"Changing Spatial Maize Price Relationships in West Africa"

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1. Introduction

Over the past three decades the economies of West Africa have experienced a period of fundamental structural change. For example, as in many parts of the world, West African government marketing boards were involved in setting agricultural product prices and other marketing activities until well into the 1980s. More recently many of the countries in this region embarked on a long-term process of market reform by scaling back both the level and scope of their influence on domestic market prices. When taken together, these reforms reflect a general trend toward market liberalization.

In parallel with these domestic policy trends, efforts have been made at a regional level to coordinate and harmonize policies to facilitate gains from trade and to meet other social and political objectives that span across national borders (Soulé and Gansari, 2010; Staatz et al., 2008; Egg and Gabas, 1999). Agricultural and, more specifically, cereals market reform has played a central role in both domestic and regional reform processes. The focus on cereals markets is due to the dual roles of this sub-sector in West African economies in terms of its contribution to both trade and gross domestic product and its role in assuring food security of both rural and urban populations. The reform process is hypothesized to have improved the performance of cereals markets by increasing the level of competition and decreasing transaction costs associated with transferring commodities across both time and space. Agricultural production and consumption basins and the trade between them are likewise not confined to national borders (Boughton et al., 2011; Haggblade, 2010). It can therefore be argued that in a post-reform market environment, the performance of cereal markets across both time and space is closely linked to domestic as well as regional economic, social and political stability.

While the policy environment has evolved, so have other aspects of the economies within the sub region. For example, major public investments have been made in recent years to improve the quality and coverage of physical infrastructure, including the roads linking major urban centers and information communication technology (ICT) infrastructure such as telephone land lines, mobile network towers and fiber optic cables (Aker 2010b; Lavergne, 1997; Teravaninthorn and Raballand, 2009). National governments and donors originally financed these large-scale investments, although the private sector plays an increasingly important role in the ICT industry today. Such investments are generally not designed solely with the agricultural sector in mind, but rather intended to support the process of broad based economic growth.[1] Food and non-food item consumption patterns have likewise changed with the rapid rate of urbanization, increased incomes and other changes in tastes and preferences stemming from lifestyle changes and the more general process of globalization (ReSAKSS 2011; Kennedy and Reardon, 1994). West African governments are increasingly held accountable for both their policy and investment decisions. However, policy decisions do not occur in a vacuum, and their outcomes are likely influenced by factors such the process of demographic transition, shifting agricultural production patterns, the spillover effects of policies implemented in neighboring countries and agro-climatic conditions. Agricultural markets within the sub region have been deeply entwined in these processes.

It is not well understood how all the changes outlined above have influenced spatial cereals price relationships (indicators of market performance) in West Africa. Without knowing

[1] One caveat to this statement is with respect to areas of major public sector investments in areas of particularly high agricultural potential (such as the cotton and rice producing zones of Mali and the rice and peanut production zones of Senegal), where value chain development approaches (often with support of the French) took on a "vertically integrated approach" (filière intégrée in French). In such areas, major investments were made to support all aspects of the value-chain, including the accessibility of the final products to be marketed (Samaké et al, 2008a and Samaké et al, 2008b)

this, it is difficult to put forth policies and forecast changes. This research makes several contributions to existing literature and policy debates within the sub region by improving our understanding of the factors driving the evolution of maize market performance across time and space. In order to do so, recent advances by Myers and Jayne (2011) in spatial price analysis methods are applied to a unique database spanning the post market liberalization period of 1994-2010 to study the evolution of spatial price relationships along existing and emerging grain marketing corridors in West Africa. The dataset contains maize price observations, details regarding the timing of infrastructure investments and major policy changes and indicators of maize demand along twelve marketing corridors linking Senegal, Burkina Faso, Mali and Niger. [2]

The commodity, geographic focus and period considered is therefore the first contribution of this research. Unlike other popular locally produced cereals in the Sahel (millet and sorghum), the maize subsector has recently experienced a particularly dynamic period in terms of both its supply and demand patterns. Second, there is no consensus in the literature that market reform or infrastructure improvements unilaterally improve the performance of agricultural markets (Aker, 2010; Araujo-Bonjean et al., 2008; Araujo et. al, 2010; Cirera and Arndt, 2008, Van Campenhout, 2007). This information therefore allows us to explicitly consider the relative importance and complementarity of national and supra-national investment programs in support of vibrant private agricultural marketing chains. Together this provides us with a more nuanced picture by estimating the relative impact of the tools available to policy makers on spatial price transmission as one indicator of staple food market performacne. Third, unlike other studies on West Africa maize markets, this research considers the potential impact of evolving regional maize supply and demand patterns within a regional context. Fourth, by

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[2] Throughout the following discussion "Burkinabé" will be used as an adjective to describe anything pertaining to Burkina Faso, "Malian" for Mali, "Nigerien" for Niger, "Nigerian" for Nigeria and "Senegalese" for Senegal.

including both domestic and cross border market pairs this research allows us to explicitly estimate the cost of lingering cross-border non-tariff trade barriers by marketing corridor within the sub-region. These results are therefore particularly relevant in discussions regarding the targeting of funds for projects and the design of policies intended to help improve the performance of agricultural value-chains in both a local and regional context.

This paper is organized into five sections. Section two defines the concept of spatial market equlibrium as one of several indicators of agricultural market performance Section three describes the West African maize subsector and the structual changes it has recently experienced. Section four lays out the details of a multiple regime threshold spatial price transmission model and our testable hypotheses. Section five presents our empirical results. The final section concludes.

2. Spatial Price Transmission as an Indicator of Market Performance

Several metrics have been used to measure the performance of agricultural markets across both time and space. Spatial agricultural market integration is one such performance measure, generally defined as the extent to which supply and demand conditions are transmitted through the marketing system (Fackler and Goodwin, 2001). One measure of the success of agricultural market reforms and accompanying investments is therefore the extent to which they improve the price signals transmitted between markets (Abdulai, 2006) —both within and across national borders. Within a post-reform context, these price signals are what communicate supply and demand conditions and therefore incentives to the private sector incluidng traders participating in spatial arbitrage, storing agents participating in temporal arbitrage, farm-level producers as well as food and feed processors. This research uses recent advances in spatial price analysis methods to study the evolution of two cereals market performance indicators (the extent and speed of spatial price transmission) within the post-reform market environment.

3. West African Maize Market Performance and Structural Change

Several studies have investigated spatial maize market performance indicators in the coastal West African countries of Benin and Ghana, where this commodity has played an prominent role in household consumption baskets and farmer crop portfolios for some time. For example, Lutz et al. (2006) find that markets in Benin are co-integrated in the long run before and after the market reform process. These authors find that the speed of price adjustment across between market pairs did not improve following marketing policy changes and conclude that this is likely due to a lack change in private incentives and marketing behavior during the post-reform period. Badiane and Shively (1998) find that prices are lower and less volatile following market reforms in Ghana.They also find that prices in the central production market strongly influences the level and volatility of prices in the country's main consumption zone (in Accra), but they have less influence in prices in the more remote upland regions of the country. Using the same market pairs, Abdulai (2000) find that price adjustment in Ghana during the post-reform period is assymetric, with positive price shocks transmitted through the marketing system more quickly than negative price shocks. Both papers suggest that differences in infrastructure quality along the different marketing channel could play and important role in the observed different price transmission results.

As suggsted by the FAO food balance sheets in Table 1, millet and sorghum have traditionally played a key role of household food security in the Sahel. However, the West African maize sub-sectors are among the most dynamic staple food sub-sectors in the sub-region today. This can be attributed to recent changes in both supply and demand patterns that may have jointly changed spatial maize price relationships. In the Sahelian nations of Burkina Faso and Mali, maize was historically incorporated into cotton production rotations and mainly sold as a cash crop, as both rain-fed crops grow well under similar agro-climatic conditions and are responsive to inorganic fertilizer (historically supplied by government cotton parastatals). Activities in the cotton sector therefore had an important influence on maize market dynamics (particularly the level of maize produced during a given year). The recent cotton-sector crises and staple food price spikes have led many farmers to orient themselves more toward cereals (including maize) production (Diallo, 2010), although many maintain a small cotton plot in order to assure continued access to government input procurement channels (Perakis fieldwork 2011).

On the demand side, the geographic scope of maize consumption has expanded to include not only coastal countries also other inland countries within the sub region. This has been driven by changing direct human consumption patterns as consumers substitute away from other cereals during periods when maize is more affordable and as the collective memory of maize as a "famine crop" during the severe droughts of the 1970s fades into the distance (Diallo, 2011; MSU Studies 2011). The derived demand for maize through the poultry feed marketing channel has gained importance in recent years as broilers and fresh eggs have assumed prominent role in food baskets , particularly among urban and peri-urban consumers within the sub region (Diallo, 2010; ReSAKSS 2011; Staatz et al., 2011). Despite efforts at a regional level to reduce tariff and non-tariff trade barriers, poultry producers in Senegal (and *de facto* in Mali) have managed to remain protected from inflows of relative inexpensive poultry products from World markets as a result of the sanitary and phytosanitary concerns over Highly Pathogenic Avian Influenza (HPAI) pandemic in 2005 (Sharma et al., 2005). Figure 1 illustrates changes in Senegalese poultry imports across international trade regimes. The possibility of reducing those non-tariff barriers has important implications for the breadth and depth of current market outlets for maize produced in the sub-region.

Industrial and semi-industrial poultry production is generally located within close proximity to urban consumers because of the risks and other transaction costs associated with transporting finished live birds across large distances and a lack of a reliable cold chain to easily transport highly perishable fresh or frozen carcasses. Maize, on the other hand, as a storable and non-perishable commodity, is more easily transferred across time and space. Industrial and semi-industrial poultry production and feed milling industries are therefore highly concentrated around urban centers across the sub-regiona, while feed grain (to be consumed directly or in processed form) is trucked in from spatially dispersed domestic and regional maize production zones.

Although maize is at the heart of many local and regional agricultural investment programs in West Africa today (e.g. UEMOA, ECOWAP, and national CAADP investment plans), there is a dearth of information regarding the drivers of local and regional maize market performance outcomes. For example, if price transmission is particularly weak along certain marketing axis linking supply and demand centers, it may weaken market demand signals thereby trumping efforts to improve farmer incentives to invest in production and productivity enhancing technologies. If the underlying assumption behind regional investment programs is that domestic and international marketing corridors perform identically, we may also see inefficiencies in the use of government and donor funds in support of a vibrant private sector. This lack of insight complicates the planning, execution and effectivness of local and regional investment plans and policies intended to improve the performance of maize value-chain within a local and regional context.

FAO food balance sheets and recent research (Diallo, 2011) suggest that the demand and derived demand for maize in West Africa has increased and become more spatially concentrated over time. This phenomenon is analogous to the shifts in corn demand patterns through the recent expansion of the corn-ethanol industry in the United States and Western Europe. As discussed by McNew and Griffith (2005) and Fackler and Goodwin (2001), shocks to demand, supply, transport and transaction costs can induce shifts in grain trade patterns, with differential impacts on production and consumption zone prices and their underlying spatial relationships. The emergence of new maize trade corridors and increased trade flows along existing corridors resulting from new supply and demand conditions may have led to changes in spatial maize price relationships in West Africa. This research seeks to evaluate the extent to which recent policies and investment programs and the more general process of structural chane have influence spatial cereals price relationships along the maize market corridors found in Table 3 and Figure 4 that link markets in Senegal, Mali, and Burkina Faso and Niger.[3] To this end, this research seeks to empirically test the following hypotheses:

(1) Maize prices along some of West Africa's major marketing arteries share no long-run equilibrium relationship and have no common autocorrelation structure.

(2) Shifting maize demand and derived demand patterns have had no influence on spatial price relationships along the main maize marketing corridors linking production and consumption zones in West Africa r time.

(3) The border effect of cross-border trading market pairs have not diminished with regional economic policy harmonization and coordination.

[3] It is worthwhile to note that Burkina Faso and Mali's neighbor, the Ivory Coast, plays an important role in regional maize trade through the marketing triad of Sikasso-Bobo Dioulasso – Korhogo (CSAO/OECD, 2002). However bouts of civil unrest over the period considered in this study makes it very difficult to compile continuous data series from this country. The Ivory Coast is therefore omitted from the main part of the analysis.

(4) Other structural changes within the economies of West Africa (road rehabilitation investments and the expansion of GSM cell phone network coverage) have had no influence on our spatial price relationship parameters.

4. Conceptual and empirical model

The study of spatial, temporal and vertical price transmission has played a central role in economists' understanding of the functioning of agricultural markets. A large body of literature focuses on the evolution of price transmission in the wake of fundamental changes to the economic environment. Several authors have surveyed the literature regarding the theoretical models and empirical approaches to studying agricultural market price relationships (Barrett, 1996; Fackler and Goodwin, 2001; Barrett and Li, 2002; Goodwin and Piggott, 2001; Van Campenhout, 2007). These authors note that the methods used have generally evolved along with improvements in our understanding of the statistical properties of time series as well as the functioning of agricultural markets.

Many models available today allow researchers to estimate both the extent of price transmission between market pairs as well as the short-run speed of price adjustment back to a single long-run equilibrium relationship following a price shock. A class of models has been developed to analyze whether there is a threshold value (typically measured by price differences) above which such adjustments occur and below which they do not. These include Threshold Autoregressive (TAR) and Threshold Cointegration models (TIC), depending on the statistical properties of the time series. However, authors have recently questioned the validity of the (explicit or implicit) assumption of a single underlying long-run relationship between market price pairs. For example, market price relationships could potentially vary with trade or information flow levels between market pairs (Myers and Jayne, 2010; Burke, 2011; Stephens et al., 2011), across seasons (Stephens et al., 2011 and Götz et al., 2008), with changes in transport costs (Araujo et al., 2010), or with import levels of substitute goods (Götz et al., 2008). In light of these concerns, a new class of models has been developed to allow for both the long-run co-integrating relationship and the structure of the autocorrelation between market price prices to vary based on the value of certain threshold variables (imposed or estimated). The regime switching threshold value can either be imposed by the researcher (Stephens et al., 2011) or be a parameter to estimate (Götz et al., 2008; Araujo et al., 2010; Myers and Jayne, 2010; Burke, 2011).

This research builds upon the Single Equation Error Correction Model (SEECM) introduced by Myers and Jayne (2011) to analyze the effects of agricultural marketing policy changes and infrastructure investments as well factors hypothesized to influence the supply and demand of cereals on spatial market price relationships. When taken together, these effects collectively constitute the general process of structural change. As in Myers and Jayne (2011), threshold effects are identified and estimated using the Gonzalo and Pitarakis (2002) penalty function approach.

Following Myers and Jayne (2011), we begin with an expression of the equilibrium relationship between market price pairs between which agricultural commodities are traded

(1) $P_t^D = \alpha_i + \beta_i P_t^S + \gamma_i TC_t + u_{it}^D$

where P_t^D represents commodity prices in a food-deficit zone (e.g., importing market) and P_t^S represents prices in a food surplus zone (e.g., exporting market) and is a random shock. Reliable time series of trade-corridor specific marketing costs are not available in West Africa. We therefore augment the base model by incorporating transfer costs, TC_t, which are taken to represent a function of observable transfer costs that are measured with error with respect to actual transfer and transaction costs (Negassa et Myers, 2007; Burke, 2011). Transfer costs include published fuel price series, fuel prices adjusted to reflect estimated annual operator transfer cost parameters, and indicators of the evolution of the quality of road linking two markets.[4] [5] [6] The parameters α_i, β_i and γ_i in equation (1) are allowed to vary across regimes *i= 1,2,…n*.

Although we are interested in the value of the parameter β_i, the nature of the regime-specific long-run relationships between market price pairs, we are also interested in understanding how their autocorrelation structure, measuring the speed of price adjustment back to equilibrium (if it exists) following an exogenous shock, changes across regimes. As discussed in Myers and Jayne (2011) and Burke (2011), if the stochastic term u_{it}^D above is serially uncorrelated, there is an immediate reversion to equilibrium following a shock. However, if the stochastic term is serially correlated, the adjustment process depends on the structure of the autocorrelation in u_{it}^D. In order to understand the nature of the dynamic adjustment process, we need to specify equations for the surplus market price, transfer costs, as well as the structure of the autocorrelation in the stochastic term:

(2) $P_t^S = \pi_i + u_{it}^S$

(3) $TC_t = \kappa_i + u_{it}^{TC}$

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[4] Estimates suggest that 50 to 85 percent of variable transfer costs are directly attributable to the cost of fuel (Aker, 2007; Teravaninthorn and Raballand, 2009).

[5] In West Africa, trucker unions as well as government ministries charged with regulating the transport of goods as well as some NGOs periodically publish commodity transfer cost estimates along major trading corridors in West Africa. Indeed, the transport sectors were heavily regulated (with government price setting) until the 1990s. These reports are therefore designed to provide a rough estimate of these costs for marketing intermediaries.

[6] The quality of roads linking surplus and deficit zones also likely contribute to transfer and transaction costs and potentially captured by the percentage of paved road linking two markets (Araujo-Bonjean et al., 2008), an indicator (binary) variable reflecting the period following the end of major overland infrastructure improvement project (Cirera and Arndt, 2008), or a time trend that coincides with that same period, thereby allowing for an adjustment period following the completion of road construction or rehabilitation.

We allow $\boldsymbol{u}_t = (u_t^D, u_t^S, u_t^{TC})$ to share a rich and dynamic correlation structure that can generally be expressed as

(4) $\boldsymbol{a_i}(L)\boldsymbol{u}_{it} = \varepsilon_{it}$

where $\boldsymbol{u}_t = (u_t^D, u_t^S, u_t^{TC})$, $\varepsilon_t = (\varepsilon_t^D, \varepsilon_t^S, \varepsilon_t^{TC})$ is an i.i.d. (0, Ω) error vector and the matrix polynomial in the lag operator is defined such that $a(L) = \sum_{i=0}^{n} a_i L^i$ with a_0 = I. In equilibrium $|\pi_i| \le 1$ and $|\kappa_i| \le 1$.

While it is possible to estimate equations (1)-(4) within a system of equations framework, Myers and Jayne (2011) note that for threshold estimation, a single equation framework is more convenient. Following the process outlined in Myers and Jayne (2011), equations (1) - (4) can then be written as a single equation error correction model (SEECM) that is flexible enough to allow for stationary or non-stationary price series depending on the parameter restrictions made:

$$(5)\ \Delta p_t^D = \mu_i + \beta_i \Delta p_t^S + \rho_{1i}\Delta p_t^S + \gamma_i \Delta TC_t + \rho_{2i}\Delta TC_t + \lambda_i\left(p_{t-1}^D - \beta_i p_{t-1}^S - \gamma_i TC_{t-1}\right) + \phi_{1i} p_{t-1}^S + \phi_{2i} TC_{t-1}$$

$$+ \sum_{j=1}^{m} b_{ji}\left(\Delta p_{t-j}^D - \beta_i \Delta p_{t-j}^S - \gamma_i \Delta TC_{t-j}\right) + \sum_{j=1}^{m} c_{ij}\Delta p_{t-j}^S + \sum_{j=1}^{m} d_{ij}\Delta TC_{t-j} + \xi_t$$

where the μ_i are composite constant terms that depend on α_i, π_i and κ_i from equations (1)-(3), the ρ_i are measures of the within-regime correlation between u_{it}^D, u_{it}^S and u_{it}^{TC} and the parameters λ_i, b_{ij}, c_{ij}, ϕ_{1i} and ϕ_{2i} represent the dynamics of the adjustment process captured in $a_i(L)$. We control for transfer costs (observed with error) by allowing $\gamma_i \ne 0$. All of the parameters in (5), including those representing the long-run relationship between prices and those capturing the adjustment process, are allowed to vary across regimes *i= 1,2,…n.*

At this point we still do not know the regime-specific stochastic properties of the data (e.g. stationary or not, cointegrated or not) and the parameters in equation (5) cannot be identified. The specific parameter restrictions we impose for identification will depend on the regime-specific stochastic properties of the data. For example, when P_t^D and P_t^S are both stationary and the latter satisfies exogeneity assumptions, we restrict $\rho_i = 0$, $\phi_i<0$ and $\lambda_i<0$.[7] The parameter λ_i is the regime-specific speed of adjustment parameter that indicates the period of time necessary for price series to revert back to equilibrium following a shock, assuming price transmission occurs. Under non-stationarity and cointegration we restrict $\phi_i=0$ and $\lambda_i<0$. Within the error correction framework, the exogeneity of explanatory variables is less of a concern, allowing for periods of trade flow reversals (REF). Under specific circumstances we can conclude that no price transmission occurs and therefore no adjustment process exists: the case when one variable is stationary and the other non-stationary and the case when the variables are non-stationary but not cointegrated.

5.1 Regime Identification

The main objective of this research is to contribute to our understanding of the evolution of spatial commodity price relationships within West Africa. The proposed framework described above will allow us to (1) identify different price transmission regimes that may have existed over time and (2) to generate estimates of the regime-specific degree of price transmission and speed of price adjustment (Myers and Jayne, 2011) — our cereal market performance indicators.

[7] It may be necessary to introduce instrumental variables (such as predicted price series from structural equations).

Consider an alternative expression of equation (5) $\Delta p_t^D = f(X_i, \theta_i) + \xi_t$ where $\mathbf{X_i}$ are the explanatory variables and θ_i is the associated parameter vector. Following Myers and Jayne (2011) we can therefore define a multiple-regime model as:

(6) $\Delta p_t^D = f(X_i, \theta_i) + \xi_t \qquad \tau_t \in R_i(\delta)$

where *i= 1,2,…n* indexes a set of multiple regimes defined by values of the exogenous threshold variable vector τ_t. This research will take two alternative approaches to identify price transmission regimes that may have existed over time. The specific regime switching value of τ_t could be imposed (as in Stephens et al. 2011). However, a more flexible approach is to leave δ as a parameter to estimate. Myers and Jayne (2011) describe the simple example of a two-regime model based on the level of trade between market pairs. An alternative is a simple two-regime model based on a proxy for regional private cereal stock levels

(6a) $\Delta p_t^D = f(X_i, \theta_1) + \xi_t \qquad \tau_{1t} \leq \delta_1$

(6b) $\Delta p_t^D = f(X_i, \theta_2) + \xi_t \qquad \tau_{1t} > \delta_1$

where τ_{1t} represents the calculated precipitation index for a given marketing basin and δ_1 is the critical precipitation level above which the price transmission process changes (e.g. because of changes in the quantity and direction of cereal trade flows along marketing corridors). In the context of this second approach, threshold estimation could follow the grid search method proposed by Hansen 2000 in the presence of a single threshold value. However, it is possible that more than two regimes exist over time. As in Myers and Jayne (2011), this research will follow the Gonzalo and Piterakis (2002) penalty function approach for identifying and estimating multiple threshold parameter values.

5.2 Regime Switching Threshold Variable Candidates

Although we are particularly interested the impact of factors that jointly contribute to the process of structural change on staple food markets within the sub region, other factors may well influence the direction and level of trade along marketing corridors and therefore the nature of the long-run relationship between prices in spatially distant markets. We will refer to potential variables (τ_t) that could trigger a regime-change in these market price relationships as threshold variables. Much of the recent work on multiple regime threshold models has explicitly investigated the possibility of trade-based thresholds (Stephens et al. 2011; Myers and Jayne, 2011; Burke, 2012; Goetz et al., 2008). However, reliable trade flow data is often difficult to collect in a developing country setting with evolving trade data collection methods.[8]

This research uses both a flexible time trend and the timing of major policy reforms and marketing infrastructure improvements as our candidate threshold variables. These are hypothesized to influence both the long-run equilibrium relationship and autocorrelation structure through their influence on the level and direction of cereals trade flows between market price pairs. Future work will look more explicitly at proxies for cereal stock (precipitation indices) and demand levels. As discussed in van Campenhout (2007) and Negassa et al. (2004), there are often continuous and unobservable factors that might influence spatial market relationships over time. This is particularly the case within the context of a market environment characterized by (hypothesized) falling transaction costs over time. We may therefore consider a simple time trend (t, taking on values 1 through 204) as our first potential threshold variable

[8] For example, with the recent signing of regional trade agreements most by governments in the UEMOA zone adopted harmonized trade data collection, analysis and dissemination methods starting in 2000. Data collected prior to 2000 may only have been available in paper format and held in the hands of a select few, making it difficult to track down such information. Another issue is that trade data is frequently aggregated at the national level by the central government. Any marketing corridor specific data would need to be collected in decentralized ministry offices, where civil servants may be even less likely to hold onto archives.

candidate.

Although many West African countries initiated major domestic market reforms during the 1980s and early 1990s, a parallel effort has been made to harmonize and coordinate economic policies within the sub region as a whole. These efforts have been particularly strong among countries that are part of the current UEMOA (West African Economic and Monetary Union)[9]. In 1999, these eight countries started the processes towards greater economic integration through a common external tariff (CET) on most goods and the free movement of people and goods within the union. If upheld, the latter component of regional market integration could have particularly strong implications for cross-border spatial staple food relationships by increasing the competitiveness of goods produced and marketed within the UEMOA region vis-à-vis imports. However, as in many parts of the world, periods of crisis frequently pave the way for food policies designed to drive down local prices in order to appease vocal (and potentially violent) urban consumers. Such policies include both formal and informal trade bans and government staple food purchase, sales at "social prices" and free distributions, and are potentially pursued at the expense of both domestic rural agricultural production and marketing incentives and regional policy agreements.[10] At the same time, border officials benefitted from formal cross-border trade barriers through side payments such as bribes. Today, authentic as well as clandestine "border officials" can be found along all major cross-border agricultural trade corridors within the sub region. Bromley and Foltz (2010) estimate that this "cost of corruption" constitutes between 15 and 30 percent of total transport costs. The

[9] These include the countries of Benin, Burkina Faso, Côte d'Ivoire, Guinea-Bissau, Mali, Niger, Senegal and Togo.

[10] For example, if domestic policies are designed to keep staple food prices low for urban consumers (by officially setting prices or closing off borders to neighboring markets) rural producers are potentially faced with important production disincentives.

magnitude of side payments has been estimated to increase up to eight-fold during periods of official and unofficial trade bans (Staatz et al., 2008).

Marketing infrastructure improvements could plausibly influence both the number of markets and the physical distance over which cereals buyers and sellers trade (Aker 2008 and Jensen, 2007) as well as the governance of market exchanges (e.g., moving from personal connections to more anonymous exchanges). Our hypothesis is that these policy changes and accompanying marketing services and infrastructure have influenced the evolution of spatial cereals price relationships within the sub region. However, although we may know the date of completion of a major infrastructure improvement project or the date of a major policy change, it impossible to know a priori how long of an adjustment period it will take to reach its full effect. For example, reliable disaggregated ICT (e.g., cell phone) usage data are not available. We therefore introduce threshold variables that coincide with the timing of the introduction of alternative ICTs. This can be represented as a binary variables (e.g. $D_t = 0$ if $t < ICT$ and $D_t = 1$ if $t \geq ICT$) or take on the form of a time trend coinciding with the introduction of the new technology allowing improved access of agricultural market information (e.g. $D_t = 0$ if $t < ICT$ and $D_t = t - ICT$ if $t \geq ICT$). A similar approach can be taken for the timing of known agricultural marketing policy changes or road rehabilitation projects.

6. Data and Marketing Corridors

Several types of data were collected to study spatial price transmission within the sub-region. When possible, these data were collected at monthly intervals spanning the period of January 1994 to December 2010 (204 observations). The specific trade axes and market pairs chosen for this analysis were identified through literature review as well as discussions with key informants during the author's fieldwork in 2011. The marketing axes are described in Table 3 and illustrated in Figure 4 and are taken to represent the main emerging marketing arteries for maize between Senegal, Mali, Burkina Faso and Niger rather than cover all possible marketing axes within the sub region. Several axes cross national borders, thereby allowing us to differentiate between the evolution of the performance of maize markets within and across national borders. The distance between market pairs varies from 176 (between Sikasso and Bobo-Dioulasso) to 1342 Km (between Bamako and Dakar).

Monthly price (FCFA/kg) series from the primary maize trading markets along each axis were obtained from the national AMISs in Burkina Faso, Mali, Niger and Senegal (SIM/SONAGES, SIMA, OMA and SIM/CSA respectively).[11] When possible, retail prices for locally (or regionally) produced maize were selected over a mix of wholesale, producer and retail prices because of the relative uniformity in data collection methods across the three countries for prices series at this level.[12] Related to this is the assumption that cereals sold at the retail level are relatively homogenous across time and space versus cereals sold at the wholesale or farm-gate levels. One important exception is the price series from Thiaroye, a suburb of Dakar, Senegal. Locally (or sub-regionally) produced maize prices were reported irregularly for this market and therefore imported maize prices (from international markets), are used for this market. The following analyses and discussions involving Dakar can therefore be taken to reflect the evolving relationship betweenWest African and international (world) maize prices. Summary statisitcs for the maize price series are presented in Table 4 and the price series for each market pair used in the analyses are illustrated in Figure 3. It is worthwhile to note that, as expected, prices in the

[11] There are gaps in some of the price series that generally reflect periods during which the AMISs were not able to send agents out to collect data (due to enumerator morbidity or mortality, or due to budgetary or other problems)— a case of missing data. However, during certain periods there was actually no grain available on the market (e.g., the summer months of 2007 in Senegal) and so it is an unobserved data issue, rather than simply missing data points.
[12] For example, in Mali, it is standard for wholesale maize to be bought and sold in 50 or 100 kg sacks, whereas the industry standard in Burkina Faso is 80 kg bags. At the retail level, the AMIS agents across all four countries collect per kilogram prices for all commodities (grains, fruits, vegetables, etc.).

structurally food deficit urban centers are highest. Average prices appear to have decreased although the coefficient of variation increased in Senegal and Burkina Faso while the opposite is true in Mali and Niger.

In addition to the maize price series, four additional types of data were collected that are hypothesized to directly influence either transfer costs or trade flow patterns (the level or direction). The first are monthly fuel price series (FCFA/liter) illustrated in Table 4 and Figure 3, that have previously been estimated to contritube up to 50 to 85 percent of variable transfer costs (Aker, 2007; Araujo-Bonjean et al., 2010; Teravaninthorn and Raballand, 2009).[13] [14] Annual road quality indicators were created through a combination of the reported dates of major road rehabilitation work along the maize marketing corridors by government agencies or donor infrastructure project reports or annual road quality indicators obtained directly from national transport ministries. The dates (including the month and year) of the introduction of GSM cell-phone network coverage in the markets covered in this analysis were obtained from local government officials and national telecommunications regulatory commissions. Finally, the dates of major official and unofficial policy changes related to cross-border grain trade were compiled through official government documents, grain marketing research reports (by AMISs and regional organizations like FEWSNet and the World Food Program), a review of available gray literature and discussions with key informants.

[13] Government sponsored fuel import and marketing panels in each country still tightly control fuel prices. Although the specific methods of retail fuel price discovery differ by country, prices are set through regular (monthly) panel discussions with industry, government and consumer advocacy groups. Retail prices are technically pan-territorial, although some minor variation is observed at times to take into account the cost of transporting fuel to distant interior markets.

[14] The ministries of transport in each country regularly publish detailed merchandise (including agricultural commodity) transport cost structure reports. These allow for different assumptions about types of vehicle used as well as different levels of road quality. The maintained assumption in the estimates used in this analysis is that cereals are transported in 40T vehicles.

7. Preliminary Results

In order to evaluate the effects of structural change on spatial maize market price relationships, this research first tests for the presence of threshold effects over time within a flexible grid search framework. Although other threshold criteria exist (Hansen, 1996), this research uses the Gonzalo and Piterakis (2002) criterion, which ultimately allows us to test for the presence of two or more regimes (e.g. one or more thresholds). The following discusses the results from the single threshold case, as a preliminary step before testing for additional threshold effects. Once we have established that our price series do exhibit evidence of threshold effects over time on both the long-run equilibrium relationship and short-run speed of adjustment of our market price pairs over time, we move on to our results of the impact of the introduction of improved access to information via the roll of out the mobile cell phone network in West Africa on spatial price relationships. The potential effects of other structural changes in West Africa on spatial maize market relationships will be discussed in subsequent drafts.

Myers and Jayne (2011) discuss some of the difficulties associated with establishing the time-series properties of our data within the proposed framework. More specifically, they note and illustrate via simulation, that, within this non-standard testing framework there is a bias in favor of acceptance of the null of non-stationarity (and no cointegration) of our price series. With these concerns in mind, this research begins by testing for threshold effects within our time series using the G-P criterion. Second, we provide conduct standard unit root tests (Augmented Dickey-Fuller and Philips-Perron) and present the results from Engle and Granger cointegration tests, with the understanding that our results may well be biased. Third, regime-specific estimation and testing of the long-run spatial price transmission parameters (β) and the speed of adjustment parameters (λ) is carried out within the SEECM framework. In the event that our stationarity test results suggest that our price series are not cointegrated, we make the assumption that our results provide an upper bound on the extent of price transmission between spatially distant maize market price pairs in West Africa. In the event that the estimated timing of the threshold behavior or toward the tail end of our time series we only present results from the first regime (for example, several regimes contain less than 15 observations making estimation and inference difficult).

7.1 Results from flexible grid search method

If we were to ignore the possiblity of changing long run and speed of adjustment parameters over time, we would conclude that price transmission is on average greatest along the domestic marketing corridors in Mali (ranging between .89 and 1.11) and along the cross-border corridors linking Burkina Faso and Niger (.94). However, our grid search results suggest each of the maize marketing corridors considered in this study exhibits changing spatial market relationships over time. In a first stage, our two-regime grid-search technique suggests that the timing of the regime changes vary greatly across marketing axes. In Table 5 we present the results from a single threshold search for our sample of marketing corridors using both the G-P and Hansen tests. Our findings suggest that in all but three cases, these tests yield very different results. The results from a sequential grid search approach suggest the existence of between three and five price transmission regimes (between two and four cointegrated regimes) along each marketing corridor over the course of the sample period (January 1994- Decmeber 2010). Despite the discussed challenges of estimating the time-series properties of our data within the present highly non-linear setting, our findings in Tables 6 - 10 generally suggest that our prices series exhibit non-stationary behavior and are co-integrated across regimes. This is in line with the findings of other research on cereals markets in the sub-region (Araujo-Bonjean et al., 2010; Vitale and Bessler, 2006).

The parameter estimates from our spatial price transmission model indicate that indeed, long-run spatial price relationships and that the speed of adjustment back to equilibrium following a shock appear to have varied considerably over time and across marketing corridors, although both indicators of market performance have generally increased. most cases, including a single lag is sufficient to eliminate the autocorrelation from the error term from our estimated equation (5). As in other related studies, the estimated long-run price transmission ($\hat{\beta}$) is interpreted as the extent to which a one unit price change in an exporting market is felt in an importing market while the speed of price adjustment ($\hat{\lambda}$) is expressed in terms of half-lives (hl = $\ln(.5)/\ln(1+\hat{\lambda})$) and can be interpreted as the number of time periods it takes for half of the adjustment back the long-run equilibrium to occur in the importing market following a shock in the exporting market.

Our results suggest that price transmission along the Senegalese marketing corridor linking Tambacounda and Kaolack was strongest between 2004 and 2007 (.68), although the speed of price adjustment was fastest after 2007 (instantaneous). Markets along the corridors linking Bobo-Dioulasso and Ouagadougou, Sikasso and Bobo-Dioulsasso and Sikasso and Ouagadougou were not cointegrated before 1998, although both indicators of market performance (price transmission and the speed of adjustment) have gradually increased since that time. For the market pairs linking Burkina Faso and Niger (Ouagadou and Niamey and Bobo-Dioulasso and Niamey) the extent of price transmission was highest before 2008, although the speed of price adjustment was fastest between 2008-2010.

Our results suggest that Malian maize markets were not cointegrated prior to 1998. For the marketing corridor linking Mali's main maize production and consumption zones (Sikasso and Bamako, respectively), spatial price transmission was strongest between 2002 and 2005, although the speed of price adjustment was slowest. When we consider the marketing corridors linking Malian marketsto Kayes (Sikasso and Bamako) price transmission was strongest between 2001 and 2005, while for the Senegalese market of Tambacounda it was strongest before 2000. The speed of price adjustment along all the marketing corridors linked to Kayes was strongest before 2001. These results indicate that there is no clear trend towards improved outcomes of our market performance indicators over time. The following sections investigate the impact of other macro-economic and corridor-specific structural changes in the economy on spatial price relationships in effort to provide some reasoning behind our disparate results.

7.2 Impact of UEMOA policy changes on spatial maize price relationships in West Africa

The entry into force of the UEMOA regional trade agreement in January 2000 was theoretically designed to remove the border effects of trade flows of goods and services between member countries. If fully implemented, we would expect this to have the impact of reducing both transaction and transfer costs along cross-border marketing corridors thereby improving the ability of the private sector to achieve spatial market efficiency by making it easier to respond to shifting supply and demand patterns in both food surplus and deficit zones. However, the presence periodic official and unofficial trade bans and of non-tariff trade barriers (road blocks, bribes to let goods pass during periods trade bans) along these marketing corridors could thwart the potentially positive impact of such regional policy efforts on maize market performance indicators.

Our spatial price transmission regression results are presented in Tables 11 (for domestic marketing corridors) and Table 12 (for cross-border marketing corridors). Our results indicate that if we consider the entire pre-UEMOA time period, no market pairs were cointegrated during that time. This finding is more or less consistent with our flexible grid search results which suggested that maize market prices in Senegal, Mali, Burkina Faso and Niger were not cointegrated until after 1998. For the remainer of this discussion we will then only concentrate on the extent and speed of spatial price transmission during the post-UEMOA period.

Our regression main results suggest that trends from three separate sub-basins emerge aross the marketing corridors linking these four countries including Burkina Faso and Niger to the east, Southern Mali and Burkina Faso in the center and Western Mali and Senegal in the West. Most specifically, spatial price transmission is stronger for the cross-border market pairs linking Burkina Faso to Niger, athough the speed of price transmission is strongest between the Burkinabé markets of Bobo-Dioulasso and Ouagadougou. Between Southern Mali and Burkina Faso, we find the strongest long run equilibrium relationship existing between Sikasso and Bobo-Dioulasso, which are also the closest market pairs in our sample. With that said, the speed of domestic price transmission is faster between Sikasso and Bamako than between Sikasso and its southern Burkinabé trade partners. When we consider the markets in Western Mali and Senegal, we find that Tambacound and Kaolack share the weakest long-run equlibrium relationship. Price transmission is strongest for the marketing corridors linking Kayes with Bamako, Sikasso and Tambacounda, athough the link is strongest for the domestic market pairs. The speed of price transmission is very similar among these markets as well (with half lives ranging form 2.2 to 2.94 months).

Although it is somewhat surprising the find such varied results across domestic and cross-border market pairs and across marketing "sub-basins", our results do suggest that indeed, many cross border market pairs have stonger spatial price relationships than their domestic counterparts. This may not be clear evidence that the entry into force of the UEMOA agreements has had a positive impact on our market performance indicators and a negative impact on transfer and trasaction costs, but these findings do suggest movement towards a borderless sub-region—even in the presence of frequent offcial and unofficial trade bans. Efforts by regional, national and local entities in support of this process (that is underway despite numerous challenges) should therefore be further bolstered.

7.3 Impact of ICT roll-out on spatial maize price relationships in West Africa

Improved access to timely and accurate market information via the roll-out of mobile cell phone networks can influence spatial maize market price relationships in several ways. First, it can simply open up new trade partners and therefore increase the quantities of maize traded along marketing corridors. Under this scenario we might expect to find an increase in the value of our parameter estimate of our long-run equilibrium relationship. Second, improved access to information could reduce unobserved transaction costs, and therefore reduce the estimated value of the constant term in our SEECM. Third, improved access to market information may increase the speed at which marketing actors respond to shifting supply and demand conditions, and therefore impact our speed of price adjustment back to equilibrium following a shock. It is difficult a priori to predict how many of these three scenarios play out in the case of maize markets in West Africa, so allow our data to inform our discussion. Before going into the details our findings, it is important to note the cell phone service coverage occurred before the estimating timing our time-based single threshold effects for each of the marketing corridors studied.

As illustrated in Table 3, the roll out of cell phone coverage in the cities considered in this study began in 1996, in Senegal, and ended in 2002 in Mali. Although several cell phone service providers now exist in West Africa, this study considers simply the introduction of the first cell phone service provider in a given area. At this point, this study imposes a regime change when the cell phone network covers both markets—although it is possible that information begins to travel more quickly and freely once just one market is covered.

When we turn to the statistical properties of our data before an after our imposed regime change we find that, generally speaking, our market price pairs are non-stationary and co integrated. With that said, there is some evidence that maize prices in the cross border markets linking Niger (Niamey) and Burkina Faso (Ouagadougou and Bobo-Dioulasso) and Mali (Bamako) and Senegal (Dakar) may not have been co integrated prior to the roll out of ICT, while the cross-border market pairs of Tambaconda and Kayes may not be cointegrated following the introduction of ICT. This is consistent with other findings in the literature (refs) that ICT network coverage does not necessarily change the underlying statistical properties of the data (cointegrated or not), but rather the transaction costs, as well as the extent and speed of price transmission across space.

As with our other regression results, our findings in Table 13 vary greatly by marketing corridor studied. For example, we only find a positive increase in our our indicator of the extent of price transmission for the cross-border markets linking Dakar and Bamako and Niamey with Ouagaoudou and Bobo-Dioulasso. In addition to being cross-border market pairs, these markets are among the most spatially distant in our sample (1342, 514 and 871 Km, respectively). As discussed above, there is some evidence that these markets were not cointegrated prior to ICT coverage, but it is difficult to say whether this new equilibrium relationship was achieved thanks to ICT coverage or thanks to the entry into force of the UEMOA regional trade agreemets at around the same time (both occurred in 2000). For the cross-border marketing corridors linking Sikasso with Burkina Faso (Ouagadougou and Bobo-Dioulasso) we find that the amout of time it takes the maket prices to revert to equilibrium following a shock decreases following the introduction of ICT from 1.7 to 1.4 months in the former case and 4 to 1.2 months in the latter. In Mali, we find that the introduction to ICT coverage does not have a positive impact on the extent of price transmission, but rather the distribution of transaction and transfer costs along the marketing corridors. In Burkina Faso, we find that ICT coverage has a positive impact on the speed of price adjustment between Ouagadoug and Bobo-Dioulasso, while also influencing distribution of transaction and transfer costs along the marketing corridor.

Several factors could explain these seemingly divergent results. First, it is possible that the roll out of cell phone coverage in West Africa has changed the underlying price discovery process. In other words, trade may well have increased between Mali and Senegal or Sikasso and Bamako in Mali with the roll out of the cell phone network. But, if the resulting contracts are part of a vertically integrated chain (e.g. feed processing) and embody some interlinked characteristics they occur in parallel to market transactions and therefore may contribute little or nothing to spatial market price relationships. Second, previous studies have suggested that the Malian border markets of Kayes and Sikasso are engaged in far more trade with neighboring country markets than those in Mali. As a result, these markets share much stronger long-run equilibrium relationships than their domestic counterparts. This may certainly be playing out in our data as well. In other words, the roll out of ICT in these border markets appears to have reinforced existing cross-border trade relationships. Finally, it is quite surprising to find no clear pattern regarding the impact of the roll out of ICT on unobserved transaction costs, as captured by our constant term. This may be attributed to other changes in the marketing environment that could influence transaction costs including marketing policies, road infrastructure and fuel price policies. These topics will be investigated in future drafts.

7.4 Impact of road rehabiliation on spatial maize price relationships in West Africa

As discussed by Cirera and Arndt (2008) road rehabilitation may impact spatial market performance via two channels: by lowering transfer and transaction costs and by facilitating the entry to the market of more traders, particularly informal traders that lack transport capacity. Although our data will not allow us to parse out these individual effects (among others), we can say that road-rehabilitation may influence each of the parameters estimates in our spatial price transmission regression by increasing competition, facilitating information flow, and lowering both observed transfer costs and unobserved transaction costs.

At first glance, the regression results in Tables 14 and 15 indicate that rural road construction and rehabilitation has had a positive impact on the speed of price adjustment for each marketing corridor and both of our market performance indicators for each cross-border market pair except those linking Senegal with Mali (including the most distant market pair, Dakar and Bamako). We consider two different marketing sub-basins for this discussion including Senegal and western Mali on the one hand and Southern Mali, Burkina Faso and Niger on the other. Much of the road construction and rehabilitation work completed along the marketing corridors linking Senegal and Western Mali occurred around the same time in 2003-2007. For the marketing corridor linking Tambacounda and Kaolack, we find price transmission increased as well as the speed of price adjustment (instantaneous adjustment). For the remainder of the marketing corridors in this sub-basin, we find that rural road rehabilitation actually had a negative impact on our long-run price transmission parameter and a positive impact on the speed of price adjustment. In other words, with rural road rehabilitation the extent of price changes transmitted decreased but the amount of time it took to revert to equilibrium following a shock decreased.

Rural roadwork along the marketing corridors linking southern Mali, Burkina Faso and Niger occurred in phases between 1998 and 2010, with much of the work completed in 2000 and then again between 2006 and 2008. Indeed, when we look at the results for the market pairs linking these three countries, we find that both of market performance indicators have unilaterally increased. In the case of the cross-border market pairs, this may be due to the complementary impact of the UEMOA regional policy agreement that occurred at around the same time as the bulk of the first set of road work over our sample period. This also provides further explanation for our findings of the increased speed and extent of price transmission along the domestic marketing corridor linking Bobo-Dioulasso and Ouagadougou.

8. Conclusions and Policy Implications

National governments and regional supra-governmental organizations many put into action several tools to improve staple food market performance indicators. However, these policy and investment decisions do not occur in a vaccum. The outcomes (impact) are therefore influenced by other structural changes within the economy. These include changing tastes and preferences, shifting crop production patterns and evolving agro-climatic conditions. Efforts to understand these processes shed light onto the appropirateness of alternative protection mechanisms for the poor and alternative approaches for assuring continued investment in agriculture by the private sector within a regional context. The extent and speed of staple food price transmission between surplus and deficit zones are two indicators of market performance with implications for the incentives faced by producers on the one hand and the purchasing power of poor urban households on the other.

The results from this research indicates the spatial price relationships along the maize marketing corridors linking Senegal, Mali, Burkina Faso and Niger during our sample period (1994-2010) has been quite dynamic. If we consider the case of no regime change over our sample period, we would likely conclude that market integraion in Mali is strongest, followed by the marketing corridor linking Niamey and Ouagadougou, the marketing corridors linking Sikasso (in Southern Mali) with the markets in Burkina Faso, followed the corridors in and linked to Senegal. However, as the results in Tables 5-15 illustrate, if we allow for the possibility of changing spatial price relationships over time, a very different picture emerges. We still generally find two to three marketing sub-basins with fairly different market performance outcomes. We find that at least two regimes have existed along each marketing corridor when using a flexible grid search approach, that the regional trade agreements and ICT introduction both had a positive impact on market integration between Senegal and Mali and Burkina Faso and Niger, and that rural road rehabilitation improved the speed of price transmission along all marketing corridors and the extent of maize price transmission between Mali, Burkina Faso and Niger. There is strong evidence of movement towards a single regional market in the sub-basin linking Mali, Burkina Faso and Niger, while markets are somewhat segmented between Senegal and Mali. These results emerge despite the frequent use of both formal and informal trade barriers within the subregion. Future effort at the regional, national and local to improve maize market performance should bolster these processes, rather than hinder them. At the same time, the parallel and persistent challenge of providing marketing incentives to farmers and food security to urban households should be addressed regionally, rather than segmented by national boundaries. Future work will use a proxy for regoinal stock levels (a rainfall index) to further explain our varied results--- across marketing corridors and over time.

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10. Figures and Tables

Table 1: Indicators of Consumption Pattern Changes in West Africa						
Country	Year	Per Capita Rice Supply (KG)	Per Capita Maize Supply (KG)	Per Capita Millet Supply (KG)	Per Capita Sorghum Supply (KG)	Total Cereals Supply for Food (000s MT)
Burkina Faso	1990	11.6	36.8	78.4	85.1	2230
	2000	20.4	45.9	69.8	69.3	2923
	2005	19.3	40.7	73.9	90.8	3716
Mali	1990	25	17.5	73.1	60.7	1586
	2000	50	24.3	58.4	43.2	2448
	2005	54.4	28.3	61.6	42.8	3019
Niger	1990	10	0	168.8	36.6	2361
	2000	11.4	6.7	148.7	22.3	2876
	2005	22.9	3	120.6	39.1	3565
Senegal	1990	65.1	16.6	61.1	18	1626
	2000	72.9	8.2	37.3	11.6	1857
	2005	69.5	30.9	22.1	10.6	2262
References: FAO Food Balance Sheets (1990-2005)						

Table 2: Poultry Supply in West Africa 1990-2005 (MT)					
Country	**Source**	**1990**	**1995**	**2000**	**2005**
Burkina Faso	Import	0	0	0	32
Mali	Import	0	0	67	312
Senegal	Import	1,252	269	504	11,654
Niger	Import	39	39	34	34
Burkina Faso	Production	19,163	22,470	26,469	30,882
Mali	Production	23,680	25,600	29,200	36,000
Senegal	Production	12,700	17,460	23,239	29,042
Niger	Production	9,168	10,120	10,976	11,708
Burkina Faso	Domestic supply	19,163	22,470	26,469	30,912
Mali	Domestic supply	23,680	25,600	29,267	36,312
Senegal	Domestic supply	13,908	17,728	23,729	40,617
Niger	Domestic supply	9,207	10,159	11,010	11,742
References: FAO Food Balance Sheets (1990-2005)					

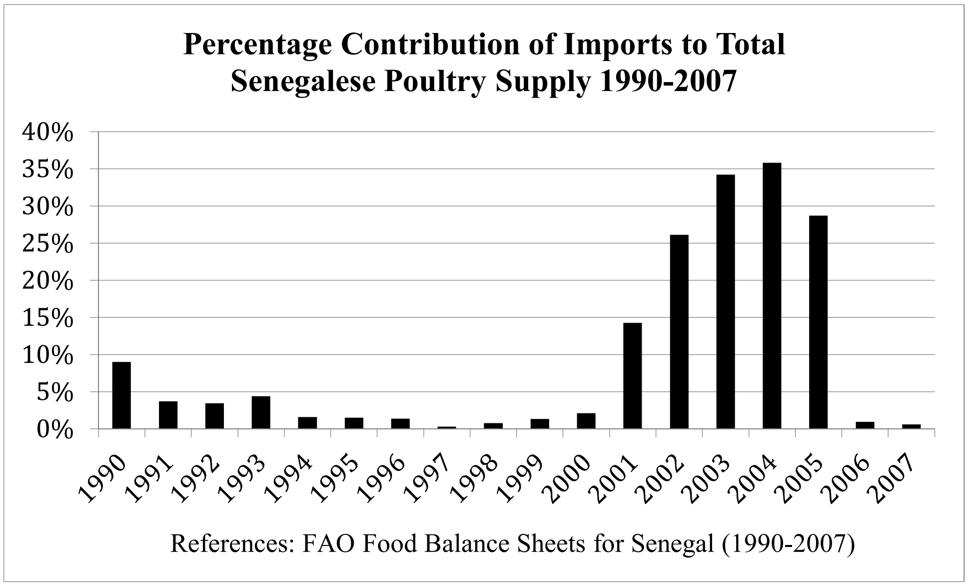

Figure 1: Percentage Contribution of Imports to Total Senegalese Poultry Supply

Figure 2: Maize Marketing Corridors in West Africa

Table 3: Description of Market Pairs Along West African Maize Marketing Corridors									
Importing Market P	Exporting Market S	Distance (KM)	Average price spread (Real 2000=100 FCFA/Kg)	Cross border	ICT Introduction			Major road rehabilitation completed between 1994-2010	
				Y= yes N= no	Market P	Market S	Both	First	Second
Dakar (Senegal)	Tambacounda (Senegal)	423	17.9	N	Dec-96	Dec-97	Dec-97	2007	-
Kaolack (Senegal)	Tambacounda (Senegal)	279	5.1	N	Dec-97	Dec-97	Dec-97	2007	-
Kayes (Mali)	Tambacounda (Senegal)	282	17.5	Y	Jan-02	Dec-97	Jan-02	2003	2007
Bamako (Mali)	Dakar (Senegal)	1342	37.4	Y	Oct-00	Dec-96	Oct-00	2007	-
Kayes (Mali)	Bamako (Mali)	612	27.9	N	Jan-02	Oct-00	Jan-02	2003	2005
Kayes (Mali)	Sikasso (Mali)	980	59.7	N	Jan-02	Jan-02	Jan-02	2003	2007
Bamako (Mali)	Sikasso (Mali)	364	31.7	N	Oct-00	Jan-02	Jan-02	2005	2008
Bobo-Dioulasso (Burkina Faso)	Sikasso (Mali)	176	6.9	Y	Dec-97	Jan-02	Jan-02	1998	2010
Ouagadougou (Burkina Faso)	Sikasso (Mali)	529	22.0	Y	Dec-96	Jan-02	Jan-02	2000	2008
Ouagadougou (Burkina Faso)	Bobo-Dioulasso (Burkina Faso)	353	15.1	N	Dec-96	Dec-97	Dec-97	2000	2008
Niamey (Niger)	Ouagadougou (Burkina Faso)	514	30.3	Y	Oct-00	Dec-96	Oct-00	2000	2006
Niamey (Niger)	Bobo-Dioulasso (Burkina Faso)	871	45.4	Y	Oct-00	Dec-97	Oct-00	2000	2006

Table 3: Description of Market Pairs Along West African Maize Marketing Corridors

Table 4: Description of Real (2000=100) Price Series Along West African Maize Marketing Corridors (FCFA/Kg)

Price Series	Market	Entire Sample (1994-2010) Obs	Mean	Std. Dev	Min	Max	C.V.	Before UEMOA Regional Agreements (Jan '94- Dec '99) Obs	Mean	Std. Dev	C.V.	After UEMOA Regional Agreements (Jan '00- Dec '10) Obs	Mean	Std. Dev	C.V.
	Senegal														
Maize	Dakar	166	157.33	19.56	113.98	209.22	0.12	34	174.60	19.29	0.11	132	152.88	17.05	0.11
	Kaolack	192	138.10	22.54	75.60	188.32	0.16	60	152.94	22.35	0.15	132	131.36	19.22	0.15
	Tambacounda	192	143.22	28.64	69.79	209.12	0.20	60	151.48	28.20	0.19	132	139.47	28.15	0.20
	Mali														
	Kayes	204	142.09	32.50	78.46	206.68	0.23	72	117.49	31.28	0.27	132	155.50	24.35	0.16
	Bamako	204	117.07	30.58	55.05	182.29	0.26	72	90.72	23.37	0.26	132	131.44	23.74	0.18
	Sikasso	204	88.55	24.32	39.87	154.04	0.27	72	72.12	20.25	0.28	132	97.51	21.57	0.22
	Burkina Faso														
	Bobo-Dioulasso	204	103.20	24.48	58.69	242.01	0.24	72	104.00	21.19	0.20	132	102.76	26.17	0.25
	Ouagadougou	204	117.41	23.28	79.17	207.43	0.20	72	119.96	21.71	0.18	132	116.02	24.06	0.21
	Niger														
	Niamey	204	149.43	28.38	95.35	254.32	0.19	72	145.23	29.21	0.20	132	151.71	27.76	0.18
Fuel	Senegal	132	412.03	83.80	295.38	676.05	0.20	--	--	--	--	132	412.03	83.80	0.20
	Mali	204	362.55	72.04	258.19	475.87	0.20	72	289.24	25.44	0.09	132	399.62	56.80	0.14
	Burkina Faso	204	385.26	77.37	277.49	519.79	0.20	72	319.64	35.33	0.11	132	421.06	70.30	0.17
	Niger	204	330.55	112.09	173.19	594.54	0.34	72	219.41	48.01	0.22	132	391.18	87.90	0.22

References: Maize price series are from national market information systems in Mali and Niger (OMA and SIMA, respectively) and the food security commissioners of Burkina Faso and Senegal (SONAGESS and CSA, respectively); Fuel price series are from the Ministry of Commerce in Senegal and the national fuel regulatory commissions in Mali, Burkina Faso and Niger.

Notes: For Dakar, the price series are taken from a suburban wholesale market in Thiaroye. The analyses use imported maize (from the world market) in lieu of local maize prices because of the completeness of the price series of the latter. The analysis and discussion pertaining to Dakar in this paper are therefore indicative of the evolution of West African and world maize market relationships.

Table 4: Description of Real (2000=100) Price Series Along West African Maize Marketing Corridors (FCFA/Kg

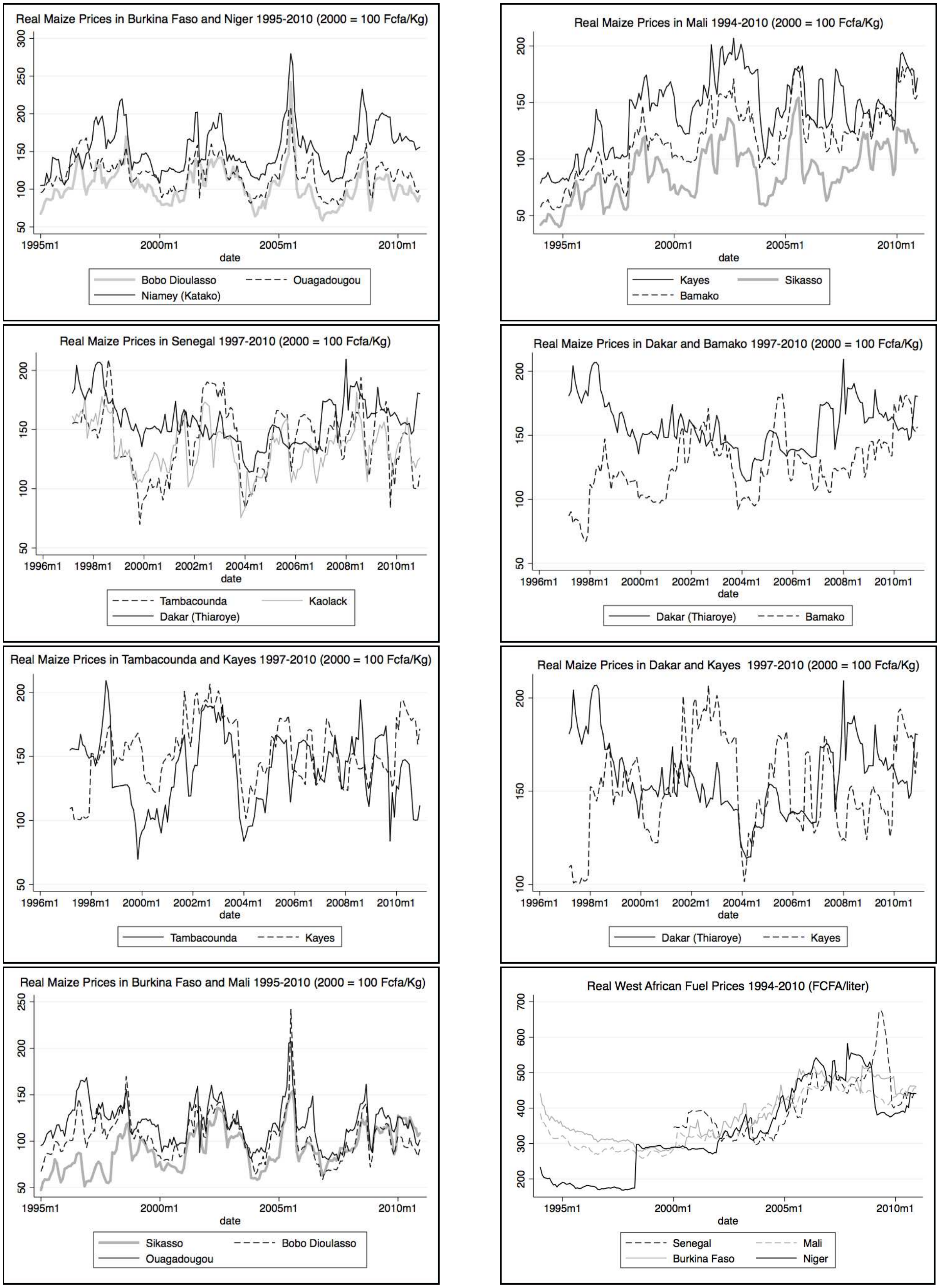

Figure 3: Real Prices Series (2000 =100)

Table 5: Regimes estimated using G-P grid search criterion

Maize Marketing Corridor	First threshold using G-P criterion	Single threshold using Hansen's test	Regimes Estimated using G-P criterion	Regimes with co-integrated prices
Dakar - Tambacounda	Dec-06	Nov-06	4	2
Kaolack - Tambacounda	Nov-08	Jul-02	3	3
Kayes- Tambadounda	Oct-05	Aug-03	5	2
Bamako - Dakar	Jul-05	Aug-03	4	3
Kayes - Bamako	Oct-03	Nov-03	5	3
Kayes - Sikasso	May-05	Oct-03	5	2
Bamako - Sikasso	Jul-05	Jun-05	4	3
Bobo-Dioulasso - Sikasso	Jun-05	Jul-02	4	2
Ouagadougou- Sikasso	Jun-04	May-01	5	4
Ouagadougou - Bobo-Dioulasso	Jul-05	Nov-96	5	4
Niamey- Ouagadougou	Jan-08	Sep-98	4	2
Niamey - Bobo-Dioulasso	Jan-08	Aug-05	4	4

Table 5: Regimes estimated using the G-P grid search criterion

Table 6: Regime Estimates Over Time Along Domestic Marketing Corridors in Senegal and Burkina Faso

	Tambacounda - Dakar					Tambacounda- Kaolack				Bobo-Dioulasso - Ouagadougou				
	No threshold	Regime 1	Regime 2	Regime 3	Regime 4	No threshold	Regime 1	Regime 2	Regime 3	No threshold	Regime 1	Regime 2	Regime 3	Regime 4
Time Period	Jan'00- Dec '10	Jan'00- July '01	Aug'01- July'06	Feb'07- Feb'08	Mar'08- Dec'10	Jan'00- Dec '10	Jan'00- Feb'04	Mar '04- June '07	Nov'08 - Dec'10	Apr '94- Dec '10	Apr '94- Jan'99	Dec '00- Sept '04	Oct '05- Aug '07	Oct '07- Dec '10
$\hat{\alpha}$	12.47+	167.62**	34.24*	4.87	41.63	19.49*	44.85	20.08	155.79*	9.88*	44.60	28.24	38.14	62.51+
	(6.21)	(38.41)	(10.62)	(631.46)	(25.54)	(6.44)	(25.65)	(12.49)	(41.07)	(3.65)	(47.02)	(15.71)	(94.26)	(23.43)
$\hat{\beta}$	-0.08	0.18*	0.24*	0.42	-0.26	0.32+	0.40**	0.68**	0.46**	0.76**	0.47	0.85**	1.66**	1.07**
	(0.26)	(0.05)	(0.08)	(1.99)	(0.64)	(0.13)	(0.08)	(0.17)	(0.09)	(0.09)	(0.32)	(0.08)	(0.34)	(0.11)
$\hat{\gamma}$	0.21*	0.09	0.00	0.23	0.04	0.08*	0.01	-0.01	-0.02	0.04+	-0.70	-0.02	-0.17	-0.10
	(0.07)	(0.05)	(0.04)	(1.58)	(0.12)	(0.03)	(0.11)	(0.05)	(0.02)	(0.02)	(0.88)	(0.04)	(0.32)	(0.05)
$\hat{\lambda}$	-0.14+	-1.66**	-0.31**	-0.57	-0.19	-0.34**	-0.61**	-0.49*	-1.47*	-0.37**	-0.16+	-0.90**	-0.63**	-0.81**
	(0.06)	(0.29)	(0.09)	(0.58)	(0.15)	(0.08)	(0.15)	(0.16)	(0.39)	(0.07)	(0.07)	(0.19)	(0.20)	(0.20)
Half life	4.60	N/A	1.87	0.97	3.29	1.67	0.74	1.03	N/A	1.50	3.98	0.30	0.70	0.42
Obs	129	22	55	13	33	129	48	43	25	201	69	56	23	34
Adj R-sq	0.04	0.56	0.17	0.41	0.13	0.20	0.43	0.37	0.48	0.36	0.15	0.45	0.72	0.88
E-G test DF	0.152	0.026	0.010	0.837	0.241	0.001	0.019	0.009	0.074	0.000	0.035	0.000	0.001	0.000
E-G test PP	0.132	0.014	0.087	0.526	0.550	0.000	0.054	0.100	0.015	0.000	0.091	0.000	0.002	0.000

Standard errors in parentheses and ** p<0.01, * p<0.05, + p<0.10

Table 6: Regime Estimates Over Time Along Domestic Marketing Corridors in Senegal and Burkina Faso

Table 7: Regime Estimates Over Time Along Domestic Marketing Corridors in Mali

	Sikasso- Kayes					Sikasso-Bamako				Bamako- Kayes						
	No threshold	Regime 1	Regime 2	Regime 3	Regime 4	No threshold	Regime 1	Regime 2	Regime 3	No threshold	Regime 1	Regime 2	Regime 3	Regime 4	Regime 5	Regime 6
Time Period	Apr'94-Dec'10	Apr'94-Oct'98	Nov'98 - Jan'01	Apr'01 - Mar'05	Apr'05-Dec'10	Apr'94-Dec'10	Sept'98-Aug'01	Jan'02-Mar'05	July'06-June'10	Apr'94-Dec'10	Nov'98-Jan'01	Apr'01-Sept'03	Dec'03-May'05	Aug'05-Oct'06	Dec'06 - Dec'08	Jan'09-July'10
$\hat{\alpha}$	10.49**	-1.00	66.01+	21.25	1.89	6.57**	-0.38	15.26	-29.66	8.71*	48.38	6.32	-76.36	72.41	-54.11	-11.94
	(2.92)	(0.00)	(24.33)	(18.04)	(11.71)	(1.97)	(16.53)	(27.79)	(19.03)	(2.62)	(25.82)	(28.47)	(97.22)	(73.21)	(41.86)	(45.46)
$\hat{\beta}$	0.97**	1.29**	0.66**	1.40**	0.65**	0.89**	0.93**	1.00**	0.82**	1.11**	0.79**	1.25**	0.75	0.51+	0.78**	0.94**
	(0.12)	(0.14)	(0.09)	(0.08)	(0.06)	(0.04)	(0.07)	(0.13)	(0.04)	(0.09)	(0.11)	(0.13)	(0.38)	(0.15)	(0.14)	(0.16)
$\hat{\gamma}$	-0.05	0.06	-0.04	-0.05	0.12+	0.03*	0.06	-0.03	0.14+	-0.08**	-0.00	0.01	0.39	-0.02	0.20	0.08
	(0.03)	(0.043)	(0.060)	(0.050)	(0.049)	(0.01)	(0.06)	(0.09)	(0.05)	(0.02)	(0.06)	(0.10)	(0.52)	(0.13)	(0.13)	(0.14)
$\hat{\lambda}$	-0.18**	-0.27*	-0.90**	-0.73**	-0.45**	-0.47**	-0.86**	-0.63+	-0.76**	-0.22**	-1.05**	-0.79**	-0.58	-0.93+	-0.76+	-0.54+
	(0.04)	(0.09)	(0.13)	(0.13	(0.11)	(0.08)	(0.20)	(0.27)	(0.14)	(0.04)	(0.15)	(0.18)	(0.31)	(0.35)	(0.27)	(0.22)
Half life	3.49	2.20	0.30	0.53	1.16	1.09	0.35	0.70	0.49	2.79	N/A	0.44	0.80	0.26	0.49	0.89
Obs	201	56	26	47	67	201	35	38	47	201	26	28	17	15	24	19
Adj R-sq	0.542	0.573	0.769	0.785	0.677	0.66	0.67	0.63	0.86	0.61	0.76	0.81	0.77	0.86	0.87	0.90
E-G test DF	0.000	0.021	0.003	0.000	0.013	0.000	0.039	0.062	0.013	0.000	0.000	0.008	0.129	0.535	0.011	0.282
E-G test PP	0.000	0.155	0.000	0.000	0.007	0.000	0.000	0.000	0.004	0.000	0.000	0.008	0.010	0.211	0.077	0.011

Standard errors in parentheses and ** p<0.01, * p<0.05, + p<0.10

Table 7: Regime Estimates Over Time Along Domestic Marketing Corridors in Mali

Table 8: Regime Estimates Over Time Along Cross-Border Marketing Corridors between Mali and Senegal

	Tambacounda - Kayes					Dakar- Bamako			
	No threshold	Regime 1	Regime 2	Regime 3	Regime 4	No threshold	Regime 1	Regime 2	Regime 3
Time Period	Mar '94- Dec '10	Feb'96- Oct '98	Jan'99 - Jan'01	Sept '05- Feb'08	May'08- Dec'10	June '97 - Dec '10	June'97- Oct'98	Nov '98- July '04	July '05- Dec '10
$\hat{\alpha}$	5.61	-1.00	66.06	128.01+	124.10+	0.32	-1.00	-32.53	-19.90
	(3.14)	0.00	(44.14)	(57.32)	(45.56)	(5.58)	0.00	(35.15)	(25.09)
$\hat{\beta}$	0.63**	0.96*	0.55*	0.33	0.31**	0.47+	0.79	2.28	0.38+
	(0.16)	(0.26)	(0.14)	(0.16)	(0.07)	(0.24)	(0.83)	(1.52)	(0.22)
$\hat{\gamma}$	-0.01	-0.06	-0.15	-0.34+	-0.14	0.08	-0.16	0.09	0.23
	(0.04)	(0.15)	(0.09)	(0.15)	(0.11)	(0.05)	(0.56)	(0.29)	(0.20)
$\hat{\lambda}$	-0.13**	-0.41+	-0.69*	-0.52**	-0.69**	-0.15**	-0.44*	-0.12+	-0.28**
	(0.03)	(0.17)	(0.23)	(0.10)	(0.15)	(0.04)	(0.16)	(0.07)	(0.06)
Half life	4.98	1.31	0.59	0.94	0.59	4.27	1.20	5.42	2.11
Obs	201	29	24	28	32	162	17	63	65
Adj R-sq	0.37	0.64	0.54	0.78	0.55	0.17	0.43	0.05	0.40
E-G test DF	0.004	0.028	0.709	0.008	0.006	0.002	0.963	0.003	0.000
E-G test PP	0.001	0.066	0.367	0.032	0.014	0.018	0.467	0.059	0.005

Standard errors in parentheses and ** $p<0.01$, * $p<0.05$, + $p<0.10$

Table 8: Regime Estimates Over Time Along Cross-Border Marketing Corridors between Mali and Senegal

Table 9: Regime Estimates Over Time Along Cross-Border Marketing Corridors between Burkina Faso and Niger

	Bobo-Dioulasso - Niamey					Ouagadougou - Niamey			
	No threshold	Regime 1	Regime 2	Regime 3	Regime 4	No threshold	Regime 1	Regime 2	Regime 3
Time Period	Apr '94- Dec '10	Apr '94- June '98	July '98- Nov '04	Dec '04- Oct '07	Jan'08- Dec '10	Apr '94- Dec '10	July '97- Nov '99	Jan'00- Dec '07	Jan'08- Dec '10
$\hat{\alpha}$	4.57	146.73	29.27+	71.08	-22.30	-1.89	-581.79+	7.49	-76.28+
	(3.63)	(128.76)	(11.36)	(34.81)	(28.50)	(3.53)	(215.28)	(6.03)	(35.48)
$\hat{\beta}$	0.82**	0.99	0.83**	0.97*	0.90**	1.07**	1.28**	1.10**	0.80**
	(0.16)	(0.56)	(0.11)	(0.28)	(0.08)	(0.13)	(0.30)	(0.07)	(0.10)
$\hat{\gamma}$	0.12**	-2.45	0.01	-0.39	0.17**	0.07*	2.48**	0.01	0.25**
	(0.03)	(2.24)	(0.05)	(0.44)	(0.04)	(0.03)	(0.46)	(0.02)	(0.04)
$\hat{\lambda}$	-0.23**	-0.19+	-0.59**	-0.25	-1.55**	-0.24**	-0.80+	-0.53**	-1.12**
	(0.06)	(0.09)	(0.13)	(0.18)	(0.29)	(0.05)	(0.31)	(0.09)	(0.22)
Half life	2.65	3.29	0.78	2.41	N/A	2.53	0.43	0.92	N/A
Obs	199	51	74	35	35	201	26	91	35
Adj R-sq	0.37	0.02	0.39	0.66	0.69	0.45	0.58	0.62	0.70
E-G test DF	0	0.147	0.0117	0.0464	0.1943	0	0.3041	0	0.2426
E-G test PP	0	0.173	0.0714	0.0004	0.0012	0	0.3264	0	0.0665

Standard errors in parentheses and ** $p<0.01$, * $p<0.05$, + $p<0.10$

Table 9: Regime Estimates Over Time Along Cross-Border Marketing Corridors between Burkina Faso and Niger

Table 10: Regime Estimates Over Time Along Cross-Border Marketing Corridors between Mali and Burkina Faso								
		Sikasso- Bobo-Dioulasso			Sikasso - Ouagadougou			
		No threshold	Regime 1	Regime 2	No threshold	Regime 1	Regime 2	Regime 3
Time Period		Apr '94- Dec '10	May '97- Apr '06	May '07 - Dec '10	Apr '94- Dec '10	Aug '97- June '01	Aug '01- Apr '04	June '05- Dec '10
$\hat{\alpha}$		6.63+	12.57*	-86.78*	12.67**	42.42	139.13+	55.83**
		(3.44)	(5.66)	(41.31)	(3.92)	(33.60)	(74.93)	(19.47)
$\hat{\beta}$		0.98**	0.75**	0.98**	0.83**	0.71**	0.60**	1.01**
		(0.10)	(0.10)	(0.08)	(0.10)	(0.15)	(0.13)	(0.11)
$\hat{\gamma}$		-0.03	-0.00	0.19+	0.01	-0.08	-0.16	-0.16*
		(0.02)	(0.04)	(0.10)	(0.02)	(0.12)	(0.14)	(0.07)
$\hat{\lambda}$		-0.31**	-0.32**	-0.80**	-0.35**	-0.56**	-1.18**	-0.53**
		(0.06)	(0.08)	(0.15)	(0.06)	(0.20)	(0.30)	(0.11)
Half life		1.87	1.80	0.43	1.61	0.84	N/A	0.92
Obs		201	106	50	201	41	31	78
Adj R-sq		0.53	0.60	0.73	0.3	0.3	0.4	0.5
E-G test	DF	0.000	0.179	0.070	0.000	0.293	0.031	0.131
	PP	0.000	0.001	0.000	0.000	0.033	0.000	0.003
Standard errors in parentheses and ** p<0.01, * p<0.05, + p<0.10								

Table 10: Regime Estimates Over Time Along Cross-Border Marketing Corridors between Mali and Burkina Faso

Table 11: Price Transmission Regression Results Before and After UEMOA Regional Trade Agreements for Domestic Market Pairs

Marketing corridors	UEMOA	CI	$\hat{\alpha}$	$SE(\alpha)$	$\hat{\beta}$	$SE(\beta)$	$\hat{\gamma}$	$SE(\gamma)$	$\hat{\lambda}$	$SE(\lambda)$	Half life	Obs	Adjusted R-sq
Tambacounda - Dakar	After	N	15.62*	-6.61	-0.06	-0.22	0.20**	-0.06	-0.17**	-0.06	3.72	130	0.04
Tambacounda - Kaolack	After	Y	19.36**	-6.35	0.33**	-0.12	0.08**	-0.03	-0.34**	-0.08	1.67	130	0.20
Bamako- Kayes	Before	N	-1.00	0.00	1.31**	0.09	-0.01	0.03	-0.46**	0.10	1.12	68	0.54
Bamako- Kayes	After	Y	18.22**	5.29	1.07**	0.09	-0.12**	0.03	-0.27**	0.06	2.20	132	0.44
Sikasso- Kayes	Before	N	-1.00	0	1.29**	0.124	0.05	0.04	-0.35**	0.087	1.61	68	0.60
Sikasso- Kayes	After	Y	17.34*	5.57	0.92**	0.124	-0.09+	0.04	-0.21**	0.056	2.94	132	0.58
Sikasso- Bamako	Before	N	-1.00	0.00	0.88**	0.08	0.09**	0.03	-0.43**	0.13	1.23	68	0.65
Sikasso- Bamako	After	Y	6.33*	3.19	0.90**	0.05	0.03+	0.01	-0.49**	0.10	1.03	132	0.67
Bobo-Dioulasso - Ouagadougou	Before	N	39.25	47.05	0.48	0.29	-0.53	0.82	-0.17*	0.07	3.72	68	0.27
Bobo-Dioulasso - Ouagadougou	After	Y	7.31	5.53	0.81**	0.07	0.06**	0.02	-0.62**	0.11	0.72	132	0.47

Standard errors in parentheses ** $p<0.01$, * $p<0.05$, + $p<0.10$

Table 11: Price Transmission Regression Results Before and After UEMOA Regional Trade Agreements for Domestic Market Pairs

Table 12: Price Transmission Regression Results Before and After UEMOA Regional Trade Agreements for Cross-Border Market Pairs

Marketing corridors	UEMOA	CI	$\hat{\alpha}$	$SE(\alpha)$	$\hat{\beta}$	$SE(\beta)$	$\hat{\gamma}$	$SE(\gamma)$	$\hat{\lambda}$	$SE(\lambda)$	Half life	Obs	Adjusted R-sq
Tambacounda- Kayes	Before	N	-1.00	0.00	0.46	0.61	0.40	0.35	-0.07	0.05	9.55	68	0.423
Tambacounda- Kayes	After	Y	19.30**	7.02	0.83**	0.15	-0.06	0.05	-0.23**	0.05	2.65	132	0.384
Dakar - Bamako	Before	N	-1.00	0.00	0.41	0.26	0.11	0.17	-0.39**	0.12	1.40	30	0.297
Dakar - Bamako	After	Y	2.04	6.05	0.67*	0.33	-0.01	0.10	-0.14**	0.04	4.60	132	0.158
Sikasso- Bobo-Dioulasso	Before	N	-1.00	0.00	1.25**	0.36	-0.03	0.12	-0.14+	0.07	4.60	68	0.562
Sikasso- Bobo-Dioulasso	After	Y	13.95*	6.04	0.97**	0.09	-0.05+	0.03	-0.44**	0.09	1.20	132	0.585
Sikasso - Ouagadougou	Before	N	-1.00	0.00	1.01**	0.22	0.11	0.07	-0.20**	0.06	3.11	68	0.323
Sikasso - Ouagadougou	After	Y	13.39*	6.54	0.81**	0.09	0.03	0.03	-0.50**	0.09	1.00	132	0.406
Bobo-Dioulasso - Niamey	Before	N	1.47	60.81	0.80	0.48	0.17	1.23	-0.16+	0.08	3.98	68	0.293
Bobo-Dioulasso - Niamey	After	Y	2.46	5.43	0.86**	0.14	0.13**	0.03	-0.29**	0.08	2.02	132	0.469
Ouagadougou- Niamey	Before	N	-24.02	67.56	1.03+	0.55	0.68	1.67	-0.13*	0.06	4.98	68	0.224
Ouagadougou- Niamey	After	Y	-3.44	4.80	1.11**	0.09	0.06**	0.02	-0.41**	0.07	1.31	132	0.590

Standard errors in parentheses and ** $p<0.01$, * $p<0.05$, + $p<0.10$

Table 12: Price Transmission Regression Results Before and After UEMOA Regional Trade Agreements for Cross-Border Market Pairs

Table __: Spatial Price Transmission Regression Results Before and After the Introduction of ICT

Marketing corridors	Policy regime	CI	Distance	ICT Intro	α	*SE(α)*	β	*SE(β)*	γ	*SE(γ)*	λ	*SE(λ)*	Half life	Obs	Adj R-sq
Tamba- Kayes	Before ICT	Y	282	2002	-14.98	*13.72*	0.82**	*0.28*	0.58+	*0.34*	-0.12**	*0.04*	5.42	92	0.43
Tamba- Kayes	After ICT	N	282	2002	24.05*	*10.52*	0.70**	*0.20*	-0.09	*0.07*	-0.21**	*0.06*	2.94	108	0.38
Dakar - Bamako	Before ICT	N	1342	2000	31.89	*35.13*	0.50*	*0.23*	-0.28	*0.22*	-0.36**	*0.10*	1.55	40	0.41
Dakar - Bamako	After ICT	Y	1342	2000	5.83	*6.55*	0.69*	*0.30*	-0.06	*0.10*	-0.16**	*0.04*	3.98	123	0.23
Bamako- Kayes	Before ICT	Y	612	2002	-22.90*	*9.96*	1.28**	*0.07*	0.15*	*0.06*	-0.52**	*0.09*	0.94	92	0.68
Bamako- Kayes	After ICT	Y	612	2002	20.39**	*7.39*	1.00**	*0.09*	-0.14**	*0.03*	-0.24**	*0.07*	2.53	108	0.70
Sikasso- Kayes	Before ICT	Y	980	2002	-6.69	*9.58*	1.25**	*0.09*	0.11	*0.08*	-0.42**	*0.08*	1.27	92	0.65
Sikasso- Kayes	After ICT	Y	980	2002	20.03+	*7.79*	0.78**	*0.17*	-0.13+	*0.05*	-0.17*	*0.06*	3.72	108	0.58
Sikasso- Bamako	Before ICT	Y	364	2002	12.58+	*7.46*	0.93**	*0.06*	-0.03	*0.05*	-0.47**	*0.12*	1.09	92	0.73
Sikasso- Bamako	After ICT	Y	364	2002	10.59*	*4.72*	0.89**	*0.06*	0.01	*0.02*	-0.48**	*0.11*	1.06	108	0.68
Sikasso- Bobo	Before ICT	Y	176	2002	-5.02	*10.17*	1.10**	*0.24*	0.10	*0.21*	-0.16*	*0.07*	3.98	92	0.59
Sikasso- Bobo	After ICT	Y	176	2002	16.39+	*9.10*	0.97**	*0.10*	-0.06+	*0.04*	-0.44**	*0.10*	1.20	108	0.58
Sikasso - Ouaga	Before ICT	Y	529	2002	18.54	*15.62*	0.92**	*0.18*	-0.09	*0.16*	-0.33**	*0.08*	1.73	92	0.28
Sikasso - Ouaga	After ICT	Y	529	2002	12.18	*8.11*	0.81**	*0.11*	0.03	*0.04*	-0.39**	*0.08*	1.40	108	0.47
Bobo- Ouaga	Before ICT	Y	353	1997	105.59	*106.79*	0.85*	*0.35*	-1.34	*1.19*	-0.24*	*0.11*	2.53	38	0.38
Bobo- Ouaga	After ICT	Y	353	1997	11.53*	*4.68*	0.76**	*0.07*	0.05**	*0.01*	-0.54**	*0.09*	0.89	162	0.45
Bobo - Niamey	Before ICT	N	871	2000	26.36	*22.28*	0.79**	*0.27*	-0.15	*0.28*	-0.26**	*0.09*	2.30	89	0.28
Bobo - Niamey	After ICT	Y	871	2000	-0.02	*7.33*	0.92**	*0.17*	0.13**	*0.05*	-0.23*	*0.09*	2.65	111	0.51
Ouaga- Niamey	Before ICT	N	514	2000	-1.45	*21.45*	0.99**	*0.30*	0.11	*0.38*	-0.18**	*0.06*	3.49	89	0.41
Ouaga- Niamey	After ICT	Y	514	2000	-7.48	*6.42*	1.14**	*0.10*	0.08**	*0.03*	-0.37**	*0.08*	1.50	111	0.56

Standard errors in parentheses and ** p<0.01, * p<0.05, + p<0.10

Notes: (1) ICT introduced into Senegalese markets Before our sample begins (1996/97) and (2) here we consider when both markets have coverage

Table 13: Price Transmission Regression Results Before and After the Introduction of ICT

Table 14: Price Transmission Regression Results Before and After Road Rehabilitation Work for Domestic Market Pairs

Marketing corridors	Road rehabilitation	CI	$\hat{\alpha}$	$SE(\alpha)$	$\hat{\beta}$	$SE(\beta)$	$\hat{\gamma}$	$SE(\gamma)$	$\hat{\lambda}$	$SE(\lambda)$	Half life	Obs	Adjusted R-sq
Tambacounda - Dakar	Before	N	13.21+	7.14	0.06	0.19	0.22**	0.07	-0.21**	0.07	2.94	106	0.06
Tambacounda - Dakar	After	N	182.95**	56.94	-0.40*	0.15	0.11**	0.03	-0.92**	0.31	0.27	24	0.15
Tambacounda - Kaolack	Before	Y	15.92*	6.99	0.38**	0.12	0.10*	0.04	-0.37**	0.09	1.50	106	0.29

Tambacounda - Kaolack	After	Y	137.48**	44.84	0.45**	0.11	-0.03	0.02	-1.28*	0.43	N/A	24	0.28
Bamako- Kayes	Before	Y	6.91*	3.42	1.15**	0.11	-0.06+	0.04	-0.22**	0.05	2.79	152	0.60
Bamako- Kayes	After	Y	1.45	14.92	0.93**	0.06	0.03	0.06	-0.53**	0.14	0.92	48	0.85
Sikasso- Kayes	Before work in 2003	Y	-10.57	7.16	1.23**	0.08	0.15+	0.06	-0.44**	0.08	1.20	104	0.64
Sikasso- Kayes	Between rehabilitation work	N	11.16	11.35	0.50	0.35	-0.01	0.13	-0.14	0.08	4.60	60	0.55
Sikasso- Kayes	After work in 2008	Y	16.76	34.74	0.84**	0.12	0.02	0.12	-0.53+	0.22	0.92	36	0.77
Sikasso- Bamako	Before work in 2005	Y	7.90*	3.52	0.91**	0.06	0.01	0.02	-0.48**	0.11	1.06	140	0.67
Sikasso- Bamako	Between rehabilitation work	Y	86.90	61.91	0.75**	0.19	-0.18	0.18	-0.65*	0.22	0.66	24	0.62
Sikasso- Bamako	After work in 2005	Y	-12.06	29.23	0.89**	0.07	0.08	0.06	-0.87**	0.22	0.34	36	0.85
Bobo-Dioulasso -	Before	N	39.25	47.05	0.48	0.29	-0.53	0.82	-0.17*	0.07	3.72	68	0.27
Bobo-Dioulasso - Ouagadougou	After	Y	7.31	5.53	0.81**	0.07	0.06**	0.02	-0.62**	0.11	0.72	132	0.47

Standard errors in parentheses and ** p<0.01, * p<0.05, + p<0.10

Table 14: Price Transmission Regression Results Before and After Road Rehabilitation Work for Domestic Market Pairs

Table 15: Price Transmission Regression Results Before and After Road Rehabilitation Work for Cross-Border Market Pairs

Marketing corridors	Road rehabilitation	CI	$\hat{\alpha}$	$SE(\alpha)$	$\hat{\beta}$	$SE(\beta)$	$\hat{\gamma}$	$SE(\gamma)$	$\hat{\lambda}$	$SE(\lambda)$	Half life	Obs	Adjusted R-sq
Tambacounda-Kayes	Before	Y	6.71	3.74	0.68**	0.18	-0.06	0.06	-0.13**	0.04	4.98	4.98	164
Tambacounda-Kayes	After	N	53.82	46.69	0.35+	0.17	-0.12	0.24	-0.34*	0.12	1.67	1.67	36
Dakar - Bamako	Before	N	1.65	6.56	0.42	0.28	0.08	0.07	-0.14**	0.04	4.60	139	0.16
Dakar - Bamako	After	N	88.70	145.39	0.38	0.55	-0.16	0.25	-0.55*	0.19	0.87	24	0.35
Sikasso- Bobo-Dioulasso	Before work in Burkina Faso	N	-1.00	0.00	0.54*	0.18	0.13*	0.05	-0.46+	0.24	1.12	20	0.47
Sikasso- Bobo-Dioulasso	Between rehabilitation work	Y	8.20	5.55	0.99**	0.12	-0.04	0.03	-0.33**	0.08	1.73	144	0.56
Sikasso- Bobo-Dioulasso	Following work in Mali	Y	-13.98	53.76	0.94**	0.13	0.04	0.10	-0.84**	0.21	0.38	36	0.78
Sikasso - Ouagadougou	Before work in Burkina Faso	N	-1.00	0.00	0.56**	0.16	0.19**	0.05	-0.45+	0.25	1.16	20	0.26
Sikasso - Ouagadougou	Between rehabilitation work	Y	19.53**	6.75	0.72**	0.14	-0.02	0.03	-0.34**	0.07	1.67	144	0.28
Sikasso - Ouagadougou	Following work in Mali	Y	43.07	53.38	0.93**	0.15	-0.06	0.14	-0.65**	0.17	0.66	36	0.77
Bobo-Dioulasso - Niamey	Before work in Burkina Faso	N	1.47	60.81	0.80	0.48	0.17	1.23	-0.16+	0.08	3.98	68	0.29
Bobo-Dioulasso - Niamey	Between rehabilitation work	Y	10.44	9.04	0.76**	0.22	0.10	0.08	-0.33*	0.14	1.73	72	0.50
Bobo-Dioulasso - Niamey	Following work in Niger	Y	-9.27	27.40	1.27**	0.17	0.09	0.12	-0.47**	0.13	1.09	60	0.56
Ouagadougou-Niamey	Before work in Burkina Faso	N	-24.02	67.56	1.03+	0.55	0.68	1.67	-0.13*	0.06	4.98	68	0.22
Ouagadougou-Niamey	Between rehabilitation work	Y	3.54	6.59	1.17**	0.08	0.01	0.03	-0.62**	0.11	0.72	72	0.73
Ouagadougou-Niamey	Following work in Niger	Y	-31.65	29.79	0.98**	0.22	0.24	0.16	-0.32**	0.11	1.80	60	0.51

Standard errors in parentheses and ** p<0.01, * p<0.05, + p<0.10

Table 15: Price Transmission Regression Results Before and After Road Rehabilitation Work for Cross-Border Market Pairs