Estimation of Inter-regional Maize Market Integration in Tanzania and Its Determinants

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タンザニアにおけるメイズの地域間市場統合度の計測とその決定要因

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メイズはタンザニアの主食で、国民の食事のカロリーの約42%をまかなっている。

全国の20の地域のうち恒常的にメイズ生産に余剰があるのは6州に過ぎないため、余剰地域から不足地域への地域間交易がきわめて重要になっている。全国的にメイズが不足の時期は、不足分が在庫の放出や輸入によって賄われている。このような食糧不足は散発的ではあるが4、5年ごとに生じ、深刻な食糧安全保障問題を引き起こしている。市場が統合されていると、次のような面から、食糧市場への介入プログラムに要するコストは減少するであろう。即ち、在庫や輸入分で、ある1つの市場の供給を増加させると、その価格効果は他の市場に移転され、この効果に従って地域間交易におけるメイズ供給を調整させるということである。逆に市場が統合されていない場合、各々の市場で、それぞれの地域が独自に食糧市場への介入を行わなければならない。その場合、計画執行コストは大きくなる。

本論文では、タンザニアにおける地理的に分散したメイズの地方市場の間の統合度を、ラバリオン・モデルを適用して分析した。2大中心都市、即ちダルエスサラームとムワンザはメイズの価格形成の基準地点であり、この基準の市場価格の変化が周辺地方の市場に波及する形で、地域間メイズ市場が統合されるという

仮説を立て、実際にその検証を行った。検証にあたっては、選出された10市場におけるメイズの小売り価格の通時的变化を用いて、その市場間で形成されると仮定される17の市場ペア間の統合度合いを分析した。

分析の結果により、ダルエスサラームとムワンザが、それぞれ東部と西部における地域間メイズ市場の価格形成の中心地として重要であるという仮説が実証された。同時に緩やかに統合されているメイズ市場と、互いに分断されている市場が存在することが明らかになった。このように、遠隔地にあり、劣悪な輸送インフラしかない市場間では統合がなされていない傾向があることが判明し、ダルエスサラームとムワンザのみを通じて食糧安全保障のための供給安定化を図ることは不十分であるという示唆が得られた。

従って、タンザニアのメイズ市場に関しては、東部地域の統合されている市場群に対しては、広域的食糧安全保障政策が必要であり、分断されている西部地域の市場群に対しては、それぞれ地域別に異なった政策が必要であることが示唆された。本論文は、主として地域間のメイズ取引、なかでも都市間のそれに焦点をあててきたが、上記の政策的含意に基づいて地域内部の市場統合が行われ、空間的な完全競争が達成されるならば、農村部における食糧安全保障にもより広く貢献するであろう。

1. Introduction

Food markets in Tanzania, like in other developing economies, are suspected of segmentation due to inadequate infrastructure and various other reasons. This paper attempts to empirically test the degree of market integration in inter-regional trade for maize, the country's staple food. Two trading markets are assumed to be integrated if price change in one leads to identical price response in the other. Monke and Petzel (1984) define integrated markets as markets

in which prices of differentiated products do not behave independently. Identical products can be differentiated by location, and statistical tests of independence are employed to indicate the degree of integration (Merle and Benson, 1990). Associated with market integration is the degree of price transmission which may have an effect on the speed of traders' response to move food to deficit areas, especially during emergencies such as drought, floods or pestilence, before the affected people suffer from hunger.

Understanding the degree of market integration is

crucial to appropriate formulation of food security policies such as those related to food price stabilization through storage or trade. De Janvry and Sadoulet (1996) assert that the cost of food price stabilization is reduced if internal markets are integrated in the sense that if the price in one (central) market is stabilized, the effect will be transmitted to other markets. If markets are not integrated, each market would need its own stabilization program which is costly. Decisions on when, how, and by how much to intervene in food markets depend on knowledge of how markets are integrated.

1.1 Factors Affecting Market Integration

Factors affecting the degree of market integration differ from place to place and the kind of products under consideration. Tomek and Robinson (1990) list principles that underlie price difference between two regions in a perfect competitive market as follows:

- a) Price difference between any two regions (or markets) that trade with each other will just equal to transfer costs.
- b) Price difference between any two regions (or markets) that do not engage in trade with each other will be less than or equal to transfer costs.

The most important component of transfer costs is transportation cost. Other transfer costs are handling (loading and unloading), insurance, refrigeration, etc. Transportation cost depends on distance, topography (e.g. plain versus mountainous road), and road quality through depreciation. Hence, these factors affect market integration indirectly through their contribution to transportation cost. With the exception of Hays and McCoy (1977), most recent analysis of market integration employs methods that do not require use of transportation costs. The degree of competition in the market and efficiency in the flow of market information as determined by telecommunication infrastructure, also affects the integration of markets. Government policies, social and political institutions can have positive and negative effects on market integration (Tsujii, 1991).

1.2 Objectives and Hypotheses

Maize is Tanzania's staple food and contributes to about 42% of dietary energy (MOA, 1992). It is estimated that on average, households allocate 40 percent

of their staple food budget to maize. This suggests that markets play an important role in linking surplus producers and consumers in deficit areas (Byreson, 1993). Maize is produced in all 20 regions of Tanzania, but only 6 regions are reported to have a regular surplus (MDB). The maize surplus regions, in descending order are: Iringa, Mbeya, Rukwa, Ruvuma, Arusha and Singida. Inter-regional maize trade is thus of great importance due to the presence of few surplus and many deficit regions. Average annual maize production is 2.5 million tons and the 6 surplus regions contribute 50 to 62 percent of the country's production. The Marketing Development Bureau estimates the marketable surplus of maize to be 25 percent. The national food stock is known as the Strategic Grain Reserve (SGR) and operates under the supervision of Food Security Department (FSD). SGR has a capacity of 150,000 tons and about 90% of grain stock held is maize. Under the structural adjustment program, the Tanzanian government has made a firm commitment to pursue market oriented development that places clear restrictions on government intervention in the market by setting prices or other means except in a very limited situation, where SGR is used to avert a food security crisis (World Bank, 1995).

During a nationwide maize shortage, the deficit is covered by release of stock or food imports. Such a deficit is sporadic but usually occurs in intervals of 4 or 5 years, and causes a serious food security problem. The objective of this paper is to analyze the degree of integration among geographically dispersed maize markets in Tanzania with a focus on the impact of Dar es Salaam and Mwanza prices on other markets¹⁾. If markets are integrated, the maize supply stabilization program could focus on these two major markets so as to reduce cost. If on the other hand markets are segmented, such a countrywide food market intervention policy would be irrelevant and hence separate regional policies would be recommended. The hypotheses to be tested are as follows:

- a) Dar es Salaam and Mwanza are focal points of maize price formation in Tanzania.
- b) The inter-regional maize market is integrated in such a way that price changes in the maize price focal markets are transmitted to other markets.

2. The Geographical Flow of Maize in Tanzania: Hypothesized Spatial Price Relationships

A maize market is characterized by a large number of small traders who operate from both production and deficit markets in rural or urban areas. Maize traders rarely own means of transport. Usually two or more traders hire a private truck and share transport costs among themselves. Some traders team up and hire a rail wagon. A number of studies have indicated that transport cost accounts for over 50 percent of marketing costs and could be as high as 70 percent in areas with poor roads.

It can be hypothesized that the cities of Dar es Salaam and Mwanza are the major focal points for maize price formation in Tanzania for a number of reasons. One, Dar es Salaam is the largest urban center in the country with a population of about 3 million people. Two, the city relies entirely on maize from other regions or through imports during nationwide deficit. Three, Dar es Salaam port is the largest import and export site for maize. Furthermore, the city has the highest per capita income, which denotes an effective demand. And lastly, major livestock feed industries and some breweries located in Dar es Salaam add to the total demand for maize.

Mwanza is the second largest city, with its port strategically located in Lake Victoria. This makes it an easy connection to the Mara and Kagera regions and two neighboring countries, Kenya and Uganda. These factors are expected to have a significant influence on the inland maize prices. Aside from the two major consumption markets of Dar es Salaam and Mwanza, there is a maize trade among other regions as indicated by previous studies (Figure 1). It should be noted that the Tabora and Morogoro markets are not located in maize surplus areas, but their strategic location at the intersection of major trade routes, have led to the development of a secondary maize trade with neighboring regions. Aside from the inter-regional trade, some studies have revealed a significant trade along border regions with neighboring countries.

Figure 1. Tanzania: Roads and Railways Network Showing the Geographical Flow of Maize

3. Methodology

3.1 Bivariate Correlation

An early pioneer of this method is Blyn (1973). High price correlation between markets is assumed to be an indication for integration and the reverse for segmentation. This method suffers a number of shortfalls as discussed by Harris (1979). Markets may not trade with each other at all but their prices could be highly correlated via a common destination market or due to common factors influencing prices such as similar climatic patterns. Correlation may also fail to capture the time lag in price transmission. In spite of these shortfalls, the method has been used for preliminary analysis in conjunction with other methods.

3.2 The Ravallion Model

The Ravallion (1986) model has been widely applied, modified, and discussed in recent analyses of market integration (Webb, 1992; Broun, 1991). In reviewing various methods of assessing market integration, de Janvry and Sadoulet, consider the Ravallion model as the most powerful. The Ravallion model considers a radial distribution of markets where one central (reference) market with price R , is related to n feeder (regional) markets. The model of spatial price determination is thus:

- (1) $R = f(P_1, \dots, P_n, X)$ and
- (2) $P_i = f_i(R, X_i)$ for $i = 1, \dots, n$

Where there are n regional markets with prices P_i and R is the reference market price. X_i is a vector for other exogenous variables which might influence price for-

mation in market i , such as seasonal changes and government policy. Since equation (1) can be easily under-identified, Ravallion concentrates on the equation (2). The dynamic form of equation (2) with l lags is thus;

$$(2.1) \quad P_t = \sum_{j=1}^l \alpha_j P_{t-j} + \sum_{j=0}^l \beta_j R_{t-j} + \gamma X_t + e_t$$

Estimation of the equation (2.1) can lead to testing of the following hypotheses about market integration:

Segmentation of a Supplier Market: present and past reference market price do not influence the regional market price.

$$(2.1.1) \quad \beta_j = 0, j = 1, \dots, l.$$

Short Run Market Integration: a price increase in the reference market is fully and immediately passed on to the regional market without lagged effects.

$$(2.1.2) \quad \beta_0 = 1, \beta_j = \alpha_j = 0, j = 1, \dots, l.$$

Long Run Market Integration: Under a long run equilibrium, over time, a permanent price change in the reference market is fully passed to the regional market but potentially through lagged effects. Ravallion defines a long run equilibrium as a situation where prices are constant over time undisturbed by local stochastic effect. Solving equation (2) for the long run equilibrium change dP due to a change dR in the reference market gives²⁾:

$$(2.1.3) \quad 1 - \sum \alpha_j = \sum \beta_j \quad \text{or} \quad (2.1.4) \quad \sum \alpha_j + \sum \beta_j = 1$$

It was Timmer (1987) who modified this model and introduced the use of log prices rather than absolute values. In the first difference equation, regression coefficients (right hand side terms of the equation) are interpreted as percentages rather than as absolute values since $\log a - \log b = \log \frac{a}{b}$. A dynamic model for equation (2.1) with one period lag as proposed by Timmer is given as;

$$(3) \quad P_t = \alpha_0 + \alpha_1 P_{t-1} + \beta_0 R_t + \beta_1 R_{t-1} + \gamma X_t + e_t$$

But equation (3) is susceptible to multicollinearity when regional and reference market prices are highly correlated. Estimation in the first difference reduces the severity of multicollinearity since $(R_t - R_{t-1})$ and $(P_t - P_{t-1})$ are less correlated than R_t and P_t .

To transform equation (3) into first difference: subtract P_{t-1} from both sides

$$(3.1) \quad P_t - P_{t-1} = \alpha_0 + (\alpha_1 - 1)P_{t-1} + \beta_0 R_t + \beta_1 R_{t-1} + \gamma X_t$$

$$+ e_t$$

Add and subtract $\beta_0 R_{t-1}$ on the right hand side of the equation

$$(3.2) \quad P_t - P_{t-1} = \alpha_0 + (\alpha_1 - 1)P_{t-1} + \beta_0(R_t - R_{t-1}) + (\beta_0 + \beta_1)R_{t-1} + \gamma X_t + e_t$$

Add and subtract $(\alpha_1 - 1)R_{t-1}$ on the right hand side of the equation

$$(3.3) \quad P_t - P_{t-1} = \alpha_0 + (\alpha_1 - 1)(P_{t-1} - R_{t-1}) + \beta_0(R_t - R_{t-1}) + (\beta_0 + \beta_1 + \alpha_1 - 1)R_{t-1} + \gamma X_t + e_t$$

The model can be written as the first difference as follows;

$$(4) \quad P_t - P_{t-1} = d_0 + d_1(P_{t-1} - R_{t-1}) + d_2(R_t - R_{t-1}) + d_3 R_{t-1} + d_4 X_t + e_t$$

Where; $d_0 = \alpha_0$, $d_1 = \alpha_1 - 1$, $d_2 = \beta_0$, $d_3 = \beta_0 + \beta_1 + \alpha_1 - 1$ and $d_4 = \gamma$.

The above equation can be clearly rearranged for a clearer interpretation such that;

$$(5) \quad P_t = d_0 + (1 + d_1)P_{t-1} + d_2(R_t - R_{t-1}) + (d_3 - d_1)R_{t-1} + d_4 X_t + e_t$$

Where; P_t = the logarithm of the regional market for month t ; R_t = the logarithm of the reference market for month t ; X_t = a matrix of exogenous seasonal, regional or other variables that might influence regional price formation independent of the reference market, d_i = estimated parameters, and e_t = random error term. The tests for market integration are then: Market Segmentation: $\beta_0 = \beta_1 = 0$. Short-run market integration: $\beta_0 = 1$, $\beta_1 = \alpha_1 = 0$. Long-run market integration: $\alpha_1 + \beta_0 + \beta_1 - 1 = 0$.

With one lag³⁾ and without x variables⁴⁾, Timmer suggested an index of market connectedness (IMC) defined as the ratio of the regional market coefficient (α_i) to the reference market coefficient (β_i). That is:

$$(6) \quad IMC = \frac{\alpha_1}{\beta_0 + \beta_1} \quad \text{but } d_1 = \alpha_1 - 1, \text{ thus,}$$

$$(6.1) \quad \alpha_1 = 1 + d_1. \quad \text{since } d_3 = \beta_0 + \beta_1 + \alpha_1 - 1 \text{ and } d_1 = \alpha_1 - 1, \text{ therefore,}$$

$$(6.2) \quad d_3 = \beta_0 + \beta_1 + d_1 \text{ or } \beta_0 + \beta_1 = d_3 - d_1; \text{ thus}$$

$$(6.3) \quad IMC = \frac{1 + d_1}{d_3 - d_1}.$$

IMC indicates the contribution of the regional market and the reference market past prices on current regional prices. IMC with values of less than one is an indication for short-run integration. Also, Timmer shows that d_2 is a measure of the degree to which the

price change in the reference market is transmitted to the regional market. This parameter measures long run market integration and its value which is expected to be equal or close to 1. The difference between these two indicators is that d_2 shows what percentage of the price change in the reference market is transmitted to the regional market price, whereas IMC indicates the relative percentages of the current regional price that are originating from regional market and reference market past prices⁵⁾.

3.3 Model Application and Estimation Procedure

Food prices in Tanzania are collected by the Marketing Development Bureau (MDB) from 44 urban and rural markets. These are weekly retail prices which are reported in radio, newspapers, etc. The series, aggregated on a monthly basis, was obtained from the MDB data base and runs from September 1991 to April 1996; there are 56 observations for each market. All prices are quoted in Tanzanian Shillings per Kilogram (Tsh./Kg). Ten markets, as shown in Figure 1, were selected as representative of various agro-ecological zones and are included in the analysis. The indicated maize market trade relationships were identified from previous studies. Since the series suffers from some gaps, in order to make it possible to run the lag model, missing values were generated from the data time series procedure in Statistical Analysis System (SAS) program which takes into account the time factor⁶⁾. To eliminate the effect of inflation, which according to Alderman (1993) can make prices look integrated. The price series was deflated by using the consumer's price index (CPI). Equation (4) was estimated for each

of the 17 pairs of trading markets (figure 1). All regressions were run using the SAS program. As mentioned earlier, since Tanzania adopted market oriented development, market interventions are restricted, therefore no policy variable has been included in this analysis. Also, the author's experience and literature do not show any strong evidence of social factors likely to influence market integration in Tanzania hence social variables were not analyzed.

4. Results and Discussion

4.1 Mean Prices

Average monthly real prices (deflated by CPI) for maize in 10 selected markets across Tanzania are displayed in Table 1. For the period from September 1991 to April 1996, the highest average price is observed in Dar es Salaam market followed by Mwanza. A remarkable trend was that prices declined the further the market was from these two highest price markets. For example, in Dar es Salaam the average maize price per Kilogram is 0.963 Shillings, whereas the Morogoro market which is about 193 Km away, has an average price of 0.87 Shillings. As distance increases to the Iringa (503 Km) and Mbeya (893 Km) markets, the price drops to 0.835 and 0.701 Shillings per Kilogram, respectively. A similar pattern is evident for Mwanza and its trading markets, Tabora and Mbeya. Such price patterns support the hypothesis that Dar es Salaam and Mwanza are focal points of maize price formation in the Eastern and Western zones of Tanzania, respectively. The lowest maize price was observed in the Njombe market. Njombe is

Table 1. Tanzania: Average Monthly Real Price of Maize in Selected Trading Markets, September 1991 to April 1996

Market	Mean Price Tsh/Kg	Coeff. of Variation	Months (n)
Dar es Salaam	0.963	0.173	56
Morogoro	0.870	0.216	53
Iringa	0.835	0.198	54
Mbeya	0.701	0.154	53
Njombe	0.583	0.259	53
Tanga	0.862	0.316	52
Arusha	0.894	0.314	52
Mwanza	0.932	0.310	52
Tabora	0.778	0.360	51
Kasulu	0.656	0.353	46

Source: Calculated from the Marketing Development Bureau price data.

Figure 2. Maize price (in 1/100Tsh) per kg along Dar es Salaam-Mbeya market channel

Figure 3. Maize price (in 1/100Tsh) per kg along Mwanza-Mbeya market channel

located in the center of the country's maize surplus area of Southern Highlands. However, the low price in

Kasulu seems to stem from different reasons since it is located in a maize deficit zone. The most probable reason is a lack of effective demand. The Kigoma region where Kasulu is located is one of the 6 poorest among the 20 regions of Tanzania (World Bank 1995). For that reason, cassava is an alternative source of energy.

4.2 Spatial Price Differential and Bivariate Correlation

For a pair of trading markets, the spatial price differential is not expected to be zero, due to marketing costs of which the most important is transport cost. Average monthly spatial price differentials for maize markets are shown in Table 2⁷. The effect of distance on prices is evident as spatial price differential increases with distance. For instance, the magnitude of spatial price differential for Dar es Salaam with its trading markets in; Morogoro, Iringa and Mbeya, increases in the same order with distance. A similar trend is observed for Dar es Salaam with Arusha and Tanga. For the Mwanza market in the west zone, the distance effect is seen as the price differential increases from Tabora to Mbeya. The negative sign in some trading markets may be due to the failure of this method to capture time lag which may exist during price transmission. Coefficient of variation for the spa-

Table 2. Tanzania: Average monthly Real Price Differentials and Correlations Among Maize Trading Markets, September 1991 to April 1996

Market Channel	Road Distance (Km)	Mean Price Difference (Tsh/Kg)	Coeff. of Variation	Correlation	n	Railway (l=linked or near nl=not linked)	Road (condition p=paved np=not paved)
Morogoro-Dar es Salaam	193	0.102	1.304	0.717	53	l	p
Iringa-Dar es Salaam	503	0.135	1.015	0.643	51	nl	p
Mbeya-Dar es Salaam	893	0.270	0.493	0.575	53	l	p
Njombe-Dar es Salaam	722	0.380	0.342	0.683	53	l, near	p
Arusha-Dar es Salaam	649	0.074	2.365	0.821	52	l	p
Iringa-Morogoro	310	0.045	3.356	0.643	51	nl	p
Mbeya-Morogoro	700	0.183	0.678	0.749	50	nl	p
Njombe-Morogoro	505	0.287	0.557	0.574	50	nl	p
Tabora-Mwanza	363	0.162	1.111	0.802	47	l	np
Arusha-Mwanza	826	0.024	11.292	0.528	49	nl	np
Mbeya-Mwanza	1363	0.239	1.084	0.464	49	nl	np
Mbeya-Kasulu	1329	-0.028	7.429	0.458	43	nl	np
Tabora-Kasulu	360	-0.129	1.736	0.668	43	l, near	np
Mbeya-Tabora	1242	0.096	2.520	0.515	48	nl	np
Arusha-Tanga	435	-0.038	3.921	0.859	49	l	p
Tabora-Dar es Salaam	1078	0.183	1.143	0.630	51	l	np
Tabora-Morogoro	885	0.087	2.611	0.560	48	l	np

Source: Calculated from the Marketing Development Bureau price data.

tial price differential may shed some light on the degree of market integration as it indicates the stability of margins. Integrated markets are expected to have stable margins (spatial price differential) since prices move together as the local market is influenced by the reference market price. The limitation of this method is when lags in price transmission exist. Among the market pairs analyzed, Arusha-Mwanza and Mbeya-Kasulu have unusually large coefficients thus suggesting that they may not be integrated. These two market pairs are the worst linked in terms of transportation infrastructure, with neither paved roads nor railways.

Bivariate correlation seems to be inversely related to distance, thus confirming the importance of transport cost in market integration (Table 2). A similar trend to the one observed earlier exists for Dar es Salaam and Mwanza and their trading markets; where correlation coefficients declines as distance increases. The most highly price correlated market pairs (over 0.80) are Arusha-Dar es Salaam, Tabora-Mwanza and Arusha-Tanga. The least price correlated market pairs (less than 0.50) are Mbeya-Kasulu and Mbeya-Mwanza. Poor transportation infrastructure explains such a weak price correlation in latter markets.

Each of the 10 markets were also correlated with the other 9 markets and results are presented in Table 3. Dar es Salaam and Arusha have the largest average correlation of 0.63 with the other 9 markets. The Kasulu market performs the most poorly with an average correlation of 0.34. High correlation may suggest market integration and the reverse for seg-

mentation. However, due to the deficiencies mentioned earlier, a more rigorous Ravallion model was applied to test the hypothesis for market integration.

4.3 Empirical Results-Ravallion Model Application

Results for the estimated market integration model from equation (4) are displayed in Table 4. The Durbin-Watson statistics are significant in all equations which signify absence of serial correlations. When the model is re-estimated from equation (5), the Adjusted R^2 s range is from 0.60 to 0.93 which confirms a reasonably good statistical performance. After model validation, then the hypothesis for market integration can be tested.

This paper follows Timmer's procedure in estimating equation (4) of the model instead of equation (5) as some market analysts have done. For comparison, when equation (5) was estimated, it yielded d_2 and IMC values similar to those of equation (4) but with more explicit (higher) R^2 s.

The coefficient d_2 indicates market segmentation when it is insignificant, which implies that a price change observed in the reference market ($R_t - R_{t-1}$) in the past month (1 lag) was not reflected in the current local price change ($P_t - P_{t-1}$). Among the 17 estimated market pair equations, 6 have statistically insignificant d_2 s. Of the segmented market pairs, Mbeya-Mwanza, Arusha-Mwanza (negative), and Mbeya-Kasulu, are all poorly linked with neither paved roads nor railways. The Mbeya-Dar es Salaam markets seem to be segmented despite a well paved road and a railway line that joins them. Such segmented markets

Table 3. Tanzania: Maize Real Price Correlation Matrix for Selected Trading Markets, September 1991 to April 1996

Market	DA	MR	IR	MB	NJ	TN	AR	MW	TB	KS
Dar es Salaam (DA)	1.00									
Morogoro (MR)	0.72	1.00								
Iringa (IR)	0.66	0.64	1.00							
Mbeya (MB)	0.57	0.75	0.80	1.00						
Njombe (NJ)	0.68	0.57	0.62	0.57	1.00					
Tanga (TN)	0.73	0.74	0.72	0.67	0.78	1.00				
Arusha (AR)	0.82	0.63	0.78	0.61	0.77	0.86	1.00			
Mwanza (MW)	0.66	0.52	0.32 ^a	0.46	0.33 ^a	0.42	0.53	1.00		
Tabora (TB)	0.63	0.56	0.50	0.52	0.25 ^b	0.40	0.55	0.80	1.00	
Kasulu (KS)	0.27 ^b	0.32 ^a	0.30 ^b	0.46	0.10 ^b	0.09	0.19 ^b	0.69	0.67	1.00
Mean Corr. with other 9 markets	0.63	0.61	0.59	0.60	0.52	0.60	0.63	0.53	0.54	0.34

Source: Calculated from the Marketing Development Bureau price data.

The ^a and ^b superscripts indicate statistical insignificance at probability level 5% and 1%, respectively.

Table 4. Regression Coefficients for Test of Market Connection-equation 5 (n=56)

Market Channel		Independent Variables (t-stat in brackets)				Adj. R ²	D.W
Local	Reference	Intercept	$P_{t-1} - R_{t-1}$	$R_t - R_{t-1}$	R_{t-1}		
Morogoro	Dar es Salaam	-0.051** (-2.065)	-0.434** (-3.514)	0.308** (2.030)	-0.074 (-0.675)	0.162	1.816*
Iringa	Dar es Salaam	-0.047* (-2.229)	-0.280** (-2.979)	0.244* (2.123)	-0.010 (-0.126)	0.124	1.701*
Mbeya	Dar es Salaam	-0.088* (-2.322)	-0.261** (-2.531)	0.165 (1.609)	-0.129 (-1.534)	0.080	1.476*
Njombe	Dar es Salaam	-0.208** (-3.762)	-0.406** (-4.124)	0.294* (1.954)	0.095 (0.838)	0.236	1.442*
Arusha	Dar es Salaam	-0.029** (-1.739)	-0.314** (-3.655)	0.338* (2.675)	0.212* (2.162)	0.182	1.629*
Iringa	Morogoro	-0.018 (-0.950)	-0.256** (-3.012)	0.274** (2.790)	-0.026 (-0.367)	0.181	1.774*
Mbeya	Morogoro	-0.105** (-3.141)	-0.404** (-3.720)	0.298** (3.616)	-0.137* (-1.926)	0.263	1.484*
Njombe	Morogoro	-0.118* (-2.353)	-0.286** (-3.115)	0.313* (2.198)	-0.003 (-0.030)	0.191	1.559*
Tabora	Mwanza	-0.093** (-3.133)	-0.528** (-5.268)	0.283* (1.877)	-0.053 (-0.780)	0.360	1.966*
Arusha	Mwanza	-0.016 (-0.926)	-0.164** (-2.734)	-0.040 (-0.350)	-0.016 (-0.271)	0.100	1.633*
Mbeya	Mwanza	-0.085* (-2.492)	-0.281** (-3.128)	0.104 (1.149)	-0.132* (-1.671)	0.222	1.574*
Tabora	Kasulu	0.062 (1.446)	-0.302** (-3.701)	0.176** (1.982)	0.024 (0.298)	0.199	1.964*
Mbeya	Kasulu	-0.026 (-0.807)	-0.255** (-3.251)	0.044 (0.984)	-0.114 (-1.494)	0.212	1.777*
Mbeya	Tabora	-0.047 (-1.546)	-0.227* (-2.607)	0.193** (3.031)	-0.116 (-1.535)	0.261	1.601*
Arusha	Tanga	0.025* (1.769)	-0.364** (-5.387)	0.399** (5.428)	0.068* (1.674)	0.529	2.208*
Tabora	Dar es Salaam	-0.056 (1.565)	-0.222 (-2.094)*	0.153 (0.695)	0.012 (0.074)	0.035	1.872*
Tabora	Morogoro	-0.043 (-1.251)	-0.167 (-1.778)*	0.292 (1.532)	-0.109 (-0.865)	0.060	1.972

Source: Estimated from the Marketing Development Bureau price data.

The superscripts * and ** indicate statistical significance at 1% and 5% probability levels, respectively.

may be explained by the long distance between the source and destination market. The presence of two maize surplus markets Iringa and Njombe which are much closer to Dar es Salaam may also weaken the price relationship between the latter market and Mbeya. Also, availability of alternative markets for Mbeya in the west zone (Tabora and Kigoma) and in the maize deficit markets of a neighboring country, Zambia may have contributed to such a weak price relationship. However, integration in some seasons or when there is insufficient maize supply from other sources cannot be ruled out (not tested here). The MDB also noted that after the liberalization of food grain trade and the removal of government subsidy to its parastatal such as National Milling Corporation, there has been a change in source of grains supplied to Dar es Salaam, with less grain being brought from

distant markets such as Mbeya. Other, segmented markets are Tabora-Dar es Salaam and Tabora-Morogoro. Long distances between the markets seems to be a major factor in segmentation of the latter markets. In spite of a poor road between Tabora and Mbeya, the markets are not segmented. The strong demand for maize in Mwanza, seems to create a derived demand for Mbeya maize in Tabora. As mentioned previously, Mwanza's large population and its port which gives it easy access to other potential markets is likely to create a high demand for maize. However, Mwanza is not directly integrated with Mbeya which may be explained by distance.

Table 5 takes into consideration Timmer's suggested yardstick for measuring the degree of market integration. d_2 measures the long run integration. For integrated markets the coefficient is expected have a

Table 5. Integration of Maize Markets in Tanzania From Analysis of Real Prices, September 1991 to April 1996

Market Channel		Market Integration Indicators	
Local	Reference	Long Run Integration, d_2	Short Run Connection, IMC
Morogoro	Dar es Salam	0.31*	1.58
Iringa	Dar es Salam	0.24*	2.67
Mbeya	Dar es Salam	0.16	5.69
Njombe	Dar es Salam	0.29*	1.18
Arusha	Dar es Salam	0.34**	1.30
Iringa	Morogoro	0.27**	3.08
Mbeya	Morogoro	0.30**	2.23
Njombe	Morogoro	0.31*	2.45
Tabora	Mwanza	0.28*	0.81
Arusha	Mwanza	-0.04	5.61
Mbeya	Mwanza	0.10	4.80.
Tabora	Kasulu	0.18*	2.14
Mbeya	Kasulu	0.04	5.32
Mbeya	Tabora	0.19**	7.00
Arusha	Tanga	0.40**	2.21
Tabora	Dar es Salam	0.153	3.279
Tabora	Dar es Salam	0.292	14.362

Source: Derived from table number 4. Last column is calculated from equation number 6.

The superscripts * and ** indicate statistical significance at probability levels 1% and 5%, respectively.

value close or equal to 1. That is, a given percentage change in the reference market price is exactly transferred to a regional market causing its price to change by the same percentage. According to Timmer, d_2 reflects the structure of marketing costs. None of the estimated equations have a unitary d_2 which suggests that markets are not perfectly integrated in the long run. That is, a maize market is not efficient in transmitting all the price change from reference to the regional market. An alternative explanation could be that it takes more than one month for long run price change to be reflected in the regional markets. Markets with d_2 far from 1 are Tabora-Mbeya and Kasulu-Tabora. Market pair with values just above 0.3 are Morogoro-Dar es Salam, Arusha-Dar es Salam, Njombe-Morogoro, and Arusha-Tanga. Also, it is noteworthy that Adjusted- R^2 decreases with distance.

IMC which is the ratio between regional market parameter (α_i) and reference market parameter (β_i) measures the degree of short-run connection. An IMC value of greater than 1 implies poor connections across markets, therefore, it is the past regional price dominating the current price situation. When the IMC is less than 1, then it is the reference market dominating regional price formation and it is said the markets are well connected. Following this criteria, a

strong market connection is found only between Tabora and Mwanza with an IMC of 0.81. Market pairs with an IMC close to 1 are Morogoro-Dar es Salaam, Njombe-Dar es Salaam, Arusha-Dar es Salaam and Arusha-Tanga. Distance, price (arising from demand), and infrastructure quality seem to account for the observed variation in the degree of market connection. As mentioned previously, there is a secondary maize trade in Morogoro and Tabora, due to their strategic location on major trade routes. Market pairs that perform well in both long and short run integration are Arusha-Dar es Salaam and Morogoro-Dar es Salaam (Appendix 1)⁸. Poorly performing markets in both the long and short run are Iringa-Morogoro, Iringa-Dar es Salaam and Mbeya-Tabora. Other markets do not show a strong relationship between long and short-run⁹.

5. Conclusions and Policy Implications

Maize is Tanzania's staple, contributing about 42% of the population's dietary calories. Of the country's 20 regions, only 6 are regular maize surplus producers hence inter-regional trade from surplus to deficit areas is of great importance. During a nationwide maize shortage, the deficit is covered by the release of stock or food imports. Such a deficit is sporadic but usually

occurs in intervals of 4 or 5 years and causes a serious food security problem. This paper applies the Ravallion model to test the degree of maize market integration in Tanzania with a focus on assessing the feasibility of reducing the cost of the food market intervention policy by focusing on two major markets Dar es Salaam and Mwanza. If markets are integrated, the impact of price changes due to maize imports or stock release to the two major markets, would be transmitted to other markets and cause supply in the inter-regional trade to adjust accordingly. Otherwise, costly separate regional market intervention policies would be required. The hypotheses that two major markets, Dar es Salaam and Mwanza, are focal points of the inter-regional maize trade price formation in the Tanzania and that their prices are integrated with those of other markets was tested.

The analysis identified segmented and moderately integrated markets. Two major factors, quality of transportation infrastructure (roads and railways) and distance between local (regional) and reference (destination) markets, are identified as influencing the degree of integration. Figure 4 summarizes the model results. Among the factors mentioned above, transportation infrastructure quality is the most important. Of the 17 hypothesized trading market pairs, the Ravallion model identifies 6 pairs to be segmented. Three of the segmented market pairs which are Arusha-Mwanza, Mbeya-Kasulu, and Mbeya-Mwanza, are poorly linked with neither paved roads nor railways. Other segmented market pairs, most likely due to long distance between them are Mbeya-Dar es Salaam, Tabora-Dar es Salaam and Tabora-Morogoro.

Segmented markets have a statistically insignificant indicator for long run market integration, d_2 , which shows that price in the reference market is not transmitted to the regional market. That is to say, the maize price change in the regional market is independent from price change in the reference market. The short run market integration indicator, IMC, which shows the relative contribution of regional and reference market prices to regional price change, indicates that markets are well connected where there is a quality transportation infrastructure.

Figure 4. Estimated degree of integration in maize markets in Tanzania

Following Timmer's suggested yardstick, a strong market connection is found between Mwanza and Tabora. Other moderately connected markets are Morogoro-Dar es Salaam, Njombe-Dar es Salaam, Arusha-Dar es Salaam and Arusha-Tanga. The effect of distance is evident where magnitudes of model indicators, d_2 and IMC, vary with distance. For example, in the maize market channel Morogoro-Dar es Salaam d_2 is closer to 1 but as distance increases to Iringa its value declines (further from 1). As distance increases further to Mbeya, d_2 becomes statistically insignificant thus signifying market segmentation. In this case, the effect of infrastructure quality is ruled out, as the markets are linked with both a paved road, and railway. Also, the IMC exhibits a similar trend where its value increases with distance (further from 1). Mwanza-Tabora-Mbeya channels show a similar distance-effect where Mwanza is segmented from Mbeya but with a significant d_2 with Tabora. In this case, both distance and transportation infrastruc-

ture quality seem to play a role. Results also confirm the importance of Dar es Salaam and Mwanza as focal points of price formation in Eastern and Western zones, respectively. The magnitudes of the Ravallion model indicators for market integration, d_2 and IMC change with distance from these markers. Whereas d_2 and R^2 decline, the IMC increases the further the market is away from Dar es Salaam or Mwanza. Average prices and bivariate correlation coefficients decline as distances from these markets increase. From the reasons given previously, high demand in these markets leads to high maize price which in turn creates a large price differential in the regional markets. Parameter estimates for this study are quite close to those of similar studies. For instance, the IMC ranges from 0.81 to 7 while d_2 is from 0.04 to 0.40. Timmer's estimates for Indonesia's corn markets are 0.54–5.50 for IMC and 0.235–1.144 for d_2 which indicate more integrated markets than in the Tanzania's case. This is quite logical since Indonesia has a more developed transportation infrastructure. Sahn's (1996) estimates for Ghana's food grain are 0.23–11.75 for IMC and 0.051–1.23 for d_2 .

From this study it can be implied that a food market intervention policy focusing on two major markets, Dar es Salaam and Mwanza would not be sufficient to stabilize maize supply on a nationwide inter-regional scale since some markets are segmented or have weak integration. Therefore a number of policy implications can be drawn in order to improve integration of maize markets:

i) Zonal food security policies for a group of integrated markets would reduce supply stabilization cost. From the analysis results, two zones are recommended, the Eastern zone for markets integrated with Dar es Salaam and the Western zone for markets integrated with Mwanza. Since the two markets are focal points of price formation in their respective zones, price change resulting from maize stock release or imports would be transmitted to other markets integrated to them and cause supply to adjust accordingly. However, since some markets are segmented from the maize price focal markets, intervention in the two markets alone would not be sufficient and thus further suggestions are

made.

- ii) Where good transportation infrastructure exists such as in the Mbeya-Dar es Salaam markets, the problem of distance on market integration can be resolved partly by improving economies of scale in maize marketing operations so as to reduce the transportation cost.
- iii) Improvement of transportation infrastructure would reduce transport cost and thus increase the degree of market integration.
- iv) The non-unitary indexes of market integration suggest a need to improve market functions so as to attain spatial competition.

Notes

- 1) At the national level, Tanzania has been food self-sufficient in normal years and has even produced an exportable surplus on some occasions (see MOA., op. Cit., p.1). However, periodically the country has been faced with draughts leading to food shortages. The importance of the market stems from the fact that there are food deficit and surplus areas but the transportation infrastructure and marketing institutions are not well developed in some areas. Before market reforms in the mid 80s, food marketing was facilitated by heavily subsidized state companies. After reforms, the state companies were abolished and subsidies removed to allow for a free market. Since then the issue of market integration has become one of the concern to policy analysts. The major question is whether the current market is capable of adjusting fast enough to allow food to flow to deficit areas in response to price changes before people starve.

$$2) dP = \sum_{j=1}^I \alpha_j dP + \sum_{j=0}^I \beta_j dR \text{ or } dP - \sum_{j=1}^I \alpha_j dP = \sum_{j=0}^I \beta_j dR \text{ Factorize, } dP \left(1 - \sum_{j=1}^I \alpha_j \right) = \sum_{j=0}^I \beta_j dR \text{ or } dP = \frac{\sum_{j=0}^I \beta_j}{1 - \sum_{j=1}^I \alpha_j} dR \text{ or } dP = \frac{\sum_{j=0}^I \beta_j}{1 - \sum_{j=1}^I \alpha_j} dR. \text{ When the term } \frac{\sum_{j=0}^I \beta_j}{1 - \sum_{j=1}^I \alpha_j} = 1, \text{ price change}$$

in the reference market will result in a corresponding price change in the regional market.

- 3) Timmer's model specification with a time lag of 1 period, gives limited information on the functioning of the market. However, calculation of IMC is based on this

assumption. Alternative estimation procedures such as co-integration (See de Janvry *et al.*) can only explain the long run integration.

- 4) Other variables assumed to affect market integration such as government policies, quantities, etc., can be included in the model as x-variables. Such information is not used in this study due to lack of data. However, the model with prices and without x-variables is sufficient and has an advantage of avoiding subjectivity in model specification. See, Mendoza, M.S. and Rosegrant, M.W.
- 5) See Timmer, p.216.
- 6) The price data series run from September 1991 to April 1996 which gives a total 56 months or observations per market. The missing cases for each market can be found in Table 1 (i.e. 56-n).
- 7) Price difference=(Reference market price—Regional market price).
- 8) There are no cut-off points for long run integration and short run connection indexes. However, markets can be compared according to their relative closeness to the baseline which is 1.
- 9) A large value of IMC can occur even when $d_2=1$ (Timmer, p.216), which implies that a pair of markets may be poorly integrated in the short run even when well integrated in the long run.

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Appendix I. Ranking of Markets According to Their Relative Degree of Long Run Integration and Short Run Connection.

Test for Market Segmentation (S=segmented)	Long Run Integration (Rank from strong to weak)	Short Run Connection (Rank from strong to weak)
Arusha—Dar es Salaam	Arusha—Tanga	Tabora—Mwanza
Iringa—Morogoro	Arusha—Dar es Salaam	Njombe—Dar es Salaam
Mbeya—Morogoro	Morogoro—Dar es Salaam	Morogoro—Dar es Salaam
Arusha—Tanga	Njombe—Morogoro	Arusha—Dar es Salaam
Mbeya—Tabora	Mbeya—Morogoro	Tabora—Kasulu
Morogoro—Dar es Salaam	Njombe—Dar es Salaam	Arusha—Tanga
Iringa—Dar es Salaam	Tabora—Mwanza	Mbeya—Morogoro
Njombe—Dar es Salaam	Iringa—Morogoro	Njombe—Morogoro
Njombe—Morogoro	Iringa—Dar es Salaam	Iringa—Dar es Salaam
Tabora—Mwanza	Mbeya—Tabora	Iringa—Morogoro
Tabora—Kasulu	Tabora—Kasulu	Mbeya—Tabora
Mbeya—Mwanza (S)		
Mbeya—Kasulu (S)		
Arusha—Mwanza (S)		
Mbeya—Dar es Salaam (S)		
Tabora—Dar es Salaam (S)		
Tabora—Morogoro (S)		

Source: Derived from Table 5. If d_2 is not statistically significant, the market is segmented and the long run integration and short run connection index are irrelevant, hence excluded.