University of Wisconsin-Madison
Department of Agricultural Economics
Staff Paper Series

Staff Paper No. 380
September 1994

THE IMPACTS OF AGRICULTURAL LIBERALIZATION ON COMMODITY PRICE DISTRIBUTIONS: EVIDENCE FROM MADAGASCAR*

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Throughout most of the low- and middle-income world, the past decade has brought ambitious economic liberalization efforts. With respect to the agricultural sector, a primary ambition has been to present farmers with prices sufficiently remunerative as to induce output growth and technological innovation. Considerable evidence that government interventions historically were biased against agriculture, depressing average real agricultural prices indirectly if not always directly,[1] led naturally to the belief that liberalization, defined as reduced government distortion of prices, improves incentives to agricultural production. Today, in all but a handful of developing countries, government distortions are less and pricing is far closer to that which would prevail under perfectly free markets than was the case twenty years ago. Yet in many places, including most of Africa, anticipated agricultural supply response and technological innovation have been weak or absent. This disappointment has elicited considerable debate over constraints to agricultural supply response and the magnitude of the relevant price elasticities. Surprisingly, a logically antecedent question has been overlooked: have market-oriented reforms ushered in more stimulative agricultural commodity prices?

Economic theory is ambiguous about how liberalization impacts on the incentives to agricultural production. The theoretical obstacles are two. First, there is the question of what constitutes a stimulative price shift. Because of the biological lag between the commitment of inputs and harvest in agricultural

production, temporal price risk is ever present and few (if any) farmers in the developing world can fully mitigate such risk through capital or contingency markets. The standard microeconomic theory of the firm under price uncertainty[2] holds that output increases in the mean of output price and decreases in the variance. In a semi-subsistence context, however, in which producers may be net buyers or net sellers, these results do not hold generally, but depend on households' ordinal preferences for goods and, implicitly, on households' endowments of productive assets. [3] Contemporary microeconomic theory thus provides little foundation for confident prediction of how agricultural production will respond to a given shift in an agricultural price distribution.

Second, and of more immediate relevance to this paper, there is no well-articulated theory of how stochastic prices evolve in response to economic liberalization measures. Even the most parsimonious specification of a distribution requires identification of a mean and variance. So, the comparative statics of an equilibrium price distribution must describe changes in no less than two endogenous moments. So how should the mean and variance of agricultural prices shift in the wake of liberalization measures? Agricultural liberalization typically combines reform measures which have countervailing impulses on the moments of agricultural price distributions and which may impact quite differently on distinct subsectors. For example, the dismantling of state trading monopolies may induce more spirited competition and increased spatial integration of markets as private intermediaries become free to bid

prices up or down and to move harvest among regions or countries. However, the loss of implicit taxes earned by agricultural parastatals may reduce government maintenance of rural infrastructure, impeding competition and fostering local natural monopolies, and termination of the panterritorial prices commonly administered by parastatals may create an informational vacuum inhibiting efficient spatial arbitrage and market integration. It is not clear in general which impulses will prevail. If structural reforms are accompanied by macroeconomic stabilization efforts, dampened domestic demand may have important effects on equilibrium agricultural prices.

Similarly, real currency devaluation increases the mean and variance of tradables' prices by multiplying the internationally-determined mean and variance by a larger conversion rate. Of course, if agricultural commodities are nontradable, as is often true in infrastructure-poor countries, [4] the partial equilibrium impact is negligible and the general equilibrium impact is ambiguous. Real devaluation can also shift commodities' equilibrium conditions, turning importables into nontradables or nontradables into exportables. If price volatility is greater under autarky than in open international markets, as is generally true, switching from nontradability to tradability, or vice versa, may have considerable impact on price variance. In particular, devaluation that renders formerly nontradable commodities exportable -- so-called nontraditional exports -- would be expected to increase the mean but reduce the variance of equilibrium prices. So different subsectors within agriculture may

exhibit quite different price responses to a common policy change. *Ex ante*, the aggregate effects of agricultural liberalization on commodity prices is ambiguous.

Ascertaining the impact of agricultural liberalization on commodity price patterns is thus an inherently empirical task, one surprisingly absent in the literature. This paper estimates the reduced form effects of agricultural liberalization measures on commodity prices in Madagascar, an agricultural economy in Africa that has undergone considerable structural reforms in the past decade. The plan of the remainder of the paper is as follows. Section I describes agricultural liberalization as pursued in Madagascar. Section II presents econometric evidence on the impact of policy reform on the means and variances of several agricultural commodity price series. Section III synthesizes the statistical results into a broader interpretation of the impacts of agricultural on commodity price distributions, both in Madagascar and more generally.

I. An Overview of Agricultural Liberalization in Madagascar

Madagascar provides a good site for exploring the connections between agricultural liberalization policies and price response. The country is heavily dependent on agriculture, and its rich geography results in great regional variety in microclimates, permitting the country to support many different agricultural activities. After a decade of state economic planning and heavy-handed intervention brought economic disaster, major structural economic

reforms were badly needed by the early 1980s. Over the course of the 1980s, the government implemented a wide array of reform measures supported by the IMF, the World Bank and other international donors. Although it was incomplete or uneven in important respects, [5] Madagascar's reform program was widely hailed as one of the earliest, most comprehensive, and most durable efforts in the low-income world. [6]

Agricultural liberalization in Madagascar consisted of a wide range of macroeconomic and sectoral reforms, beginning with serious macroeconomic stabilization measures from the second half of 1981. More fundamental structural reforms began from about 1986. While the dividing line between the liberalization era beginning in 1986 and the preceding stabilization era is somewhat fuzzy, a clear shift in objectives and methods began roughly in early 1986. Where the objective of the early 1980s was to reverse current account and fiscal deficits, and to contain monetary growth and inflation in the hope that financial stabilization would restore macroeconomic growth, the aim of the latter part of the decade was "to move Madagascar toward an open and market-oriented economy [including] far-reaching structural reforms in the areas of internal and external trade, financial and public enterprise sectors, social policy, and public expenditure programming, coupled with the continuation of a prudent demand management policy." [7] Liberalization measures traversed the economy, from massive devaluation of the Malagasy franc (FMG) and substantial opening to external trade and investment, to caps on credit and budgetary

transfers to public enterprises, and banking reforms. Administrative price-setting was eliminated for almost all goods, as was government control over foreign exchange and credit allocation. A moratorium on the creation of new public enterprises was enacted, several state-held companies, such as the coffee, clove and pepper export monopolies, were abolished, and several others were privatized, including the country's second and third largest commercial banks.

Within the agricultural sector, the government raised controlled producer and retail prices several times in early 1980s, ultimately decontrolling domestic agricultural prices entirely in 1985. The state had held a legal monopoly in the trade of rice, beans, maize and manioc since 1973. Although parallel markets blossomed, especially in areas far from the capital city, the state's incomprehensive and eroding influence over domestic agricultural marketing should not be mistaken for impotence. As an island nation, private cross-border smuggling posed less of a challenge to Madagascar's public sector monopolists than was the case in many other countries. Indirectly, if not always directly, the government's adverse influence on agriculture was substantial.[8] Throughout the 1980s the Malagasy government sought to remedy this situation and, especially in the second half of the decade, reforms were relatively dramatic and far-reaching, including complete liberalization of all agricultural marketing (except for cotton and vanilla exports) over the period 1983-88.

The macroeconomy improved in the liberalization period (Table 1). The reforms of the stabilization and liberalization eras laid the foundation for agricultural recovery and contributed to accelerated growth in agricultural output and recovery in the agricultural trade balance. But agricultural output growth, like GDP, remained slower than growth in population. Furthermore, the gains from liberalization have been concentrated in particular commodity and regional subsectors. Given the weakness and unevenness of the recovery, it is by no means clear whether the gains from agricultural liberalization in Madagascar are sustainable, especially during a fragile transition to multiparty democracy.

II. Empirical Evidence On The Effect of Liberalization on Commodity Prices

A common assertion about economic liberalization programs such as Madagascar's is that the internal terms of trade shift in favor of agriculture. The real (mean) prices received by farmers are assumed to improve with reforms that dismantle structures the state previously used to suppress agricultural prices.[9] The administrative suppression of agricultural producer prices by the Malagasy state to 1980, especially in the post-1972 socialist era, has been extensively documented.[10] What remains unclear is how the liberalization measures of the 1980s changed agricultural prices. How have the mean and

variance of real prices evolved? Are there discernable differences in these patterns across commodities or geographic regions?

The analysis here employs monthly retail-level observations of nominal commodity prices from Madagascar's 17 agricultural enumeration regions. [11] Nominal data were deflated by the traditional sector consumer price index (CPI)[12] to construct real price series for milled rice since January 1983 and for dried beans, fresh manioc, granular maize, and potatoes since January 1984. All series go through December 1991. The average real national price series for each of the five commodities are depicted in Figures 1 and 2. [13]

For the purposes of the present analysis, the period since January 1986 constitutes the reform era. This is a somewhat arbitrary choice since reforms were implemented over a number of years during the 1980s. But for the commodities under examination, complete decontrol of prices and marketing networks was achieved between early 1985 and early 1987. The statistical results which follow are qualitatively invariant to respecification of the reform era definition within that interval. So 1983-85 data henceforth represent the pre-reform era, and 1986-91 data represent the liberalization era. Coverage varies by commodity and region. Only for rice are complete series available for each of the 17 enumeration regions. [14]

Table 2 presents descriptive statistics on these five series for the pre-reform and liberalization periods. With the exception of rice, mean national prices fell after serious structural reforms began. Much of this is likely due to

persistent weakness in the macroeconomy due to restrictive demand management efforts necessary under agreements with the IMF and the World Bank. [15] While mean prices may have been falling, real price variability appears to have increased significantly in each of the commodity series. This suggests that the pro-competitive effects of terminated state monopolies may have been outweighed by the destabilizing impulse of price decontrol.

Visual review of Figures 1 and 2 reveals a period of unusually high and volatile prices in the two years from early 1985 to early 1987. Previous commentators have attributed this to poor government execution of the policy transition, to speculative binges by newly empowered private traders, or both. [16] Whatever the reason, the government tackled this politically explosive issue by introducing a rice buffer stock facility in November 1986 with the intent to stabilize domestic rice prices by releasing rice to defend a pre-announced retail price ceiling. [17] Thus it was primarily a seasonal operation, and indeed 87 percent of rice sales over the life of the mechanism occurred during the *soudure* months of October-April. According to internal DSA data, buffer stock sales climbed quickly, from 14,311 tons in 1986-87, [18] to 47,197 tons in 1987-88 and 83,329 tons in 1988-89 before dropping to 22,381 tons in 1989-90. The buffer stock facility was terminated in 1990 despite widespread sentiment that the "mechanism played a decisive role in stabilizing prices." [19] Editorials in Madagascar's free press have mourned the passing of the facility during each of the past four *soudures*. Indeed, the data in the final three rows

of Table 2 support the claim that the buffer stock succeeded in dampening price variability, although for maize, manioc and rice -- the three principal foodgrains -- price stability was associated with lower mean prices.

Although informative, the descriptive statistics in Table 2 inevitably fail to control for the considerable variation taking place in many variables related to real agricultural prices. Econometric estimation permits more precise empirical assessment of the effects of liberalization on the mean and variance of commodity prices. We estimate reduced form models because the demand and supply data necessary to estimate appropriate structural equations are not available at the same monthly frequency as the price data. Since our concern is with the effect of liberalization on prices, and less with the direct causal mechanisms, we opt for the greater number of observations available with reduced form estimation.

Autoregressive conditional heteroskedastic (ARCH) modeling permits simultaneous estimation of temporal variation in the conditional means and variances of a dependent variable. Because price uncertainty tends to influence retail prices and marketing margins of agricultural commodities, [20] the ARCH-in-mean (ARCH-M) variant is employed here, permitting time-varying price risk to influence conditional mean price estimates. [21]

The estimation pools the regional commodity price data into five separate series: beans, maize, manioc, potatoes, and rice. The resulting panel structure to the data series permits estimation of "aggregate" parameters

describing the effects of liberalization on commodity price distributions as well as of region- and season-specific effects. Because data availability yields different numbers of regions in each commodity-specific panel, multivariate estimation of the system of equations would require sacrificing a considerable portion of the data. As with the decision in favor of reduced form estimation, we opted for including more data and estimating a series of five univariate models instead of a more flexible multivariate system estimated off fewer degrees of freedom.

The precise specification of the model is as follows. Each price series, $\{P_t\}$, is represented by an autoregressive model of the general linear ARCH-M(p) form

$$\begin{aligned} \beta(L)P_t &= \beta_0 + \beta_\tau t + \sum_{i=1}^{m} \beta_i X_{it} + \delta g(h_t) + u_t \\ u_t &= \sqrt{h_t} v_t \\ h_t &= \alpha_0 + \alpha_\tau t + \sum_{j=1}^{p} \alpha_j u_{t-j}^2 + \sum_{k=1}^{q} \gamma_k Z_{kt} \end{aligned} \qquad (1)$$

where $\beta(L)$ is a polynomial lag operator, α_0 and β_0 are constants, and t is a unit time index the coefficient of which represents a linear monthly trend (TREND). The vector X contains m exogenous variables included in the conditional mean equation, the function $g(h_t)$ transforms the conditional variance function, the vector Z contains q exogenous variables included in the p^{th}-order autoregressive conditional variance equation, and the v_t are independent, standard normal errors. This structure, a simultaneous equations model of

conditional means and conditional variances, is estimated for each of the five commodity price series both before and after reforms.

The X and Z vectors include a series of dummy variables for each region in the price series except Imerina Centrale (the region in which Antananarivo is located), which is common to all five commodity panels. They also include a series of quarterly dummy variables to account for seasonality. So, the dummy variable structure in X and Z bases the coefficient estimates temporally in the first quarter, and spatially in Imerina Centrale, the capital city's region. X and Z also include the real exchange rate (ER), calculated as the nominal bilateral FMG/US dollar rate deflated by relative CPI between the two countries,[22] and the one month lagged price to account for positive relationship between prices and inventory depletion in the previous period and the volatility of current period prices. [23] In the post-reform period, X and Z also include a continuous variable, BUF, representing national releases from the rice buffer stock facility (in thousands of tons), [24] and a dummy variable for the June-December 1991 period of nationwide pro-democracy strikes (STRIKE). Finally, X includes the contemporaneous border parity price (BP) derived from international commodity market prices [25] converted into real FMG at the nominal exchange rate, then deflated by Malagasy CPI.

The square root function was chosen for g(.), so the parameter estimate for δ is interpretable as reflecting a risk premium with respect to the conditional standard deviation, measured in real FMG. A first-order autoregressive

structure was assumed in the conditional variance equations. Since the u_t are stochastic and u_t^2 must be non-negative, h_t must be positive, but this restriction is tested rather than imposed. The u_t are finite and covariance-stationary (*i.e.*, non-persistent disturbances) in an ARCH(1) model if and only if $\alpha_1<1$. The five univariate models were estimated by maximum likelihood, employing a quasi-Newton method, numerical derivatives and starting values derived from OLS in the maximization of the log-likelihood function. [26]

Estimation of these models proceeded first from identification of the autoregressive dimensionality of the conditional mean equations. Following classic Box-Jenkins techniques, [27] the sample partial autocorrelations for each series were estimated and plotted. The smooth dampening of the plotted autocorrelations and the abrupt fall to the neighborhood of zero of the second and successive plotted partial autocorrelations in each series strongly suggested an AR(1) structure to the polynomial lag. Consequently, the conditional mean equations in (1) employ P_t as a dependent variable and P_{t-1} as an explanatory variable. None of the autocorrelations exceeded 0.92 and the autocorrelation series always dampened to near zero within 24 months, so stationarity was presumed.[28] Llung-Box-Pierce portmanteau Q-statistics associated with the residuals of the estimated AR(1) series support this identification. In each case, the null hypothesis that the residuals are white noise could not be rejected at the five percent significance level.

The results from the ten ARCH-M model estimates (two periods each for five commodities) are found in Tables 3-7. A few general diagnostic comments are in order before launching into more detailed discussion of particular model estimation results. Synthesis of model results into a broader interpretation is left to the concluding section.

By and large, these models performed well statistically. All the α_1 and β_1 estimates are positive but less than unity, validating the selection of a stationary model with finite conditional variances. The α_0 are all positive and statistically significant and the predicted h_t's are everywhere positive in each of the ten models. The model predictions are closely correlated with observed prices, particularly in the liberalization period, for which all five models have an R^2 greater than or equal to 0.80. In each of the models many (if not all) of the estimated coefficients of the regional dummy variables proved statistically significant. In addition to the economic insights these permit (forthcoming below), these results are a weak form statistical test of the fixed effects specification of the model as applied to the panel price data, against the alternative of a random effects specification without region-specific intercepts. The inference that liberalization measures fundamentally changed the relationship between the moments of the commodity price series and the regressors was validated by Chow tests of structural shifts in the parameter estimates. The ARCH-M models were rerun for each commodity, stacking the data from the two periods. Each of the five test statistics far exceeded the relevant χ^2 critical value,

yielding rejection at the one percent significance level of the hypothesis that the true parameters are equal across the two time periods. The principal statistical irregularity is that $\alpha_1^2 > 1/3$ in most of the models, violating the Gaussian ARCH-M model condition for finite kurtosis.

The first commodity price series estimated is for dried beans, a nontraditional export crop that accounted for just over two percent of national agricultural output value in 1984-85. Prior to liberalization, Madagascar had occasional exports and imports of beans, but autarky generally prevailed. The country exported only 0.2 percent of national output, on average, 1984-86. But in the wake of real exchange rate depreciation and broader liberalization this figure increased to 5.4 percent in the 1989-91 period, helping stimulate a sevenfold increase in bean export volumes. Commodities that experience such a shift from nontradable to exportable status may exhibit a marked decrease in price variability as yield shocks that are highly covariate within Madagascar (*e.g.*, due to the timing of the cyclones) have no impact on prices within the broader international market.

Results for the dried beans models, displayed in Table 3 with asymptotic standard errors in parentheses, flesh out and generally corroborate the descriptive statistics. Examination of the estimated constants shows that mean prices remained roughly constant while variability fell sharply from the pre-reform to the liberalization periods. In a different way, the sharp increase in first-order autocorrelation, from 0.05 to 0.93, indicates a stabilization of prices

from one period to the next as shocks exhibited greater persistence in fully freed markets than had obtained under an administered price system. Real exchange rate depreciation (an increase in ER) is associated with a rising mean but has no significant effect on variance, so real exchange rate policy seems to have worked roughly as anticipated in the case of beans. Regional price differences, which were considerable prior to reforms, are uniformly smaller post-reform in both moments. Seasonal differences in mean bean prices were also reduced considerably with reforms. Consumer substitution effects evidently transmitted rice buffer stock operations through to bean prices. Both the mean and variance of bean prices fell with releases from the national stock.

The experience of another nontraditional export crop subsector, maize, broadly parallels that of beans. Roughly twice the size of the bean subsector in value (and three times in acreage), maize too was cultivated substantially under autarky in Madagascar prior to market-oriented reforms. But by 1989-91 almost 14 percent of national production was exported, as maize export volumes increased twenty two-fold from 1984-86.

The parameter estimates in Table 4 show a sharp fall in aggregate maize price variability after reforms. As with beans this is likely attributable to the shift from autarkic pricing to international market pricing, where demand and supply shocks can dissipate over a far broader market. The estimated base mean, as proxied by the constant α_0, was smaller by a statistically insignificant amount, while the first-order autocorrelation of prices more than doubled.

Once again, regional and seasonal price dispersion generally dampened considerably in the wake of market-oriented reforms.

Manioc, a bulky tuber, is not well-suited to trade over long distances due both to its relatively low value per unit volume or weight, upon which transport costs depend, and its perishability once harvested. [29] For these reasons manioc has been and remains internationally nontradable in most of Madagascar.[30] Although it is not important to Madagascar's balance of payments, next to rice, manioc is the most important agricultural commodity in the country, in terms of output value, land in cultivation or nutrient sourcing. Because of manioc's prominence, and quite unlike beans or maize, the government took effective (not just *de jure*) control over manioc distribution in the years before market-oriented reforms. In these two ways -- its international nontradability and its stricter control by the pre-reform nationalized agricultural marketing system -- the experience of manioc differs qualitatively from that of the two commodities previously examined.

The estimation results for the ARCH-M manioc models (Table 5) reveal important differences between the evolution of manioc prices with liberalization and those of the nontraditional export crops, beans and maize. The base mean (α_0) fell by half, while base variance (β_0) increased by almost one-third. These effects are likely due to the combined forces of a weak Malagasy economy, yielding depressed domestic demand and thinner, more volatile food markets, and the termination of the effective price stabilization delivered by

administrative pricing. Although the parastatal distribution system by no means exercised complete control over the manioc trade, it was the dominant player and its fixed prices were universally known and served as an anchor for private market perturbations. This was the case for rice as well. As with beans and maize, the spatial and seasonal variation of manioc prices fell considerably. The statistical insignificance of the real exchange rate and border parity price variables in each of the equations illustrates the general international nontradability of Malagasy manioc.

The fourth commodity considered, potatoes, is the only one of the five which was broadly exportable prior to reforms. Currency depreciation and trade liberalization extended the area from which potatoes could be exported competitively, but much of Madagascar's potato-producing regions were already (weakly) integrated into world markets. The potato market is, however, anomalous in that the world market price has generally been more unstable than the prices of autarkic markets in Madagascar, so the sort of nontradable-to-exportable equilibrium switching observed to have strong variance-dampening effects on bean and maize prices should be reversed in the case of potatoes.[31] The estimation results bear this out. Finally, potatoes are the only one of the five commodities that was not subject to a parastatal marketing monopoly and administered pricing, although there were some state controls in effect.

Table 6 presents the estimates from the potato price models. As with manioc, mean price fell and variance rose sharply with liberalization, although increased first-order autocorrelation increased month-to-month price stability. The exchange rate effects observed for dried beans -- positive and statistically significant correlation with mean price, insignificant relation to variance -- prevail for potatoes as well, indicating the linkage to world markets. The absolute value of mean spatial price dispersion increased with liberalization in four of the ten regional potato price series: the three port regions (Antsiranana, Mahajanga, and Toliary) and the zone most accessible to Antananarivo (Itasy). This suggests that reforms increased market intermediation costs, since those zones were linked into world markets both before and after liberalization. This makes sense in that the real cost of fuel, spare parts and vehicles has grown considerably over the past decade. This increase in the costs of market intermediation should be in force where markets were already well integrated into the world economy.

Rice is the centerpiece of Madagascar's economy, indeed of Malagasy society. The disastrous economic policies of the 1970s were especially evident in rice. Madagascar had been a net exporter until 1970, but by 1982 net imports accounted for more than one-quarter of the national rice supply. [32] The fortunes of economic liberalization would rise or fall with the effects felt in rice markets.

The rice price model estimation results reported in Table 7 reflect the pattern evident in the descriptive statistics (Table 2). The mean and variance of

rice prices rose and buffer stock operations exerted significant downward effects on both the mean and variance. As with most of the commodities, the difference among regional and seasonal means and variances shrunk markedly with liberalization. Meanwhile, rice import volumes fell by more than three-quarters between 1982 and 1991, as rice shifted from importable to nontradable status in many of the country's agricultural regions, a fact somewhat evident in the marked diminution of the coefficient on the real exchange rate variable between the pre-reform and liberalization periods

The ARCH-M risk term estimates, δ, enable estimation of relative risk premia ($\frac{\delta\sqrt{h_t}}{p_t}$) indicating that portion of observed price attributable to a risk premium (Table 8). The literature on risk and agricultural marketing in high-income countries uniformly predicts and finds a positive risk premium, *i.e.*, equilibrium prices compensate suppliers for bearing price risk. [33] In a low-income context, however, it is quite possible that consumers will require compensation for bearing food security risk induced by price variability. [34] Indeed, for the staple commodity, rice, one finds negative estimates for δ in both the pre-reform and liberalization periods. The price of manioc, Madagas-car's second most important nutrient source, also exhibits a negative risk premium in the liberalization period. As one would expect, the absolute value of the relative price risk premia increased for those commodities that experi-enced rising price variability with liberalization (manioc, potatoes, and rice) and decreased for those graced with diminished price variability (beans and

maize). The statistical insignificance of the risk parameter estimates may be due to the moderate frequency of the data. [35] However, insignificance is more likely attributable to an identification problem arising from the fact that if consumers and producers are all price risk averse then both demand and supply schedules have risk premia built in and the sign of the equilibrium risk premium is ambiguous. This is essentially a cross-sectional aggregation problem in reduced form estimation, akin to the more frequently raised time series aggregation problem of moderate frequency data.

Finally, a primary objective behind reducing government interventions in agricultural markets is to harness the efficiency properties of international market pricing, "getting prices right" as one common aphorism has it. In light of that objective, the estimated coefficients on the border parity price and real exchange rate variables in the liberalization period models are of surprisingly low magnitude and statistical significance. None of the estimated elasticities of mean commodity prices with respect to the real exchange rate or the border parity price exceeded 0.48 or 0.13, respectively, and most were statistically insignificantly different from zero in the liberalization period (Table 9). Trade date and the rhetoric on integrating into the world economy not withstanding, the law of one price does not seem in force in Madagascar; domestic commodity prices broadly remained domestically determined even after opening to the world economy.

III. Synthesis and Interpretation

The reader who comes away from the statistical results of the preceding section without a clear message should not be dismayed. A central point of this paper is that there are no simple conclusions to be drawn about the relationship between agricultural liberalization and the evolution of commodity price distributions. Although sectoral and economywide interventions of a preceding era may have resulted in widespread aggregate taxation of the agricultural sector, policy reforms designed to remedy that situation do not immediately generate unambiguously stimulative agricultural price signals.

In Madagascar, mean prices rose for rice, the staple crop, but fell for the other four commodities with liberalization. Price variability fell for the two nontraditional export crops (beans and maize), but rose for the traditional export crop (potatoes), the nontradable (manioc) and the importable (rice). The pre-reform upward trend in mean prices was substantially muted by liberalization, if not erased. If policymakers looked to liberalization for primarily for higher and more stable real agricultural prices, the empirical evidence suggest reforms were generally ineffective.

There are, however, a number of more encouraging signs. Interseasonal differences in real prices were uniformly reduced, in some cases (beans, maize) quite substantially. Similar results emerge with respect to spatial variation in means and variances, which generally diminished with liberalization. Furthermore, the first-order autocorrelation of prices increased

considerably from the pre-reform period as demand or supply shocks were better able to persist in a system not subject to parastatal intervention at fixed prices.[36]

One prospective interpretation of these results is that state monopoly, which had permitted price discrimination across spatially and temporally distinct markets, gave way to private competition, in which prices are assured to converge by profit-taking arbitrageurs. Given the manifest ineptitude of Madagascar's agricultural parastatals and a good bit of evidence that imperfect competition persists in privatized agricultural trade, [37] this explanation is rather incredible.

An alternative explanation might best be described as the paradox of panseasonal and panterritorial pricing. This turns on the recognition that quasi-panseasonal or quasi-panterritorial pricing can only occur under price rationing.[38] Government systems of fixed pricing inevitably lead to quantity rationing, since marketing boards will almost surely run out of storage or transport capacity (thus limiting purchase volumes), or out of stocks (thus limiting sales volumes) at some point, with such incidents more common the less competent the organization. Moreover, the likelihood of parastatal presence varies enormously across regions, as the cost of maintaining a depot and transport network seem to expand exponentially with geographic scope. [39] Also, because of the urban concentration of bulk storage and banking facilities, distance from central cities is related positively to the probability of either the

local marketing board office becoming illiquid, driving producers to make spot market sales below fixed prices, or its stocking out inventories, driving consumers to make spot (parallel) market purchases above fixed prices. [40] In Madagascar, the state-controlled system of fixed prices, administered by parastatal marketing boards vested with legal monopoly powers, was never able to respond fully to the needs of consumers and producers throughout the island. The geography of bureaucratic (in)activity thus tied directly to spatial variation in both the means and the variances of commodity prices. [41]

The end of state control over agricultural marketing thus ended the overlapping of quantity-rationed and price-rationed markets; markets are now purely price-rationed. Where the government had been reasonably effective in controlling prices (as with manioc and rice), [42] liberalization resulted in a jump in aggregate price variability (as reflected in the estimate constant terms of the conditional variance equations), but a convergence of all regions toward a common central tendency and variance. In this process, prices moved by considerably different amounts, and often opposing directions, for the same commodity in different locales. Sharp regional variation in supply response follows naturally. The discontinuation of state-administered pricing likely also accounts for the observed dampening of the mean price trend estimates. Prior to serious structural reforms there had been a series of substantial upward adjustments to controlled agricultural prices, despite exceptionally weak domestic demand. But once the central tendency in real prices was no longer

set irrespective of demand conditions, there was no basis for continued growth in real prices in a recessionary economy.

The government quickly tackled the rise in rice prices and their variability that emerged as it fully freed domestic food markets by introducing a rice buffer stock, over the staunch objections of the World Bank. While the facility suffered poor management and high costs that ultimately forced its termination,[43] the econometric evidence suggests that the buffer stock succeeded in dampening rice price variability. In fact, releases from the rice buffer stock were negatively and statistically significantly correlated with conditional variance in each of the commodity price series, suggesting that consumer substitution effects effectively transmitted the stabilization of a single commodity price to interrelated commodity markets. [44]

There is no robust theoretical basis for confident prediction that agricultural liberalization will generate stimulative shifts in commodity price distributions. The empirical evidence Madagascar suggests there is no (even qualitative) uniformity across subsectors to the effects of liberalization on either the means or the variances of agricultural price distributions. The results vary substantially by commodity, region and season. The evidence generally suggests that liberalization reduced the absolute and relative magnitudes of seasonal and spatial differences in the means and variances of commodity prices. The interpretation of these results may be subject to reasonable dispute. Some will take them as evidence of the rise of competitive markets performing

necessary intertemporal and spatial arbitrage functions. Others will infer not the emergence of competition but merely the abandonment of a quantity-rationed state marketing system, which was inherently discriminatory across space and time, in favor of a perhaps imperfect price-rationing system already in existence in private, parallel markets.

Table 1: Madagascar Macroeconomic Indicators By Period

	Neo-colonial Era 1960-72	Socialist Era 1973-80	Stabilization Era 1981-85	Liberalization Era 1986-90
Annual averages (percent)				
Real GDP growth	3.7	0.7	-1.6	2.8
Real GDP growth per capita	1.6	-1.9	-4.2	-0.3
GDP deflator growth	3.2	10.5	19.5	16.4
Current Acct* % GDP	-1.3	-5.4	-8.6	-5.2
Gov't balance % GDP	-0.5	-5.4	-6.5	-3.9
Gross domestic investment % GDP	11.9	10.2	9.1	12.6
Real agricultural growth		1.4	1.1	1.31.9
Agricultural trade balance % GDP	7.8	8.4	5.9	7.2

* after official transfers

Sources: Banque des Données de l'Etat, Inventaire Socio-Economique , 2 volumes (Antananarivo, 1988), Banque des Données de l'Etat, Madagascar en Chiffres (Antananarivo, 1992), Frederic L. Pryor, Income Distribution and Economic Development in Madagascar: Some Historical Statistics (Washington: World Bank Discussion Paper number 37, 1988), World Bank, Madagascar: Beyond Stabilization to Sustainable Growth (Washington, 1991).

Table 2: Descriptive Price Statistics By Period

	Beans	*Maize*	*Manioc*	*Pota-toes*	*Rice*
(real FMG, base January 1983)					
Pre-Reform Period (1983-1985)					
Mean	470	195	109	268	238
Std. Dev.	31	32	17	16	45
Coeff. of Var.	0.07	0.17	0.16	0.06	0.19
Reform Period (1986-1991)					
Mean	388	150	96	193	253
Std. Dev.	45	49	29	37	59
Coeff. of Var.	0.12	0.32	0.30	0.19	0.23
Buffer Stock Period (11/86-03/90)					
Mean	408	140	92	193	243
Std. Dev.	31	35	26	27	40
Coeff. of Var.	0.08	0.25	0.28	0.14	0.17

Table 3: ARCH-M Estimates of Real Dried Bean Prices

	Pre-Reform Period				Liberalization Period			
	Mean		Variance		Mean		Variance	
Constant	226.3	(0.46)	873.9	(0.07)	223.9	(1.79)	438.4	(1.21)
P_{t-1}	0.05	(0.07)	4.48	(31.1)	0.93	(0.02)	4.55	(804.1)
TREND	4.59	(0.59)	2.61	(0.95)	0.002	(0.08)	-6.08	(217.4)
ER	0.86	(0.25)	-2.62	(38.2)	0.04	(0.01)	-1.73	(2357)
BP	-0.21	(0.21)			0.02	(0.08)		
BUF					-1.18	(0.56)	-0.34	(0.10)
STRIKE					-1.96	(1.60)	0.09	(0.02)
δ (risk term)	0.96	(16.0)			0.08	(0.28)		
α_1 (ARCH term)			0.02	(14.3)			0.14	(501.2)
Regional dummies:								
Vakinankaratra	-30.2	(2.77)	103.6	(0.03)	-2.03	(1.64)	-0.12	(0.01)
Fianarantsoa	14.5	(2.78)	0.90	(0.02)	-3.46	(1.62)	-0.11	(0.01)
Mananjary	83.4	(2.71)	-323.3	(0.28)	-1.67	(1.74)	-0.03	(0.01)
Farafangana	100.3	(2.79)	-320.4	(0.02)	0.63	(1.65)	-0.11	(0.02)
Ambat'zaka	100.7	(2.77)	-267.1	(0.02)	-0.67	(1.55)	0.90	(0.21)
Mahajanga	154.2	(3.49)	-48.9	(0.00)	1.81	(1.52)	-0.01	(0.11)
Antsohihy	80.6	(2.84)	-126.7	(0.02)	-2.39	(1.63)	-0.08	(0.02)
Toliary	-82.2	(3.40)	1254	(0.43)	4.52	(1.52)	-0.05	(0.03)
Antsiranana	130.9	(3.33)	67.4	(0.01)	-3.41	(0.99)	-0.06	(3.48)
Antalaha	188.0	(14.9)	-536.7	(0.04)	1.05	(4.84)	0.21	(0.65)
Seasonal dummies:								
Apr-Jun	86.2	(0.23)	-472.7	(0.05)	-2.17	(0.09)	-0.14	(20.9)
Jul-Sep	5.61	(0.21)	68.6	(0.02)	2.37	(0.88)	0.12	(19.0)
Oct-Dec	66.9	(0.23)	-264.3	(0.03)	-0.54	(0.32)	2.18	(0.77)
n	264				792			
R^2	0.81				0.97			

(asymptotic standard errors in parentheses)

Table 4: ARCH-M Estimates of Real Maize Prices

	Pre-Reform Period		Liberalization Period	
	Mean	**Variance**	**Mean**	**Variance**
Constant	46.8 (21.6)	1275 (0.80)	35.1 (3.90)	587.4 (3.24)
P_{t-1}	0.43 (27.2)	5.90 (89.0)	0.90 (0.08)	5.83 (4.85)
TREND	16.6(106.9)	0.86 (1.18)	-0.13 (0.06)	-8.76(217.2)
ER	-0.18 (4298)	-3.66(426.1)	0.04 (0.08)	-0.80 (43.3)
BP	1.48 (1658)		0.32 (0.15)	
BUF			-0.56 (0.61)	-0.15 (0.04)
STRIKE			-4.06 (1.78)	0.08 (0.01)
δ (risk term)	0.36(564.2)		0.08 (31.6)	
α_1 (ARCH term)		0.40 (75.2)		0.51 (15.5)
Regional dummies:				
Fianarantsoa	-76.1 (21.7)	-0.12 (0.80)	2.58 (1.67)	-0.14 (0.00)
Toamasina	-124.4 (0.33)	0.56 (0.01)	1.94 (1.52)	-0.21 (0.02)
Ambat'zaka	-185.5 (0.13)	0.10 (0.01)	2.11 (1.61)	-0.08 (0.01)
Mahajanga	-252.6 (0.30)	0.14 (0.01)	5.19 (1.27)	-0.02 (0.05)
Antalaha	-315.0 (0.25)	-0.34 (0.01)	5.26 (3.86)	0.05 (3.24)
Seasonal dummies:				
Apr-Jun	-12.3 (24.5)	-0.22 (0.17)	-0.60 (0.27)	1.46 (0.10)
Jul-Sep	-4.04 (48.2)	-0.33 (0.85)	0.64 (0.83)	1.19 (0.31)
Oct-Dec	32.8 (0.22)	0.80 (0.03)	-0.03 (168.6)	0.02 (41.6)
n	144		432	
R^2	0.53		0.87	

(asymptotic standard errors in parentheses)

Table 5: ARCH-M Estimates of Real Manioc Prices

	Pre-Reform Period				Liberalization Period			
	Mean		Variance		Mean		Variance	
Constant	75.1	(2.14)	520.5	(0.28)	37.1	(3.75)	684.7	(2.38)
P_{t-1}	0.46	(0.08)	7.47	(20.1)	0.86	(0.06)	3.21	(192.7)
TREND	5.18	(0.34)	4.12	(2.80)	0.33	(0.11)	-2.70	(164.7)
ER	-0.02	(0.09)	-1.99	(155.1)	0.05	(0.10)	-0.56	(1557)
BP	-0.34	(0.23)			-0.17	(0.12)		
BUF					-0.27	(0.43)	-0.34	(0.10)
STRIKE					-1.96	(1.60)	-2.69	(0.75)
δ (risk term)	0.16	(26.1)			-0.20	(58.5)		
α_1 (ARCH term)			0.46	(15.9)			0.52	(17.0)
Regional dummies:								
Itasy	-17.4	(1.32)	-0.23	(0.05)	-1.17	(1.54)	-0.03	(0.01)
Fianarantsoa	-27.0	(1.36)	0.11	(0.04)	0.10	(1.50)	-0.03	(0.01)
Farafangana	-20.9	(2.01)	0.07	(0.01)	-6.09	(1.44)	-0.04	(0.01)
Toamasina	-38.2	(2.14)	0.11	(0.01)	-0.66	(0.85)	-0.02	(0.41)
Ambat'zaka	-55.8	(1.55)	-0.01	(0.27)	-6.50	(1.40)	-0.04	(0.13)
Fenerive Est	-58.7	(1.87)	-0.03	(0.01)	-2.73	(1.70)	-0.02	(0.02)
Mahajanga	-57.9	(2.18)	-0.20	(0.01)	-7.92	(1.59)	0.01	(0.02)
Antsohihy	-74.7	(2.04)	-0.10	(0.01)	-11.20	(1.44)	0.00	(0.04)
Maintirano	-86.2	(2.20)	0.00	(0.01)	-8.22	(1.49)	-0.05	(0.00)
Toliary	-97.3	(2.66)	0.13	(0.01)	-13.1	(1.34)	-0.01	(0.02)
Antsiranana	-52.2	(2.82)	0.12	(0.01)	-21.8	(1.35)	0.02	(0.07)
Antalaha	-103.6	(8.32)	0.09	(0.01)	-35.8	(5.07)	0.02	(2.35)
Seasonal dummies:								
Apr-Jun	5.64	(1.49)	0.14	(0.05)	-0.22	(197.8)	-0.30	(715.6)
Jul-Sep	-0.98	(1.57)	-0.10	(0.04)	0.18	(474.0)	-0.38	(661.9)
Oct-Dec	9.72	(0.04)	0.27	(0.04)	0.01	(183.3)	-0.72	(122.8)
n	312				936			
R^2	0.69				0.80			

(asymptotic standard errors in parentheses)

Table 6: ARCH-M Estimates of Real Potato Prices

	Pre-Reform Period				Liberalization Period			
	Mean		Variance		Mean		Variance	
Constant	23.1	(5.28)	123.6	(0.09)	3.61	(6.06)	252.2	(6.37)
P_{t-1}	0.59	(0.06)	2.04	(35.8)	0.93	(0.07)	2.61	(7.84)
TREND	5.41	(0.44)	0.33	(0.60)	-0.04	(0.05)	-3.66	(439.7)
ER	0.24	(0.09)	-2.64	(163.5)	0.15	(0.07)	-0.35	(38.4)
BP	0.06	(0.11)			-0.01	(0.07)		
BUF					0.27	(0.44)	-0.61	(0.28)
STRIKE					0.38	(1.25)	0.17	(0.00)
δ (risk term)	0.09	(0.40)			0.19	(31.5)		
α_1 (ARCH term)			0.32	(4.52)			0.49	(9.11)
Regional dummies:								
Itasy	-3.40	(1.27)	0.07	(0.02)	5.32	(1.29)	-0.63	(0.02)
Fianarantsoa	-14.0	(1.63)	-0.22	(0.02)	4.48	(1.32)	-0.01	(0.01)
Ambat'zaka	3.19	(1.79)	0.71	(0.01)	1.56	(1.39)	-0.06	(0.02)
Mahajanga	-1.24	(2.05)	-0.25	(0.005)	3.36	(1.30)	-0.14	(0.02)
Antsohihy	22.7	(2.11)	0.26	(0.01)	4.73	(1.24)	-0.38	(0.03)
Toliary	3.31	(2.16)	0.04	(0.01)	4.22	(1.15)	-0.26	(0.04)
Morondava	33.3	(2.71)	-0.24	(0.07)	6.88	(1.38)	-0.14	(0.03)
Antsiranana	1.60	(3.73)	-0.13	(0.01)	6.75	(1.11)	-0.17	(0.08)
Antalaha	72.7	(7.07)	0.09	(0.005)	6.20	(3.90)	0.79	(6.37)
Seasonal dummies:								
Apr-Jun	13.2	(1.62)	1.16	(0.03)	0.17	(0.31)	1.39	(0.68)
Jul-Sep	-2.86	(1.76)	-0.25	(0.01)	-0.13	(0.69)	2.42	(0.23)
Oct-Dec	-3.84	(1.86)	-0.45	(0.00)	0.06	(2.03)	2.07	(0.24)
n	240				720			
R^2	0.92				0.96			

(asymptotic standard errors in parentheses)

Table 7: ARCH-M Estimates of Real Milled Rice Prices

	Pre-Reform Period				Liberalization Period			
	Mean		Variance		Mean		Variance	
Constant	65.0	(7.99)	894.0	(1.42)	92.2	(12.1)	1364	(0.18)
P_{t-1}	0.73	(0.02)	3.76	(312.7)	0.95	(0.07)	5.12	(7.75)
TREND	8.45	(0.26)	16.5	(5.73)	0.27	(0.14)	-8.19	(13.0)
ER	0.22	(0.05)	12.40	(8.27)	0.03	(0.11)	-1.79	(35.4)
BP	-0.48	(0.18)			-0.03	(0.12)		
BUF					-2.67	(0.57)	-3.94	(0.06)
STRIKE					12.4	(1.79)	0.07	(0.02)
δ (risk term)	-0.19	(308.6)			-0.72	(35.0)		
α_1 (ARCH term)			0.44	(24.5)			0.01	(400.3)
Regional dummies:								
Vakinankaratra	-11.7	(1.47)	-443.6	(1.42)	2.64	(2.08)	-0.03	(0.01)
Itasy	-38.3	(2.22)	-96.0	(0.01)	-2.08	(2.09)	0.00	(0.09)
Fianarantsoa	-54.8	(2.04)	-355.5	(2.04)	-0.53	(2.05)	-0.11	(0.02)
Mananjary	-67.0	(2.37)	67.8	(9.34)	-3.53	(2.01)	2.01	(0.06)
Farafangana	-77.7	(2.39)	-99.0	(2.10)	-4.71	(3.07)	29.4	(0.00)
Toamasina	-95.1	(2.75)	575.9	(14.9)	-4.39	(1.05)	-0.02	(0.01)
Ambat'zaka	-124.0	(2.92)	1701	(0.01)	-5.30	(2.40)	5.04	(0.03)
Fenerive Est	-114.8	(2.95)	1021	(0.01)	-8.95	(1.10)	6.11	(0.01)
Mahajanga	-163.5	(0.28)	-252.1	(0.01)	-6.73	(2.01)	-0.02	(0.00)
Antsohihy	-197.0	(1.87)	-479.2	(0.26)	-7.74	(1.98)	37.9	(0.21)
Maintirano	-215.0	(2.05)	-390.6	(0.19)	-14.9	(1.90)	21.4	(0.25)
Toliary	-209.1	(2.46)	-110.1	(0.02)	-12.3	(4.12)	-0.29	(0.04)
Taolagnaro	-227.2	(2.65)	24.0	(0.00)	-10.7	(1.96)	-0.20	(0.03)
Morondava	-256.4	(2.36)	-517.0	(0.00)	-17.0	(1.94)	24.6	(0.01)
Antsiranana	-246.0	(3.00)	-12.7	(0.01)	-18.1	(1.90)	-0.01	(0.02)
Antalaha	-282.2	(0.02)	-131.4	(0.10)	-14.7	(0.01)	77.4	(1.85)
Seasonal dummies:								
Apr-Jun	-16.9	(7.85)	-38.4	(1.42)	-2.12	(30.4)	-0.47	(106.5)
Jul-Sep	-1.58	(0.49)	78.5	(0.03)	-0.57	(0.42)	-0.41	(61.9)
Oct-Dec	4.06	(0.44)	141.7	(0.21)	-0.38	(82.9)	-0.45	(100.2)
n	612				1224			
R^2	0.69				0.93			

(asymptotic standard errors in parentheses)

Table 8: Relative Risk Premia

Period	Beans	Maize	Manioc	Potatoes	Rice
Pre-Reform	.06	.06	.03	.01	-.04
Liberalization	.01	.02	-.06	.04	-.17

Table 9: Estimated Elasticities of Mean Prices

	Beans	Maize	Manioc	Potatoes	Rice
With respect to the real exchange rate :					
Pre-Reform	0.88*	-0.44	-0.09	0.43*	0.44*
Liberalization	0.06*	0.16	0.32	0.48*	0.07
With respect to the border parity price :					
Pre-Reform	-0.10	0.49	-0.17	0.04	-0.24
Liberalization	0.02	0.13*	-0.18	-0.01	-0.02

* Statistically significant at the five percent level.

Figure 1: Rice, Manioc and Maize Prices

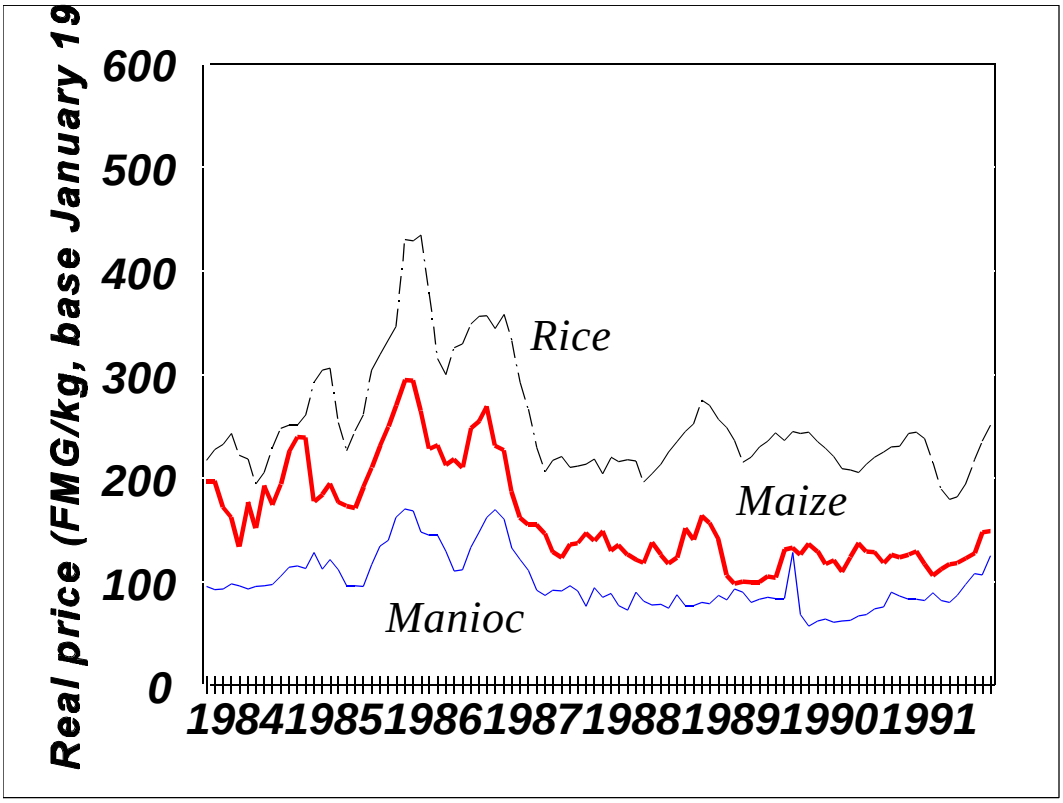
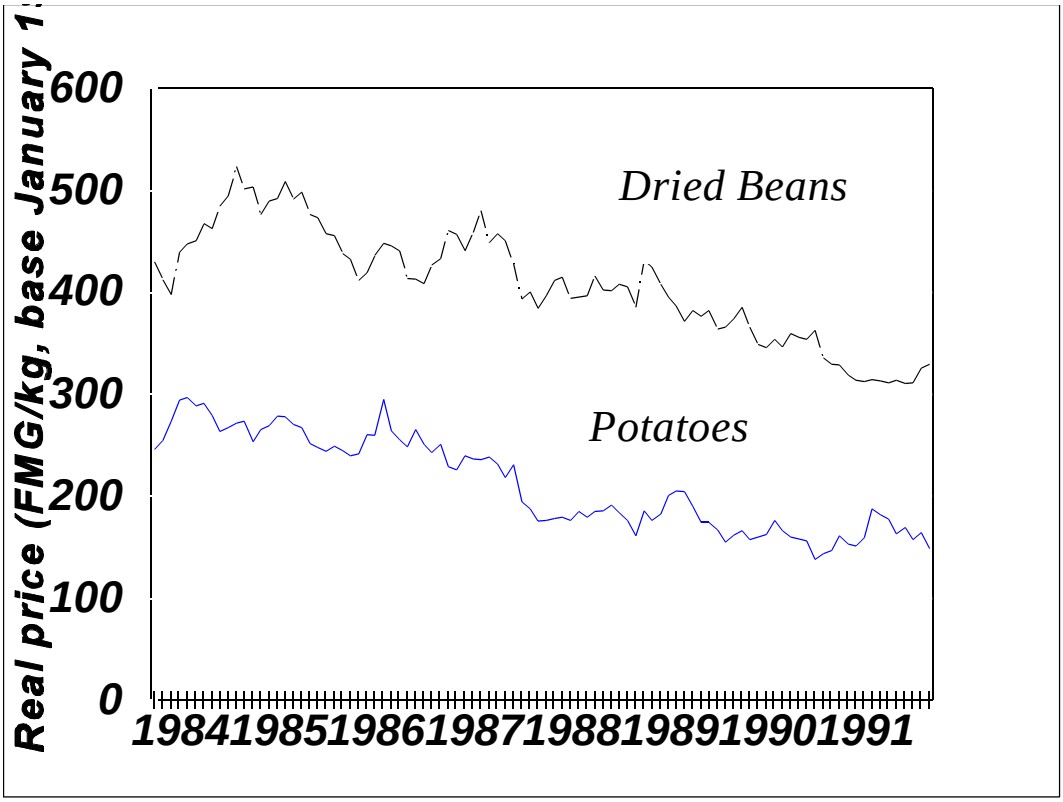


Figure 2: Beans and Potatoes Prices



NOTES

* This research was made possible by financial support from the University of Wisconsin-Madison, the Social Science Research Council and National Science Foundation grant INT-9312615. Michael Carter, Jean-Paul Chavas, John Rust and Jerry Shively provided helpful comments.

[1] Michael Lipton, Why Poor People Stay Poor (London: Temple Smith, 1977), Anne O. Krueger, Maurice Schiff and Alberto Valdés, "Agricultural Incentives in Developing Countries: Measuring the Effects of Sectoral and Economywide Policies," World Bank Economic Review, 2 (1988): 255-271, and Maurice Schiff and Alberto Valdés, The Plundering of Agriculture in Developing Countries (Washington: World Bank, 1992).

[2]David P. Baron, "Price Uncertainty, Utility, And Industry Equilibrium In Pure Competition," International Economic Review, 11 (October 1970): 463-480; Agnar Sandmo, "On The Theory of the Competitive Firm Under Price Uncertainty," American Economic Review, 61 (1971): 65-73, and Yasunori Ishii, "On The Theory of the Competitive Firm Under Price Uncertainty: Note," American Economic Review, 67 (1977): 768-769.

[3]Israel Finkelshtain and James A. Chalfant, "Marketed Surplus Under Risk: Do Peasants Agree With Sandmo?" American Journal of Agricultural Economics, 73 (August 1991): 557-567.

[4] Steven Kyle, "Pitfalls in the Measurement of Real Exchange Rate Effects on Agriculture," World Development, 20 (July 1992): 1009-1019, Jean-Philippe Platteau, "Sub-Saharan Africa As A Special Case: The Crucial Role of (Infra)Structural Constraints," Cahier de la Faculté Des Sciences Economiques Et Sociales De Namur number 128 (1993), and Christopher B. Barrett and Michael R. Carter, "Microeconomically Coherent Agricultural Policy Reform in Africa," unpublished report to the World Bank Research Program on Reforms in Socialist Economies in Africa (1994).

[5] Christopher B. Barrett, "Understanding Uneven Agricultural Liberalisation in Madagascar," Journal of Modern African Studies, 32 (forthcoming).

[6] The IMF dubbed these reforms some of the most comprehensive in Africa (S. Rajcoomar, "Crafting Comprehensive Reforms," Finance & Development, 28 (1991): 46-48), and the World Bank labelled Madagascar an "early intensive adjustment lending country" (World Bank, Adjustment Lending Policies for Sustainable Growth, Policy and Research Series paper number 14, 1990). The World Bank's Vice-President for Africa singled out Madagascar as "an economic miracle [due to] successful implementation of structural reforms" (as quoted in Adrian Hewitt, "Madagascar," Structural Adjustment & the African

Farmer, ed. Alex Duncan and John Howell (Portsmouth, NH: Heinemann, 1992): 93), and the Bank's resident representative to Madagascar said that "Madagascar is the only country in the world to have effected a 180-degree turn, with the same government and without bloodshed" (JURECO "Etat de la question de la libéralisation à Madagascar," 45 (1990)). USAID awarded Madagascar "focus country" status for assistance because it had "changed freely from a socialist failure to a promising structural reformer and free-market advocate" (USAID, Madagascar: Country Program Strategy Plan 1993-1998 (Washington, 1992): 9), an assessment based largely on consultants' judgement that "since 1982, Madagascar has introduced one of the most comprehensive liberalization programs in the world" (Elliot Berg, Ann McDermott and Michael Cullen, "The Impact of Economic Liberalization on Madagascar's Agricultural Sector and Its Implications For USAID Strategy," unpublished report to USAID/Madagascar, 1990: 1).

[7] International Monetary Fund, "Madagascar - Staff Report for the 1990 Article IV Consultation," (Washington, 1991): 2.

[8] Paul A. Dorosh, René E. Bernier and Alexander H. Sarris, Macroeconomic Adjustment and the Poor: The Case of Madagascar (Ithaca, NY: Cornell University Food and Nutrition Policy Program monograph 9, 1990), Frederic L. Pryor, The Political Economy of Poverty, Equity, and Growth: Malawi and Madagascar (Oxford: Oxford University Press, 1990).

[9] C. Peter Timmer, Getting Prices Right: The Scope and Limits of Agricultural Price Policy (Ithaca, NY: Cornell University Press, 1986), William Jaeger and Charles Humphreys, "The Effect of Policy Reforms on Agricultural Incentives in Sub-Saharan Africa," American Journal of Agricultural Economics , 70 (December 1988): 1036-1043, Omotunde E.G. Johnson, "Agriculture and Fund-Supported Adjustment Programs," Finance & Development , 25 (1988): 38-40, Krueger, Schiff and Valdés, Simon Commander, editor, Structural Adjustment & Agriculture: Theory and Practice in Africa and Latin America (Portsmouth, NH: Heinemann, 1989), Schiff and Valdés 1992.

[10] World Bank, Madagascar: Agricultural and Rural Development Sector Memorandum (Washington, report 4209-MAG, 1983), Maureen Covell, Madagascar: Politics, Economics and Society (London: Frances Pinter, 1987), Pryor 1988 and 1990, Richard Szal, "Is There An Agrarian Crisis In Madagascar?" International Labour Review , 127 (1988): 735-760, Dorosh, Bernier and Sarris, Hewitt, World Bank, Madagascar: Beyond Stabilization to Sustainable Growth .

[11] The data were made available by the statistical service of the Ministry of Agriculture.

[12]The CPI is not an ideal deflator for two reasons. First, the market basket weights in the CPI are based on a household expenditure survey of 132 items fielded in Antananarivo from March 1968 through February 1969. Expenditure patterns have certainly changed in the ensuing quarter of a century. Second, food comprises more than 60 percent of the index (rice alone is almost 16 percent), thereby muting somewhat the relative changes between agricultural and other commodities. Unfortunately, there is no practical alternative to the traditional sector CPI for generating real price series out of the nominal data. Furthermore, any bias introduced by this variable is common to all series, and given the magnitudes of the parameter estimates, an enormous adjustment would be needed to change the signs of the coeffients of interest. The general results, especially regarding cross-commodity comparisons are likely robust to recomputation with an improved deflator.

[13] Pre-reform monthly price data are not available for traditional export crops (*e.g.*, cloves, coffee, pepper, vanilla), and a complete series of comparable international market prices are not available for a few others (*e.g.*, groundnuts, sweet potatoes). Hence the focus on the principal domestic food crops, although several of these commodities are internationally traded in substantial volumes. These five commodities represented more than 71 percent of total cultivated area and 72 percent of the value of total agricultural output in 1984-85. Ministère de la Production Agricole et de la Réforme Agraire, Projet Recensement National de l'Agriculture et Système Permanent des Statistiques Agricoles, 5 volumes (Antananarivo, 1988).

[14] Series were considered sufficiently complete for inclusion if at least 95 percent of the monthly observations were available. Any missing observations were imputed based on leading and lagging period observations for that region, contemporaneous observations for neighboring regions, and seasonality adjustments.

[15] Some portion is likely also a statistical artifact reflecting the prominence of rice (16 percent) in the CPI used to deflate the nominal price series.

[16] Robert Hirsch, "Rapport Final d'une Mission de Réflexion sur le Secteur Rizicole Malgache" (Paris: Département d'Appui aux Opérations, Caisse Centrale de Coopération Economique, 1986), Philippe Hugon, "The Impact of Adjustment Policy in Madagascar," IDS Bulletin, 19 (1988): 43-50, Graham Shuttleworth, Ross Bull and Peter Hodgkinson, "Food Security Through Seasonal Stabilization: The Case of Madagascar," Food Policy, 13 (1988): 140-153, and Graham Shuttleworth, "Policies in Transition: Lessons From Madagascar," World Development, 17 (March 1989): 397-408 , Elliot Berg, "The Liberalization of Rice Marketing in Madagascar," World Development, 17 (May 1989): 719-728.

[17] Direction de la Securité Alimentaire, Bilan des Opérations Stock Tampon (Antananarivo, 1986).

[18] The accounting period begins October 1, with the onset of the *soudure* period, and continues through the following September.

[19] Bechir Rassas, Charles Rabenarivo and Lawrence Meserve, "Evaluation of the Food for Progress Rice Program in Madagascar," (unpublished report to USAID/Madagascar, 1988): iii.

[20] B. Wade Brorsen, Jean-Paul Chavas, Warren R. Grant and L.D. Schnake, "Marketing Margins and Price Uncertainty: The Case of the U.S. Wheat Market," American Journal of Agricultural Economics , 67 (August 1985): 521-528, and Matthew T. Holt, "Risk Response in the Beef Marketing Channel: A Multivariate Generalized ARCH-M Approach," American Journal of Agricultural Economics , 75 (August 1993): 559-571.

[21] The original reference for the ARCH literature is Robert F. Engle, "Autoregressive conditional heteroscedasticity with estimates of the variance of United Kingdom inflation," Econometrica , 50 (1982): 987-1008. The ARCH-M refinement is due to Robert F. Engle, David M. Lilien and Russell P. Robins, "Estimating time varying risk premia in the term structure: The ARCH-M Model," Econometrica , 55 (1987): 391-407. Good reviews of the ARCH literature and its variants can be found in Tim Bollerslev, Ray Y. Chou and Kenneth F. Kroner, "ARCH Modeling in Finance: A Review of the Theory and Empirical Evidence," Journal of Econometrics , 52 (1992): 5-59, and in Russell Davidson and James G. MacKinnon, Estimation and Inference in Econometrics (Oxford: Oxford University Press, 1993).

[22] As reported by the International Monetary Fund, International Financial Statistics , various years.

[23] Angus Deaton and Guy Laroque, "On The Behaviour of Commodity Prices," Review of Economic Studies , 59 (January 1992): 1-23.

[24] The data on rice buffer stock releases was made available by Madagascar's Direction de la Securité Alimentaire.

[25] As reported by the Food and Agriculture Organization of the United Nations, Quarterly Bulletin of Statistics , various issues.

[26] Parameter estimates from a simpler ARCH(1) model were among the alternative starting values used, with no difference in results. The Broyden-Fletcher-Goldfarb-Shanno (BFGS) algorithm was chosen because, like the more commonly employed Davidon-Fletcher-Powell (DFP) algorithm, it has superlinear convergence but, unlike DFP, BFGS updates the Hessian approximation directly. This avoids inversion of the Hessian approximation,

which often tends DFP toward singularity. Because direct updating algorithms sometimes take many iterations to build up the covariance matrix, a low convergence criterion (0.00001) was chosen to ensure sufficient iterations. The regressions were run in SHAZAM, version 7.0.

[27] George E. P. Box and Gwilym M. Jenkins, Time Series Analysis: Forecasting and Control (San Francisco: Holden-Day, 1976).

[28] Augmented Dickey-Fuller tests corroborated this assumption. The test results are available from the author by request.

[29] From a production standpoint manioc is unusually durable, in that it can be left in the ground for months, providing natural storage and obviating the need for intensive harvest activities. Once harvested, however, the root's high hydrocyanic acid content yields deadly concentrations of cyanide if left unprocessed, in some environments for periods as short as one week. So timeliness in processing or transport is far more important for fresh manioc than for most roots, tubers or grains.

[30] Although Madagascar does export some manioc, and those volumes increased with market-oriented reforms, exports have never constituted more than two percent of national output in recent years.

[31] The coefficient of variation of the border parity price was 0.31, 1984-85, versus a range of 0.07 to 0.17 for the five enumeration regions in which potatoes were internationally nontradable.

[32] Dorosh, Bernier and Sarris, Table 27, pp. 85-6.

[33] See, for instance, Brorsen *et al.*, Holt, or John Schroeter and Azzeddine Azzam, "Marketing Margins, Market Power, and Price Uncertainty," American Journal of Agricultural Economics , 73 (November 1991): 990-999.

[34] One can easily conceive of this as risk to exchange entitlements, following Amartya Sen, Poverty and Famines , (Oxford: Clarendon Press, 1981).

[35] Bollerslev, Chou and Kroner point out that the statistical significance of ARCH-M risk parameter estimates tends to vary directly with the frequency of the data. Estimates derived from daily data almost invariably yield statistically significant estimates, while those from monthly data tend to be less precise.

[36] A high degree of autocorrelation is common in commodity price data, attributable in some part to speculative storage behavior and, more, to autocorrelation in the underlying processes of supply and demand. See Deaton and Laroque, as well as Angus Deaton and Guy Laroque, "Estimating the commodity price model," mimeo (November 1991).

[37] For anecdotes and data to this effect, see Berg; Patricia Kristjanson and Jerry Martin, "More Than Free Markets Are Needed: The Case of a Peasant Millionaire in Madagascar," Choices, (1991): 19-21; René E. Bernier and Paul A. Dorosh, "Constraints on Rice Production: The Farmer's Perspective," Cornell University Food and Nutrition Policy Program working paper 39 (Ithaca, NY, 1993); and Jean-Paul Azam, Elliot Berg, Catherine Bonjean and Lawrence Kent, "Etude du Marché du Riz à Madagascar," mimeo (1993).

[38] The prefix "quasi-" is added since transfer costs between markets inevitably lead to some spatial price variation and storage costs, including the opportunity cost of capital, almost surely produce some seasonal variation.

[39] William A. Masters and Ernst-August Nuppenau, "Panterritorial Versus Regional Pricing For Maize in Zimbabwe," World Development, 21 (October 1993): 1647-1658.

[40] Barbara Harriss, "Going Against The Grain," Development and Change, 10 (July 1979): 363-384, identifies several of these problems in the context of what she dubs the "composite marketing system" for grains in the Sahel.

[41] Note that regional price dispersion was least pre-reform for potatoes, the one crop not controlled by parastatals and linked into world markets through exports.

[42] Note that effective control need only have existed in at least one region, most likely around the capital city, which served as the reference point for the econometric estimates.

[43] Barrett discusses this episode in some detail.

[44] This observation has significant implications for both the design and evaluation of commodity price stabilization schemes.