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Spatial Price Transmission and Market Integration in Senegal's Groundnut Market

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Notices

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ABSTRACT

The groundnut sector is the largest of Senegal's agricultural sectors. It has been subject to various degrees of intervention since the country's independence. Some, including the determination of farm prices by the government have survived the wave of reforms of the 1980s. Groundnut pricing policies have been the source of major transfers from farmers to the groundnut milling industry, which until 2007, was dominated by SONACOS, a publicly owned parastatal. The state was thus a major beneficiary of the transfers. In 2007, the company was privatized and is now privately owned, raising even greater concerns about the distribution of implications of pricing policies for groundnuts.

The paper examines the potential ramifications of liberalizing groundnut prices in terms of its impact on prices received by producers and paid by the milling industry. One fundamental question in the analysis is the extent to which local markets would respond to such a move. To answer this question, the paper presents a dynamic model of price formation that uses estimates of spatial integration across local markets to measure the response of local agricultural prices to policy changes. We then apply this model to simulate the impact of liberalizing groundnut prices to allow domestic prices to reflect their international levels. We find that doing so would change prices in the border city of Dakar, which happens to be the central market that determines prices in the local markets of the producing regions of Kaolack and Fatick. We also find that if markets had been fully liberalized when SONACOS was privatized in January 2007, then groundnut prices would have been higher and that the increase in prices would have been passed on almost entirely to producers in Kaolack and, to a lesser extent, to producers in Fatick. Such reforms would have reversed the longstanding discrimination of groundnut farmers. Prices received by farmers in Kaolack over a period of one year would have increased from 352 FCFA/kg to 494 FCFA/kg of shelled groundnuts. For farmers in the Fatick region, prices would increase from 389 FCFA/kg to 474 FCFA/kg.

Keywords: groundnuts, marketing integration, liberalization, pricing policies, privatization, Senegal

1. INTRODUCTION

Senegalese agriculture is unusually specialized in just three products: groundnuts, rice, and millet. Groundnuts have remained Senegal's premier export crop, rice remains the principle importable food, and millet is the principal food crop (Masters 2007). Senegal has been considered one of the most highly controlled markets in West Africa (Masters 2007). Historically, the Senegalese government has maintained a monopoly both on the purchase of groundnuts and on processing them into oil. At the beginning of the season, the government would set one producer price for groundnuts throughout the country. Accepting this pan-territorial price, farmers were required to sell their groundnuts to official agencies. Since the cost of transporting the groundnuts from the collection points near the villages to the mill was borne by the government or its parastatal groundnut agency (la Société Nationale de Commercialisation des Oléagineux du Sénégal [SONACOS]), every farmer received the same price, regardless of how far the farm was from the groundnut mill (Gray 2002).

Government control of the groundnut market has led to distortions that create a gap between domestic prices and what those prices would be under free markets (Masters 2007). One estimate for marketing year 2001–2002 suggested that, given all of SONACOS's procurement costs, its tradable inputs were subsidized at a rate of about 23 percent, which more than offset the 8.5 percent premiums it paid on nontradable factors, such as labor. This rate was also much larger than the 7.7 percent implicit subsidy that SONACOS received from protection on it sales. The net effect was a substantial transfer to SONACOS, amounting to 20 percent of the firm's market revenue (Masters 2007).

In recent years, the Senegalese government has attempted to liberalize the groundnut market. SONACOS was privatized in 2007 to encourage a further expansion of the open market. One fundamental question that faces policymakers undertaking economic reform is the extent to which local markets respond to sectoral and macroeconomic policy changes. It is recognized that the response of agricultural producers to sectoral, trade, and macroeconomic policies depends upon the extent to which local market prices respond to changes in central market prices. It is thus necessary to have an idea of the relative isolation of rural markets and the implications thereof for agricultural producers. A second question is what would happen to groundnut prices if the marketing of groundnuts were fully liberalized—that is, if domestic prices actually reflected their international levels. In particular, answering this second question would indicate how much of the distortions to the groundnut market have remained since the privatization of the publicly owned SONACOS, which has now become a privately owned company SUNEOR.

To answer both questions, this paper presents a dynamic model of price formation that uses estimates of spatial integration across local markets to measure the response of local agricultural prices to policy changes. We then apply this model to simulate the impact of the liberalization of groundnut prices in Senegal, allowing domestic prices to reflect their international levels. Our findings show that Dakar is the central market that determines prices in the local markets of Kaolack and Fatick. We also find that if markets had been fully liberalized when SONACOS was privatized in January 2007, then groundnut prices would have been higher. In addition, this increase in prices would have been passed on almost entirely to producers in Kaolack and, to a lesser extent, to producers in Fatick. In combination, these findings suggest that local prices would respond to price reforms initiated in Dakar (the central market) and that distortions to the groundnut market continue to exist after the transition from SONACOS to SUNEOR.

2. METHODOLGY[1]

The contemporaneous relationship between the local and central market prices—P^L and P^C, respectively—can, at any given time, be written as

$$P_t^L = P_t^C - T_t^L \tag{1}$$

or equivalently as

$$P_t^C = P_t^L + T_t^L, \tag{2}$$

where T^L is the cost of arbitrage between the local and central markets. To capture the dynamic nature of the relationship between prices in the two markets, a fully specified dynamic model needs to be used. In this price adjustment model, the relationship between the prices in two markets is given by

$$P_t^L = \sum_{j=1}^{n} \alpha_j P_{t-j}^L + \sum_{j=0}^{n} \beta_j P_{t-j}^C + \gamma X_t + \varepsilon_t \tag{3}$$

In equation (3), in a local market for groundnuts, , the price is determined by the price in a reference (or central) market, C.; j is used to indicate lags; and X denotes a matrix that includes an intercept, a time trend, seasonal dummies, and other variables. If $\beta_j = 0 \ \forall \ j$ (for all j), then the local market is segmented from the central market—that is, the local market operates independently from the central market, and policy-induced changes in the latter are not transmitted to the former. In contrast if $\beta_0 = 1$, then price changes are immediately transmitted (at $t = 0$) from the central market to the local market, and we have short-run market integration (Ravallion 1986). We will have lagged effects on future prices, unless$\alpha_j = \beta_j = 0$. If both $\beta_0 = 1$ and $\alpha_j = \beta_j = 0$, then within one time period, the local market will be integrated with the central market.

If the central and regional markets are integrated in the long run, then $\sum_{j=1}^{n} \alpha_j + \sum_{j=0}^{n} \beta_j = 1$, and; the number of lags required to ensure this equality provides evidence of integration that is less immediate than instantaneous price transmittal. The cumulative effect after j periods of a central-market price shock on the price in an outlying market can be computed as

$$\beta_j^{C,L} = \sum_{h=0}^{j} \frac{\partial E\,[P_{t+h}^L]}{\partial P_t^C}. \tag{4}$$

In (4), the cumulative effect of a central-market price shock is given by the expected value of the local price at time $t + h$ divided by the change in the central price at time t. Complete adjustment of the process is given by the long-run dynamic multiplier:

$$\beta^{C,L} = \lim_{j \to \infty} \beta_j^{C,L}. \tag{5}$$

The speed of price transmission can be calculated by computing the time τ that it takes for the intermediate multipliers to converge within a certain range of the long-run multiplier. The convergence rule is to find τ such that $|\beta_\tau/\beta - 1| < \varepsilon$ and $|\beta_j/\beta - 1| < \varepsilon$ for every $j > \tau$, where ε is a tolerance limit, and β_j is the estimated multiplier after j periods. Approximating derivatives by first differences and defining as one period the h units of time required for the long-run multiplier to converge to its long-run value, equation (4) can be rewritten as

[1] Annex A presents the derivation of the price time path in the context of a multimarket setting. See also Badiane (1997) and Badiane and Shively (1998).

$$\Delta P_{t+1}^{L} = \beta^{L} \Delta P_{t}^{C}. \tag{6}$$

Writing out equation (4), dropping the superscript on β for the sake of notational simplicity, and inserting the values for P^{C} from equation (2) yields2

$$P_{t+2}^{L} = (P_{t+1}^{L} + T_{t+1}^{L})\beta - (P_{t}^{L} + T_{t}^{L})\beta + P_{t+1}^{L}. \tag{7}$$

Rearranged slightly, equation (7) yields a second-order linear difference equation that can be solved to obtain local prices as a function of the long-run multiplier β and local arbitrage costs, as given by

$$\frac{1}{\beta} P_{t+2}^{L} - \frac{(1+\beta)}{\beta} P_{t+1}^{L} + P_{t}^{L} = \Delta T^{L} \ . \tag{8}$$

Equation (8) can be solved for local prices, yielding the following expression for the time path of local prices:

$$P_{t}^{L} = \varsigma_{t} P_{(t=0)}^{L} + \varrho_{t} P_{(t=1)}^{L} + \varphi_{t} \Delta T^{L}, \tag{9}$$

where $\varsigma_{t} = \frac{\beta - \beta^{t}}{\beta - 1}$; $\varrho_{t} = \frac{\beta^{t} - 1}{\beta - 1}$ and $\varphi_{t} = \left(\frac{\beta}{\beta - 1}\right) t$.

Equation (9) expresses the local-market price at time t as a function of the initial price, the long-run multiplier, and the change in arbitrage costs. In other words, changes in the degree of market integration or the cost of marketing not only affect local prices contemporaneously, but also affect the evolution of these prices over time. The expression for the time path of local prices derived here exposes the relationships between spatial integration among local markets, the cost of local arbitrage, and the adjustment of local prices to shocks in leading markets.

[2] From (6) we get: $\Delta P_{t+1}^{L} = \beta \Delta P_{t}^{L} + \Delta T_{t}^{L}$

$\Delta P_{t+1}^{L} = P_{t+2}^{L} - P_{t+1}^{L}$ and $\Delta P_{t}^{L} = P_{t+1}^{L} - P_{t}^{L}$ and $\Delta T_{t}^{L} = T_{t+1}^{L} - T_{t}^{L}$

Then we have:

$P_{t+2}^{L} - P_{t+1}^{L} = \beta(P_{t+1}^{L} - P_{t}^{L}) + \beta(T_{t+1}^{L} - T_{t}^{L})$

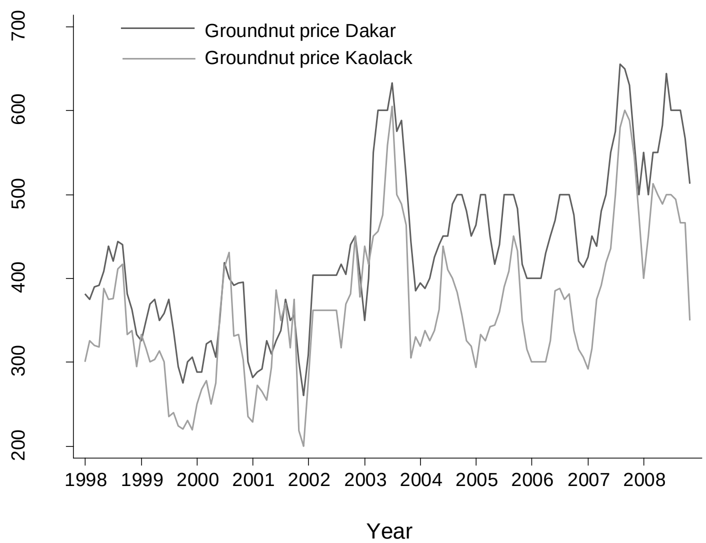
Rearranging gives:

$P_{t+2}^{L} = \beta(P_{t+1}^{L} + T_{t+1}^{L}) - \beta(P_{t}^{L} + T_{t}^{L}) + P_{t+1}^{L}$

3. DATA

The methodology set out in the previous section is applied to monthly retail prices for Dakar, Kaolack, and Fatick from January 1998 until December 2007 (120 observations). Figures 1a and 1b show the evolution of prices for shelled groundnuts. The spread between retail prices at Kaolack and Fatick markets and the consumer market of Dakar seems to have increased from about 2004 onward. Furthermore, prices appear to be moving upward together.

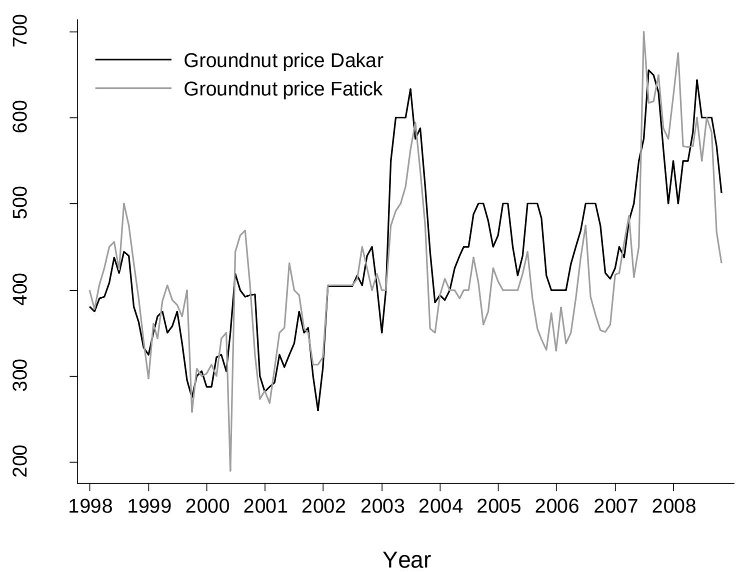
Figure 1.a. Dakar-Kaolack retail margin



Source: Authors' own calculations.

Note: FCFA = Franc Communautaire Financiere Africaine

Figure 1.b. Dakar-Fatick retail margin



Source: Authors' own calculations.
Note: FCFA = Franc Communautaire Financiere Africaine

4. RESULTS

To test the degree of market integration between the Dakar markets and the markets in Kaolack and Fatick, the two-step estimation method proposed by Engle and Granger (1987) can be applied. In the first step, price series in the individual markets are tested separately for their order of economic integration—that is, the number of time a series needs to be differenced for it to become stationary. For that purpose, we used the Augmented Dickey-Fuller test (Dickey and Fuller 1979). Table 1 shows that stationarity is rejected for all three markets at the 1 percent level—in other words, a unit root exists for the Dakar, Kaolack, and Fatick markets. All series are stationary at their first difference.

Table 1. Augmented Dickey-Fuller test

	Test statistic	1% critical value	5% critical value	10% critical value
Dakar	–1.739	–3.506	–2.889	–2.579
Kaolack	–2.825			
Fatick	–2.993			
D1.Dakar	–7.414			
D1.Kaolack	–9.737			
D1.Fatick	–11.834			

Note: D1 stands for first differential

Although the individiual series are not stationary, they are integrated of the same order. Thus, it is possible to test whether they are cointegrated. In the second step, the residual of the ordinary least squares (OLS) regression between a given pair of local price series, given by

$$p_t^i = \beta_0 + \beta_1 p_t^j + z_t \ , \quad (10a)$$

is in turn tested for stationarity, using the same Augmented Dickey-Fuller test. However, this time it is used to establish the stability of the relationship patterns between the two series. The presence of cointegration between the two price series indicates interdependence between their respective markets. Results of the test are given in Table 2.

Table 2. Ordinary least squares regression results

	Groundnut price Kaolack	
Groundnut price Dakar	0.80 (0.05)**	
Constant	14.85 (20.19)	
R-squared	0.73	
ADF (residuals)[a]	–5.98	(MacKinnon p-value for $Z(t)$ = 0.0000)
	Groundnut price Fatick	
Groundnut price Dakar	0.73 (0.06)**	
Constant	95.09 (23.96)**	
R-squared	0.61	
ADF (residuals)	–5.83	(MacKinnon p-value for $Z(t)$ = 0.0000)

Notes: ** Denotes significance at the 5% level.
[a] Augmented Dickey Fuller

Table 2 shows that for both regressions, residuals are stationary, indicating that a cointegrated relationship exists between the groundnut price on the Dakar retail market and the Kaolack and Fatick markets. The cointegrated linear combination is given by

$$z_{t-1} = p_{t-1}^{i} - \beta_0 - \beta_1 p_{t-1}^{j}. \tag{10b}$$

Once the presence of cointegration between two price series is established, the relationship between the two series can be represented as an error correction mechanism (ECM):

$$\Delta p_t^i = \gamma^i z_{t-1} + \sum_{k=1}^{k=m_i} \delta_k^i \, \Delta p_{t-k}^i + \sum_{h=1}^{h=n_i} \varphi_h^i \, \Delta p_{t-h}^j + \varepsilon_t^i \tag{11a}$$

$$\Delta p_t^j = \gamma^j z_{t-1} + \sum_{k=1}^{k=m_i} \delta_k^j \, \Delta p_{t-k}^i + \sum_{h=1}^{h=n_i} \varphi_h^j \, \Delta p_{t-h}^j + \varepsilon_t^j, \tag{11b}$$

where Δ is the difference operator; m_i and n_i are the number of lags; and $\gamma, \delta,$ and φ are parameters to be estimated. Causality from market j to market i can then be tested as follows:

$$H_{0j}: \gamma^i \neq 0, \varphi_h^i = 0, h = 1,2, \ldots n_i,$$

and causality from market i to market j can be tested as

$$H_{0i}: \gamma^j \neq 0, \delta_k^j = 0, h = 1,2, \ldots n_i.$$

Estimation results are given in Table 3.

Table 3. Error correction mechanism estimation results

	Kaolack–Dakar groundnut markets		
	Δ Groundnut price in Kaolack		**Δ Groundnut price in Dakar**
$\boldsymbol{\gamma^i}$	–0.33 (0.10)**	$\boldsymbol{\gamma^j}$	–0.07 (0.08)
$\boldsymbol{\delta_k^i}$	0.10 (0.12)	$\boldsymbol{\delta_k^j}$	0.11 (0.10)
$\boldsymbol{\varphi_h^i}$	0.18 (0.13)	$\boldsymbol{\varphi_h^j}$	0.27 (0.09)**
Constant	0.70 (3.87)	Constant	–1.00 (2.85)
R-squared	0.13	R-squared	0.16
Number of observations	117		
	Fatick–Dakar groundnut markets		
	Δ Groundnut price in Fatick		**Δ Groundnut price in Dakar**
$\boldsymbol{\gamma^i}$	–0.38 (0.10)**	$\boldsymbol{\gamma^j}$	0.06 (0.07)
$\boldsymbol{\delta_k^i}$	0.09 (0.10)	$\boldsymbol{\delta_k^j}$	0.03 (0.07)
$\boldsymbol{\varphi_h^i}$	0.18 (0.13)	$\boldsymbol{\varphi_h^j}$	0.32 (0.10) **
Constant	–0.88 (4.16)	Constant	0.60 (3.32)
R-squared	0.15	R-squared	0.12
Number of observations	117		

Note: ** Denotes significance at the 5% level.

Table 3 shows that causality exists from the Dakar market to the Kaolack and Fatick markets but that the reverse does not hold. Dakar can thus be considered the central market.

5. DYNAMIC ADJUSTMENTS

Cointegration analysis helps us establish whether a systematic relationship exists between two economic time series. However, it does not provide any information on (a) the strength of the relationship between the price series of the considered pair of markets or (b) the length of time it takes for a shock to be transmitted from one market to another. For marketing policy purposes, it is important to be aware of the existence of long-term market interdependence and to have knowledge of the poles of market influence. It is also important to have an idea of the magnitude of this interdependence and the speed with which changes in the price system are transmitted across individual markets. This additional information allows for better interpretation of the consequences of changes in central markets in terms of the implication for price behavior in distant markets. Perfect market integration would be indicated if the price in one market were an exact translation of the price in another market, implying that price changes were fully transmitted between the two markets. Market segmentation, on the other hand, would be reflected in the absence of cointegration. In reality, however, perfect integration or segmentation are both extreme cases, with intermediate degrees of integration being the normal situation. The main issue thus becomes how to measure the magnitude of intermarket price transmission, which can be done by applying autoregressive techniques to price series in order to yield dynamic multipliers that can be used to measure the transmission of price changes.

In the process of intermediate price transmission, the impacts of immediate shocks must be distinguished from their cumulative impact, which builds up over time. This step is necessary because the process of price transmission usually takes time and involves complex dynamic adjustments among individual markets. Analyzing the price adjustment process over time, using the convergence of dynamic multipliers, allows us to study the speed of price transmission—that is, the number of days, weeks, or months it takes for prices in one market to be transmitted fully or partially to other markets. Normally, the speed of cross-market price responses is determined by the distribution system's efficiency and by the structural characteristics of local markets. Rapid adjustments reflect sufficient flexibility and responsiveness of the domestic marketing system. Furthermore, given the magnitude of price adjustment between two markets, the better integrated a given pair of markets are, the lower the amount of time it takes for the two markets to complete the adjustment to induced price shocks.

We have established that Dakar is the central market and now want to know how groundnut prices in Kaolack and Fatick respond over time to a change in the groundnut price in Dakar. We analyze these dynamic causal effects within a distributed lag model. We take the percentage change in the groundnut price in Kaolack and Fatick as a dependent: $100\Delta \ln P\hat{}(i, j)$. Price changes, rather than price levels, are the preferred unit of analysis. First differences of logarithm are taken because they offer an immediate interpretation in terms of percentage change. Figures 2a–2c show percentage price changes in Dakar, Kaolack, and Fatick, respectively.

Figure 2a. Monthly percentage change in the price of shelled groundnuts for Dakar

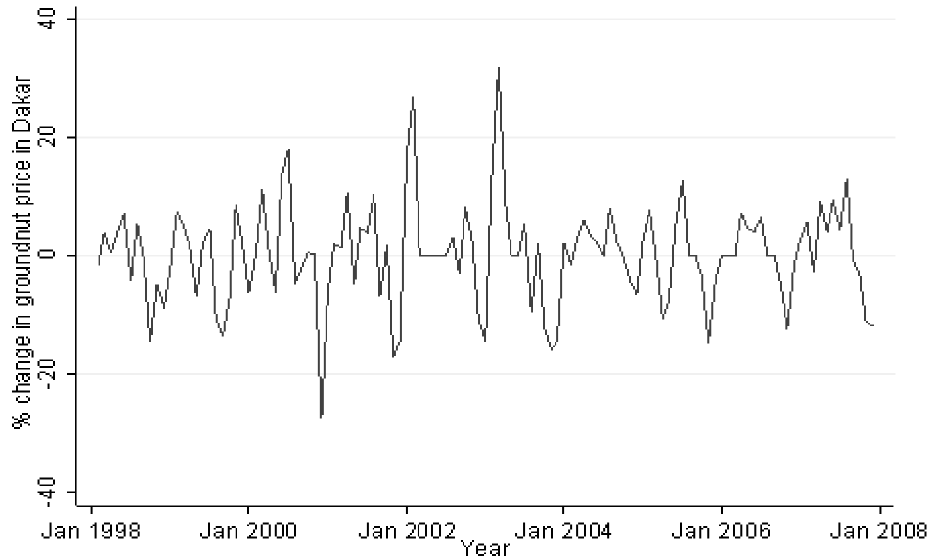


Figure 2b. Monthly percentage change in the price of shelled groundnuts for Kaolack

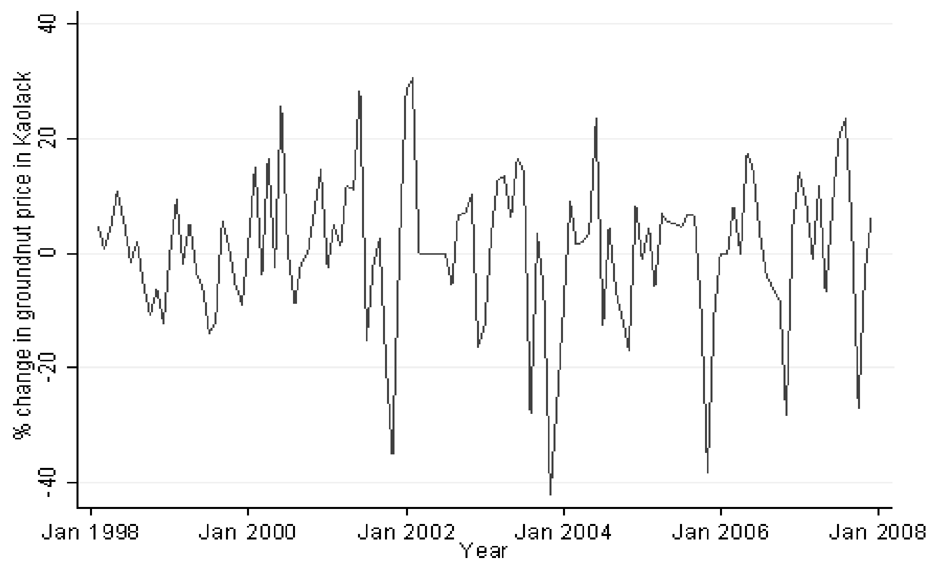
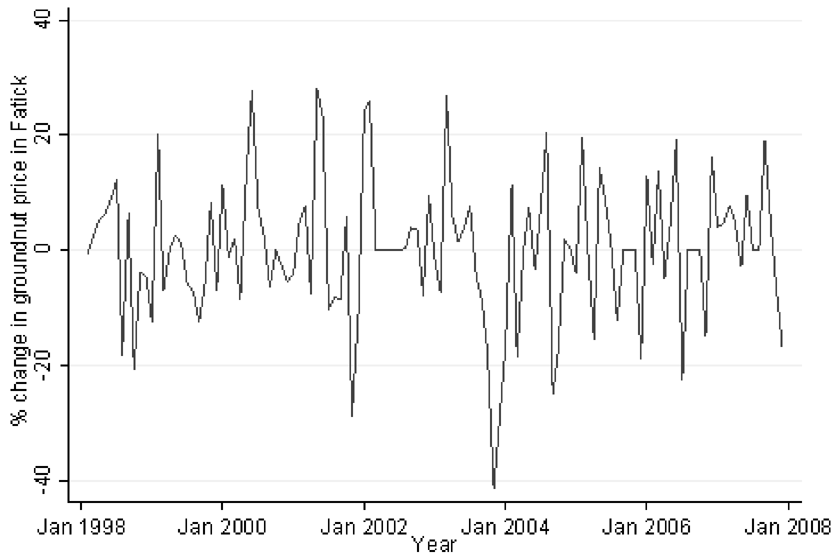


Figure 2c. Monthly percentage change in the price of shelled groundnuts for Fatick



Autoregressive processes can be applied to prices in individual markets to obtain indicators for the magnitude and speed of the price transmission process across these markets. For every pair or market locations i and j, the following bivariate autoregressive process can be estimated:

$$\%\Delta p_t^i = \sum_{k=1}^{k=m_i} \alpha_k^i \%\Delta p_{t-k}^i + \sum_{h=0}^{h=n_i} \beta_h^j \%\Delta p_{t-h}^j + \varepsilon_{i,t} \quad (12)$$

Ordinary least squares regression results of the estimation of (12) are given in Table 4.

Table 4. Ordinary least squares regression results

	% Δ prices in Kaolack	**% Δ prices in Fatick**
% Δ prices in Dakar	0.61 (0.11)*	0.44 (0.10)*
Constant	0.90 (0.91)	0.11 (0.80)
R-squared	0.21	0.16
Number of observations	117	115

Note: * Denotes significance at the 5% level.

The results in Table 4 show that a statistically significant, positive relation exists between groundnut prices in the central market of Dakar and those in the local markets of Kaolack and Fatick. A price increase in Dakar thus implies that prices in Kaolack and Fatick will also increase. In the estimation, problems of simultaneity may be encountered that are related to the contemporaneous use of prices in market i and market j. Since both prices may respond to the same shock, it is expected that the error term $\varepsilon_{i,t}$ will be correlated with the price $p_{j,t}$. Following Mendoza and Farris (1992), the error term of equation (12) can be modeled as an autoregressive conditional heteroskedasticity (ARCH) process (see Engle 1982). The ARCH model specifies the contemporaneous conditional variance as a function of past square residuals. This specification captures the volatility clustering characteristics of price time series—that is, the tendency of large residuals to be followed by large residuals and small residuals to be followed by small ones. The two lags—one for prices in market i and one for prices in market j j—are determined simultaneously by application of the Akaike Information Criterion (results given in the appendix). According to this criterion, three lags should be included for Dakar and Kaolack and four for Dakar and Fatick.

The magnitude of price adjustment is estimated with dynamic multipliers, which are interpreted as the effect of a price change due to a random shock or a shift in an exogenous variable (Goletti and Christina-Tsigas 1995). In the context of the model introduced above, the cumulative effect of a shock to price in market j on the price in market i after k periods is given in equations (4) and (5). The immediate impact of price p_t^i and p_t^j on the expected value of p_t^i is given by $\partial E_t p_t^i / \partial p_t^i = 1$, and $\partial E_t p_t^i / \partial p_t^j = \beta_0^i$. For subsequent periods, the effect of a shock to the price in market j on the price in market i is given by

$$\frac{\partial E_t p_{t+h}^i}{\partial p_t^j} = \sum_{s=0}^{m\ in\ (n_i,k)} \beta_s^i \frac{\partial E_t p_{t+k-s}^i}{\partial p_t^j}, k = 1,2, \ldots. \tag{13a}$$

The effect of a shock to the price in market i at time t on the price in market i for subsequent periods is given by

$$\frac{\partial E_t p_{t+h}^i}{\partial p_t^i} = \sum_{r=1}^{m\ in\ (m_i,h)} \alpha_r^i \frac{\partial E_t p_{t+h-r}^i}{\partial p_t^i}, h = 1,2, \ldots. \tag{13b}$$

Or combining expressions, the long-run dynamic multiplier is given by[3]

$$\frac{\partial E_t p_{t+h}^i}{\partial p_t^j} = \frac{\beta_0^i + \beta_1^i + \cdots \beta_k^i}{(1 - \alpha_1^i - \cdots \alpha_h^i)}. \tag{14}$$

Estimation results for the ARCH and the resulting cumulative dynamic multipliers are given in Table 5.

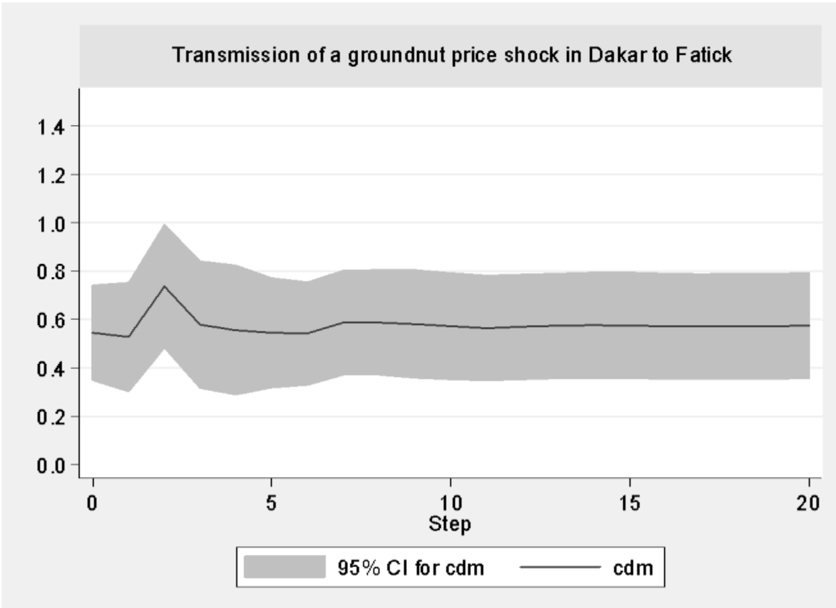
Table 5. Autoregressive conditional heteroskedasticity estimation results

	% Δ prices in Kaolack	**% Δ prices in Fatick**
% Δ prices in Dakar	0.77 (0.11)[a]**	0.54 (0.11)**
L1. % Δ prices Dakar	0.15 (0.15)	0.09 (0.12)
L2. % Δ prices in Dakar	0.34 (0.12)**	0.32 (0.13)**
L3. % Δ prices in Dakar	0.32 (0.17)*	0.01(0.13)
L4. % Δ prices in Dakar		0.11 (0.13)
L1. % Δ prices in Kaolack	–0.21 (0.10)**	
L2. % Δ prices in Kaolack	–0.22 (0.08)**	
L3. % Δ prices in Kaolack	–0.28 (0.09)**	
L1. % Δ prices in Fatick		–0.20 (0.07)**
L2. % Δ prices in Fatick		–0.20 (0.08)**
L3. % Δ prices in Fatick		–0.25 (0.08)**
L4. % Δ prices in Fatick		–0.24 (0.09)**
Constant	0.86 (0.90)	0.19 (0.81)
Long-run dynamic multiplier	0.92	0.57

Notes: [a] OPG (outer product of the gradient) standard errors are in parentheses.
* Denotes significance at the 10% level.
** Denotes significance at the 5% level.
L stands for the lag operator.

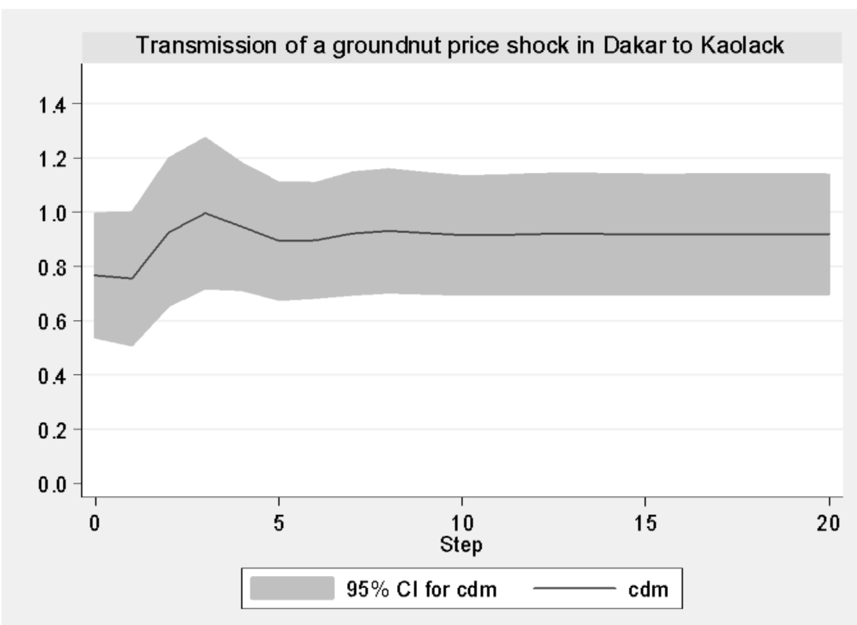
[3] The long-run equilibrium is given by the unconditional expectations or the expected value of p_t^i.
Let $p*j = (ptj)$ and $p*i = (pti)$ for all t. If the two processes moved together without error, then in the long-run they would converge to $p*i = \alpha 0i + \alpha 1ip*i + \ldots. \alpha hip*i + \beta 0ip*j + \beta 1ip*j + \ldots \beta kip*j$. Solving for p_*^i, we get $p*i = \beta 0i + \beta 1i + \ldots \beta ki1 - \alpha 1i - \cdots \alpha hip*j + \alpha 0i1 - \alpha 1i - \ldots \alpha hi$.

Figure 3a. Long-run adjustments of prices in Fatick to a shock in Dakar



Notes: CI stands for confidence interval, cdm stands for cumulative dynamic multiplier

Figure 3b. Long-run adjustments of prices in Kaolack to a shock in Dakar



Notes: CI stands for confidence interval, cdm stands for cumulative dynamic multiplier

In addition to knowing the magnitude of the total effect of a shock as measured by the long-run multiplier, it is often useful to know how many periods it takes for some portion of a shock's total effect to dissipate or how much of the shock has dissipated after some number of periods. Table 5 shows that the long-run dynamic multiplier is 0.92 for Kaolack, implying that a price shock to the Dakar groundnut market is almost fully transmitted to the Kaolack market. However, for the Fatick market, the multiplier is only 0.57, implying that only about half of the price shock in Dakar is transmitted to Fatick. Results from

Table 5 show that 77 percent and 54 percent of the total price shock in Dakar is immediately transmitted to the Kaolack and Fatick markets, respectively.

Based on this information, we can calculate the effect of liberalization of the groundnut market. Liberalization implies that the world market price for groundnuts will become the groundnut price in Dakar. The peanut sector is still dominated by SUNEOR, which took over from SONACOS (Société Nationale de Commercialisation des Oléagineux du Sénégal), which was created in 1965 with a mission to evict private operators from the processing sector and to give the government control over the most important section of the country's nascent industry. As of January 1, 2007, SONACOS has been renamed SUNEOR, thus marking the end of the privatization process that started in 2004, when the government decided to sell its shares to Advens, a private consortium, including private investors,, the Belgian peanut machinery manufacturer Desmet, SODEFITEX (Senegal's cotton ginning company), and SONACOS employees.

Table 6. Data used for estimating the time path of prices in Kaolack and Fatick

Pre-liberalization			Post-liberalization			Long-term multiplier		Change in transfer cost	
$P^{D}_{a}{}^{(t=0)}$	$P^{K}_{b}{}^{(t=0)}$	$P^{F}_{c}{}^{(t=0)}$	$P^{D'}_{d}{}^{(t=1)}$	$P^{K'}_{e}{}^{(t=1)}$	$P^{F'}_{f}{}^{(t=1)}$	Kaolack	Fatick	Kaolack	Fatick
453	352	389	601	493	474	0.92	0.57	–0.47	–0.47

Note: Given the difficulties in getting information on the actual cost of marketing or arbitrage, the observed average margin between prices in Dakar and Kaolack and between Dakar and Fatick is used as a proxy.

[a] Average pre-liberalization price of shelled groundnuts in Dakar for 2004–2006

[b] Calculated as the pre-liberalization price of shelled groundnuts in Dakar minus the average marketing costs between Kaolack and Dakar for 2004–2006, which is 101 CFA/kg

[c] Calculated as the pre-liberalization price of shelled groundnuts in Dakar minus the average marketing costs between Fatick and Dakar for 2004–2006, which is 64 CFA/kg

[d] Average world market price for 2006–2008 applied to Dakar in January 2007

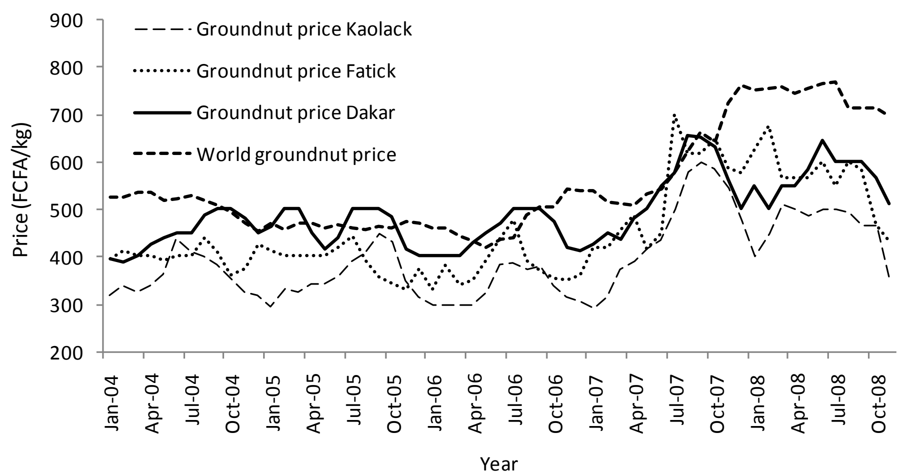
[e] Simulated prices for Kaolack after full adjustments, assuming a complete liberalization of the market on January 1, 2007

[f] Simulated prices for Fatick after full adjustments, assuming a complete liberalization of the market on January 1, 2007

The Dakar price at time $t = 0$ is the average price for the three years before liberalization (2004–2006), which is 453 CFA Francs/kg. A shock is introduced by allowing Dakar prices to adjust to world market prices. Thus, at $t = 1$, the new price in Dakar becomes $P_{t=1} = P^W * r + T$, where P^W is the world market price for shelled groundnuts available from Oil World (U.S. runners), r is the exchange rate, and T is tariffs. World market prices for shelled groundnuts, as well as prices in the Dakar, Kaolack, and Fatick markets, are given in Figure 4.

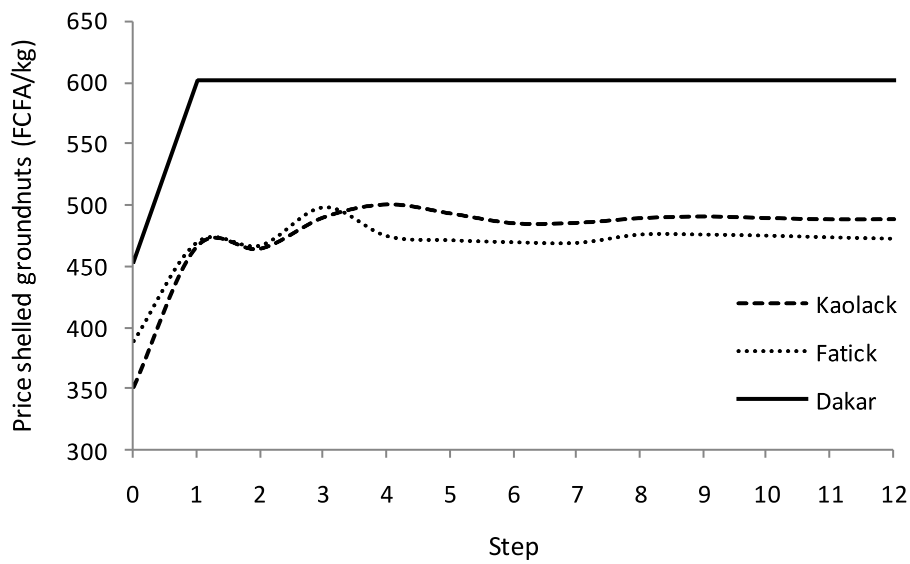
Assuming tariffs are 0 and using guided adjustment, the price in Dakar will jump from 453 CFA/kg to 601 CFA/kg, which is the 2006–2008 average world market price for shelled groundnuts. Given the shock to prices in Dakar, the prices in Kaolack and Fatick can be calculated based on equation (9). The local price in each of these markets at $t = 0$ is 352 CFA/kg for Kaolack and 389 CFA/kg for Fatick (see Table 6). Between 1998 and 2007, arbitrage costs between Dakar and Kaolack and between Dakar and Fatick fell by an average of 0.47 FCFA per month. Figure 5 displays the time path of prices in Kaolack and Fatick resulting from a liberalization of the groundnut markets in January 2007 as the multiplier converges to its long-run equilibrium. The lines describe the evolution toward the long-run equilibrium after a shock to the observed average pre-reform observed price in Kaolack and Fatick between 2004 and 2006. Prices in Fatick overshot their long-run level, whereas prices in Kaolack initially undershot and then adjusted upward from the third-period onward.

Figure 4. Shelled groundnut price (FCFA/kg)



Note: FCFA = Franc Communautaire Financiere Africaine

Figure 5. The time path of price adjustment in Kaolack and Fatick



Note: The figure shows prices that would have prevailed, had the government liberalized grourndnut prices to reflect world market prices at the time of the privatization of SONACOS.
Source: Authors' own calculations.

Table 6 presents the prices used in the simulation and explains how they were derived. The simulations were carried out for the year 2007. For this period, the effects of the reforms were simulated by adjusting the prices in Dakar for January 2007 (PD'd(t = 1/07) = 601), assuming that an effective liberalization would have increased them to the level of average world prices between 2006 and 2008. With an average transfer cost between Dakar and Kaolack of 101 CFA/kg, the initial price in Kaolack can be calculated using equations (9) and (10).

In Figures 6a and 6b, the front axis shows the distribution of the impact of policy changes across local markets as a function of the level of market integration. The Y-axis shows the level of prices, the X-axis the degree of market integation, and the Z-axis the time period. For Kaolack (Figure 6a), over a period of one year, prices would increase from 352 FCFA/kg to 494 FCFA/kg. For Fatick (Figure 6b), which has a lower level of integration with Dakar, the price increases by less—from 389 FCFA/kg to 474 FCFA/kg.

Figure 6a. Market integration and the dynamics of price transmission in Kaolack

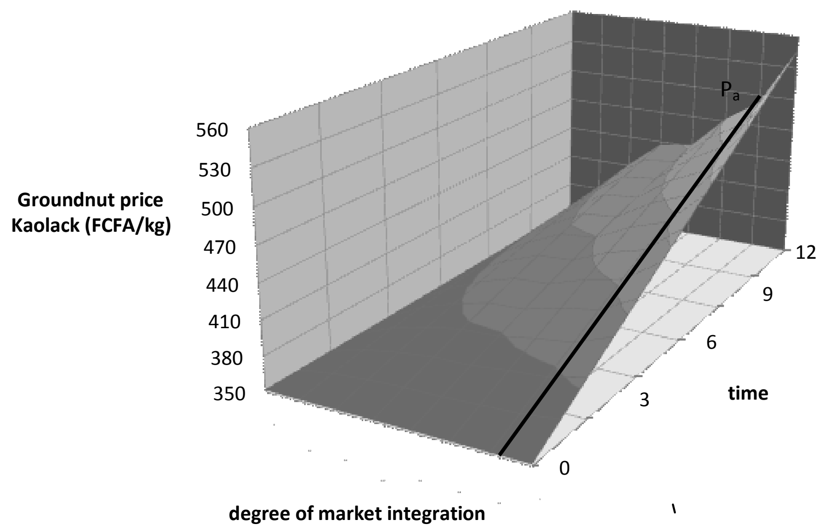
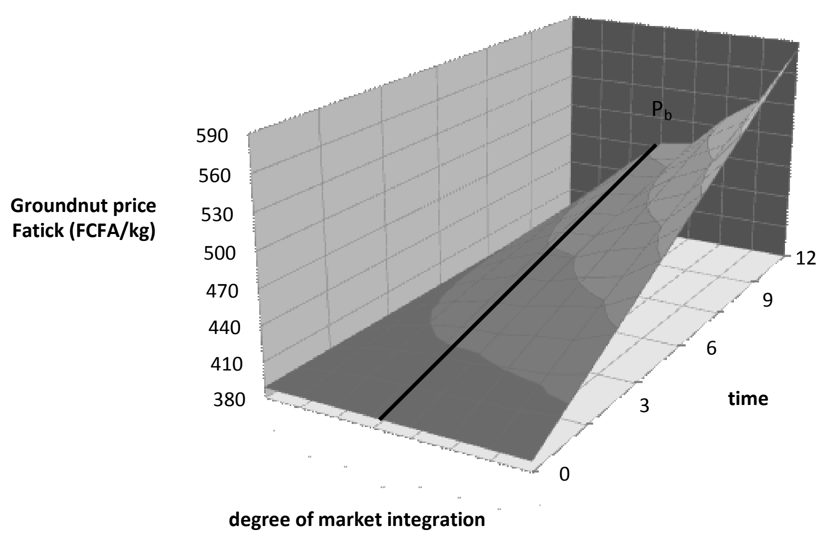


Figure 6b. Market integration and the dynamics of price transmission in Fatick



Figures 6a and 6b illustrate some of the additional information that the proposed model adds to the traditional analysis of market integration. The proposed model shows the cost of market segmentation and the benefits of improving market integration in terms of the potential impact at the local level of policy reforms. Not only does it show how the level of market integration affects the short-term geographic distribution of the impact of policy changes, but it also shows how that impact evolves over time in individual markets. Following liberalization, if no complementary measures are adopted to promote marketing activities between a given market *M* and the central market, the level of integration between the two markets can be expected to proceed with its "normal" rate of change to a value of $\mu_a^K = 0.92$ for Kaolack and $\mu_a^F = 0.57$ for Fatick, with a corresponding change in the price level of p_a and p_b, respectively, in the end period.

Figures 6a and 6b clearly show that adopting measures to improve market integration would raise the price level in the final period.

The above analysis demonstrates that world market prices are higher than those that have currently prevailed in the market since privatization of SONACOS. A liberalization of groundnut prices would thus increase market prices, and this price increase would almost entirely be passed on to farmers in Kaolack and, for a large part, to farmers in Fatick. By keeping groundnut prices fixed after privatization of SONACOS, the Senegalese government is actually implicitly subsidizing its new private owners to the disadvantage of groundnut farmers. Therefore, liberalization of these policies should be expected to redistribute transfers in favor of producers. The liberalization of groundnut prices alone would not yield much benefit, unless the tightly controlled marketing systems are also reformed to allow competition between traders in the informal and formal sectors, including procurement by the milling industry. In particular, the practice of licensing selected private traders (operateurs prives), administratively determining the marketing season, and occasionally interdicting movement by informal traders would have to be eliminated. Otherwise, a significant part, if not all, of the rent arising for the higher border prices would be captured by other actors along the chain to the detriment of farmers.

APPENDIX A: SUPPLEMENTARY TABLES

Table A.1a. OLS regression of price change in Dakar on price change in Kaolack

Source	SS	df	MS
Model	3146.18945	1	3146.18945
Residual	10889.0964	114	95.5183898
Total	14035.2859	115	122.045964

Number of obs =	116
F(1, 114) =	32.94
Prob > F =	0.0000
R-squared =	0.2242
Adj R-squared =	0.2174
Root MSE =	9.7734

chkaoret	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
chdakret	.6635419	.1156164	5.74	0.000	.4345067	.8925771
_cons	.9963464	.9078696	1.10	0.275	-.8021363	2.794829

Table A.1b. OLS regression of price change in Dakar on price change in Fatick

Source	SS	df	MS
Model	1775.17353	1	1775.17353
Residual	11741.3915	114	102.994662
Total	13516.565	115	117.535348

Number of obs =	116
F(1, 114) =	17.24
Prob > F =	0.0001
R-squared =	0.1313
Adj R-squared =	0.1237
Root MSE =	10.149

chfatret	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
chdakret	.4972412	.1197716	4.15	0.000	.2599745	.7345079
_cons	.1143391	.9430132	0.12	0.904	-1.753763	1.982441

Source: Authors' own calculations

Table A.2. Augmented Dickey-Fuller test

```
Dickey-Fuller test for unit root                   Number of obs   =       118

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)            -10.343            -3.504            -2.889            -2.579
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0000

. dfuller chdakret

Dickey-Fuller test for unit root                   Number of obs   =       118

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -7.863            -3.504            -2.889            -2.579
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0000

. dfuller chfatret

Dickey-Fuller test for unit root                   Number of obs   =       118

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)            -13.555            -3.504            -2.889            -2.579
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0000
```

Table A.3. Determination of number of lags for autoregressive conditional heteroskedasticity

```
varsoc chfatret chdakret if ex63 & ex31, maxlag(8)

   Selection-order criteria
   Sample:  1998m10 - 2007m12, but with gaps    Number of obs      =       108
  +---------------------------------------------------------------------------+
  |lag |    LL      LR      df    p      FPE       AIC      HQIC      SBIC    |
  |----+----------------------------------------------------------------------|
  |  0 | -783.638                      7137.36   14.5489    14.569   14.5985* |
  |  1 | -778.448  10.381    4  0.034  6981.95   14.5268   14.5872   14.6758  |
  |  2 | -768.735  19.426    4  0.001  6281.69    14.421   14.5217   14.6694  |
  |  3 | -763.351  10.768    4  0.029  6124.14   14.3954   14.5364   14.7431  |
  |  4 |  -757.82  11.062    4  0.026   5955.4    14.367   14.5483   14.8141  |
  |  5 | -748.187  19.265    4  0.001  5368.97*  14.2627   14.4843*  14.8091  |
  |  6 | -746.941  2.4921    4  0.646  5655.13   14.3137   14.5755   14.9594  |
  |  7 | -741.019  11.845    4  0.019  5464.26   14.2781   14.5802   15.0232  |
  |  8 | -736.123   9.791*   4  0.044  5383.35   14.2615*  14.6039   15.1059  |
  +---------------------------------------------------------------------------+
   Endogenous:  chfatret chdakret
    Exogenous:  _cons

varsoc chkaoret chdakret, maxlag(8)

   Selection-order criteria
   Sample:  1998m10 - 2007m12                   Number of obs      =       111
  +---------------------------------------------------------------------------+
  |lag |    LL      LR      df    p      FPE       AIC      HQIC      SBIC    |
  |----+----------------------------------------------------------------------|
  |  0 | -822.376                      9680.43   14.8536   14.8734   14.9024  |
  |  1 | -810.588  23.576    4  0.000  8413.25   14.7133   14.7727   14.8598* |
  |  2 |  -803.72  13.735    4  0.008  7990.35   14.6616   14.7606*  14.9057  |
  |  3 | -798.328  10.784    4  0.029   7794.1*  14.6365*  14.7752   14.9783  |
  |  4 | -797.027  2.6011    4  0.627  8185.66   14.6852   14.8634   15.1246  |
  |  5 |  -791.79  10.475    4  0.033  8009.89   14.6629   14.8807   15.1999  |
  |  6 | -787.209  9.1627    4  0.057   7933.2   14.6524   14.9099   15.2871  |
  |  7 | -785.421  3.5752    4  0.467  8265.47   14.6923   14.9893   15.4246  |
  |  8 | -779.091   12.66*   4  0.013   7937.8   14.6503    14.987   15.4802  |
  +---------------------------------------------------------------------------+
   Endogenous:  chkaoret chdakret
    Exogenous:  _cons
```

Source: Authors' own calculations.

APPENDIX B: DERIVATION OF THE TIME PATH OF LOCAL PRICE ADJUSTMENTS FOR MULTIPLE MARKETS

Following Gonzalez-Rivera and Helfand (2001), consider an $n \times 1$ nonstationary $I(1)$ vector of prices, $P_t = \{p_{1t}, p_{2t}, ..., p_{nt}\}$, where p_{it} is the price of a commodity at time *t* in market *i*. Suppose that P_t can be decomposed into two components, as follows,

$$P_t = A_{n \times s} f_t + \tilde{P}_t, \tag{B1}$$

where f_t is an $s \times 1$ vector of *s* (*s* < *n*) common unit root factors, and $\tilde{P}_t$ is an $n \times 1$ vector of stationary components. Every element in the vector P_t can be explained by a linear combination of a smaller number of $I(1)$ common factors f_{jt} (permanent component) plus an $I(0)$ transitory component. In the long run, the variables p_{it} move together, because they share the same stochastic trends.

Equation (B2) is known as the common factor representation, and its existence is guaranteed if and only if there are $n - s$ cointegrating vectors among the elements of vector P_t. As shown before, any cointegrated system can be written as a vector error correction (VEC) model:

$$\Delta P_t = \mu + \Pi P_{t-1} + \Gamma_1 \Delta P_{t-1} + \Gamma_2 \Delta P_{t-2} + ... + \Gamma_{p-1} \Delta P_{t-p+1} + \varepsilon_t, \tag{B2}$$

where Γ and Π are $n \times n$ matrices and Π has reduced rank $n - s$. The matrix Π can be written as $\Pi = \alpha \beta'$, where α is an $n \times (n - s)$ matrix of coefficients and β is an $n \times (n - s)$ matrix of cointegrating vectors. Thus, $\Pi P_{t-1} = \alpha \beta' P_{t-1} = \alpha Z_{t-1}$, with $Z_{t-1} = \beta' P_{t-1}$ being the error correction term (or the short-run disequilibrium) and with α being the matrix of adjustment coefficients. The element of matrix β cancel the common unit roots in P_t and, in the long run, link the movements of the elements of P_t.

After estimation, a typical VEC model takes the form

$$\Delta P_t = \hat{\mu} + \hat{\Pi} P_{t-1} + \hat{\Gamma}_1 \Delta P_{t-1} + \hat{\Gamma}_2 \Delta P_{t-2} + ... + \hat{\Gamma}_{p-1} \Delta P_{t-k+1}. \tag{B3}$$

Hence, for each location *i*, equation (B3) can be rewritten as

$$\Delta p_{it} = \hat{\mu}_i + \sum_{j=1}^{m} \pi_j p_{jt-1} + \sum_{j=1}^{m} \sum_{k}^{K} \gamma_{jk} \Delta p_{jt-k} \tag{B4}$$

$$\Delta p_{it} = \hat{\mu}_i + \alpha_i \left(p_{it-1} - \sum_{\substack{j=1 \\ j \neq i}}^{m-1} \beta_j p_{jt-1} \right) + \sum_{j=1}^{m} \sum_{k=1}^{K} \gamma_{jk} \Delta p_{jt-k}. \tag{B5}$$

The long-run equilibrium is achieved if $p_{it-1} = \sum_{\substack{j=1 \\ j \neq i}}^{m-1} \beta_j p_{jt-1}$. In other words, in the long run,

$$\Delta p_{it} = \sum_{j=1}^{m} \sum_{k=1}^{K} \gamma_{jk} \Delta p_{jt-k} \tag{B6}$$

or

$$\Delta p_{it+1} = \sum_{j=1}^{m} \sum_{k=1}^{K} \gamma_{jk} \Delta p_{jt-k+1}. \tag{B7}$$

At equilibrium,

$$p_{it} + T_{ijt} = p_{jt}, \tag{B8}$$

where T_{ijt} is the transportation or transaction cost between locations *i* and *j* at period *t*. For *k* = 1, it follows that

$$\Delta p_{it+1} = \gamma_{i1}(p_{it+1} - p_{it}) + \sum_{\substack{j=1 \\ j\neq i}}^{m-1} \gamma_{j1}\left[\left(p_{it+1} + T_{ijt+1}\right) - \left(p_{it} + T_{ijt}\right)\right]. \tag{B9}$$

After rearranging and grouping some terms, equation (B9) yields

$$p_{it+2} - \left(1 + \sum_{j=1}^{m} \gamma_{j1}\right)p_{it+1} + \left(\sum_{j=1}^{m} \gamma_{j1}\right)p_{it} = \sum_{\substack{j=1 \\ j\neq i}}^{m-1} \gamma_{j1}\Delta T_{ijt} \tag{B10}$$

or

$$\frac{1}{\beta}p_{it+2} - \frac{(1+\beta)}{\beta}p_{it+1} + p_t = \Delta\overline{\mathrm{T}}_{\mathrm{t}},$$

where $\beta = \sum_{j=1}^{m} \gamma_{j1}$ and $\Delta\bar{T}_t = \sum_{\substack{j=1 \\ j\neq i}}^{m-1} \gamma_{j1}\Delta T_{ijt} / \sum_{j=1}^{m} \gamma_{j1}$.

Application

Table B.1. Determination of maximum lag[a]

Lag	FPE	AIC	HQIC	SBIC
0	0.00001	–2.99	–2.96	–2.92
1	1.0e-06	–5.29	–5.17[b]	–5.00[b]
2	9.7e-07[b]	–5.33	–5.13	–4.83
3	9.7e-07	–5.33	–5.04	–4.62
4	9.7e-07	–5.33[b]	–4.96	–4.41

Note” [a]Final prediction error (FPE), Akaike's information criterion (AIC), Schwarz's Bayesian information criterion (SBIC), and the Hannan and Quinn information criterion (HQIC).
[b] Maximum lag

As shown in Table B.1, the maximum number of lags to be included varies, depending on the statistic used; it is 4 when using AIC, and 2 with HQIC and SBIC. Therefore, we decided to run Johansen’s integration test for both lags. The results (see Table B.2) suggest the existence of two cointegrating vectors for both max lambda and trace statistics. In other words, following Gonzalez-Rivera and Helfand (2001), the three markets share the same long-run characteristics and thus constitute a genuine integrated market. However, for a maximum lag of 4, the existence of integration is established only with intercept in the VAR.

Table B.2. Cointegration results

	Value statistics					Osterwald-Lenum critical values (95% interval)			
	Lag = 2		Lag = 4			With intercept in CE		With intercept in VAR	
Rank	Maximum lambda	Trace	Maximum lambda	Trace	H0	Maximum lambda	Trace	Maximum lambda	Trace
0	35.4	63.1	30.6	52.5	0	22.0	34.9	21.0	29.7
1	17.5	27.7	15.8	21.9	1	15.7	20.0	14.1	15.4
2	10.2	10.2	6.1	6.1	2	9.2	9.2	3.8	3.8

To identify an exogenous central market, Gonzalez-Rivera and Helfand (2001) suggested the following test of weak exogeneity: $H_0: \alpha_{ij} = 0, \forall\, j = 1, \ldots, n-1$. Results are reported in Table B.3.

Table B.3. Estimation results of vector error correction (lag = 2 and rank = 2)

Dakar	Kaolack	Fatick	
	0.002	0.002	0.0003
Intercept	(0.007)	(0.011)	(0.011)
	–0.075	0.247**	0.253**
$\hat{\alpha}_{1i}$	(0.072)	(0.109)	(0.110)
	0.014	–0.401*	0.203*
$\hat{\alpha}_{2i}$	(0.075)	(0.114)	(0.116)
$\hat{\Gamma}_i$:			
	0.183*	0.137	0.239
Dakar	(0.108)	(0.164)	(0.166)
	0.203**	0.166	0.100
Kaolack	(0.078)	(0.119)	(0.121)
	–0.063	–0.039	–0.044
Fatick	(0.067)	(0.102)	(0.103)

Note: *, **, and *** mean significant at 1%, 5%, and 10%, respectively. Figures in parentheses are standard errors.

Table B.3 shows that in the short term, the Dakar market does not adjust to either Kaolack or Fatick, thus confirming that Dakar is indeed the central market. On the reverse, both Kaolack and Fatick significantly adjust to short-term disequilibrium.

Table B.4. Simulation data for the time path of price adjustment

	Dakar	Kaolack	Fatick
p0	500	475	575
p1	754	680	693
Gamma: $\hat{\gamma}_{ij}$			
Dakar	0.183	0.137	0.239
Kaolack	0.203	0.166	0.1
Fatick	–0.063	–0.039	–0.044
Sum of gamma ($\hat{\beta}_i$)	0.323	0.264	0.295
Trans at *t* = 2			
Dakar	—	54.8	62.5
Kaolack	–54.8	—	7.7
Fatick	–62.5	–7.7	—
$\Delta\overline{T}_i$	–22.3	35.6	20.0

With no transaction cost among the three markets, prices are expected to jump immediately after privatization, though they will remain stable afterward (see Figure B.1). The price of groundnuts in Dakar will also stay above prices for groundnuts in Kaolack and Fatick. However, with transaction costs, simulation results exhibit an upward trend for prices in Dakar, while prices in Kaolack and Fatick are expected to decline after a short increase following the reform (see Figure B.2).

Figure B.1. Price time path with no transaction cost between Dakar and Kaolack

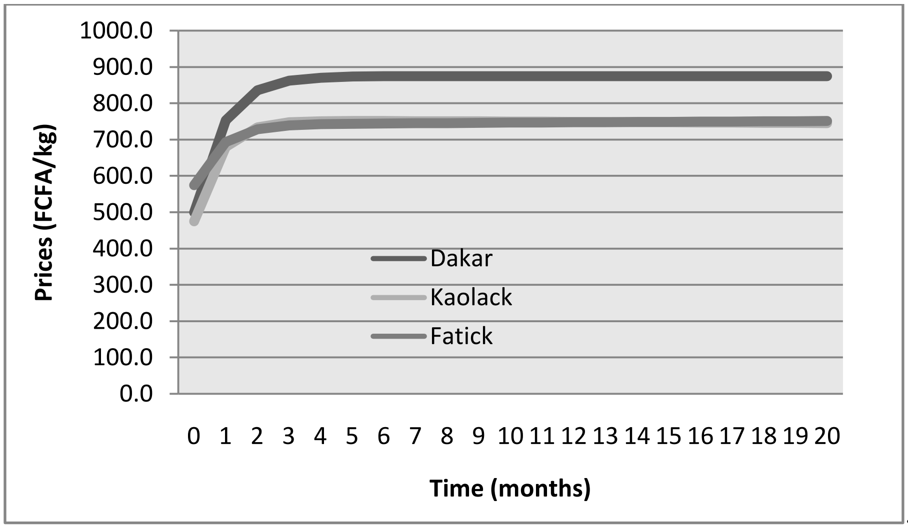


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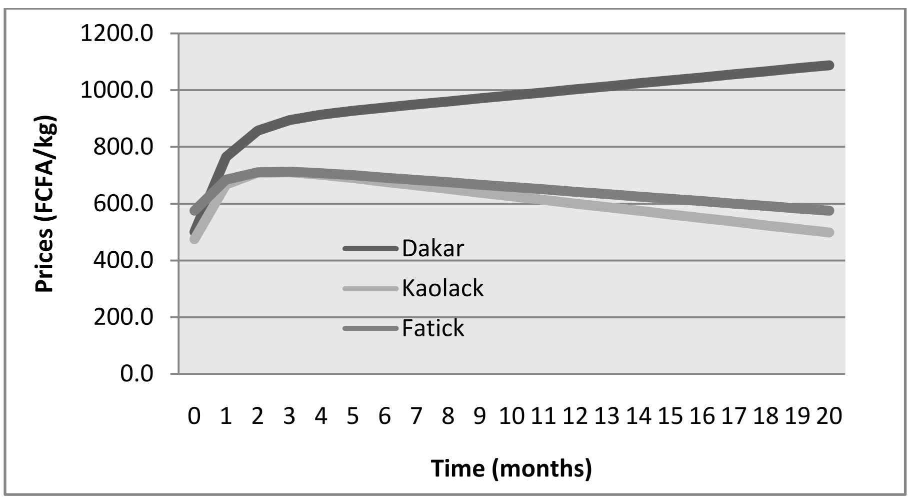
Figure B.2. Price time path with transaction cost between Dakar and Kaolack



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