statistics, using the monthly data where they exist to predict the months in which trade is likely to have occurred. To handle the issues of source and destination of reported trade, trade literature for the region[4] were referred to. Because of these numerous assumptions and adjustments made to derive frequent, reasonably accurate trade statistics could only be derived for four market pairs: Gaborone – Gauteng, Gauteng – Maputo, Maputo – Mocuba, and Mocuba – Blantyre. The parity bounds analysis was applied to these market pairs, and the results are presented in section 4.

4. RESULTS

Description of Markets

This section offers a non-parametric description of the markets to help explain some of the trends observed in the econometric assessments that follow, and to assess the goodness of fit for the variable distributions and other statistical restrictions on the data imposed by the maximum likelihood estimations. The main characteristics of each market are summarized in Tables 3 and 4, and a description of the returns to arbitrage between markets is provided. Figure 1 shows the location of the markets in the sample (Gauteng is the region of South Africa in which the cities Johannesburg and Pretoria are located), some of the major ports, the transportation networks linking them together and the estimated distances between the markets included in the sample. For clarity of presentation, the figure does not show most of the road networks, only those that link major ports for which rail does not exist are shown. Figure 2 shows the cumulative distribution of returns to arbitrage between distinct markets given price and transfer costs movements.

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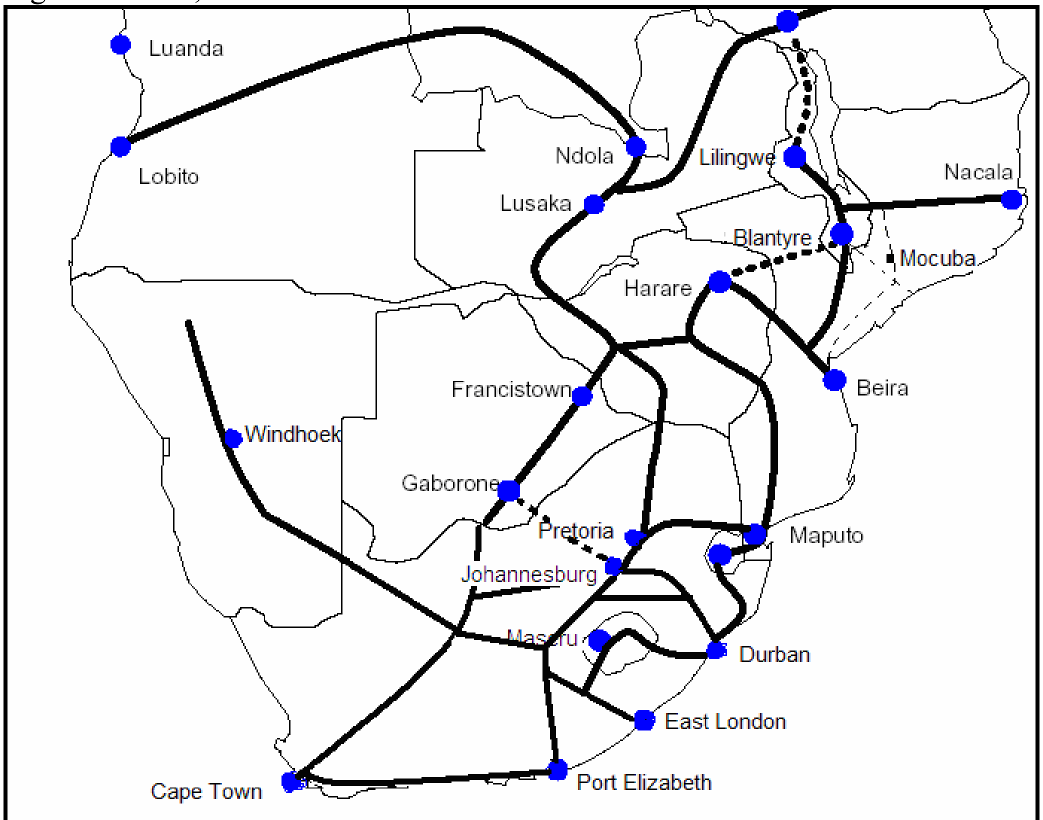
[4] Such as FANRPAN publications, SADC publications, MSU Food Security studies, and TIPS publications.

Figure 1: Ports, Inland Terminals and Main Transit Routes for SADC States



DISTANCE BETWEEN MARKETS:
Gauteng to Gaborone – 358km
Gauteng to Maputo – 602km
Maputo to Mocuba – 1320 km
Blantyre to Mocuba – 310 km

Major market
Rail/Road

An assessment of the sources of imports and destinations of exports for the SADC region indicates that although intra-regional trade generally contributes a small proportion of total trade volumes, the trend is significantly different for trade of maize. Statistics indicate that formal trade among SADC countries accounts for over 95% of total maize exports and about 80% of maize imports, in addition to an estimated 270,000tons (about 8.5% of total trade quantity) traded informally between neighboring states (WITS 2005, FEWS NET 2005, USAID 1995).

Table 3: Trade Frequencies, Annual Between Countries: 1994 to 2005

From \ To	South Africa	Botswana	Mozambique	Malawi
South Africa	-	100%	100%	89%
Botswana	100%	-	0%	0%
Mozambique	56%	0%	-	78%
Malawi	47%	0%	44%	-

Source: WITS 2005

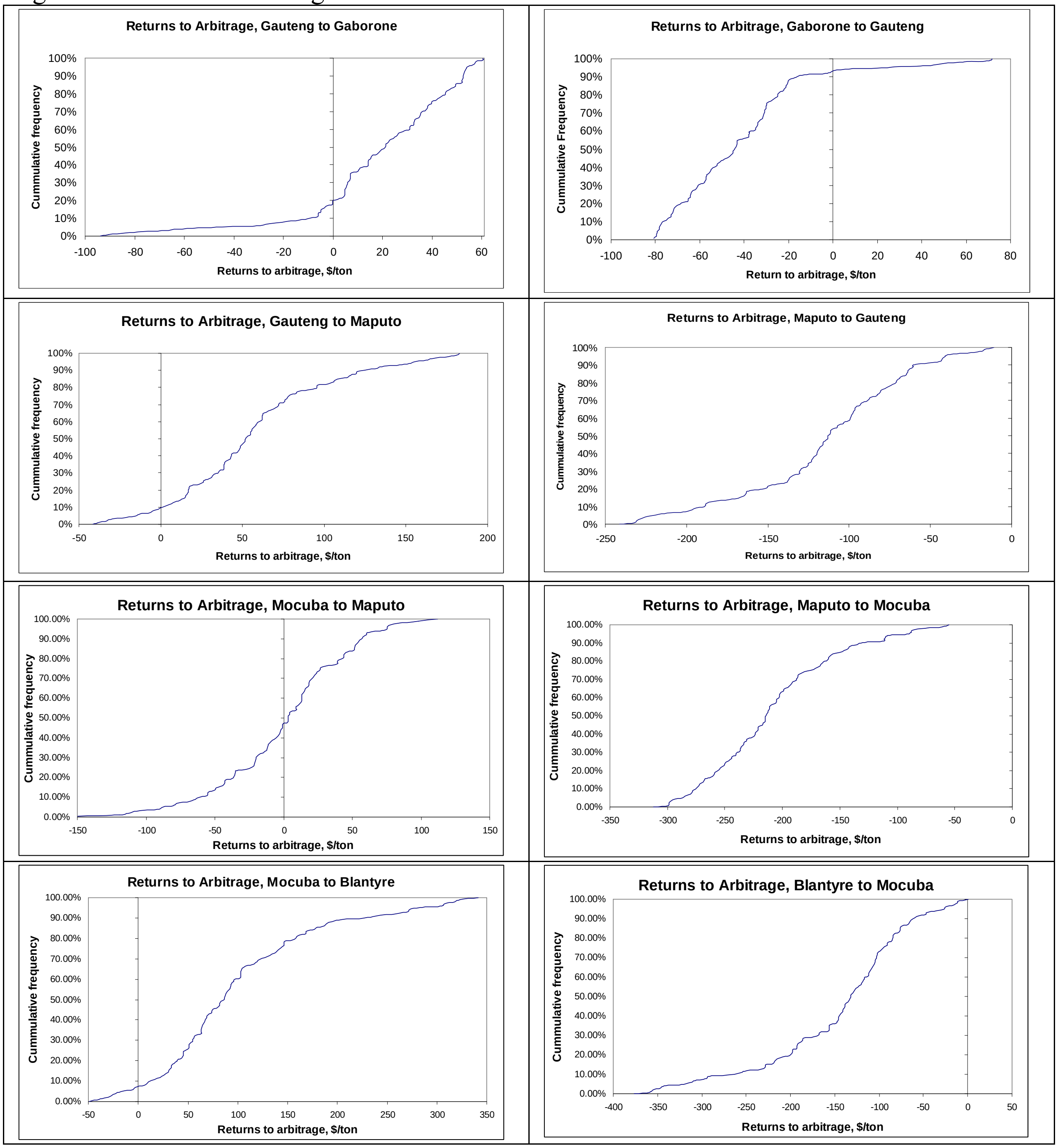
Table 4: Description of Sample Markets

	BOTSWANA	MOZAMBIQUE	SOUTH AFRICA	MALAWI
Cereal production	10% of aggregate needs	1.25 million tons per year	10 million tons per year	1.2-2.5 million tons per year
Cereals consumption	80,000 tons per year	1.35 million tons per year	7.5 million tons per year	1.5million tons per year
Imports	71,000 tons per year	200,000 tons a year	550,000 tons per year	125,000 tons (about 8.5% of aggregate needs) per year
Exports	1,000 tons per year	7,000 tons per year	1.5 million tons per year	18,500 tons per year
Major regional trading partners	South Africa (95% of imports, 75% of exports), Namibia (14% of exports), Zimbabwe (5% of imports)	South Africa (80% of imports), Swaziland (3.6% of imports), Malawi (close to 60% of total exports). Limited trade with Zimbabwe, Namibia, Angola and DRC	Zimbabwe (40% of total exports, 1.5% of total imports, 75% of *regional* imports)[5], Botswana (5-7% of total exports), Malawi and Mozambique (10% of exports, ≈0.1% of imports)	Mozambique (60% of imports), South Africa (25% of total imports, 3.5% of total exports), Zimbabwe (24% of exports), Tanzania (14% of exports), Zambia (3% of total imports, 0.1% of total exports)
Tariffs and taxes on maize	0% for SACU imports 6.7c/kg on grain, 10c/kg on maize flour	0% on maize grain, 25% on maize flour, 17% VAT on imported grain	0% for SACU imports 6.7c/kg on grain, 10c/kg on maize flour	0% for COMESA imports 0% on grain, 15% on maize flour
	GABORONE	MAPUTO	GAUTENG	BLANTYRE
Geographic Status	Capital City	Capital Province	Capital Province	Commercial Capital
Population	270,000 (15% of total)	> 1 million (7.5% of total)	3.2 million, 17% of total	502, 000 (1/3 of urban population, 4% of total)
Maize production	-	2% of aggregate	5% of aggregate	15.8% of aggregate

Sources: WITS, FAOSTAT, National statistics offices

[5] Most of South Africa's imports are from the international market, and in aggregate, South Africa's imports from Zimbabwe are only 1.75% of total imports.

Figure 2: Returns to Arbitrage - Market Price Estimates



Price and transfer costs statistics indicate that the prices in Gaborone exceed Gauteng prices for most of the study period, and that the returns to arbitrage of grain from Gauteng to Gaborone are positive about 90% of the time. Conversely for the Gaborone to Gauteng trade direction, returns to arbitrage are almost always negative. For the Gauteng-Maputo market pair we observe again a one-sided trend in positive returns to arbitrage, with Maputo prices consistently exceeding the market prices for Gauteng. Market prices in Blantyre are also observed to exceed the Mocuba prices for most of the study period, and returns to trade on the Mocuba to Blantyre trade route are non-negative for nearly 90% of the time. We also observe that although market prices in Maputo consistently exceed Mocuba prices, the fairly high transfer costs on the Mocuba to Maputo trade route erode a significant proportion of the arbitrage profits. A more detailed pair-wise description of the markets is presented under the BLM results section, and shows trends that are largely consistent with the observed trade frequencies presented in Table 3, and the cumulative arbitrage returns distributions presented in Figure 2; with more distinctly defined regime frequencies.

The Barrett-Li Model Results

The log of the maximum likelihood function defined in equation (15) is used to estimate the parameters λ_1 to λ_6 as defined above for the BLM, and α, σ_v and σ_u. The optimization program Solver, which utilizes the generalized reduced gradient (GRG) algorithm, implemented in an enhanced version of the GRG2 code (Lasden and Waren 1979), is used in solving the maximization problem. The resultant parameter estimates are presented in Table 5.

Table 5: Summary of Barrett-Li Model Results

Direction of Trade	Regime Probability								
	λ_1	λ_2	λ_3	λ_4	λ_5	λ_6	σ_u	σ_v	α
Gauteng to Gaborone	0.2501	0.000	0.6292	0.000	0.1194	0.000	42.539	0.0000	-6.3584
Gaborone to Gauteng	0.000	0.0158	0.0390	0.0645	0.1161	0.7636	38.635	1.95042	-19.3133
Gauteng to Maputo	0.0097	0.000	0.8932	0.000	0.0971	0.000	74.997	0.001	1.09869
Maputo to Gauteng	0.1074	0.000	0.000	0.000	0.0470	0.8444	61.255	31.1558	-42.4078
Blantyre to Mocuba	0.000	0.0633	0.0415	0.000	0.1160	0.7781	109.97	32.9646	-72.5606
Mocuba to Blantyre	0.2298	0.0877	0.6130	0.0675	0.000	0.000	117.70	37.4335	17.66256
Maputo to Mocuba	0.000	0.0353	0.0000	0.0000	0.000	0.9636	57.481	45.8424	-16.4739
Mocuba to Maputo	0.000	0.5229	0.0000	0.1501	0.000	0.3269	58.957	38.0174	14.9787

Because regime frequencies are defined for each market pair in a direction specific manner (generally $\lambda_k^{ji} \neq \lambda_k^{ij}$), integration and efficiency also seem to be uniquely defined for specific trade directions. We maintain direction specific descriptions of markets with regards to the concept of market integration, since tradability and contestability are also unidirectional concepts. However, because equilibrium is an omni-directional concept, we generally need to establish for each market pair, a range of frequencies describing the lower and upper bounds for efficiency. Thus in the following discussion, efficiency conclusions are drawn by considering regime frequencies and trade trends for both trade directions.

Gauteng – Gaborone: This market pair is in perfect integration with a frequency of at least 25% observed on the Gauteng to Gaborone trade route. Trade is bidirectional between these markets, continuous on the South Africa to Botswana trade route and discontinuous on the Botswana to South Africa route. Because returns to arbitrage are often negative on the Gaborone to Gauteng trade route, the limited trade on route is consistent with efficiency. Cases of imperfect integration also exist, at a fairly high frequency when trade fails to exhaust arbitrage returns (observed on the Gauteng to Gaborone trade route), and at a lower frequency when trade occurs in spite of negative returns (observed in both trade directions). The occurrence of regime 4 (positive returns without trade), as well as with regime 5 (negative returns with trade) in the Gaborone to Gauteng trade route appears to indicate that although trade in this direction is limited, it is often not consistent with the limited periods in which Gaborone prices exceed Gauteng prices, an indication of inefficiency in such market interactions.

We observe at a national level that the per-unit value of maize exported from Botswana to South Africa generally exceeds the market prices prevailing in Gauteng. Some possible explanations could be given for these seeming disparities in prices, for example, that some form of product differentiation exists that allows Botswana exports to fetch a higher than average selling price in South Africa; that maize exports from Botswana are destined to markets other than Gauteng, where higher market prices prevail; or that some form of inefficiency exists in the markets to sustain these price differences. We can dismiss the first possibility based on the observation that the maize grain under study is a fairly homogenous product. On the second possibility, an assessment of South Africa's maize producing regions and deficit regions, considering proximity of these regions to Botswana, indicates that Gauteng is in fact one of the major maize producing regions in the South Africa[6], and we may expected other deficit regions such as Northern Cape to offer higher prices for Botswana's exports. It is also possible that South African consumers pay more for maize sourced from Botswana either due to imperfect information on prices prevailing elsewhere in the market (especially possible for consumers located in remote parts of the country, close to the Botswana exporting regions), or due to hidden costs imbedded in currency conversion[7] and transfer costs. Note however, that Botswana's total exports of maize to South Africa are rather insignificant, making up a mere 0.5% of the total trade volumes between these two markets.

Gauteng – Maputo: This market pair is characterized mostly by imperfect integration with positive returns to arbitrage, whereby the flow of maize from Gauteng and neighboring regions to Maputo fails to exhaust the arbitrage returns, with limited occurrence of regime 1. Positive

[6] South Africa's major maize producing region includes parts of Gauteng, North-West, Free State and Mpumalanga.

[7] Possible given that the Botswana Pula is generally stronger than the South African Rand, so that prices quoted in Pula may appear lower they actually are when converted to their Rand equivalents.

returns imperfect integration appears to be the dominant form of inefficiency for this market pair; with negative returns imperfect integration also observed at much smaller frequency in either trade direction. At national level, trade is almost continuous on the South Africa to Mozambique trade route, with trivial, discontinuous trade in the opposite direction (less than 5% of Mozambique's total exports and an insignificant proportion of South Africa's total imports). Because the trade variable is included as a 'trade or no-trade' dummy variable, these trade proportions tend to be masked in observed regime frequencies.

The regular positive returns imperfect integration observed on the Gauteng-Maputo trade route is probably explained by the presence of the restrictive 17% VAT on imported maize meant for re-sale in grain form, that if incurred, would substantially increases the transfer costs for grain traders. In the opposite trade route, it appears that the very limited trade observed from Mozambique to South Africa does constitute some form of inefficiency since, considering market prices of maize, the prices prevailing in South Africa relative to Mozambican prices are generally not large enough to provide an incentive for this positive flow of maize. Only when per-unit trade values are considered are non-negative returns to trade sometimes expected on this trade route. Thus it appears that Mozambican imports attract an above average price in South African markets, for at least parts of the seasons when trade is observed, probably for reasons similar to those discussed above for the Botswana case. Occasionally however, positive trade is observed from Mozambique to South Africa that is supported by neither prevailing market prices nor per-unit values of traded maize.

Blantyre – Mocuba: For this market pair, perfect integration is observed with a frequency of up to 22%, where zero returns to trade are observed on the Mocuba to Blantyre trade route, whereas regime 2 perfect integration is observed in the opposite direction. More regularly, positive returns imperfect integration is observed in the Mocuba to Blantyre trade direction and segmented equilibrium in the Blantyre to Mocuba trade direction. Market prices in Mocuba are consistently lower than Blantyre prices, accounting for the frequently negative returns with limited trade on the Blantyre to Mocuba trade route, and the positive returns with higher trade in the opposite direction. Considering that Mocuba lies in Mozambique's maize surplus region, whereas Blantyre lies in the southern, mostly deficit region of Malawi, the observed price and trade trends are expected.

On the Mocuba-Blantyre route, trade generally fails to exhaust arbitrage profits and occasionally, positive returns go entirely unexploited (regime 4), possibly due to inadequacy or seasonality of maize supply on the Mozambican side. The limited trade observed in the Blantyre to Mocuba direction is also largely inefficient, with negative arbitrage returns, as evidenced by the occurrence of regime 5. Note again though that the proportion of Malawi's exports to Mozambique is rather small, with trade accounting for at most 1.6% of total exports from Malawi (and only about 0.1% of Mozambique's imports).

Maputo – Mocuba: This market pair is used to evaluate the level of integration and efficiency between the southern and northern regions of Mozambique. In terms of geographic location, Mocuba is more centrally located than most surplus producing areas of the northern region, so that transfer costs are not as restrictive, and limited trade is in fact observed from Mocuba to Maputo[8]. Efficiency holds with a high frequency, up to 52% in zero returns to arbitrage, mostly without trade, and up to 96% in segmented equilibrium. Inefficiency is observed in the Mocuba to Maputo trade route, where positive returns to arbitrage appear to go unexploited with a

[8] A trade frequency of about 2.25% is estimated by Tostão and Brorsen 2005.

frequency of up to 15%. An assessment of the seasonality trend in arbitrage returns on the Mocuba to Maputo trade route indicates that these are highest in the months immediately following harvest, when the prices in Mocuba are lowest. Therefore it does not seem that seasonal supply constraints inhibit the flow of maize from the surplus to the deficit region. Interesting to note though is the presence of an alternative recipient for the maize surpluses in the northern region (Malawi) where, due to market proximity, larger arbitrage returns can be realized. The southern region of Mozambique is thus served by South Africa's surplus region – also more closely located and serviced by an efficient transport system[9].

Discussion of Results

In concluding this section, some of the reasons for the market segmentation and different forms of inefficiency observed in the sample markets are explored. Imperfect integration with positive returns is often a result of either insufficient arbitrage or significant unobservable transfer costs. Imperfect integration with negative returns is explained as resulting from temporary disequilibria that arise from information and contracting lags, or the existence of significant unobservable trade benefits. In this sample of southern Africa's maize markets we have market pairs for which positive trade is observed even when the observable price differences are negative (for example trade from Botswana to South Africa and on occasion, from Malawi to Mozambique). In such cases, it appears that trade is a result of inter-country transport bottlenecks that force excess producers located close enough to the border to sell across the border for less, if that

[9] The distance from Maputo to say Gauteng is less than half the distance to Mocuba, and given the geographic location of Maputo, this distance lies almost entirely on the South African side of the border, where more efficient transport network systems are in place.

market is more easily accessible. If those producers acquire most of their daily goods and services from across the border, near batter trade of maize grain for consumer goods is not uncommon. In such cases, and also considering the differences in currency denominations and exchange rate fluctuations, observable price differences could easily become ‘hidden’ to smallholder producers and informal traders of maize. As has already been suggested earlier however, returns to arbitrage may appear negative, when in fact the exchange price differs from prevailing market prices in either the source or the destination markets. In an efficient market system, we expect that higher import prices would encourage an influx of maize that eventually drives the price of imports down to the local levels. However if the market does not operate competitively, for example when the state is a significant player in grain trade, we have cases in which the government is willing to pay more for imports than it eventually sells the imported commodities for on the local market – a form of subsidy often used in shortage periods to support food insecure households. In a country such as Malawi, where the state is still a dominant player in maize importation, such trends are not uncommon[10].

With regards to unexhausted or unexploited positive returns to arbitrage, it is possible that significant unobservable transfer costs exist. As noted earlier in the description of the transfer costs variable, the estimated costs do not account for costs such as insurance, spoilage, border inefficiency costs, contracting costs, sanitary and phyto-sanitary compliance costs, exchange rate risk, and several other trade-related costs. Barriers to trade may also be structural, so that even when commercial traders are willing to take advantage of higher market prices in a neighboring country, government restrictions on grain movement may prevent that from happening. The markets in Malawi certainly have been subject to such regulatory restrictions in the past, though reform of such policies has been observed in recent years. Supply side

[10] See also Zant 2005

constraints might also prevent countries from taking advantage of positive arbitrage opportunities. Imperfect information and risk aversion also play a role here, where issues such as differences in currency denominations for prices, imperfect information on transfer costs, imperfect currency exchange markets, and imperfect information on how to enter foreign markets may inhibit trade.

5. CONCLUSION

As the SADC region grapples with the recurrent issue of food insecurity, reference is often made to increased intra-regional trade as an important integral element of a comprehensive food strategy. The assumption is that as countries reduce tariff and non-tariff barriers to trade, they become more integrated and more efficient, facilitating commodity movement at lower transfer costs, hence lower prices to the final consumer. With the reform of maize markets in most of the region in the past decade, from controlled to market-oriented, we evaluate the extent to which these markets have become integrated and efficient, and identify the nature of inefficiency where it exists. This paper employs the Barrett-Li model, in collaboration with comprehensive non-parametric descriptions of market pairs, to provide a holistic assessment of pair-wise market interaction.

Results show that the maize markets in Botswana and South Africa exhibit a fairly high level of integration, with limited efficiency; returns to arbitrage are mainly positive on the South Africa to Botswana trade route; and markets are linked by bilateral trade, continuous on the South Africa to Botswana trade route and discontinuous in the opposite direction. For South Africa and Mozambique, trade is bidirectional and discontinuous, with low frequency of perfect integration. Trade between South Africa and Mozambique's Southern region generally fails to exhaust arbitrage profits, and though integrated, the market pair appears largely inefficient. Malawi and Mozambique's Northern region exhibit perfect integration of a relatively high frequency, although imperfect integration with positive returns appears dominant on the Mozambique to Malawi route. Trade is bidirectional and discontinuous, predominantly in the Mozambique to Malawi direction.

Overall, the southern Africa maize markets considered in the sample seem to exhibit significant frequency of market integration, indicating tradability of commodities and contestability of markets. Efficiency holds less frequently, although non-trivially; we observe that for those markets characterized by near continuous trade, returns to arbitrage are exhausted for about 25% of the time. Often however, when trade is observed, efficiency appears to be weakened by insufficient arbitrage, possibly a result of non-cost barriers to trade (infrastructural or regulatory), imperfect information, or supply side constraints. For these markets, positive trade is also occasionally observed when arbitrage returns are negative, possibly due to contracting lags, and exchange rate fluctuations. Where trade is not observed, efficiency appears to hold with a slightly higher frequency (up to 52%), so that the lack of trade often is justified by the lack of positive arbitrage returns. Significant segmented equilibrium also seems to characterize these markets, where again the lack of trade is consistent with expected arbitrage returns. For those markets, efficiency also is occasionally compromised by insufficient arbitrage, whereby trade sometime fails to occur even when the returns to arbitrage incentives appear favorable (segmented disequilibrium). Therefore in order of frequency, we observe a high frequency of positive returns imperfect integration (regimes 3) and segmented equilibrium (regime 6), a fairly regular occurrence of perfect integration (regimes 1 and 2), and irregular occurrence of segmented disequilibrium (regimes 4) and the negative returns type of imperfect integration (regime 5).

The main limitation of this study is that it makes use of imperfect transfer costs data, extrapolated from isolated point estimates, obtained from various sources for different time periods. Such inconsistencies increase measurement error, and compromise the accuracy of parameter estimates. More work is required to accurately measure these variables, and monitor trade between specific markets in the region. In addition, the analysis suffers most of the limitations of parity bounds models identified in section 4.3, such as susceptibility of parameter estimates to choice of probability distribution functions, and the static nature of the analyses. Similar studies handle the former through Monte Carlo sensitivity analyses, to evaluate robustness of the chosen distributional forms (Barrett and Li 2001, Barrett *et al* 2000, Baulch 1997). Similar robustness test for this study would provide additional information on the validity of test results.

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