INTEGRATION IN BENIN MAIZE MARKET: AN APPLICATION OF THRESHOLD COINTEGRATION ANALYSIS

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Summary

Hansen and Seo's multivariate threshold cointegration model is used to characterize integration between selected maize markets in Benin over the period of market liberalization. Observed transaction costs for market pairs are compared with the estimated thresholds obtained from the multivariate model. We find mixed evidence with respect to threshold cointegration.

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1- Introduction

During the period from the 1970s to the 1990s, a number of African countries have maintained a strong interventionist approach with respect to their agricultural marketing policies. Government intervention has consisted mainly of controlling the quantity of grain marketed and the prices received by farm households, the restriction of private traders' participation in trade, and interregional grain movement. In Benin, the government has successively imposed some regulatory controls on the agricultural marketing system through several institutions:

- Office de Commercialisation Agricole du Dahomey (OCAD) in 1967;
- Societe de Commercialisation et de Credit Agricole du Dahomey (SOCAD) in 1970;
- Centre d'Action Regionale pour le Developpement Agricole (CARDER) in 1975;
- Regies d'Approvisionement et de Commercialisation (RAC) in 1976;
- Societe d'Alimentation Generale du Benin (AGB) in 1976;
- Office Nationale des Cereales (ONC) in 1982.

The policies of these regulatory bodies have hampered the development of a free market system.

During the 1990s, in line with the economic reform promoted by the Bretton-Wood institutions, the removal of administrative trade controls and price liberalization, in particular with respect to national food markets, became a prevailing policy in many developing countries. It is assumed that a free-market system will perform better than the more government controlled systems of the past. Following these reforms the Benin government has adopted the liberalization policy under the Structural Adjustment Program (SAP) in close co-operation with the IMF (International Monetary Fund) and the World Bank. The main element of the SAP concerned macroeconomic stabilization measures: reduction of budget deficit, foreign exchange liberalization, privatization and deregulation. The reforms in the food marketing sector have consisted of the abolishment of the cereal marketing board (Office Nationale des Cereales) and the establishment of new institutions responsible for setting a free market environment. The various market reforms have influenced to some extent the grain market development in the country. The maize industry is an extremely important sector of Benin's agricultural economy, and maize is the primary source of food for Benin's population. Hence the impact of market reforms on the marketing performance of the maize industry has always been of particular concern to the Benin Government. To be able to efficiently manage reforms in the maize industry, policy makers need a good understanding of the functioning of markets, price integration between markets, and how those factors relate to changes in the institutional and policy environment of markets. This understanding will allow them to design effective market policies, institutions, and marketing infrastructures required for the development of the maize markets. The present research is intending to analyze the degree of market integration in Benin's maize industry over the post reform period.

2- Statement of the research problem

The economy of Benin is essentially based on agriculture, and maize is the most important food crop. In the south of Benin, maize is the main staple food crop and is largely produced for domestic consumption. Over the year, the maize surpluses are sold on markets by many small-scale farmers. Only a minority of large-scale farmers produce maize as a cash crop. This situation in the North is quite different. Maize is produced as a cash crop and serves as an alternative for cotton which is the main cash crop. Maize usually follows cotton in the crop rotation to benefit from its remaining fertilizing effect.

Maize is marketed by private traders. Small traders and wholesalers, especially women, intervene on local, regional or consumer markets. A smaller group of wholesalers is involved in spatial arbitrage between markets at an inter-regional level.

Before 1990, the Benin government with its former Marxist-Leninist regime has always tried to control and regulate the maize market through some policies which have hampered locally and temporally the development of a free market system (Lutz). In 1990, the free-market system was finally adopted as a result of the economic reforms undertaken within the Structural Adjustment Program (SAP).

Lutz found that over the period of government regulation the maize markets are integrated in the long run but price adjustment are sluggish in the short run and he concluded that the maize markets are not integrated in the short run. He explained this situation by the existence of formal regulation that hamper exchange between surplus and deficit regions and also by the lack of information on market opportunities. Other studies also found that the lack of appropriate information system does not allow the maize market to function efficiently (Fanou, Ahohounkpanzo, Dissou, Soule).

In line with the recommendations set by the liberalization policy reform, the Benin government has established the Market Information System (MIS) that provides information on prices and market conditions to the market agents. The Market Information System functions through the publication of monthly bulletins, posting of the maize prices at different locations on each market place and the broadcasting of prices and market information on several radio stations. It is assumed that the availability of equal and reliable market information for all the market agents will allow the market to perform more efficiently. Moreover, it was assumed that the free-market system would perform more efficiently and enhance market integration compared with the more government-regulated systems of the past. The markets for a homogenous commodity are integrated if their prices move proportionally to each other along time, which means the law of One Price (LOP) holds. According to the Law of One Price, efficient trade and arbitrage activities will ensure that prices in spatially separated markets, once adjusted for exchange rates and transportation costs, will be equalized. Cointegration analysis to test the Law of One Price has been frequently used in academic studies. Recent literature has focused on the influence of transaction costs, seasonality, and threshold effects on tests for integration: Balke and Fomby, Balke and Wohar, Lo and Zivo, Baum et al., Baum and Karasulu, Enders and Falk, Hansen and Seo, Ching-Chung Lin, Goodwin and Piggot. Even though several studies have analyzed maize market integration in Benin, they have all ignored the influence of transaction costs, and threshold effects. Transaction costs represent important features of the marketing system in Benin, and hence have potentially a large influence on the degree of market integration. Ignoring transaction costs, which may inhibit price adjustments, will affect test results and inferences about market integration (Goodwin and Piggot).

After several years of implementation of the free market system, it is of great importance to assess the extent to which it has led to a higher level of market integration. The present study is placed in this context and is intending to analyze the integration of maize markets in Benin with emphasis on transaction costs and threshold effects.

In this paper, we attempt to characterize the integration between markets using the threshold cointegration model. We used the multivariate threshold cointegration model developed by Hansen and Seo. We also applied the empirical univariate threshold model originally developed by Balke and Fomby. Real transaction costs computed between markets pairs are compared with the estimated threshold coefficient obtained from the multivariate model.

The remainder of this paper is organized as follows. In section 1, we first describe the functioning of the maize market in Benin. In section 2 we describe the multivariate threshold cointegration model of Hansen and Seo. Section 3 presents the results and discussion followed by a conclusion.

3- Background on the maize market in Benin

3.1- The Agricultural sector in Benin

Benin is essentially an agricultural country. Its agricultural sector employs almost 71% of the working population (FAO). The main foodstuffs produced are: maize, cassava, yams, sorghum, beans, groundnuts and some rice. According to AGRER, Benin is considered to have a balanced food production. Besides, the food crops production, cotton is the main cash crops. Cotton plays an important role in the economy. Its accounts for 40% of GDP and roughly 80% of official export receipts. Cotton is considered as the main source of income for population of the northern part of the country which produces the majority of this crop.

3.2- The importance of Maize in the Economy and for Consumption

Maize is one of the major crops produced in Benin. Its large number of varieties allows the production under climatic conditions reaching from sub humid to semi-arid.

While maize is grown in all parts of the country, its share in the rotation differs from one region to another depending on the local consumption patterns and comparative advantages of other products. Maize constitutes an important part of daily caloric intake and diet.

Maize is the main staple food crop in the South, but it is considered a cash crop in the North to supply the maize markets in the south and the neighboring countries.

From all the cereals consumed in Benin, maize is the most important. Cereals account for 37% in total calorie intake (FAO) and maize represents 73% of total cereal area (CIMMYT).

3.3- Maize production

Maize production is subject to instability because of the uncertainty associated to rainfall. In the southern and central part of the country, the rainy season starts earlier than in the North. In the south, two periods of rainfall, the main rainy season (March through July) and the shorter rainy season (September through November), are separated by the main dry season (December through February) with a minor dry season in August. In the Northern part of the country, the rainy season only lasts from April to October and the dry season from November until March. As they can benefit from two rainy seasons, the Southern farmers enjoy two maize harvests per year as opposed to their Northern counterparts.

Local varieties of maize are mainly produced since the hybrid varieties are difficult to extend. Climatic hazards, consumer preferences and profitability are not conducive of the production of the hybrid varieties. Some efforts have been made to introduce high yielding varieties in the production but they have not always been adopted by the farmers. The main reasons commonly mentioned by farmers for the non-adoption are: uncertain climatic conditions, consumers' preferences, high net returns risks, cultural or traditional believes, high production costs requirement and the lack of adequate insects' control system.

3.4- Maize marketing

Maize is marketed by a private commercial system. Numerous petty traders and small wholesalers, especially women, intervene on a local and regional scale. A smaller group of wholesalers is involved in spatial arbitrage between markets at an inter-regional level. Due to the importance of maize in the consumption, the maize markets are scattered throughout the country. Transactions take place on market places where buyers and sellers meet and exchange the commodity. The transactions on each market happen according to a regular calendar. On a specific market day, there is a big crowd of buyers, sellers and other agents on the market place. On each market place, a retail and wholesale segment can be distinguished. Lutz found that there is a co-movement between the wholesale prices and the retail price in the same market.

Throughout the country, regional markets serve as a point of reference in price setting for village markets, either formal or informal (Lutz, C.; Pede, O.V.).

3.4.1- The structure of the maize market

3.4.1.1- Typology of markets

They are basically three types of markets:

The local markets: they are located in production region (rural areas). The majority of sellers are maize producers. Farmers bring their maize surpluses which they sell to consumers and local traders. During the harvest period, assemblers, retailers and local wholesalers make up the majority of the buyers whereas during the lean season, consumers, assemblers and retailers are the main buyers of maize. Most of the buyers on the local markets sell or buy their maize at the regional market, to which the local market is highly linked.

The regional markets: they serve as assembly markets by collecting maize from the local markets. Most of the actors on these markets are traders engaged in spatial and temporal arbitrage. Agricultural products and manufactured goods are marketed on those markets. During the harvest period, assemblers and wholesalers purchase maize surpluses from producers and local assemblers. In the lean season, the main agents on these markets are consumers buying from retailers. From the seven maize markets under the present study, four can be considered as regional markets: Azove, Ketou, Glazoue and Nikki.

The consumers markets: they are located in urban areas. Most of the buyers on these markets are consumers or processors. These markets are purely distribution markets where agricultural products and manufactured goods are traded. Several agents operate on consumer markets: wholesalers, retailers, brokers. Three markets under the present study can be considered as consumers markets.

3.4.1.2- The types of agents operating on markets

The collectors: they are also called assemblers. They are in direct contact with producers from whom they buy the maize. They live in the area of production and are not farmers for most of them. They have accurate information about the availability of the commodity. Most of the time, they act on behalf of traders. Their role is to collect the maize from either the farm or village or regional market. They are pre-financed by wholesalers and buy on their instructions. The collectors are paid by the wholesalers at the end of the service.

The retailers: they are in majority located on consumer markets. They buy maize either from wholesalers or directly from producers and sell to consumers and processors at convenient location and times, in various forms and quantities. Few retailers are involved in inter-regional arbitrage mainly for reason of lower capital compared to the wholesalers.

The wholesalers: They buy maize from producers, collectors or other wholesalers from regional markets. Goods are financed and business risks covered by wholesaler themselves. The wholesalers are involved in wholesale trade, and they rarely sell directly to the consumers. Although they are guided by speculation based-profit, they do provide important services such as arbitrage limiting price fluctuation in relation to price and space. There are two types of wholesalers: the small-wholesalers and the large wholesalers. They first purchase maize on the local market and sell back on the regional or consumers markets in the vicinity of their home. The small size of the quantity traded and the capital of operation are the limiting factors for these small wholesalers. The large wholesalers buy from small-wholesalers and collectors and resell through a broker on the urban market. They have the capacity to invest in buying and selling networks. They are able to purchase large quantities which allow economies of scale as fixed marketing costs can be spread out over larger quantities (Lutz). The large wholesalers are the only agent involved in long-distance inter-regional arbitrage. They are very flexible and according to the market supply and demand conditions, they may decide to temporally decrease the volume of their operations.

The brokers: their role is to sell maize to the retailers and consumers on the behalf of wholesalers. They are located on consumer markets and represent the intermediaries who bring together potential buyers and sellers. These intermediaries play an important role in the arbitrage process on the Cotonou and Bohicon markets. The brokers run stores on the market-place and collect a commission on each product sold. They do not invest in trade, nor do they take any price risks.

Traders' associations: Traders associations are informal organizations and they exist on each of the regional markets under the present study. They have been set up on the initiative of traders (not under control by the legal authorities) with the objectives of regulating members' behavior. These organizations remain obscure because of their informal characteristics and the prevailing conflicts of interest. They are mainly based on the interests of traders (mostly wholesalers) living in the markets area. Some of these associations represent important trade barriers for non-resident traders who are often obliged to comply with their rules and instructions. Lutz explained the sluggishness of price adaptation in the short run by the formal regulations of these traders associations, that he thinks hamper exchange between surplus and deficit areas.

3.5- Flows of maize between markets during the year

The flows of maize between markets in a given year vary mainly according to the season. Since the seasons in the south are different from the ones in the north, the maize flows change every quarter of the year. Akker, van den E., provided a description of the maize flows between markets over a year.

During the first quarter of the year (January to March) a large surplus of maize is building up in Northern and Central Benin following the harvest in December / January and a low level of consumption from the local population. At the same period in the south there is a deficit of maize. The situation allows the flows of maize from the north to the south.

In the second quarter (April to June) only two regions in the entire country show a light surplus due to the production of early maturing maize. During this period, the main growing season starts in the South. In line with the dwindling stocks of maize, prices increase, the highest prices can be found in May / June. The trade flows still go from the North to the South, even though the profit margins become smaller.

The third quarter (July to September) is characterized by a surplus of maize in the South and the Center due to the harvest of the first growing season starting in July. In the North, the first quantities are harvested in August / September. The different price levels reflect this situation; while in the South prices reach their lowest level during this period, they are still high in the North. During this period, maize is traded from the South to the North.

During the fourth quarter (October to December), the second harvest comes up in the South while in the Center, maize is still growing on the field. In the North, the harvest goes on until January. During this period, most of the prices reach their lowest level due to relative market saturation in the South (stored quantities of the previous period and harvested quantities). The trade flows are directed from the South to the Center. Trade also happens within the southern markets on one hand and within the northern markets on the other hand.

4- Model

The estimation strategy can be summarized as follows. First in order to determine whether the market price series are stationary, standard Augmented Dickey-Fuller (ADF) unit root test are used. Second, linear cointegration was tested between markets price series using the Engle-Granger test and the multivariate Johansen cointegration model. The tests were carried out for all market pairs. Then Hansen and Seo's bivariate two-regime, threshold vector error-correction model TVECM, is used to test for non-linear cointegration among all market pairs. Intuitively the two-regime TVECM allows us to characterize a trading environment in which trade between spatially separated markets only occurs when relative price differences exceed some level of transaction costs. In this case, which we will refer to as the a-typical regime, trade will promote market integration and induce price movements and responses between markets. In this sense markets may be cointegrated within this a-typical regime. The typical regime occurs when relative price differences between markets are less than transaction costs. In this case there is no incentive to trade and price movements between markets and within the transaction cost band will be unrelated. In other words the markets will not be cointegrated.

Let x_t be a two-dimensional vector of price series. If the price series are both I(1) and we assume that there is a long term relationship between the two price series with cointegrating vector β, the Vector Error Correction Model (VECM) of order *l+1* can be written as followed:

(1) $\Delta x_t = A' X_{t-1}(\beta) + u_t$

Where

$$X_{t-1}(\beta) = \begin{pmatrix} 1 \\ w_{t-1}(\beta) \\ \Delta x_{t-1} \\ \Delta x_{t-2} \\ . \\ . \\ \Delta x_{t-l} \end{pmatrix}$$

The regressor $X_{t-1}(\beta)$ is k x 1 and A is k x 2 where k = $2l + 2$. The error term u_t is assumed to be a vector martingale difference sequence (MDS) with finite covariance matrix $\sum = E(u_t u_t')$. The term w_{t-1}, represents the error correction term obtained from the estimated long term relationship between the two market price series.

The parameters (β, A, $\sum$) are estimated by maximum likelihood under the assumption that the errors u_t are iid Gaussian.

The representation of the VECM with a two-regime threshold is given as:

$$\Delta x_t = \begin{cases} A_1' X_{t-1} + u_t, & \text{if } w_{t-1} \leq \gamma \\ A_2' X_{t-1} + u_t, & \text{if } w_{t-1} > \gamma, \end{cases}$$

where γ represents the threshold parameter. This model may also be written as

(2) $\Delta x_t = A_1' X_{t-1}(\beta) d_{1t}(\beta, \gamma) + A_2' X_{t-1}(\beta) d_{2t}(\beta, \gamma) + u_t$

where

$d_{1t}(\beta, \gamma) = 1\ (if\ w_{t-1} \leq \gamma)$

$d_{2t}(\beta, \gamma) = 1\ (if\ w_{t-1} > \gamma)$

and 1(.) denotes the indicator function.

The above model is a threshold cointegration model with two regimes. The coefficient A_1 and A_2 govern the dynamics in these regimes. Values of the error-correction term w_{t-1}, in relation to the level of the threshold parameter γ, (in other words whether w_{t-1} is above or below γ) allow all coefficients – except the cointegrating vector β – to switch between these two regimes.

Threshold effects exist if: $0 < P(w_{t-1} \leq \gamma) < 1$, otherwise the model reduces to a linear cointegration form. This constraint is imposed in model estimation by assuming that $\pi_0 \leq P(w_{t-1} \leq \gamma) \leq 1- \pi_0$, where $\pi_0 > 0$ is a trimming parameter. π_0 is set equal to 0.05 in the empirical estimation.

Assuming errors u_t are iid Gaussian, the likelihood function of the model in equation (2) is:

$$Ln(A_1, A_2, \Sigma, \beta, \gamma) = -\frac{n}{2}\log|\Sigma| - \frac{1}{2}\sum_{t=1}^{n} u_t(A_1, A_2, \beta, \gamma)' \sum^{-1} u_t(A_1, A_2, \beta, \gamma)$$

where $u_t(A_1, A_2, \beta, \gamma) = \Delta x_t - A_1' X_{t-1}(\beta) d_{1t}(\beta, \gamma) - A_2' X_{t-1}(\beta) d_{2t}(\beta, \gamma)$

Following Hansen and Seo (2002), the maximum likelihood estimates (MLE) of A_1, A_2, β, γ are obtained by maximizing $Ln(A_1, A_2, \Sigma, \beta, \gamma)$. This is achieved by first holding (β, γ) fixed, and computing the constrained MLE for (A_1, A_2, ∑) using OLS regression.

$$\hat{A}_1(\beta, \gamma) = \left(\sum_{t=1}^{n} X_{t-1}(\beta) X_{t-1}(\beta)' d_{1t}(\beta, \gamma) \right)^{-1} \left(\sum_{t=1}^{n} X_{t-1}(\beta) \Delta x_t' d_{1t}(\beta, \gamma) \right)$$

$$\hat{A}_2(\beta, \gamma) = \left(\sum_{t=1}^{n} X_{t-1}(\beta) X_{t-1}(\beta)' d_{2t}(\beta, \gamma) \right)^{-1} \left(\sum_{t=1}^{n} X_{t-1}(\beta) \Delta x_t' d_{2t}(\beta, \gamma) \right)$$

$$\hat{u}_t(\beta,\gamma) = u_t\left(\hat{A}_1(\beta,\gamma), \hat{A}_2(\beta,\gamma), \beta, \gamma\right) \text{ and}$$

$$\hat{\Sigma}(\beta,\gamma) = \frac{1}{n}\sum \hat{u}_t(\beta,\gamma)\hat{u}_t(\beta,\gamma)'$$

After A_1, A_2 and $\sum$ have been estimated, the MLE of β and γ are obtained by minimizing log $|\sum(\beta, \gamma)|$ subject to the constraint: $\pi_0 \leq P(w_{t-1} \leq \gamma) \leq 1 - \pi_0$.

A grid search algorithm is used to obtain the MLE estimates of β and γ. The grid search procedure requires a region over which to search. To this end, two confidence intervals $[\gamma_L, \gamma_U]$ and $[\beta_L, \beta_U]$ are constructed for γ and β respectively. The notation L and U represent respectively lower and upper values. The grid search over (γ, β) examines all pairs (γ, β) on the grids on $[\gamma_L, \gamma_U]$ and $[\beta_L, \beta_U]$ subject to the constraint: $\pi_0 \leq P(w_{t-1} \leq \gamma) \leq 1 - \pi_0$. In the empirical application the grid search procedure is carried out with 200 gridpoints.

Once β and γ have been estimated, we proceed to test for the presence of threshold cointegration. We use the Lagrange multiplier (SupLM) test developed by Hansen and Seo (2002), where the null hypothesis of linear cointegration is tested against the alternative of threshold cointegration. Hansen and Seo's multivariate threshold cointegration model extends Balke and Fomby's univariate modeling approach by allowing for the case of unknown cointegrating vector, which is jointly estimated with the threshold parameter.

5- Data

The data to be used for the study are weekly maize prices series over the period September 1998 to September 2001. These data have been collected by ONASA (Office Nationale de Securite Alimentaire). ONASA is the government institution established after the free market system has been adopted. The prices series considered in this study are for seven spatially dispersed maize markets. Cotonou, Azove, Ketou are located in the south. Bohicon and Glazoue belong to the central region. Parakou and Nikki are northen markets. These price series on these markets are retailers' prices and they are expressed in kilogram per CFA franc[1]. The reason for using these prices is that retailers play a more prominent role in the price formation process (Kuiper, E. et al.,). The total number of observations per market is 162. Transaction cost data between market pairing were obtained from previous studies by Adegbidi, A. et al., and Lutz. The transaction costs are composed of the transfer costs between markets, the gross margin of wholesalers and the gross margin of retailers. The transfer costs represent all the costs involved in moving the commodity from one market to another. These costs are: taxes per bag of maize, transportation fees per bag of maize, transportation fees of the trader, cost of measurement per unit, cost of bag sewing, collect fees, costs of truck loading at the departure market, unloading costs at the destination market, costs of storage, and the costs of broker's service.

The computed transaction costs can not be considered as the exact transaction costs between markets because the exact transaction costs are composed of more than the above-mentioned costs. The other costs such as information costs, cost related to personal knowledge, personal network, transaction skills, time, location, organization, institutional setting, and so one, are difficult to estimate. However our estimates of the transaction costs represent good proxy for the real transaction costs.

6- Results and discussion

[1] CFA franc is the currency used in Benin. 1 USD is approximately 510 CFA francs.

ADF tests indicated that each of the price series – in levels – contain a unit root, while each of the series – in first differences – were found to be stationary. We concluded that our price series follow an I(1) process and proceeded to test for linear cointegration among each of the market pairings[2]. Results presented in Table 1 provide evidence for linear cointegration between several markets. Using the Engle-Granger test we found five of the twenty-one markets to be cointegrated, while Johansen test results showed nine markets to be cointegrated. It should be emphasized that linear cointegration does not necessarily imply market integration through trade. Cointegrating relationships may be explained by co-incidental co-movements of market prices perhaps due to shared supply and demand shocks without trade taking place.

Table 2 shows results pertaining to threshold cointegration. The left half of the table – labeled Bivariate – presents *p*-values with respect to SupLM test results for threshold effects. For comparative purposes the right half of the table – labeled Univariate – presents *p*-values with respect to Hansen (1996) threshold autoregressive test results applied to the error-correction terms as in Balke and Fomby (1997). Both sets of results include the case where β is estimated and the case where β is set equal to unity. *P*-value results are shown for one and two lags, with respect to each of the bivariate TVECM's. The *p*-values were computed by a parametric bootstrap as in Hansen and Seo (2002) using 1000 simulation replications. The univariate models (β=1 and β estimated), and the bivariate models (β=1) reject the presence of threshold cointegration between all market pairs. However, there is evidence of threshold cointegration, at the 5% level, for six of the lag-one bivariate models (β estimated). At the 10% level, thirteen of the lag-one

[2] Likelihood ratio test results, based upon an initial eight week lag structure, indicated a single lag was optimal for all of the bivariate VECM's. Results are presented for one and two lags for comparison.

bivariate models (β estimated), provide evidence of threshold effects. Results are similar for the two-lag bivariate models. It should be noted that asymptotic *p*-values estimated using a fixed regressor bootstrap, as in Hansen and Seo, were insignificant at reasonable significance levels for all market pairs, with one exception – (the X_{Azove} X_{Nikki} model). Hansen and and Seo, similarly found stronger evidence of threshold cointegration using their SupLM test in comparison to the univariate threshold autoregressive test. They noted that given the restrictive nature of the univariate specification, the power of the univariate test is undoubtedly reduced in some settings. Balke and Fomby found that standard linear cointegration tests are capable of detecting threshold cointegration. However, the results presented in Table 1 and Table 2, show no consistency between findings of linear cointegration and threshold cointegration, across the market pairs. For example, we find linear cointegration but not threshold effects for some market pairs, while other market pairs exhibit threshold effects, but are not linearly cointegrated.

In light of our mixed evidence for threshold effects, we also analyzed the threshold cointegration results by comparing the estimated threshold parameters to observed market transaction costs. Table 3 lists estimated threshold parameters along with observed transaction costs for the one and two-lag bivariate models (β estimated). The sign on the threshold parameter provides some intuition as to the direction of trade flows between markets. For example, with respect to the X_{Azove} X_{Nikki} model with one lag, the negative threshold estimate of -55.9 and the cointegrating vector estimate, β, of 1.2, would suggest that a trade inducing regime would occur, with trade flowing from Azove market to Nikki, when $X_{Azove} \leq 1.2X_{Nikki} – 55.9$, ie when the price in Azove market is more than 56 FCFA below the price in Nikki market.

In absolute value terms there is non consistent pattern between the estimated threshold parameter and observed transaction costs. A priori one would have expected higher threshold estimates to be associated with higher observed transaction costs. Also it should be noted that for some market pairings, observed transaction costs exceed the estimated thresholds, while the converse was also true. A priori we would have expected threshold estimates to exceed observed transaction costs, as the observed transaction costs are probably an underestimate of actual transaction costs.

With respect to the β estimates, which may be thought of as price transmission elasticity estimates results are again mixed, with β estimates ranging from -1 to over 2. The higher the value in absolute terms the more responsive the market to price movements. The two models ($X_{Bohicon}$ X_{Ketou} and $X_{Glazoue}$ $X_{Parakou}$) with negative cointegrating vectors would be counterintuitive to a finding of market integration, where one would expect a positive long-run relationship to exist between market prices.

Finally, the threshold cointegration results were further scrutinized with respect to the error-correction term parameter estimates. For illustrative purposes we choose to present TVECM parameter estimates for two of our more successful models, the X_{Azove} $X_{Bohicon}$, and the X_{Azove} X_{Nikki} lag-one bivariate models.

First, with respect to the X_{Azove} $X_{Bohicon}$ model, the estimated threshold is 23.5 and the estimated cointegrating relationship is $w_t = Xazove_t - 0.7Xbohicon_t$. Thus the first regime (with 85% of the total observations) occurs when the market price in Bohicon market is more than 24 FCFA above the price in Azove. The more unusual second regime (with 15% of the total observations) occurs when the market price in Bohicon market is more than 24 FCFA below the price in Azove market.

The estimated *Xazove Xbohicon* bivariate lag one TVECM is given below with Eicker-White standard errors in parentheses.

$$\Delta Xazove_t = \begin{cases} \begin{matrix} 1.45 & -0.1w_{t-1} & +0.08\Delta Xazove_{t-1} & +0.16\Delta Xbohicon_{t-1} + u_{1t}, & w_{t-1} \leq 23.5 \\ (0.83) & (0.07) & (0.12) & (0.10) & \\ 25.4 & -0.95w_{t-1} & +0.52\Delta Xazove_{t-1} & -1.0\Delta Xbohicon_{t-1} + u_{1t}, & w_{t-1} > 23.5 \\ (4.32) & (0.14) & (0.16) & (0.25) & \end{matrix} \end{cases}$$

$$\Delta Xbohicon = \begin{cases} \begin{matrix} -1.19 & +0.13w_{t-1} & +0.27\Delta Xazove_{t-1} & +0.01\Delta Xbohicon_{t-1} + u_{2t}, & w_{t-1} \leq 23.5 \\ (0.85) & (0.07) & (0.14) & (0.11) & \\ 5.86 & -0.25w_{t-1} & +0.53\Delta Xazove_{t-1} & -0.34\Delta Xbohicon_{t-1} + u_{2t}, & w_{t-1} > 23.5 \\ (4.67) & (0.16) & (0.19) & (0.22) & \end{matrix} \end{cases}$$

In the typical first regime the error-correction term effects and dynamics are small and insignificant, suggesting that in this regime markets are not integrated and do not respond to perturbations from their long run relationship. This would suggest no trade takes place between the markets in this regime. Conversely, error correction occurs at least in market Azove within the second regime. The remaining dynamic coefficients for both markets are also significant within the second regime. These results are also illustrated graphically in Figure 1, which plots the error-correction effect – the estimated regression functions of *Xazove and Xbohicon* as a function of w_{t-1}, holding the other variables constant.

In Figure 1, it can be seen that there are negligible error-correction effects on the left side of the threshold (regime one). In contrast, the price response in Xa on the right side of the threshold indicates a large and significant error-correction effect in Azove market for regime two. The results are consistent with the idea that when the price in

Azove market exceeds transaction costs between Azove and Bohicon, trade will flow from Bohicon to Azove, and price in Azove will fall as the markets adjust to a long-run equilibrium.

Second, with respect to the *Xazove Xnikki* model, as noted above the estimated threshold is -55.9 and the estimated cointegrating relationship is given by $w_t = Xazove_t - 1.2Xnikki_t$. Thus the first regime (with 8% of the total observations) occurs when the market price in Azove is more than 60 FCFA below the price in Nikki. The more typical second regime (with 92% of the total observations) occurs when the market price in Azove is more than 60 FCFA above the price in Nikki.

The estimated *Xazove Xnikki* bivariate lag one TVECM is given below with Eicker-White standard errors in parentheses.

$$\Delta Xazove_t = \begin{cases} -35.4 & -0.36w_{t-1} & +0.21\Delta Xazove_{t-1} & -0.20\Delta Xnikki_{t-1} + u_{1t}, & w_{t-1} \le -55.9 \\ (8.1) & (0.09) & (0.10) & (0.08) & \\ -0.01 & -0.04w_{t-1} & +0.01\Delta Xazove_{t-1} & +0.06\Delta Xnikki_{t-1} + u_{1t}, & w_{t-1} > -55.9 \\ (0.72) & (0.03) & (0.13) & (0.06) & \end{cases}$$

$$\Delta Xnikki_t = \begin{cases} 10.1 & +0.25w_{t-1} & -0.05\Delta Xazove_{t-1} & +0.03\Delta Xnikki_{t-1} + u_{2t}, & w_{t-1} \le -55.9 \\ (16.43) & (0.21) & (0.64) & (0.16) & \\ 1.07 & +0.05w_{t-1} & +0.05\Delta Xazove_{t-1} & +0.04\Delta Xnikki_{t-1} + u_{2t}, & w_{t-1} > -55.9 \\ (0.60) & (0.02) & (0.09) & (0.12) & \end{cases}$$

Results for the typical regime (regime two) are similar to those reported for the *Xazove Xbohicon* model, with small and insignificant dynamics and error-correction term effects. Conversely, error correction occurs at least in Azove market within the unusual first regime. These results are also illustrated graphically in Figure 2, which plots the error-correction effect – the estimated regression functions of *Xazove and Xnikki* as a function of w_{t-1}, holding the other variables constant.

In Figure 2, it can be seen that there are negligible error-correction effects on the right side of the threshold (regime two). In contrast, the price response in Azove market on the left side of the threshold indicates a large and significant error-correction effect in Azove market for regime one. The results are consistent with the idea that when the price in Nikki exceeds transaction costs between Azove and Nikki, trade will flow from Azove to Nikki, and price in Azove will rise as the markets adjust to a long-run equilibrium. Although it should be noted that there is an initial neagative price response in the Azove market. This initial reaction may be attributed to the large negative constant (-35.4) in the regression function. Price response in Nikki market is negative as expected, but the error-correction parameter estimates for Nikki in regime one, are insignificant at conventional significance levels.

On a final sobering note, the reader should be aware that all of the other bivariate TVECM's which were found to have potential threshold effects using the SupLM test, had insignificant error-correction parameter estimates. Hansen and Seo note that their modeling approach does not yield a formal distribution theory for parameter estimates and standard errors, and so our results should be interpreted somewhat cautiously. However, analysis and economic interpretation of error-correction parameter estimates would appear to be a useful check as to whether results from SupLM threshold cointegration tests are valid.

7- Conclusion

We find mixed evidence with respect to threshold cointegration. Two regime Threshold models may not adequately capture dynamics between two markets when trade flows in both directions (i.e. when trade flow is not uni-directional). Also sluggish price adjustment (previously reported by Lutz), suggests that possibly more than a two week lag period is needed to capture the full dynamic price movements between the markets.

Further analysis in terms of error-correction parameters would suggest little support for threshold effects. Also threshold estimates are not consistent with observed transaction costs. This highlights the importance of interpreting results for researchers – i.e. don't just automatically assume thresholds based on SupLM statistics.

The organizational structure of the markets might also explain the mixed results obtained from our methodological approach. Indeed, all seven markets, except Cotonou, have informal traders' associations which act as a trade barrier for non-resident traders. All these markets except Cotonou are located in or in the vicinity of major production areas. Each of these traders' associations usually set the sale prices for their respective markets according to local supply and demand conditions. For each of these markets, the trader's association has control over the maize supply for their territory. Non-resident traders are always obliged to comply with the rules and instruction of those associations. In order words, the non-resident traders are obliged to buy at the price set by the local trader's association. This represents a particular type of trade barrier for non-resident traders who cannot buy directly from farmers on a territory which is not in their own residential area. This unique type of trade barrier lengthens the marketing chain between consumers and farmers and adds additional costs and inefficiencies to the marketing system.

Although the Benin government has attempted to remove trade barriers that are not conducive to a free market system, the organizational structure imposed by the informal traders' associations represents a remaining barrier, which is at odds with the government's free trade objectives. Therefore it would not be an exaggeration to say that the presence of these informal traders' associations have seriously hampered the development of a free market trade environment in the maize industry. The determination of price is heavily influenced by the trader's associations rather by a true auction type market that we normally associate with free trade. In such an environment, the mixed results obtained from our methodological approach may not be so surprising, and threshold models may not adequately model or capture these actual trade barriers.

References:

Adegbidi, A. et al., "Dix and de liberalization du marche de mais au Benin"CDS Research report No.20, 2003, ISSN 1385-9218.

AGRER, Etude de la commercialization des produits vivriersau Benin (1986).

Ahohounkpanzo, M. "Analyse Economique des Circuits de Commercialisation du Maïs dans le Département de l'Atlantique (Sud–Bénin)" Doctorate thesis, Abidjan, CIRES, 1992.

Akker, V. E., "Maize in Benin: Production, Markets and Transport" Department of Agricultural Economics in the Tropics and Subtropics, University of Hohenheim, 70593 Stuttgart, Germany, 1999.

Balke, N. S., and Fomby, T. B. "Threshold cointegration". International Economic Review. 38(1997):627–645.

Baum, C.F., Karasulu, M., "Modelling federal reserve discount policy". Computational Economics. 11(1998):53–70.

Ching-Chung, L., Shen-Yuan, C. and Dar-Yeh, H. “An application of threshold cointegration to Taiwan stocks index futures and spot markets” Review of Pacific Basin Financial Markets and Policies. 3(2003):291-304.

CIMMYT Statistical Database, 1999/2000 World Maize Facts and Trends, Meeting World Maize Needs, Mexico, CIMMYT, 2001.

Dissou, M. “La Commercialisation du Maïs dans le Département de l’Ouémé, l’Efficacité de la Formation des Prix” Doctorate thesis, Abidjan, CIRES, 1991.

Enders, W., Falk, B., “Threshold-autoregressive, median-unbiased, and cointegration tests of purchasing power parity”. International Journal of Forecasting. 14(1998):171–186.

Fanou, K. L. “Analyse des Performances du Système de Commercialisation des Produits Vivriers au Bénin : Le cas de la Commercialisation Primaire de Maïs et du Gari sur le Plateau Adja au Mono” Doctorate thesis, Abidjan, CIRES, 1994.

FAO, Mission de securite alimentaireet de commercialisation au Benin 1(1987), Rome.

Goodwin, B. K. and Piggott, N., “Spatial market integration, in the presence of threshold effects” American Journal of Agricultural Economics. 83(2001):302-317.

Hansen, B.E., “Inference when a nuisance parameter is not identied under the null hypothesis” Econometrica 64(1996):413-30.

Hansen, B.E. and Seo, B., “Testing for two-regime threshold cointegration in vector error-correction models” Journal of Econometrics 110(2002):293-318.

Johansen S. and Juselius, K., “Maximum likelihood estimation and inference on cointegration with applications to the demand for money” Oxford Bulletin of Economics and Statistics. 52(1990):160–210.

Kuiper, E., Lutz C., Van Tilburg A., “Identifying Price-Leading Markets: An Application to Corn Markets in Benin” Journal of Regional Science, (1999):713-738.

Kuiper, E., Lutz C., Van Tilburg A., “Vertical price leadership on local maize markets in Benin” Journal of Development Economics. 71(2003):417-33

Lo, M. C. and Zivot, E., “Threshold cointegration and nonlinear adjustment to the law of one price” Macroeconomic Dynamics. 5(2001):533–76.

Lutz, C. “The Functioning of the Maize Market in Benin: Spatial and Temporal Arbitrage on the Market of a Staple Food Crop” University of Amsterdam, Department of Regional economics, 1994.

Martens, M. K. P. and Vorst, T.C.F., “A threshold error-correction model for intraday futures and index returns”. Journal of Applied Econometrics 13(1998):245–263.

Pede, O.V. “Etude des changements intervenus dans le fonctionement de quelques marches de mais du Sud-Benin après la liberalization officielle du commerce des produits vivriers: cas des marches de Dantokpa, Ouando, Pobe et Ketou” Masters thesis, Abomey-Calavi FSA/UNB, 2001.

Soule, S. “La Commercialisation du Maïs au cours de la Période de Soudure au Bénin: Organisation et Efficacité du Secteur Privé. Etude de cas des districts de Pobè et Djougou” Masters thesis, Abomey-Calavi FSA/UNB, 1992.

Table 1: Engle Granger and Johansen test of cointegration.

Markets	Markets	Engle Granger test				Johansen Cointegration test	
		L = 1	Conclusion	L = 2	Conclusion	L = 1	L = 2
Azove	Bohicon	-3.87278	cointegrated	-3.59269	cointegrated	cointegrated	cointegrated
Azove	Cotonou	-2.66292	not cointegrated	-2.6212	not cointegrated	not cointegrated	cointegrated
Azove	Glazoue	-6.23299	cointegrated	-4.58925	cointegrated	cointegrated	not cointegrated
Azove	Ketou	-2.11832	not cointegrated	-2.09984	not cointegrated	not cointegrated	not cointegrated
Azove	Nikki	-2.67818	not cointegrated	-2.76014	not cointegrated	not cointegrated	not cointegrated
Azove	Parakou	-2.50811	not cointegrated	2.51524	not cointegrated	cointegrated	not cointegrated
Bohicon	Cotonou	-2.76392	not cointegrated	-2.30267	not cointegrated	cointegrated	cointegrated
Bohicon	Glazoue	-4.75253	cointegrated	-3.27267	not cointegrated	cointegrated	cointegrated
Bohicon	Ketou	-1.84734	not cointegrated	-1.69423	not cointegrated	not cointegrated	not cointegrated
Bohicon	Nikki	-2.51232	not cointegrated	-2.4086	not cointegrated	cointegrated	cointegrated
Bohicon	Parakou	-2.28906	not cointegrated	-2.08676	not cointegrated	not cointegrated	not cointegrated
Cotonou	Glazoue	-2.10814	not cointegrated	-1.5785	not cointegrated	cointegrated	not cointegrated
Cotonou	Ketou	-2.81285	not cointegrated	-2.40164	not cointegrated	not cointegrated	not cointegrated
Cotonou	Nikki	-2.08596	not cointegrated	-1.68061	not cointegrated	not cointegrated	not cointegrated
Cotonou	Parakou	-3.82185	cointegrated	-3.05291	not cointegrated	cointegrated	cointegrated
Glazoue	Ketou	-2.32953	not cointegrated	-1.71134	not cointegrated	not cointegrated	not cointegrated
Glazoue	Nikki	-2.63071	not cointegrated	-2.87889	not cointegrated	not cointegrated	cointegrated
Glazoue	Parakou	-1.92205	not cointegrated	-1.99482	not cointegrated	cointegrated	not cointegrated
Ketou	Nikki	-1.75244	not cointegrated	-1.71816	not cointegrated	cointegrated	cointegrated
Ketou	Parakou	-3.68559	cointegrated	-3.26047	not cointegrated	cointegrated	cointegrated
Nikki	Parakou	-3.05081	not cointegrated	-2.7813	not cointegrated	not cointegrated	not cointegrated

Table 2. Test for threshold cointegration (p-values).

Markets	Markets	Bivariate				Univariate			
		$\beta = 1$		β estimated		$\beta = 1$		β estimated	
		L = 1	L = 2	L = 1	L = 2	L = 1	L = 2	L = 1	L = 2
Azove	Bohicon	0.2000	0.2650	0.0140*	0.0380*	0.8330	0.3850	0.7370	0.6000
Azove	Cotonou	0.1560	0.2590	0.1410	0.1070	0.4160	0.2960	0.6550	0.7720
Azove	Glazoue	0.1900	0.2710	0.1620	0.1890	0.3450	0.5180	0.6190	0.5100
Azove	Ketou	0.1940	0.2640	0.1220	0.1210	0.8050	0.9580	0.5740	0.3080
Azove	Nikki	0.1840	0.2630	0.0200*	0.1900	0.5320	0.6870	0.7600	0.8420
Azove	Parakou	0.1860	0.2690	0.5380	0.5280	0.4750	0.4470	0.5980	0.6470
Bohicon	Cotonou	0.2000	0.2790	0.0880**	0.1060	0.2680	0.4690	0.2420	0.4190
Bohicon	Glazoue	0.1930	0.2740	0.0300*	0.0310*	0.1850	0.3800	0.1320	0.5300
Bohicon	Ketou	0.1780	0.2680	0.0850**	0.1460	0.8410	0.8200	0.8230	0.7980
Bohicon	Nikki	0.1750	0.2910	0.1740	0.1620	0.9570	0.8240	0.8680	0.6310
Bohicon	Parakou	0.4320	0.4730	0.3480	0.5500	0.6760	0.4430	0.3690	0.6120
Cotonou	Glazoue	0.0530	0.0780	0.0110*	0.0160*	0.0980	0.3700	0.1340	0.5070
Cotonou	Ketou	0.7360	0.6870	0.0880**	0.0630**	0.7670	0.5520	0.7970	0.8720
Cotonou	Nikki	0.4360	0.8140	0.0020*	0.0050*	0.8020	0.8890	0.8150	0.7690
Cotonou	Parakou	0.2620	0.3890	0.0610**	0.0380*	0.2600	0.2570	0.2840	0.4510
Glazoue	Ketou	0.1050	0.3650	0.0910**	0.0790**	0.3860	0.6280	0.9740	0.4470
Glazoue	Nikki	0.1140	0.1420	0.0100*	0.0580**	0.4420	0.2980	0.2350	0.2290
Glazoue	Parakou	0.2710	0.2910	0.0610**	0.0100*	0.4480	0.4250	0.9240	0.1570
Ketou	Nikki	0.9180	0.9200	0.1320	0.1300	0.9670	0.7390	0.5420	0.4910
Ketou	Parakou	0.9280	0.9500	0.1250	0.2150	0.4650	0.5670	0.1570	0.3910
Nikki	Parakou	0.2680	0.2200	0.0590**	0.2900	0.2550	0.2530	0.6840	0.4260

** indicates significance at 10%

* indicates significance at 5%

Table 3 : Estimated cointegrated vector, threshold and actual transaction costs.

Markets	Markets	Estimated Cointegrated Vector β		Estimated Threshold γ		Actual Transaction Costs
		L=1	L=2	L=1	L=2	
Azove	Bohicon	0.6906	0.6926	23.4658	31.8571	37.2
Azove	Cotonou	0.6135	0.2145	-25.8574	84.6889	44.3
Azove	Glazoue	0.7977	0.7485	-3.6288	23.9570	41.3
Azove	Ketou	0.1011	0.0985	102.9060	102.9390	46.5
Azove	Nikki	1.2358	1.1559	-55.8755	-48.2411	57.5
Azove	Parakou	0.0858	0.2584	105.2310	84.1072	55.1
Bohicon	Cotonou	0.9187	0.8027	-39.9928	-23.9073	40.6
Bohicon	Glazoue	0.8074	0.9330	11.3750	19.2013	42.0
Bohicon	Ketou	-0.3484	-0.0628	146.2220	151.2330	43.8
Bohicon	Nikki	0.9612	0.9901	-3.6749	-8.4423	61.6
Bohicon	Parakou	0.9504	0.2053	-25.6103	93.7417	50.8
Cotonou	Glazoue	1.2437	1.6948	2.1098	29.1352	47.3
Cotonou	Ketou	1.0895	1.1223	20.0982	7.2820	48.9
Cotonou	Nikki	1.4629	2.0965	-11.5346	-74.2138	66.2
Cotonou	Parakou	0.5533	0.7356	54.0639	56.7983	55.4
Glazoue	Ketou	0.3880	0.3851	84.5875	58.1788	47.9
Glazoue	Nikki	1.9685	1.5279	-118.8120	-73.5850	54.1
Glazoue	Parakou	-0.9852	-0.4890	203.3820	201.2880	43.3
Ketou	Nikki	1.6167	2.1320	-23.1447	-127.4410	66.8
Ketou	Parakou	0.8916	0.9360	-31.5716	18.3248	59.7
Nikki	Parakou	0.6209	0.6007	30.5477	33.1782	40.8

Figure 1: Price Response between Azove and Bohicon markets in the two-regime model.

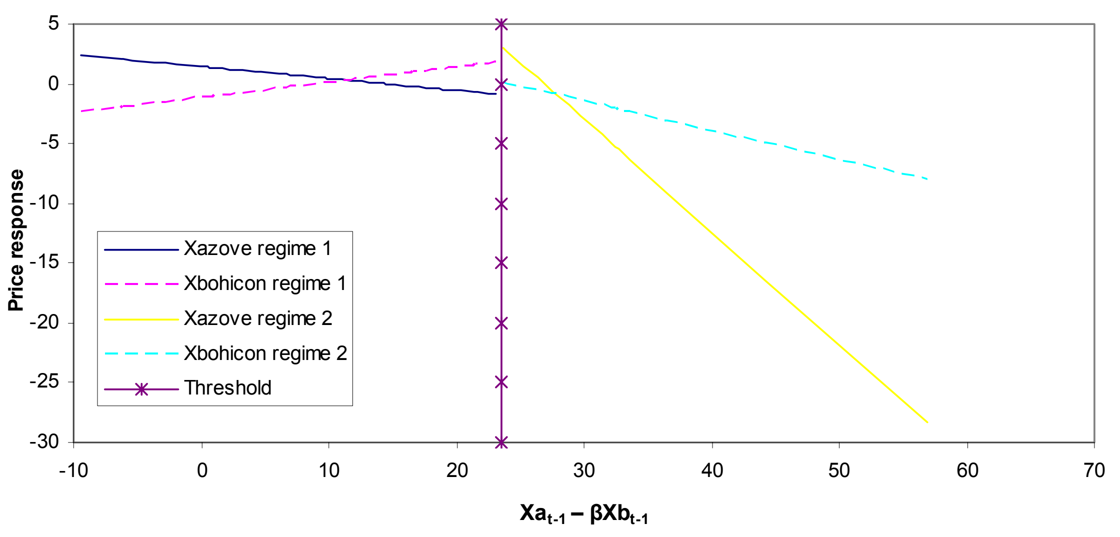

Figure 2: Price Response between Azove and Nikki markets in the two-regime model.