MSSD DISCUSSION PAPER NO. 22

Markets and Structural Studies Division

MARKETING POLICY REFORM AND COMPETITIVENESS:

WHY INTEGRATION AND ARBITRAGE COSTS MATTER

by

Ousmane Badiane

International Food Policy Research Institute
1200 17th St. N.W.
Washington, D.C. 20036 U.S.A.

March 1998

Contact: Carolyn Roper
Tel: 202/862-5600 or Fax: 202/467-4439

Contents

Tables

Figures

Abstract

The response of local markets to sectoral and macroeconomic policy changes is a key determinant of the long term impact of policy reforms on reforming economies. In other words, changes in arbitrage costs that are associated with policy reforms as well as the level of integration among local markets exert a strong influence of the economic outcome of reform programs. The objective of this paper is to explore this question theoretically and empirically.

A model that can be used to capture the long term process that is involved has been developed and tested using data from Ghana. The model is later applied to analyze the outcomes of further liberalization of groundnut markets in Senegal. The findings highlights the potential cost of failing to pay sufficient attention, when liberalizing domestic markets, to the emergence of a competitive and efficient private distribution sector. The results also indicate that, when state-run processing sectors with monopoly power are involved, effective liberalization of pricing and marketing policies in all likelihood would not yield the anticipated benefits, unless accompanied with efforts to improve productivity and cut unit costs of production in the processing sector.

1. INTRODUCTION

A fundamental question that remains unanswered in most countries undergoing economic reform concerns the extent to which local markets respond to sectoral and macroeconomic policy changes. The objective of this paper is to explore this question theoretically and empirically, and to assess the respective roles of spatial integration and arbitrage costs in explaining price changes resulting from economic reforms. The work has been motivated i) by concerns that price changes are poorly transmitted between central and regional markets in rural Africa, and ii) by a recognition that the way in which agricultural producers and consumers react to changes in sectoral, trade, and macroeconomic policies depends upon the extent to which local market prices respond to changes in central market prices. These issues are of both major policy concern and continuing academic interest. On the one hand, considerable attention has been focused on the relative isolation of rural markets and the implications of this isolation for agricultural producers and consumers (e.g. de Janvry, Fafchamps, and Sadoulet, 1991; Fafchamps, 1992; Saha and Stroud, 1994). On the other hand, policy makers in countries with large processing sectors are often worried about the impact of liberalizing crop procurement systems on the competitiveness of these sectors.

The present paper examines the implications of market integration and changes in arbitrage costs[1] for i) the adjustment of local markets to pricing and marketing policy reforms and ii) the induced impact on the competitiveness of agricultural processing activities. It is based on a dynamic model of price formation that uses estimates of spatial integration and arbitrage costs across local markets to gauge the response of local agricultural prices to policy changes. The model is first applied to data from Ghana to test its robustness in retracing ex-post the price adjustment process in selected local market areas over the 10 year period that followed the introduction of policy reforms in that country in 1983. It is then used to examine the impact of liberalizing domestic groundnut markets in Senegal on prices in the main production region and the resulting effects on the profitability of processing plants located 300 km away in the port city of Dakar.

[1] Throughout the paper, the terms arbitrage cost, marketing cost, or transfer cost will be used interchangeably.

2. MODELING THE ADJUSTMENT OF LOCAL PRICES TO POLICY CHANGES

Assume a local market *L*, the price in which is determined by the price in a reference or central market *C*[2]. We denote the local and central markets by the superscripts *L* and *C*, respectively. The relationship between the prices in the two markets can be written as:

(1) $P_t^L \quad \alpha_\eta^L \quad \alpha_\Theta^L \, time \quad \beta^C \, P_t^C \quad \mu_t^L.$

With prices measured in levels, the intercept in equation (1) denotes fixed costs of marketing, and the coefficient of P^C, the price in the central market, measures a proportional markup, i.e. the cost of arbitrage between the latter market and the local market. Although equation (1) is instructive, it does not capture the dynamic nature of the relationship between prices in the two markets. For that purpose, a fully specified dynamic model has been used. Using *j* to indicate lags, and using *X* to denote a matrix that includes an intercept, a time trend, seasonal dummies, and other variables, expansion of equation (1) can be manipulated to yield:

(2) $P_t^L \quad \sum_{j\Theta}^{n} \alpha_j P_{t\,j}^L \quad \sum_{j\eta}^{n} \beta_j P_{t\,j}^C \quad \gamma X_t \quad \varepsilon_t \quad .$

---

[2] The definition of a central market is one that leads the price formation process amongst a network of interdependent markets.

The interpretation of equation (2) is as follows: if $\$_j=0 \; \forall \; j$ then the local market is segmented from the central market, meaning that it operates independently from it and that policy-induced changes in the latter are not transmitted to the former market. In contrast, if $\$_0=1$ then price changes are immediately transmitted from the central market to the local market. Furthermore, if the central and regional markets are integrated in the long run, then $\Sigma " + \Sigma \$ =1$, and the number of lags required to ensure this equality provides evidence of integration that is less immediate than instantaneous price transmittal. Standard F- and t-tests applied to estimated coefficients of equation (2) can be used to investigate hypotheses regarding short-run or long-run integration.

Given an initial shock to the central-market price, the dynamics of the adjustment process between two markets involve a series of interim multipliers as the induced deviations of prices from their equilibrium values fluctuate, converge, and then stabilize. In the context of the model introduced above, the cumulative effect after j periods of a central-market price shock on the price in an outlying market can be computed as:

(3) $$\beta_j^{C\text{d}L} \quad \sum_{h\,\eta}^{j} \frac{\partial E[P_{t\,h}^{L}]}{\partial P_t^{C}} \quad .$$

Complete adjustment of the process is given by the long-run dynamic multiplier:

(4) $$\beta^{C\text{d}L} \quad \lim_{j\cdot\infty} \beta_j^{C\text{d}L} \quad .$$

The *speed* of price transmission can be calculated by computing the time J that it takes for the intermediate multipliers to convergence within a certain range of the long-run

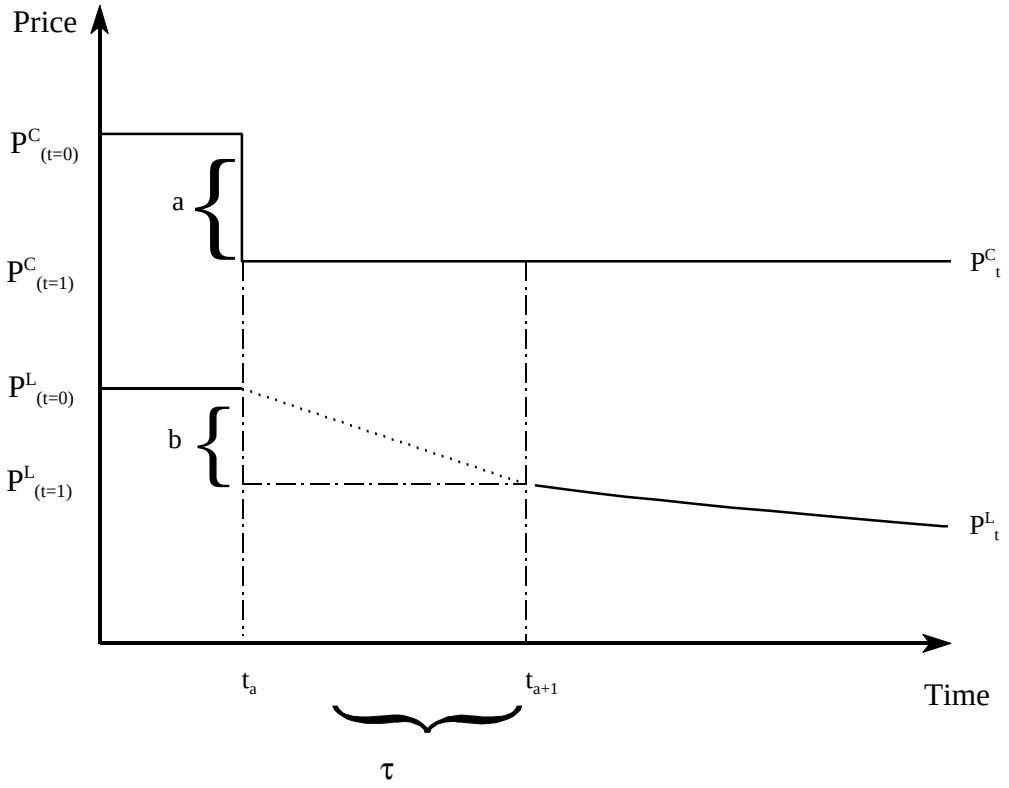
multiplier. The convergence rule is to find J such that $|\beta_\tau / \beta - 1| < \epsilon$ and $|\beta_\kappa / \beta - 1| < \epsilon$ for every $j > J$, where ϵ is a tolerance limit and β_κ is the estimated multiplier after j periods.

The process of market integration that is summed up in equations (3) and (4) needs to be linked to that of local price formation in order to model the adjustment of market prices to policy changes. Figure 1 offers a graphic illustration of the adjustment process, as it is treated in the model. In line with the observed changes in Ghana, the first case that will be studied with the model, the central price is shown here to decline following the introduction of reforms in period t_a (See Alderman and Shively, 1996). The model of spatial integration predicts that the change in price (a) in the central market will translate to a change in price (b) in the local market between the time t_a and the time t_{a+1}, a period that may range from a few weeks to a few months. The ratio b to a correspond to the long run multiplier that is estimated with equations (3) and (4).

The derivation of the long-run multiplier assumes the existence of arbitrage between the central and local markets. The multiplier can, therefore, be understood as reflecting the process of price adjustment in the local and central markets to changing supply and demand conditions in these markets. Moreover, because arbitrage costs play a key role in determining both the level and speed of adjustment of market prices to changes in supply and demand conditions, changes in these costs should be expected to affect the price adjustment process. The failure of the conventional integration model to capture this effect seriously diminishes its usefulness in studying the implications of changes in marketing policies. This is because

changes in marketing policies lead to reactions in the marketing system which in turn affect the costs of moving commodities across local markets.

Figure 1--Dynamics of Local Price Adjustment



(a = ΔP^C_{ta}; b = ΔP^L_{ta+1}; τ = speed of transmission)

The model of local price adjustment that is developed below is, therefore, based on the following reasoning. If $\$_j^{C,L}$ is the estimated value of the long run multiplier between the central market and a given local market after *j* periods, then the time path of prices in the local market can be expressed as a function $P_t^L (\$_j^{C,L}, \ldots T^L, P_{ta}^L, P_{ta+1}^L \ldots)$, where $\ldots T^L$ stands for the

change in costs of spatial arbitrage, P^{L}_{ta} the pre-reform price level in the local market at time period t_a, and P^{L}_{ta+1} the price level after the shock has bean absorbed by the local market at time period t_{a+1} (see Figure 1).

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

(5) $P_t^{L} \quad P_t^{C} \quad T_t^{L}$

or equivalently as:

(6) $P_t^{C} \quad P_t^{L} \quad T_t^{L}$,

Where T^{L} stands for the cost of arbitrage between the local and central markets. Recall from equation (5) defines the dynamic long-run equilibrium relationship between the price in a given local market and the price in the central market. It expresses the cumulative adjustment of the local price to changes in the central-market price in previous 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 (3) can be rewritten as:

(7) $\Delta P_{t\Theta}^{L} \quad \beta^{L} \ \Delta P_t^{C}$

Writing out equation (7) and inserting the values for P^{C} from equation (6) yields:

(8) $P_{t\theta}^{L} \quad (P_{t\Theta}^{L} \quad T_{t\Theta}^{L})\beta^{C\mathrm{d}L} \quad (P_t^{L} \quad T_t^{L})\beta^{C\mathrm{d}L} \quad P_{t\Theta}^{L}$.

Rearranged slightly, equation (8) yields a second-order linear difference equation that can be solved to obtain local prices P^{L}_{t} as a function of the long run multiplier $\$^{L}$ and local arbitrage costs T^{L}, as given by:

(9) $\frac{1}{\beta} P_{t\theta}^{L} \quad \frac{(1 \quad \beta)}{\beta} P_{t\Theta}^{L} \quad P_t^{L} \quad \Delta T^{L}$.

Equation (9) in turn can be solved for P^L (see Tu 1994, pp. 46-50), which obtains the following expression for the time path of local prices:[3]

$$P_t^L \quad \zeta_t P_{\gamma t \eta \Delta}^L \quad \varrho_t P_{\gamma t \Theta \Delta}^L \quad \varphi_t \Delta T^L$$

(10)

$$\textit{where} \quad \zeta_t \quad \frac{\beta \quad \beta^t}{\beta \quad 1} \; ; \; \varrho_t \quad \frac{\beta^t \quad 1}{\beta \quad 1} \; ; \; \textit{and} \quad \varphi_t \quad (\frac{\beta}{\beta \quad 1})t \quad .$$

Equation (10) expresses the local-market price at time t as a function of the initial (pre-reform) price, the long-run multiplier, and the change in arbitrage costs $) T$. In other words, changes in the degree of market integration or the cost of marketing not only affects local prices contemporaneously, but also affect the evolution of these prices over time.[4] 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.

The model presented above can now be used to examine the role of the marketing system in transmitting the effects of policy reforms. To that end, it is assumed that policy changes first affect prices in the lead markets either because these are major zones of production or trading centers. These markets lead other neighboring markets in the price discovery process which means that effects of policy changes originating there are transmitted

---

[3] See Badiane and Nuppenau (1997).

[4] Differentiating equation (10) with respect to $ gives the impact of improvements in the degree of market integration on the time path of local prices (see Badiane, 1996: pp. 14-15).

to the latter markets depending on their corresponding degrees of integration. Accordingly, the first step in modeling the transmission process is to model the effect of reforms on the central-market price.[5] To do this, note from the previous section that $P^{L}_{(t=0)}$ in equation (10) can be computed as:

(11) $P^{L}_{\gamma t \eta \Delta} \quad P^{C}_{\gamma t \eta \Delta} \quad T_{\gamma t \eta \Delta}$

In contrast, $P^{L}_{(t=1)}$ has to be calculated to reflect the immediate transmission of the impact of policy change in time t=1 to local markets *following* the adjustment of prices in the central market. For example, assume a one-time shock in the central market. Further, assume that local markets have finished adjusting to this shock. Now, defining as one period the time it takes for the long-run multiplier to converge to its equilibrium value, then the price in the local market at time t=1 is:

(12) $P^{L}_{\gamma t \Theta \Delta} \quad \beta[(P^{C}_{\gamma t \Theta \Delta} \quad P_{\gamma t \eta \Delta})^{C}] \quad P^{L}_{\gamma t \eta \Delta}$.

Recall that $T_{(t=0)}$ is the cost of spatial arbitrage before the introduction of reforms, and that $P^{C}_{(t=0)}$ is the pre-reform price observed in the central market. Substituting these two into equation (12), and using the identity given by equation (11), provides the values of $P^{L}_{(t=0)}$ and $P^{L}_{(t=1)}$ that are required to compute the local time path described by equation (10). Equation (10) thus allows us to estimate the time path of prices in the local market following a shock in the central market. In the next section the model is used to estimate the ex-post impact of economic reforms adopted by the Ghanaian government in 1983 on prices in two major local markets.

---

[5] Badiane (1996) and Badiane and Nuppenau (1996) discuss ways to model these effects.

3. SIMULATING THE ADJUSTMENT OF PRICES TO POLICY CHANGES IN GHANA

In 1983, Ghana launched an Economic Recovery Program (ERP), which among other eliminated many of the government interventions in the maize marketing system that in the past had helped depress real maize prices (Stryker, 1991). Currency devaluation was a centerpiece of Ghana's reform program, and between April 1983 and October 1985, the Cedi exchange rate to the US dollar fell from 2.75 to 60. Despite the previous policy-bias against the agricultural sector, the reforms were accompanied by a decline in real maize prices, as shown in Table 1. Furthermore, the analysis of maize prices by Badiane and Shively (1998) suggests that marketing margins have been shrinking throughout the post-reform period. The observed decline in prices may reflect the improvements in the transport sector and the reduction in marketing costs that followed the introduction of the reforms (Jebuni and Seini, 1992; Stryker, 1991).

Table 1--Evolution of Local Maize Prices During Reforms

	Wholesale Prices			Spatial Price Spread	
	Techiman	Makola	Bolgatanga	Techiman-Makola	Techiman-Bolgatanga
1980/84	42.38	41.60	41.64	0.78	0.75
1985/89	22.58	22.62	22.57	-0.04	0.01
1990/93	23.40	23.64	23.90	-0.24	-0.50

The analysis will focus on three major market areas in Ghana: Makola, near the coastal area around the capital city Accra; Techiman in the main maize producing area in the center of the country; and Bolgatanga along the Northern border with Burkina Faso. Techiman was previously identified as the lead market in the price discovery process among the three markets (Badiane and Shively, 1998). The model presented above will therefore be tested by simulating the time paths of prices in Makola and Bolgatanga as functions of the shock to prices in Techiman following the introduction of reforms in 1983, and the level of interdependence and the change in arbitrage costs between the latter markets and Techiman.

The first step in simulating the adjustment of local prices in Makola and Bolgatanga is to estimate the long-run multipliers between each of these markets and the Techiman market using cointegration analysis. Several pathways are available to test for cointegration of the local and central market price series. The procedure employed here is the Phillips-Oularis-Hansen procedure outlined by Hamilton (1994), using residuals from market-specific regressions based on equation (1). The equation is estimated for Bolgatanga and Makola with Techiman as the central market and the residuals from the regressions are retained and regressed on their lagged values, using a first-order autoregression (AR1) process. The results of the regressions are presented in equations (a1) and (a2) in the appendix. Subsequently, two tests of stationarity are conducted: the Phillips-Oularis Z-test, which is based on the AR1 residuals with undifferenced data; and the augmented Dickey-Fuller t-test, which is based on residuals using first-differences. The tests conducted at the 95 percent confidence level against

a true specification including the constant and the trend both reject the null hypothesis of no cointegration[6].

The second step in the simulation of the post-reform time paths of prices in Makola and Bolgatanga is to estimate the dynamic price equations described by equation (2) for each of these markets in relationship to the Techiman market. Based on the results of the heteroskedasticity tests, which rejected the null hypothesis of homoskedastic variance, an ARCH estimation procedure was applied to the equation.[7] The results obtained for Bolgatanga and Makola are presented in equations (a3) and (a4) in the appendix.

The values and significance levels of the coefficients for the Techiman price (P^{TE}) reject both the hypotheses of segmentation or immediate integration between the two markets and the Techiman market. However, the tests for long-run integration could not be rejected at standard significance levels. Furthermore, for models with 4-period lags in each market, the test of integration based on the criterion that $\Sigma\alpha+\Sigma\beta=1$, also failed to be rejected. In most cases, the strength of the integration relationship improves as additional lags are added, but the results do not change markedly beyond four lags. In short, these regression results support conjectures by Alderman (1993) and Asante, et al. (1989) that maize markets in Ghana are relatively well integrated.

---

[6] See Badiane and Shively (1988).

[7] The test produced ARCH test statistics of 10.6 and 11.7 for Bolgatanga and Makola, respectively, which in both cases exceed the χ^2 one-percent critical value of 6.63.

The dynamic multipliers with respect to the price in the central market of Techiman that are obtained from the estimated price equations are 0.27 and 0.54 for Bolgatanga and Makola, respectively. The multipliers with respect to the respective local prices are 0.69 for Bolgatanga and 0.52 for Makola. Thus, unlike in Makola, these estimates indicate that local-market price history in Bolgatanga is much more important in the price determination process than the central-market price. The estimates in both cases are consistent with the hypothesis of long-run integration, with the sum of parameters reaching 0.95 for Bolgatanga and 1.06 for Makola. Moreover, the computation of Timmer's Index of Market Connectedness (IMC) yields a value that is greater than 2 for Bolgatanga and one that is slightly less than 1 for Makola. These values underscore that the Bolgatanga market is relatively less integrated with the Techiman market than is the Makola market.

To obtain estimates of the time paths of local prices in each of the two markets, equation (10) is computed using the multiplier values with respect to the Techiman market of 0.27 for Bolgatanga and 0.54 for Makola. For comparison, estimates of long-run multipliers reported in the literature for other African countries typically range from 0.4 to 0.6, indicating that the estimate for Bolgatanga is relatively low (Badiane et al., 1997). The estimated time required for full transmission of the initial price shock between Techiman and the other two markets, that is the period from t_a to t_{a+1} in Figure 1, is about four months in each case. This measure of the speed of adjustment determines the length of the unit of time t that is used in the analysis. Accordingly, 4-month averages of prices and arbitrage costs are used in the simulations of the price time path that are presented below. In other words, $P^L_{(t=0)}$ and $P^C_{(t=0)}$

represent four-month averages of local (Bolgatanga and Makola) and central market (Techiman) prices at the time of reforms. The devaluation of April 1983 is used as a benchmark for the reform period. Thus, $P^{L}_{(t=0)}$ and $P^{C}_{(t=0)}$ represent the observed average prices in the second four-month period of 1983, May 1983 to August 1983, which in Figure 1 corresponds to t_a. Based on the estimated speed of transmission of four months, the first four-month period of 1984 is used as $t_{a+1.}$ The local price, $P^{L}_{(t=1)}$, computed using equation (12), also corresponds to that period.

The observed changes in spatial price spreads between Techiman, on the one hand, and Bolgatanga and Makola, on the other, are used as proxies for the changes in arbitrage costs, again using the same four-month time unit. Given that equation (9) was solved as a non-homogenous second-order difference equation, implying a constant θT, the average change in spatial price spreads between the individual four-month periods is used in the computations. During the period for which equation (10) is computed and which goes from the second four-month period of 1984 (II/84) to the second four-month period of 1993 (II/93), the average change in arbitrage cost between Techiman and Bolgatanga was -0.5 Cedis per four month-period. Between Techiman and Makola, the corresponding figure was -0.4 Cedis (Badiane and Shively, 1998)

Simulated time paths of prices for Bolgatanga and Makola are presented in Figures 2 and 3, respectively. The bottom line [APRICE] in Figure 2 shows the evolution of observed prices in Bolgatanga. The straight line [EPRICE] is the *ex post* simulation of these prices, which is computed using equations (10) and (12), the pre-reform prices, the long run multiplier

between Bolgatanga and Techiman (0.27), the observed decline in arbitrage costs between the two markets (-0.50), and Techiman prices observed immediately prior to and after the 1983 devaluation. The simulation results indicate that the some of the price decline in Techiman has indeed been transmitted to the Bolgatanga.[8] However, given the relatively weak link between Techiman and Bolgatanga, the contribution of Techiman price changes to price changes in Bolgatanga was fairly small. These results are well in line with the findings from the spatial integration model, which indicated that Bolgatanga prices are determined primarily by their own past values and local factors underlying them. In fact, based on the relatively low level of interconnectedness between Techiman and Bolgatanga one would expect that only a small amount of any price change in the former would be transmitted to the latter. To the extent that the weak connection between these markets is a reflection of a low level of arbitrage between them, one would also expect the changes in arbitrage costs to have limited impact on the evolution of Bolgatanga prices.

The importance of spatial integration for price adjustment process is confirmed by the results for the better connected Makola market (Figure 3). As before, the [EPRICE] line represents the simulated time path for Makola and the [APRICE] line the observed prices. Recall that the value of the long run multiplier for Makola is 0.54, double that for Bolgatanga. As a result, the simulated price line in Makola displays a much greater impact of the price

[8] Prices in Techiman fell from 53.17 to 40.54 Cedis between III/83 and I/84 while arbitrage costs between the two markets fell by an average of 0.5 Cedis every four-month period between III/84 and II/93.

shock in Techiman on local prices. The adjustment process is much stronger here, despite the fact that the observed reduction in arbitrage costs between Techiman and Makola (-0.40) was 25% smaller than that observed between Techiman and Bolgatanga (-0.50).

To show the importance of market connectedness for the response of local prices to changes in Techiman prices and arbitrage costs, equation (10) is solved again for Makola, using different values for the long-run multiplier and the changes in arbitrage costs. In Figure 4, the top line [LRM=0.25] represents the simulated price time path in the Makola market assuming a 50 percent lower long-run multiplier value of 0.25 and the same change in arbitrage costs. The bottom line [LRM=0.54] corresponds to the line [EPRICE] in Figure 3 and is included here for comparison. Contrasting the two simulated time paths, one sees that poor market integration helps to explain the limited impact of the decline in Techiman prices and arbitrage costs on prices in Bolgatanga. One sees for example, how similar the new simulated time path in Figure 4 is to the simulated price line in Figure 2.

Finally, two additional versions of equation (10) are computed using the data from the better integrated Makola market, to gauge the sensitivity of local price changes to changes in the costs of arbitrage. In the first version, the average decline in arbitrage costs in each period between Techiman and Makola is reduced by half to -0.2 but using the same long-run multiplier. In the second version, the average arbitrage cost is increased by 0.5 Cedis in each period. The top line [DARB=0.5] in Figure 5 indicates the simulated time path with increasing arbitrage cost. The middle line [DARB=0.2] is the price path with the lower decrease in arbitrage costs. It can be observed that the increase in arbitrage costs has a large impact on the

time path of local prices, in fact leading to an increase in Makola prices, despite the decline in prices in Techiman. As expected, the increase in arbitrage costs dampens the impact of the fall in Techiman prices. Not only do prices in Makola decline less in the early period as a result of increasing arbitrage costs, they even begin to rise after just a few periods.

The simulation results presented in the preceding sections show that the ultimate impact of policy reforms on local market prices is not only a function of the extent of the initial shock, but also of the degree of interdependence across local markets and any associated changes in the costs of moving goods between markets. Because policy reforms often include the liberalization of domestic marketing systems and thus the adjustment by traders of their marketing operations, the model laid out here presents a clear advantage over conventional integration analysis regarding the study of the impact of economic reforms on agricultural markets. In the second part of the paper, the model is therefore used to examine how the liberalization of the groundnut procurement systems in Senegal would affect the procurement prices for the country's processing industry.

Figure 2--Actual and Predicted Price Time Paths, Bolgatanga Market

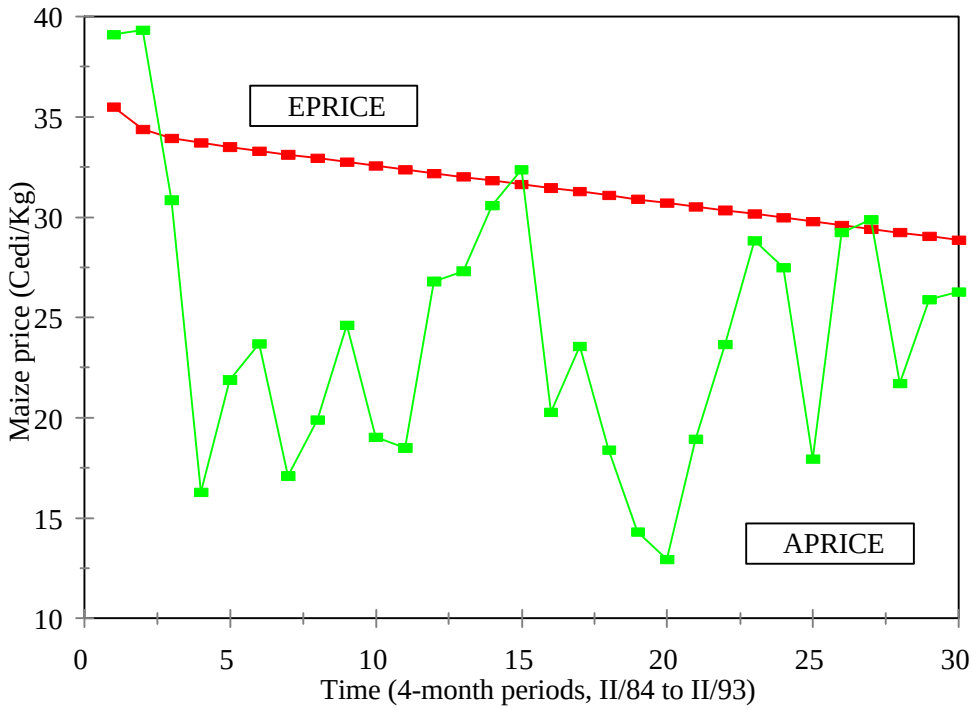


Figure 3--Actual and Predicted Price Time Paths, Makola Market

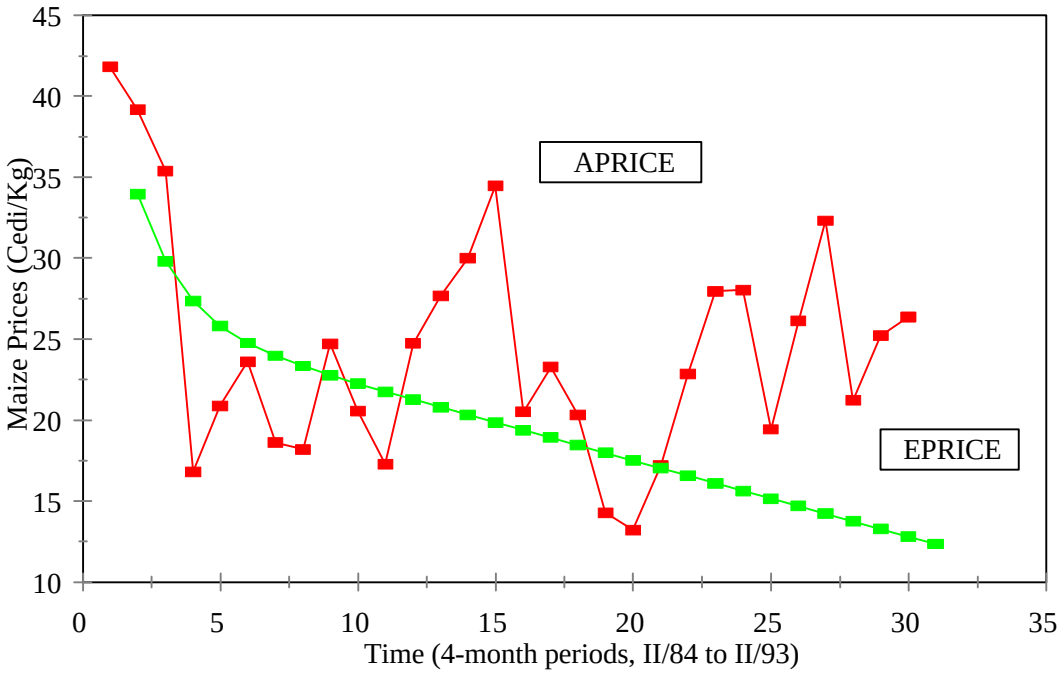


Figure 4--Market Integration and Adjustment, Makola Market

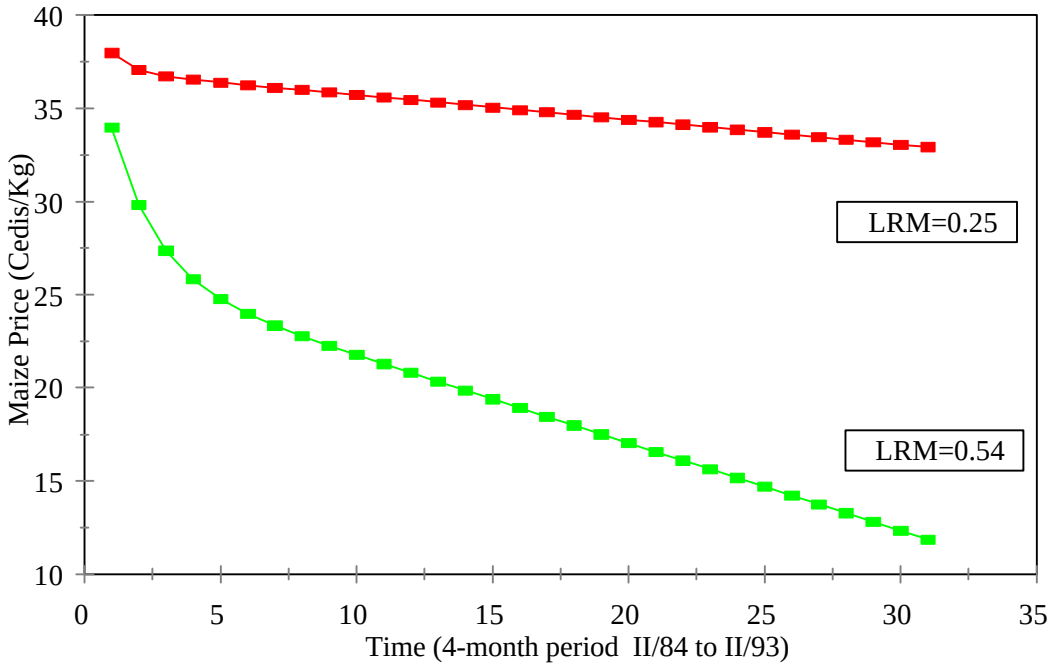
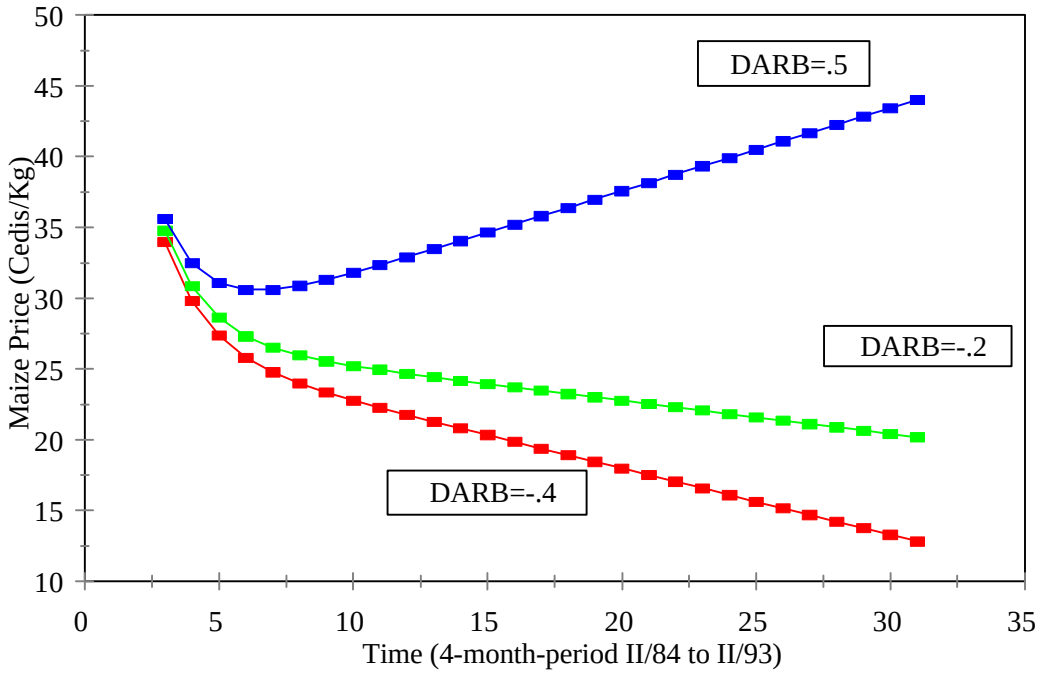


Figure 5—Arbitrage Costs and Adjustment, Makola Market



4. GROUNDNUT MARKETING POLICY REFORMS IN SENEGAL

After decades of extensive intervention in groundnut markets, the Senegalese government initiated a reform program in 1985, with the objective of increasing private sector participation and raising efficiency in the procurement system. The main rationale for state intervention in the groundnut sector has been to safeguard the viability of state-owned processing mills. Consequently, the government has slowly and only partially liberalized groundnut markets, as illustrated by i) the exclusion of the processing sector from the reform program; ii) the continued control of the procurement system of unshelled groundnuts through the official system of agricultural cooperatives and a network of private traders, *the Operateurs Prives Stockeurs* (OPS), procuring exclusively on behalf of the marketing parastatal, SONACOS; and iii) the continued administration of uniform pan-territorial and pan-season prices during the administratively determined official marketing season.

The partial approach to reforming the groundnut sector has lead to a dual marketing system with, on one hand, a sub-system controlled by the state and consisting of agricultural cooperatives and the OPS, and on the other hand, an informal sub-system of independent private traders. The official system controls the distribution of unshelled groundnuts which are delivered exclusively to processing mills. The market for shelled groundnuts, in contrast, is controlled exclusively by private traders who increasingly also compete with the official system in the procurement of unshelled groundnuts. The dichotomy of the system, which to a certain extent, is a tradition in the groundnut sector of Senegal, has been reinforced in a pronounced

way by the partial approach of the 1985 reforms. The partial liberalization has created two distinct segments in the procurement and distribution system. Each of these segments operates essentially at a different time of the year, focuses on different types of groundnut by-products, serves different geographical areas, and sells to different customers. The official system operates only during the four-month long official marketing season, while the private system is active all-year long. The official system handles only unshelled groundnuts and sells exclusively to the processing plants located mostly in the port-city of Dakar.

Moreover, despite the adoption of the reforms, the policy environment of the groundnut marketing system is still strongly affected by many of the restrictions from the pre-reform period. Eventhough they are not being enforced, the government has not been willing to take transparent and unequivocal steps in removing most of these restrictions. Private traders, as a result, tend to be skeptical of the determination of the government to tolerate their activities, particularly as they are increasing their share of the market of unshelled groundnuts. Indeed, many private traders think that the relative freedom they currently enjoy could still be questioned at any time. They view their participation in groundnut marketing as being tolerated, but not legalized. This situation obviously has a negative impact on the attitude of the entrepreneurs who would otherwise like to invest fully in these activities.

The partial and segmented approach to the reform of groundnut markets is reflected in the behavior of prices in local markets. The barrier segmentation between the official and private channels has contributed to disconnecting the process of price formation in the markets for shelled and unshelled groundnuts. This segmentation is reflected in 1) the considerable

variation of the price ratios between the two groundnut products across neighboring markets; 2) the much higher volatility of prices for unshelled groundnuts in the same markets; 3) the large number of markets displaying very dissimilar price seasonality patterns, despite the fact that the production and harvesting patterns are the same in the different areas; and 4) the substantial variability in spatial and temporal price spreads for similar distances and for the same types of groundnuts in neighboring markets in the main production zone[9].

The pricing behavior described above suggests that the reforms introduced in 1985 have not resulted in the emergence of an efficient marketing system. Prevailing pricing and marketing policies affect not only the operation of local markets, but also the profitability of farming and processing activities alike. Policy reforms may, therefore, be associated with important revenue transfers between the production and processing sectors. Effective reform of these policies would inevitably result in a redistribution of these transfers. The analysis of the redistributive effects of an eventual deepening of the reform programs and their implications for the competitiveness of the groundnut sector is a critical input into the preparation of additional liberalization measures that are currently under discussion.

[9] See Badiane and Gaye. 1997.

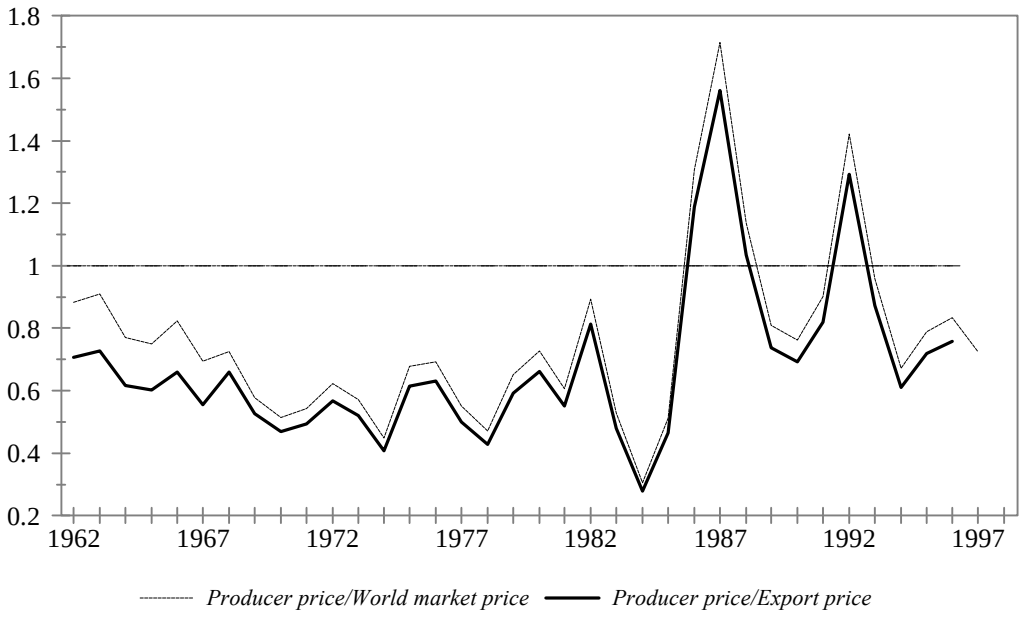
5. MARKET LIBERALIZATION AND COMPETITIVENESS OF GROUNDNUT PROCESSING

Even after the reforms, government pricing and marketing policies sought to protect the processing sector, while severely taxing groundnut producers. The magnitude of the taxation is illustrated in Figure 6, which shows that the share of groundnut farmers in the export price has consistently been lower than 60 percent. Given the consequences of such a bias for long term productivity in the groundnut farming sector, the advantage of lower raw material prices enjoyed by the processing sector has not been sufficient to sustain its competitiveness. Output stagnation and even decline in the farming sector has led to increasing excess capacities in the processing sector, which has resulted in a substantial hike in the unit cost of processing. The taxation of the production sector was especially high during the seventies. It more than doubled during this period, leading to a substantial change in Senegal's role in the global groundnut economy. From the sixties to the middle of the eighties, the country's share in world production of groundnuts decreased from 6 to 4 percent, and its share in world exports fell from 23 to 14 percent (Badiane and Kinteh. 1994) [10].

---

[10] In comparison, exports from the non-members of the Conseil Africain de l'Arachide have increased by around 50 percent during the same period (Badiane and Kinteh, 1994: p. 25).

Figure 6--Sector Policies and Taxation in the Groundnut Sector



Note: Price data used is from Freud et al. 1997

The subsequent drop in world prices and the gradual appreciation of the country's currency led to a dramatic change in the transfer effects of pricing policies towards the end of the eighties and the early nineties. They resulted in a significant decrease of the gap between export and producer prices. For several years, producer prices were even higher than export prices, inducing heavy losses for the processing industry. By the early nineties, the chronic deficits in the processing industry had exacerbated the deep crisis in the farming sector.

Under the objective of revitalizing the groundnut sector, the reform programs describe earlier were launched during the mid-eighties. The center-piece of the reforms has been the

promotion of participation by private traders in groundnut sector procurement[11]. The government has now realized that the current reforms have not been sufficient to bring about significant changes in the groundnut sector. The deepening of the reform program of the early eighties, as it is currently being discussed, would require an effective liberalization of the groundnut sector, which means allowing domestic and external market forces to dictate prices, opening the procurement system to private traders by removing the remaining obstacles to entry and the free movement of groundnut products. Such changes would lead to an increase in competition in local markets, a reduction in marketing costs, and improved integration among local markets. Effective liberalization of domestic groundnut markets is most likely to lead to an increase in producer prices and, therefore, to higher raw material prices for the processing industry.

It was indicated previously that one of the main concerns of the government with respect to reforms in groundnut sector is the anticipated impact on profitability in the processing industry. In the following sections of the paper, the model introduced earlier will be used to examine the potential impact of further liberalization of domestic groundnut markets on prices in the main producing region around Kaolack and on prices in Dakar, the main area of implementation of groundnut processing plants. The underlying reasoning is that in the context of liberalized markets, industry procurement costs would be determined by market prices in the Dakar region. Furthermore, the adjustment of prices in the Dakar market that would be

---

[11] The nature and the weaknesses of the liberalization programs are discussed in detail in Badiane and Gaye (1997).

induced by policy changes would take place gradually rather than immediately. Hence, the application of the model, which captures not only the immediate adjustment but also retraces the time path of prices in the local market in Dakar, long after the initial shock. In accordance with equation (10), changes in prices in Dakar would be a function of i) the degree of integration between the markets of Kaolack and Dakar; ii) the initial price change in the Kaolack market; and iii) the changes in arbitrage costs between the two markets.

Accordingly, the individual steps in the estimation of the impact on prices in Dakar of price changes in Kaolack, following a full liberalization of pricing and marketing policies, consist in calculating 1) the anticipated changes of producer prices in the area of Kaolack, 2) the degree of integration between the markets of Kaolack and that of Dakar, and 3) the changes in inter-market arbitrage costs between the two zones. To estimate the changes in producer prices, it is assumed that post-reform prices in Kaolack would be equal to the farm-gate equivalent of export prices, that is the prevailing world price minus the transfer cost between Kaolack and Dakar, which is also the main point of export. To estimate the degree of integration between the markets of Kaolack and Dakar, co-integration analysis is applied to the series of prices in these two markets, as explained in section 2. Equation (3) and (4) are then computed to obtain the long-term multipliers, which measure the degree of price interdependency between the Kaolack and Dakar markets. For the changes in arbitrage costs, the actual changes in price differences observed between the two markets are used. The model is estimated retrospectively to examine the likely impact of further liberalization of price and marketing policies in the groundnut sector. The computations are based on a hypothetical

complete liberalization of markets in 1992. The simulated results are then contrasted with actual prices and profit levels in the sector to illustrate the potential ramifications of furthering the reforms started in 1985. The simulation of the effects of liberalizing groundnut markets during the period that is considered has to take into consideration the impact of the devaluation of the country's currency which occurred in early 1994. The five year period covered by the estimations, which goes from July 1992 to July 1997, has therefore been divided into two sub-periods: a first one extending from July 1992 to the date of the devaluation in February 1994, and a second sub-period that covers the remaining years.

For the first step of the analysis, that is the estimation of the integration model, the results obtained in Badiane and Gaye (1997) are used[12]. The integration analysis was carried out not only for the pair Kaolack-Dakar, but for all main groundnut markets in Senegal. Monthly price data from the different markets was used. For the Kaolack-Dakar market, the co-integration analysis provided a long term multiplier of 0.52, with an adjustment speed of one month. In other words, price changes in Kaolack during the five years covered by the estimations were transmitted to the market of Dakar at a rate of 52 percent after a period of one month. Moreover, the average cost of arbitrage between the markets of Dakar and Kaolack have declined over the study period at a rate of 0.29 CFA per month. Based on the

---

[12] The integration results obtained there indicate that Kaolack is indeed leading the price formation process between the two markets. Accordingly, Dakar is specified as the local market and Kaolack as the central market. Hence, P^L and P^C in the equations refer to prices in Dakar and Kaolack, respectively.

above information, the post-reform prices in Dakar can be computed using equation (10), if the initial change in prices in Kaolack resulting from the liberalization of pricing and marketing policies is known. Table 2 presents the prices that are used in the simulation and explains how they have been derived.

The simulations are carried out for two sub-periods. The first period covers the 18 months preceding the devaluation of the Franc CFA in February 1994. For this sub-period, the effects of the reforms are simulated by adjusting the prices in Kaolack in July 1992 ($P^k_{(t=0)} = 188.58$), assuming that an effective liberalization would have decreased them in the following period, that is in August 1992, to the level of export prices in Dakar, adjusted for the cost of transfer between Kaolack and Dakar[13]. As explained in the notes to Table 2, the price under liberalization is obtained by using as reference price the average world price between 1988 and 1992. Given the large fluctuations of international market prices, this choice seems more judicious than choosing the price that prevailed in August 1992 as the reference price. With an average of 130.23 CFA and transfer costs between Kaolack and Dakar of 50 CFA, the initial price in Kaolack that would have resulted from the liberalization is estimated to be, $P^k_{(t=1)} = 80.23$. Using the above figures for $P^k_{(t=0)}$ and $P^k_{(t=1)}$ and the transfer costs observed between Kaolack and Dakar, the initial change in the Dakar price from $P^d_{(t=0)}$ to $P^d_{(t=1)}$ can be calculated using equations (11) and (12). By inserting the values for $P^d_{(t=0)}$ and $P^d_{(t=1)}$ determined in equation (10) and by using the values of 0.52 for the long term multiplier (β) and

[13] The model uses monthly price data, so that a shock introduced in July is reflected in the price level of August.

-0.29 for the average change in transfer costs (ΔT), the impact on the time path of prices in Dakar that would have resulted from the liberalization of groundnuts market in July 1992 can be simulated.

Table 2--Data Used for the Estimation of the Time Path of Prices in Dakar

Pre-devaluation period			Post-devaluation period				Long term multipliers	Change in transfer costs
$P^K_{(t=7/92)}$ [a]	$P^K_{(t=8/92)}$ [b]	$P^D_{(t=7/92)}$ [c]	$P^K_{(t=2/94)}$ [d]	$P^K_{(t=3/94)}$ [e]	$P^{K'}_{(t=3/94)}$ [f]	$P^D_{(t=2/94)}$ [g]		
Shelled groundnuts								
188,58	80,83	217,13	31,47	274,73	253,41	93,47	0,52	-0,05

Source: UPA, Ministry of Agriculture

[a] Price of shelled groundnuts in Kaolack in July 1992.

[b] Calculated as the world price in August 1992 of 98,09 CFA per kilogram, minus estimated transfer costs of 50.00 CFA/kg between Kaolack and Dakar for the same period.

[c] The Dakar price in July 1992.

[d] Simulated price for the Kaolack market in February 1994, assuming that the groundnut markets have been liberalized since 1992. This price is obtained by subtracting the transfer or marketing costs between Kaolack and Dakar from the price simulated for Dakar in February 1994, $P^d_{(t=2/94)}$.

[e] Calculated as the world price in March 1993 of 377.29 CFA/kg, minus the marketing costs between Kaolack and Dakar for the same period, which is 62.00 CFA/kg. This price is used for the "autonomous adjustment" version.

[f] Calculated as the average world price from 1994 to 1997, minus the marketing costs of 62.00 CFA/kg between Kaolack and Dakar for the same period. This price is used for the "guided adjustment' version, which assumes the existence of a mechanism to align domestic prices to the expected average of prices over the period 1992 - 1997.

[g] Simulated price for Dakar in February 1994, assuming a complete liberalization of markets since July 1992.

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 is used as a proxy.

For the post-devaluation period, the simulation must take into account the change in parity. Given that the simulations assume that markets have been liberalized since 1992, the market price in Dakar at the moment of the devaluation must correspond to the simulated export price in Kaolack plus the transfer costs to Dakar. Consequently, the pre-devaluation price in Kaolack, that is $P^k_{(t=2/94)}$, is obtained by deducting from the simulated price for the Dakar market at the end of the period, that is $P^d_{(t=2/94)}$, the transfer costs between the two

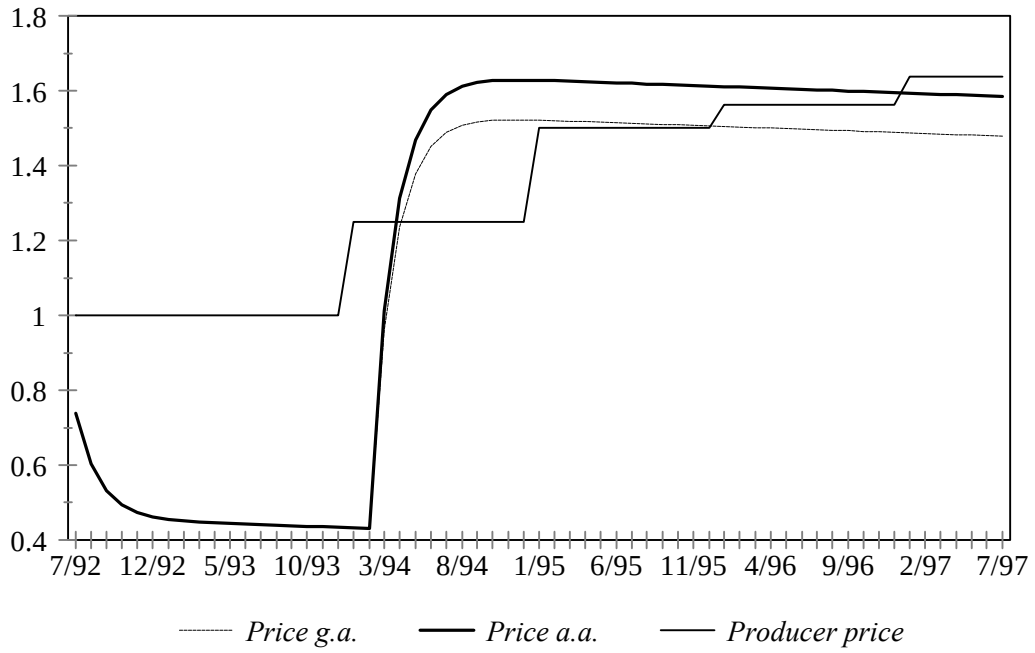
markets at the moment of the devaluation. Following the change in parity in February 1994, the immediate post-devaluation price in Kaolack, $P^{k}_{(t=3/94)}$, has to be adjusted to fully reflect the change in the exchange rate. The new reference price for Kaolack is, therefore, calculated as the export price in March 1994 minus the transfer cost to Dakar, converted at the new exchange rate (see table 2). Equation (11) and (12) are then used to compute the immediate change in the price in Dakar, $P^{d}_{(t=3/94)}$. Assuming that β and ΔT have the same values as during the pre-devaluation period, equation (10) is computed again to simulate the time path of prices in Dakar, had the government allowed producer prices in Kaolack to fully reflect the effects of the change in parity of the CFA Franc in the context of liberalized domestic markets.

As explained before, the initial post-devaluation price in Kaolack is derived from the world price by deducting the transfer costs at the moment of the devaluation. Therefore, it was necessary to choose a reference price to represent the world price at the beginning of the post-devaluation period. This has led to the following two versions of the model. The first version supposes an autonomous adjustment of prices in Kaolack to the change in parity, using as reference the world price just after the devaluation of the Franc CFA, i.e. in March 1994. The second version assumes a guided adjustment and uses as the reference price the average world market price between 1994 and 1997. The idea behind the notion of guided adjustment is the existence of a mechanism that works to align producer prices to long-term trends in international markets rather than exposing them to short-term fluctuations. For both versions, as well as for the simulations for the pre-devaluation period, the simulated price is the retail price in Dakar for unshelled groundnuts.

The simulation results are reported in Figure 7. It displays the time path of prices in the Dakar market, which would have resulted from the liberalization of pricing and marketing policies back in July 1992. The lines describe the evolution of the ratio between the simulated price and the observed pre-reform price in Dakar in July 1992, assuming fully liberalized markets as of July 1992, and thus a complete transmission of the change in parity to producer prices in Kaolack. The thick line corresponds to the version of the model that assumes an autonomous adjustment of producer prices to their international level. The dotted line correspond to the version with guided adjustment. These two lines, which are identical for the period before devaluation, indicate that a complete liberalization of the groundnut markets would have induced a decline in prices by as much as 55 percent in Dakar during the 18 months preceding the devaluation of the CFA Franc. Figure 1 showed that producer prices between 1992 and 1993 have in fact been higher than Senegal's export price, which itself was higher than the world market price, as a result of EU financed export subsidies. The subsequent drop in world market prices and the appreciation of the CFA Franc, combined with already excessively low producer prices in real terms, which the government was hesitant to decrease further, caused prices in the Dakar market to rise to more than twice the world price level. The stepped line, on the other hand, describes the evolution of actual producer prices relative to their July 1992 level. The observed increase of about 20% during the last months of 1993 and just before the devaluation reflects the effect of a retrospective adjustment of official prices that took place around the end of the marketing season in late 1994, months after the change in parity. The substantial gap between the two price lines during the pre-devaluation

period is at the source of the enormous deficits that have plagued the groundnut processing industry for years.

Figure 7--Price Adjustment in the Dakar Market



Note: The lines indicate the ratio of simulated and producer prices to their pre-reform values in 7/92. Price g.a. = price simulated under guided adjustment scenario; Price a.a.= price simulated under autonomous adjustment scenario.

With the change in parity that occurred in February 1994, prices in Dakar would have been, by the second half of 1994, 50 to 60% higher in the case of liberalized markets. The simulated price is higher for the version assuming autonomous adjustment, because it is based

on a world price that is higher than the one underlying the simulations under the guided adjustment version. It is also interesting to note that during the post-devaluation period, producer prices show a trend that is somewhat similar to that of simulated prices. In other words, the successive adjustments in producer prices made by the government after the change in parity have raised them in the same proportions as market prices would have increased under full liberalization. Hence, the ratios of the simulated market and actual producer prices to their respective values of July 1992 all lie around 1.6 at the end of the simulation period.

The changes in policies that are simulated here raise key questions relating to their effects on production incentives and on cost levels, and thereby, profitability in the processing sector. The comparison between producer prices and simulated prices in Figure 7 does not allow a full appreciation of the changes in incentives nor does it allow for the appreciation of the revenue transfers between the production and processing sectors that are associated with the shift in incentives. For that purpose, the analysis must take into account not only the difference between simulated and actual prices, but it must also take into consideration changes in procurement and processing costs.

The actual evolution of profitability in the processing sector during the period covered by the study is first examined to obtain a benchmark on which to base the analysis on the transfer effects that would have resulted from the liberalization of domestic groundnut markets. Table 3 below calculates the profit margins in the processing industry on the basis of different constellations of groundnuts and oil export prices and groundnut procurement costs. The two export prices that are used correspond to the world market price (PEM) and

Senegal's export price (PES), the latter taking into account the 10% subsidy granted by the European Union for groundnut oil exports from Senegal (Freud et al: p. 139). It is important

Table 3--Pricing Policy and Profitability in the Processing Industry

	1992	1993	1994	1995	1996
	In CFA per kg of shelled groundnuts				
Senegal export price (PES)[1]	95	124	302	268	266
World market price (PEM)	87	112	275	244	242
Processing cost (CTB)	32	69	28	33	33
Gross margin @ PES (MBS)	64	54	274	235	233
Gross margin @ PEM (MBM)	55	43	247	210	209
Transfer price FGPA (PFG)[2]	121	104	208	232	249*
Collection costs (PFC)[2,3]	161	179	200	232	249*
Net margin @ PPS & PFG (MSG)	-57	-50	67	3	-16
Net margin @ PPS & PFC (MSC)	-97	-125	74	3	-16
Net margin @ PPM & PFG (MMG)	-66	-62	39	-22	-41
Net margin @ PPM & PFC (MMC)	-106	-136	47	-22	-41

Source: Basic price and cost data are from Freud et al (1997).

[1] CIF price for raw groundnut oil in groundnut in shell equivalent based on a conversion coefficient of 1.86.

[2] Sale's prices and assembly costs reported by SONAGRAINE for unshelled groundnuts, converted to shelled groundnut prices using a conversion rate of 0.65.

[3] Assembly costs incurred by SONAGRAINE for procuring one kilogram of unshelled groundnuts, converted to shelled groundnut prices using a conversion rate of 0.65.

* After the cancellation of the agreement that called for SONAGRAINE to supply processing mills at subsidized prices, the prices PFG and PFC are supposed to be equal to the prevailing producer price of 131 CFA plus SONAGRAINE's assembly cost of 31 CFA per kilogram, assuming that the costs are the same in 1996 as for 1995. The price of groundnuts in shell thereby obtained is translated into shelled equivalent by using a conversion rate of 0.65.

PES: World price plus the 10% subsidy from the European Union.

MBS: Equals (PES-CTB) * 0.65.

MBM: calculated in the same way as MBS by using PEM in stead of PES.

CTB: Processing cost of exported raw oil reported by SONACOS. Given that 1.86 kg of groundnuts in shell yield 1 kilogram of oil, the costs reported by the SONACOS must be divided by this factor to obtain the processing cost per kilogram of groundnuts in shell.

MSG= PPS - PFG; MSG= PPS-PFC

MMG= PPM - PFG; MMC= PPM - PFC

to distinguish between the two prices in order to adequately evaluate the competitiveness of Senegalese exports. By deducting the processing costs (CTB) that are derived from table a1 in the appendix from the export prices, we obtain the gross price margins on the basis of the world export price (MBM) and on the basis of Senegal's actual export price (MBS). The possible net price margin after processing is then estimated by subtracting the costs of the quantities of groundnuts used from the gross price margins. The cost of groundnuts are calculated first on the basis of the actual prices (PFG) charged by SONAGRAINE, the procurement arm of the public processing company SONACOS. SONAGRAINE supplies unshelled groundnuts to the company's processing mills in Dakar often at subsidized prices that are well below the sum of the producer price plus assembly and transport costs. Alternatively, the cost of groundnuts to the processing mills are calculated on the basis of a price (PFC) that would at least cover SONAGRAINE's actual procurement cost, that is producer price plus assembly and transfer cost to Dakar.

Depending on the export price that is used and the definition of groundnut costs to processing mills, four different estimates of net margins in the processing sector are obtained. The net margins for the last five years are presented in the last four rows of Table 3. For 1992 and 1993, the estimates indicate losses by the processing mills which vary between 50 and 136 CFA per kilogram of processed shelled groundnuts. As has already been mentioned, the mills would not have been able to absorb these losses if there were no subsidies granted within the framework of the agreement with the procurement company SONAGRAINE (Freud et al,: p. 76). As would be expected, these losses are less important when the higher actual export price

(PES) is used instead of the world price. For the following two years, still on the basis of the actual export price, the net margins realized by the groundnut oil mills varied from 3 to 74 CFA per kilogram. If they were to export at world market prices, the oil mills would not have realized any profit until 1994. Because of the drop in the world prices, they would have suffered losses of about 22 CFA per kilogram in 1995. For the last year, the losses incurred would have been 16 to 40 CFA per kilogram. Therefore, it appears that the positive effect from the CFA devaluation on the processing sector would has lasted only a very short time and would have been much less significant if the oil mills had to export at world market prices. The two main factors that explain this development are the increase in groundnut procurement prices, which have doubled during the post-devaluation period, and the drop by almost 60% of the world prices after 1994.

Pricing and exchange rate policies do not only affect the profitability of the processing activities, they are also associated with revenue transfers between the production and the processing sectors. Given that the distribution of these transfers would be affected by changes in pricing policies, it is of interest to know the implications of furthering the reform process in Senegal's groundnut sector in that respect. The level of transfers can be estimated on the basis of the simulated prices that are discussed above, the processing costs in the milling industry, the procurement costs of groundnuts, and the producer prices. Tables 4 and 5 show the results of such computations. In the first table, the simulated price (PEA) is based on the "autonomous adjustment" version of the model, which assumes an immediate and full adjustment of prices in Kaolack to the change in the CFA parity starting in March 1994. The

price (PEG) in the second table is based on the "guided adjustment" version of the model, in which prices in Kaolack are initially set to reflect the long-term development of world market prices. In both cases, two different estimates of processing costs will be used. The first

Table 4--Market Liberalization and Inter-Sector Transfer (Autonomous Price Adjustment)

	1992	1993	1994	1995	1996
	In CFA per kg of unshelled groundnuts				
Simulated price, automatic adjustment (PEA)[1]	72*	62	187	229	226
Processing cost (CTB)	21	45	18	22	22**
Reference processing cost (CRT)	14	14	14	14	14
Maximum procurement price of oil mills @ CTB (PAB)	52	17	169	207	205
Maximum procurement price of oil mills @ CRT (PAR)	58	48	173	214	212
Private sector marketing cost (FCP)	70	24	39	75	50
Maximum producer price @ CTB (PMAB)	-18	-7	130	132	154
Maximum producer price@ CRT (PMAR)	-12	24	134	139	162
Actual producer price(PPP)	80	80	100	120	125
Transfer producers→oil mills @ CTB (TAB)	-98	-87	30	12	29
Transfer producers→oil mills @ CTR (TAR)	-92	-56	34	19	37

[1] This corresponds to the simulated price (PEA) minus all other cost of processing but that of groundnuts.

* The simulation being based on a hypothesized liberalization of the markets in mid-1992, the adoption of the simulated price for the harvest of 1992 assumes that it could have been sold at this price.

** Processing costs in 1996 are supposed to be the same as in 1995.

PEA: is the simulated price in the Dakar market assuming an autonomous adjustment of prices in Kaolack following a liberalization of the marketing system since July 1992. It is a proxy of the price that oil mills would have to pay for groundnuts under liberalized markets.

CTB: is SONACOS' processing cost for one liter of oil, converted in unshelled groundnut equivalent at the conversion rate of 2.86 (see Freud et al. P.90 for the source of these costs).

CRT: is equal to SONACOS' processing cost adjusted for the difference between its milling costs and that of its European competitors which amount to around 200 French francs per liter of oil, converted into unshelled groundnut equivalent, using the conversion rate of 2.86. Except for the year 1993, these costs are about 41,000 French francs per metric ton.

FCP: Marketing costs in the private sector, using as proxy the average difference between prices for unshelled groundnuts in the Kaolack and Dakar markets.

PAB= PEA - CTB; PAR= PEA - CTR;
PMAB= PAB - FCB; PMAR= PAR - FCP;
TAB= PMSAB-PPP; TAR= PMAR - PPP.

Table 5-- Market Liberalization and Inter-Sector Transfer (Guided Price Adjustment)

	1992	1993	1994	1995	1996
	In CFA per kg for unshelled groundnuts				
Simulated price, guided adjustment (PEG)	72*	62	176	214	211
Processing cost (CTB)	21	45	18	22	22**
Reference processing cost (CRT)	14	14	14	14	14
Maximum procurement price of oil mills @CTB (PGB)[1]	52	17	158	192	190
Maximum procurement price of oil mills @CRT (PGR)[1]	58	48	162	200	197
Private sector marketing cost (FCP)	70	24	39	75	50
Maximum producer price @ CTB (PMGB)	-18	-7	119	117	139
Maximum producer price @ CRT (PMGR)	-12	24	123	124	147
Actual producer price(PPP)	80	80	100	120	125
Transfer producers→oil mills @ CTB (TGB)	-98	-87	19	-3	14
Transfer producers→oil mills @ CTR (TGR)	-92	-56	23	4	22

[1] This corresponds to the simulated price (PEG) minus all other cost of processing but that of groundnuts.

* The simulation being based on the hypothesis that the markets have been liberalized in 1992, the adoption of the simulated price for the harvest of the year 1992 assumes that it could have been marketed at that price.

** Processing costs in 1996 are supposed to be the same as in 1995.

PEG: is the simulated price in the Dakar market assuming a guided adjustment of prices in Kaolack following a liberalization of the marketing system since July 1992. It is a proxy of the price that oil mills would have to pay for groundnuts under liberalized markets.

CTB: is SONACOS' processing cost for one liter of oil, converted in unshelled groundnut equivalent at the conversion rate of 2.86 (see Freud et al. P.90 for the source of these costs).

CRT: is equal to SONACOS' processing cost adjusted for the difference between its milling costs and that of its European competitors which amount to around 200 French francs per liter of oil, converted into unshelled groundnut equivalent, using the conversion rate of 2.86. Except for the year 1993, these costs are about 41,000 French francs per metric ton.

FCP: Marketing costs in the private sector, using as proxy the average difference between prices for unshelled groundnuts in the Kaolack and Dakar markets.

PGB= PEG - CTB; PGR= PEG - CTR;
PMGB= PGB - FCP; PMGR= PGR - FCP;
TGB= PMGB-PPP; TGR= PMGR - PPP.

estimate of processing costs corresponds to the observed actual processing costs (CTB) in the milling sector. For the second estimate (CTR), the observed costs are adjusted for the difference between the milling costs in Senegalese factories and that of their European

competitors[14]. The objective behind this adjustment is to take into account the inefficiencies in Senegal's processing sector. Finally, because liberalization of domestic markets would imply that oil mills would have to procure through the private marketing system, the observed price spreads for unshelled groundnuts between the markets of Kaolack and Dakar are used as proxies for the procurement costs of the processing industry in the context of extended reforms. Most likely, these costs represent maxima, because liberalization in all probability would result in a decline of the costs of operation within the private sector for the reasons mentioned earlier.

In the context of liberalized and competitive markets, the simulated price minus processing costs and marketing costs determines the maximum producer price that SONACOS would be able to pay for groundnuts. The difference between this price and the actual producer price gives an idea of the magnitude of the implicit revenue transfer between the production and the processing sectors. The two last rows of the tables present these transfers i) on the basis of the observed processing costs (TAB or TGB) and ii) after adjusting these costs for the excess cost of milling of SONACOS over its European competitors (TAR or TGR). The negative values indicate revenue transfers in favor of producers. The magnitude of the transfers during the first two years is identical for the two versions because the difference with regard to the simulated price enters the computations only for the post devaluation period. The total transfer in favor of producers amount to between 56 and 98 CFA

[14] This comparison is legitimate since SONACOS is well in a position to acquire the milling technologies used by its competitor in Europe.

per kilogram of procured groundnuts during the pre-devaluation period. These transfers are caused mostly by the downward rigidity of producer prices in the face of declining world prices and the continued appreciation of the CFA. At the observed processing costs, the unit value of the implicit transfer per kilogram in favor of producers is well above the producer price for this period. In other words, at the prevailing costs of processing, world prices, and CFA exchange rate just before the devaluation, the oil mills have lost for each kilogram of processed groundnuts more than the direct cost of these groundnuts. Stated alternatively, the oil mills should have been paid to procure the groundnuts from the producers, a fact that is reflected by negative prices (PMAB) and (PMAR) for this period.

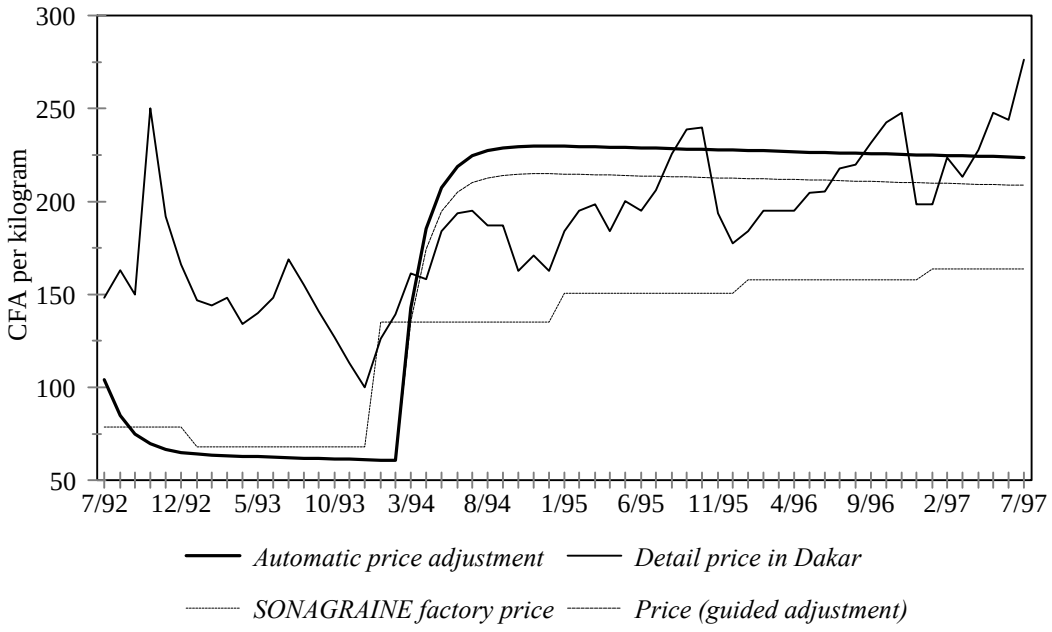
The situation described above was tenable only because of the significant subsidies mentioned earlier. In the absence of a dramatic increase in world prices, the devaluation of 1994 has been the only way of avoiding bankrupting the entire processing industry. But the change in parity has led to a change in the direction of transfers in favor of the oil mills. This time, the transfers are caused primarily by the incomplete transmission of the change in the exchange rate to producer prices, while export prices, on the other hand, have completely adjusted to the new exchange rate. For the version that is based on autonomous price adjustment, the estimated unit value of the transfers from the producers to the oil mills varies from 10 to 30 percent of the producer price. These transfers become much more important if the excess in milling costs is taken into consideration. The results in Table 5, which suppose a post-devaluation price adjustment that is managed in order to align groundnut producer prices to the long-term trends in world prices, show lower but still positive levels of transfers. The

only exception is the year 1995, which reveals a modest transfer of less than three percent in favor of producers, based on actual processing costs. These transfers, however, become positive if we take into account the extra processing costs in the groundnut oil industry.

In short, it emanates from the simulation exercises that the devaluation of the CFA in 1994 and the failure to adjust groundnut pricing and marketing policies have given rise to considerable implicit transfers from producers to processing mills; just the opposite of what happened during the last few years before the CFA devaluation. Therefore, a liberalization of these policies should be expected to redistribute these transfers in favor of producers. The mechanism through which this redistribution would take place is primarily through the adjustment of producer prices and therefore a hike in raw material costs for the oil mills. This does not cause only a profitability problem to the processing industry, it also raises the question of competitiveness of Senegalese groundnut oil exports in international markets. In the following sections, the effects on the competitiveness of Senegal's oil exports that would result from a full liberalization of pricing and marketing policies are analyzed.

Figure 8, gives a better idea of the transfer and taxation effects resulting from the pricing and marketing policies and their liberalization. The thick and the small dotted lines describe the simulated prices as explained previously. The thin line represents the retail price observed in the Dakar market, and the large dotted line is the price at which SONAGRAINE supplied groundnuts to the factories in Dakar.

Figure 8--Market liberalization and Groundnut Prices in Dakar (Unshelled Groundnuts)



For the pre-devaluation period, the price at which SONAGRAINE delivered groundnuts to the mills is very close to the price that would have prevailed in the Dakar market in the case of fully liberalized domestic groundnut markets. However, the actual price in the Dakar market during that period is much higher than these two prices. Different factors are at the root of the gap observed between the actual market price and each one of the other two prices. For instance, the difference between the simulated free market price and that of SONAGRAINE is explained, on the one hand, by the difference between SONAGRAINES' assembly and transfer costs of groundnuts to the processing plants in Dakar and the costs of arbitrage between Kaolack and Dakar for the private sector. On the other hand, and particularly for the pre-devaluation period, the difference is explained by the fact that SONAGRAINE was selling the procured groundnuts to the oil processing company SONACOS at prices much below the total of the incurred assembly costs, plus the prices paid to producers (see Freud et al: p.81). As to the difference between the actual market price and the simulated price under liberalization, it is explained by the appreciation of the CFA Franc, the level of world prices and markets conditions in the growing regions, which determine the level of purchase prices of private traders. It must be mentioned here that the transfer cost of groundnuts to Dakar for the private sector does not influence the price difference because the simulated prices are based on the assumption that these costs remain constant. It is interesting to note that, for the post-devaluation period, actual market prices have gradually moved to the level of simulated prices under full liberalization. The SONAGRAINE price, however, has

remained consistently below the level of the simulated prices, despite its substantial increase after the change in parity.

Figure 8 also shows that prices paid by SONACOS factories to SONAGRAINE for the procured groundnuts are much lower than the actual prices in the Dakar market, both for the periods before and after devaluation. However the actual market prices should not be the reference against which SONAGRAINE's prices can be evaluated, the reason being that the former prices do reflects the level of producer prices, which in turn are influenced by the prevailing pricing and marketing policies and are, therefore, bound to change in the case of liberalization. Consequently, the simulated prices offer a better reference to evaluate the adequacy of SONAGRAINE's pricing policy. A comparison between these two prices shows that for the pre-devaluation period, SONAGRAINE prices were very close to the levels that would have prevailed in the case of liberalized groundnut markets. It appears, therefore, that the subsidy mechanism under the agreement between SONACOS and SONAGRAINE has been effective during the pre-devaluation period in mitigating or even eliminating the effects of marketing and exchange rate policies on the procurement cost of processed groundnuts for the oil mills. In fact, the prices paid by the oil mills to SONAGRAINE were much lower than the prices paid by the latter to producers, even without including the assembly and transfer costs. In contrast, the difference between the simulated prices and the SONAGRAINE prices, shows that groundnut costs to the SONACOS plants would be even lower, if they had to procure directly from the Dakar market under complete liberalization. The findings are different after the currency devaluation. For the post-devaluation period, actual market prices in Dakar are

close to their simulated levels under liberalization, while SONAGRAINE prices remained at much lower levels. Consequently, a complete liberalization of domestic groundnut markets and a full transmission of the change in parity to producer prices would lead to considerably higher procurement costs for the oil mills, compared to the SONAGRAINE system.

It becomes clear that the fundamental problem of furthering the reform process and liberalizing pricing and marketing policies in Senegal's groundnut sector is the profitability and competitiveness of the processing industry. The impact that complete market liberalization would have had on financial results and competitiveness is illustrated in Figures 9 and 10. The first figure shows that before the currency devaluation, producer prices were much higher than all other prices that are reported in the figure, indicating revenue transfers in favor of producers that would be eliminated under liberalized markets. The size of the transfers is reflected in the distance between the producer price line and the simulated time path of prices under the guided adjustment scenario[15]. Consequently, the producers would have been among the first to lose if markets were liberalized during the pre-devaluation period.

It can also be observed that for the same period, the SONAGRAINE price at which oil mills have procured groundnuts, is higher than the price under liberalization. The prevailing procurement arrangements thus amounted to a direct taxation of the processing industry.

---

[15] The simulated price shows the price in Dakar under liberalization. To obtain the producer price under liberalization, the arbitrage costs between Kaolack and Dakar have to be deducted. Thus , the revenue transfer in favor of producers is in fact greater than shown by the distance between the two price lines.

However, the taxation was lower than the amount of transfers to producers, because SONAGRAINE used to absorb a portion of the cost of the transfers, by selling the procured groundnuts to the processing mills at prices that were much lower than the prices it paid to these producers (see the distance between the SONAGRAINE price line and the producer price line).

Figure 9 also shows that the SONAGRAINE price paid by oil mills has gradually moved towards world price levels after the CFA franc devaluation, especially after 1995. Producer prices, on the other hand, have remained relatively low, due to the failure by SONAGRAINE to fully transmit the effect of the change in the exchange rate to producer prices. The taxation has thus shifted from the processing to the farming sector, which loses 30 to 40 CFA per kg of procured groundnuts. Even more important is the fact that the simulated price, which is the hypothetical price that would be paid by oil mills on the free market in Dakar under full liberalization, is considerably higher than the world market price. It should, however, be noted that the simulated price is a function of both the initial change in the producer price and the cost of arbitrage in the private sector between the production zones of Kaolack and the market in Dakar. What this means is that further market liberalization without a substantial reduction of operating costs within the private trading sector would have significant negative consequences on the competitiveness of the processing industry[16]. The

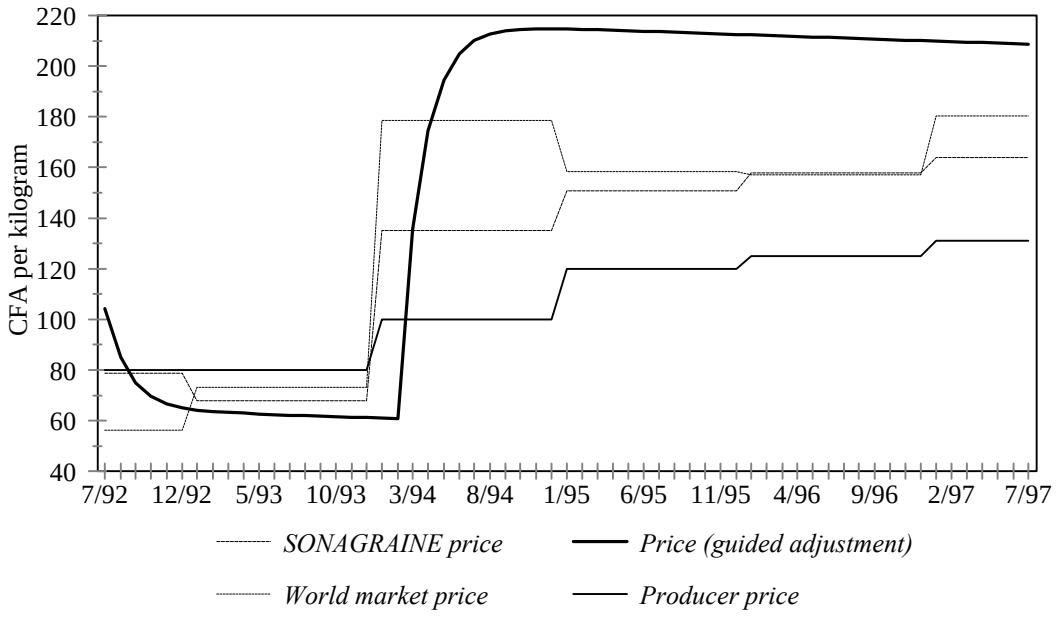
[16] It is important to mention here that the comparison is based on the world price and not the Senegalese export price. The later used to be subsidized by the EU and therefore is not an adequate reference in judging the competitiveness of Senegalese exports.

scope for reduction in marketing costs under liberalized markets will therefore be of a crucial importance to the overall performance of the groundnut sector. Such a reduction in marketing cost would not only reduce the supply cost to the milling industry but would also increase prices received by producers.

The role of marketing cost can be better appreciated by looking at the illustration in Figure 10. The simulated price, which is represented by the bold line and is the same as in the previous Figure, is based on arbitrage costs that are equal to the average spatial price spread observed in 1994 for shelled groundnuts between the markets of Kaolack and Dakar and which amounts to 62 CFA / kg[17]. For the sake of comparison, the assembly and transfer costs of SONAGRAINE between the same markets and for the same year is 30 CFA (Freud et al.; p. 81). In 1993, the average price margin between the Dakar and Kaolack markets was 25 CFA for unshelled groundnuts (Badiane et al.; 1997 p. 91). It seems, therefore, that a reduction of marketing costs well below their 1994 levels should be possible.

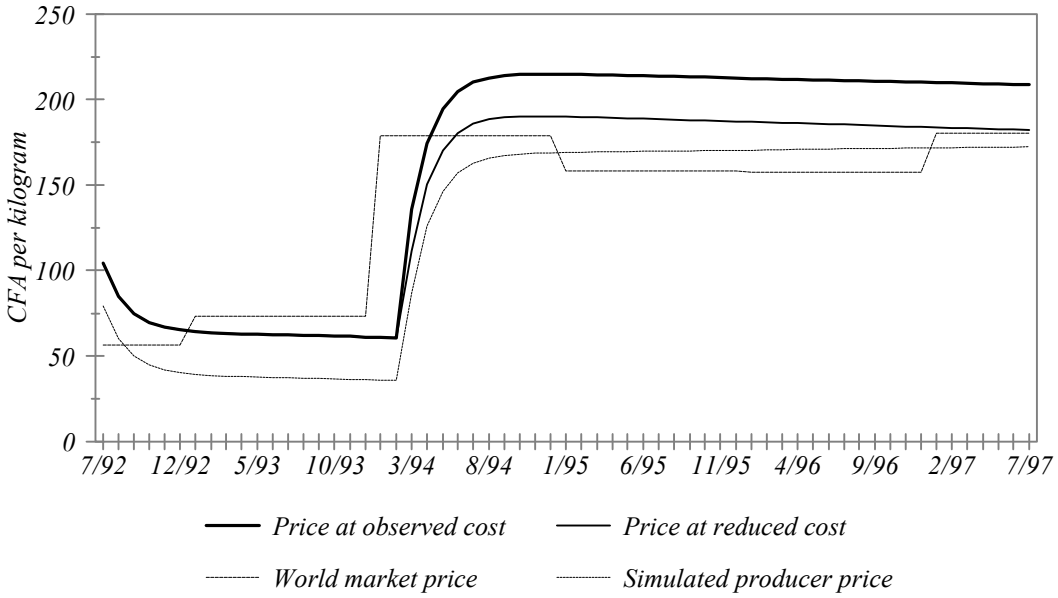
[17] The price spread for shelled groundnuts is used instead of that for unshelled groundnuts because the latter is observable on the Dakar market only during a short period of time.

Figure 9--Pricing Policy and Competitiveness in the Milling Industry



Source : Oil World, for the world market price; and CSA, for producer prices. Prices are for unshelled groundnuts.

Figure 10--Arbitrage Costs and Competitiveness



Source: Oil World, for the world market price; prices are for unshelled groundnuts.

To illustrate the importance of such a reduction in marketing costs, prices under liberalization were simulated again for the post-devaluation period, assuming: a) initial transfer cost at 25 instead of 62 CFA /kg at the beginning of the liberalization period in 1992 and b) a progressive reduction of these costs to bring them down to 10 CFA at the end of the simulation period in July 1997. The fine line shows the evolution of the simulated price with the reduction in the marketing costs that is described above. At lower cost of marketing, the simulated price drops to levels that are comparable to that of world market prices, bringing the unit costs of groundnut procurement for the processing industry in line with international levels, thereby restoring its competitiveness. This adjustment could be much faster, if the

decrease in marketing costs could be effected within a shorter period. The impact of the reduction of operating costs in the marketing sector on producer prices is equally important. As shown by the dotted line, the simulated producer price rises to 160 CFA against actual producer prices of 120 to 130 CFA for the entire period covered by the analysis.

The results summarized by the figure underline the importance of paying sufficient attention to the emergence of an efficient and competitive private marketing sector in case of full liberalization. The marketing of agricultural products is characterized by economies of scale which means that the cost of operations in the sector decrease when marketed volumes increase (Badiane et al.: 1997). The private sector currently controls less than 15 percent of the total marketed quantities. With increasing participation by private traders, the average level of activities within the sector should increase to allow for a significant decrease in average marketing costs. However, the pillars of 1985 reforms, that is the sub-contracting of private traders by SONACOS combined with the system geographic quota and local monopsony, are not compatible with the objective of reducing unit costs in the marketing system. The same can be said about the illegal taxation and abusive administrative controls which are encouraged by the current political environment of the marketing sector and which contribute to raising traders' operating costs.

The results also show that complete liberalization of pricing and marketing policies necessarily has to go hand in hand with a substantial improvement in efficiency within the processing sector. Without a considerable cut in the unit cost of processing, the adjustment of domestic prices to international levels would lead to huge losses for the groundnut oil industry

and a strong decline in competitiveness for Senegal's groundnut oil exports. Therefore, one must recognize that the problems plaguing the groundnut sector go beyond that of pricing and marketing policies or that of production technology. Paradoxically, the revitalization program being discussed still focuses exclusively on production issues. It is true that the problems of soil fertility and access to seeds constitute a critical challenge to the groundnut industry. However, one must not forget that the productivity problem will not be solved without an improvement in production incentives which necessarily have to complement the technological efforts. This has to be done through the elimination of the implicit taxation emanating from the pricing and marketing policies, (i.e. through the liberalization of domestic markets). However, market liberalization would be beneficial only if accompanied with appropriate measures in order to a) reduce the costs of operation in the private groundnut distribution sector well below their current levels, and b) significantly improve the level of productivity and lower unit costs of processing in the milling sector.

6. CONCLUSIONS

The analysis presented in this paper highlight the importance of market integration and changes in arbitrage costs for the adjustment process among local markets to economic policy reforms. A model was developed to capture the long term process involved and was tested using data from Ghana. The model was subsequently applied to analyze the implications of further liberalization of groundnut markets in Senegal for the competitiveness of its groundnut oil processing industry. The findings highlight the potential cost of failing to pay sufficient attention when liberalizing domestic markets to the emergence of a competitive and efficient private distribution sector. The results also indicate that when state-run processing sectors with monopoly power are involved, effective liberalization of pricing and marketing policies in all likelihood would not yield the anticipated benefits, unless accompanied with efforts to improve productivity and reduce unit costs of production in the processing sector. The reason is that frequently under the constellation of state monopoly in processing and marketing, pricing and procurement policies are primarily geared towards ensuring profitability in the processing sector. The consequence is often heavy taxation of farmers and generous subsidization of the processing sector, thereby reducing the need to raise efficiency in that sector. The level of productivity in the processing sector then becomes a major hurdle in liberalizing pricing and marketing policies, because of the feared effects on the competitiveness of the processing sector. The Senegal case study has indeed revealed that, in the absence of a considerable reduction in the unit cost of processing in the country's groundnut milling industry, the

adjustment of domestic prices to their international levels that would result from further market liberalization would lead to enormous losses for the oil industry and a sharp decline in the competitiveness of Senegalese exports.

REFERENCES

Alderman, H. 1993. Intercommodity price transmittal: Analysis of markets in Ghana. *Oxford Bulletin of Economics and Statistics*. 55 (1): 43-64.

Alderman, H., and G. Shively. 1996. Economic reform and food prices: Evidence from markets in Ghana. *World Development*. March.

Alexander, C. and J. Wyeth. 1994. Cointegration and market integration: An Application to the Indonesian rice market. *Journal of Development Studies*. 30(2):303-328..

Asante, E.S., S. Asuming-Brempong, and P.A. Bruce. 1989. *Ghana: Grain marketing study*. Washington, DC: The World Bank.

Badiane, O., F. Goletti, M. Kherallah, P. Berry, K. Govindan, P. Gruhn, and M. Mendoza. 1997. *Agricultural input and output: marketing reforms in African countries.* Final Report prepared for GTZ, Germany. Washington, D.C.: International Food Policy Research Institute (IFPRI).

Badiane, O., M. Gaye, M. Mendoza and K. Govindan. 1997. *Market liberalization and adjustment of the groundnut marketing sector in Senegal*. Draft Report prepared for AGCD, Belgium. Washington, D.C.: IFPRI.

Badiane, O. and M. Gaye. 1997. *L'Agriculture sénégalaise face aux politiques de liberalisation: Apercu microeconomique sur les nouvelles tendances du secteur arachidier.* Report prepared for APROMA, Senegal. Washington, D.C.: IFPRI.

Badiane, O. and S. Kinteh. 1994. *Trade pessimism and regionalism in African countries: The case of groundnut exporters.* Research Report 97. Washington, D.C.: IFPRI.

Badiane, O. and E. A. Nuppenau. 1997. *Reforming and promoting agricultural markets: A research approach*. MSSD Discussion Paper No. 10, Washington, D.C.: IFPRI.

Badiane, O. and G. Shively. 1998. Market integration, arbitrage costs, and the adjustment of local prices to policy changes. The case of Ghana. *Journal of Development Economics* (Forthcoming). IFPRI.

Badiane, O. 1997. *Market integration and the long run adjustment of local markets to changes in trade and exchange rate regimes: Options for market reform and promotion policies*. MSSD Discussion Paper No. 11, Washington, D.C.: IFPRI.

Badiane, O. 1996. *Market integration and the long run adjustment of local markets to changes in trade and exchange rate regimes: Options for market reform and promotion policies*. IFPRI, MSSD Working Paper, forthcoming.

Bollerslev, T., R. Y. Chou, and K. F. Kroner. 1992. ARCH modelling in finance: A Review of the theory and empirical evidence. *Journal of Econometrics*. 52:5-59.

Deaton, A. and G. Laroque. 1992. On the behavior of commodity prices. *Review of Economic Studies*. 59:1-23.

de Janvry, A., M. Fafchamps, and E. Sadoulet. 1991. Peasant household behavior with missing markets: Some paradoxes explained. *The Economic Journal*. 101 (November): 1400-1417.

Dercon, S. 1995. On market integration and liberalisation: Method and application to Ethiopia. *Journal of Development Studies*. 32(1):112-143.

Engle, R. 1982. Autoregressive conditional heteroskedasticity with estimates of the variance of United Kingdom inflations. *Econometrica*. 50(4):987-1008.

Fafchamps, M. 1992. Cash crop production, food price volatility, and rural market integration in the third world. *American Journal of Agricultural Economics*. 74(1):90-99.

Freud, C. E. H. Freud, J. Richard, T. Thenevin. 1997. *La crise de l'arachide au Senegal: un bilan-diagnostic*. CIRAD.

Goletti, F. 1994. *The changing public role in a rice economy approaching self-sufficiency: The case of Bangladesh.* Research Report 98. Washington, D.C.: IFPRI.

Hamilton, J. D. 1994. *Time Series Analysis*. Princeton: Princeton University Press.

Jebuni, C. D., and W. Seini. 1992. Agricultural input policies under structural adjustment. Cornell Food and Nutrition Policy Program Working Paper No. 31. Ithaca, NY: Cornell Food and Nutrition Policy Program.

Mendoza, M. and M. Rosegrant. 1995. *Pricing behavior in Philippine corn markets: Implications for market efficiency.* Research Report No. 101 Washington, D.C.: IFPRI.

Oil world. Commodity Markets and the Developing Countries. The World Bank. Washington, D.C.

Ravallion, M. 1986. Testing market integration. *American Journal of Agricultural Economics*. 68(1):102-109.

Saha, A. and J. Stroud. 1994. A Household model of on-farm storage under price risk. *American Journal of Agricultural Economics*. 76(3):522-534.

Shively, G. E. 1996. Food price variability and economic reform: An ARCH approach for Ghana. *American Journal of Agricultural Economics.* February.

Stryker, J. D. 1991. Ghana. In *The Political economy of agricultural pricing policy*. A. O. Krueger, M. Schiff, and A. Valdés, eds. Baltimore: Johns Hopkins University Press.

Timmer, C. P. 1987. *The Corn economy of Indonesia*. Ithaca: Cornell University Press.

Tu, P. N. V. 1994. *Dynamical systems: An introduction with applications in economics and biology.* Springer-Verlag.

Table a1-- Processing Costs of Raw Groundnut Oil (CFA per metric ton)

Cost categories	1992	1993	1994	1995
Production of raw oil	266,790	306,380	407,302	462,012
Preparation for exports	16,960	16,960	30,528	31,000
Total cost of raw oil	283,750	323,340	437,830	493,012
including milling cost[1]	*27,494*	*50,232*	*31,161*	*41,347*
Cost of groundnuts[2]	225,128	194,211	386,100	431,165
Processing cost of raw oil	58,622	129,129	51,730	61,847
including excess milling cost[3]	*17,494*	*40,232*	*11,161*	*21,347*
Reference processing cost	41,128	88,897	40,569	40,500

Source: Freud et al (1997)

[1] By comparison, milling costs in Europe are around 200 French franc per metric ton of shelled groundnuts, which corresponds to 10,000 CFA before devaluation and 20,000 after 1994..

[2] The cost of the quantity of groundnuts (2.86 metric tons) required for the production of one metric ton of groundnut oil is calculated on the basis of the actual price paid by oil mills to SONAGRAINES.

[3] Difference between SONACOS' milling costs and that of its European competitors (see note 2), that is SONACOS' actual cost minus 200 French francs, converted at the prevailing exchange rate.

Appendix: Equations

(a1)

$$\mu_t^{BO} \quad \underset{(2.083)}{0.021} \quad \underset{(0.0177)}{0.0004t} \quad \underset{(\ .075)}{0.367} \quad \mu_{t-1}^{BO}$$

R^2 0.41 *Autocorr. factor* $\underset{(0.074)}{0.364}$ *No. obs.* 158

(a2)

$$\mu_t^{MA} \quad \underset{(0.904)}{0.322} \quad \underset{(0.0007)}{0.0020t} \quad \underset{(0.064)}{0.581} \quad \mu_{t-1}^{MA}$$

R^2 0.15 *Autocorr. factor* $\underset{(0.071)}{0.449}$ *No. obs.* 158

(a3.1)

$$P_t^{BO} \quad \underset{(1.553)}{0.156} \quad \underset{(1.775)}{5.392} \; I_{1983} \quad \underset{(0.055)}{0.273} \; P_t^{TE} \quad \underset{(0.070)}{0.016} \; P_{t-1}^{TE} \quad \underset{(0.064)}{0.131} \; P_{t-2}^{TE} \quad \underset{(0.064)}{0.033} \; P_{t-3}^{TE} \quad \underset{(0.057)}{0.121} \; P_{t-4}^{TE}$$

$$\underset{(0.072)}{0.628} \; P_{t-1}^{BO} \quad \underset{(0.078)}{0.083} \; P_{t-2}^{BO} \quad \underset{(0.067)}{0.039} \; P_{t-3}^{BO} \quad \underset{(0.056)}{0.015} \; P_{t-4}^{BO}$$

(a3.2)

$$[\Sigma_t^{BO}]^2 \quad \underset{(8.672)}{10.235} \quad \underset{(0.069)}{0.118} \; [\Sigma_{t-1}^{BO}]^2 \quad \underset{(0.207)}{0.130} \; P_{t-1}^{TE} \quad \underset{(0.189)}{0.525} \; P_{t-1}^{BO}$$

Log likelihood value 439.9 *N* 159

(a4.1)

P_t^{MA}	5.282 (1.113)	3.501 (1.851)	I_{1983}	0.625 (0.042)	P_t^{TE}	0.116 (0.047)	$P_{t\,1}^{TE}$	0.275 (0.045)	$P_{t\,2}^{TE}$	0.071 (0.038)	$P_{t\,3}^{TE}$	0.043 (0.028)	$P_{t\,4}^{TE}$
	0.270 (0.058)	$P_{t\,1}^{MA}$	0.240 (0.057)	$P_{t\,2}^{MA}$	0.115 (0.052)	$P_{t\,3}^{MA}$	0.105 (0.042)	$P_{t\,4}^{MA}$					

(a4.2)

$[\Sigma_t^{MA}]^2$	4.814 (1.985)	0.382 (0.109)	$[\Sigma_{t\,1}^{MA}]^2$	0.534 (0.149)	$P_{t\,1}^{TE}$	0.784 (0.179)	$P_{t\,1}^{MA}$

Log likelihood value 412.2 *N* 159

Note: Standard errors are in parentheses. Mean and variance regressions contained a production measure in addition to 11 monthly dummy variables corresponding to January-November.