The Impact of Market Reforms on Spatial Volatility of Maize Price in Tanzania*

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Abstract

The impacts of market reforms on the volatility of agricultural prices in developing countries have not been well understood because economic theory does not provide a concrete basis for predicting the effects of reforms on the aggregate behavior of economic agents. The absence of such information weakens microeconomic and structural efforts to improve the efficiency of market institutions. This study investigates whether agricultural reforms have exacerbated the degree of spatial volatility of maize price in Tanzania. An Autoregressive Conditional Heteroskedasticity in Mean (ARCH-M) model is used to identify region-specific effects of the reforms on the volatility of maize price. Results indicate that highly populated and developed regions might have experienced less volatile prices than less populated and less developed regions. The study recommends infrastructure development to link these types of regions to increase the volume of trade between the regions thereby reducing the observed spatial volatility in the long-run.

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In the 1980s, the Tanzanian economy experienced dismal economic performance and severe economic hardships, which were mainly attributable to poor performance of the state-controlled marketing system, and fiscal deficits that resulted from subsidized production, consumption, and market operations.[1] The autarkic markets, fostered through curtailing the role of the private sector, produced massive distortions that required major reforms and external assistance. In 1987, the Tanzanian government adopted reform programs prescribed by the International Monetary Fund and the World Bank, which aimed at restoring macroeconomic balance and efficiency to the economy. The reforms were implemented in phases and a comprehensive liberalization of agricultural markets was achieved in 1991 when all restrictions on traders were lifted. The thrust behind these reforms was also to enhance efficiency in price formation so as to stimulate output growth and technological innovation.

However, analysts indicate that a major problem in the design and implementation of market reforms in developing countries (DCs) arose from structural impediments to identify institutional set-ups that existed (Valdés). In brief, effects of reforms on agricultural investment, productivity, and commodity prices in DCs are still vaguely understood and difficult to assess because economic theory does not provide a concrete basis for predicting effects of reforms on aggregate behavior of economic agents (Barrett). Three concerns related to market reforms in DCs have been raised.

First, most analysts contend that the private sector is weak in terms of business skill and financial ability to fill the gap left by the dismantled system, thereby restraining competition and market integration (Barrett; Speece). Second, agricultural costs and returns depend on the performance of other sectors. Therefore, reforms might be attempted in a wrong sequence and might lead to unintended outcomes (Valdés). Finally, producers in DCs are heterogeneous, and they produce and market independently, which often leads to different abilities to sustain risk and to bargain (Binswanger; Shahabulin, Mestelman, and Feeny; Valdés). These market imperfections have motivated researchers to examine effects of market reforms on farm-level income. In Tanzania there has been a growing concern whether the reforms have exacerbated the degree of spatial volatility of maize price because distances from central markets, quality of roads, and market competition have influence on risk, information flow, and transactions costs.

Maize is a food as well as a cash crop for rural population in Tanzania and its price volatility is very detrimental particularly in remote areas where producers might be tempted to sell even some of their food reserves to meet cash obligations when prices are very low. This selling habit has often jeopardized nutritional status and investment abilities of the rural communities (Feldman).[2] Price volatility has also created incentives for boarder-line growers and traders to engage in informal cross-border trading networks. These transactions might have increased regional price differences, although their income effects depend on the difference between gains and losses from trade. Generally, effects of reforms on the distribution of agricultural income in developing economies are difficult to assess because economic systems are normally intertwined. Nevertheless, regional differences in trade and economic development have become very apparent in Tanzania after economic reforms. Therefore, it is possible that the trade practices that emerged after reforms have adversely affected some regions through increased price volatility (Coulter and Golob; Santorum and Tibaijuka). Nonetheless, this conclusion is based on qualitative analysis of price data. The use of parametric approaches to test for spatial volatility over time has been rare in most empirical studies.

The objective of this study is to determine if the dismantling of the state-owned monopolies that resulted from the liberalization of agricultural markets in Tanzania has exacerbated the degree of spatial volatility of maize price. The study also tests whether the volatility might be attributable to differences in population and economic development, commercial milling activities, and cross-border trade linkages. To our best knowledge most previous studies that addressed this problem investigated this question in a static sense using descriptive statistics. Thus, inferences were not based on statistical tests and price dynamics. The uniqueness of this study is the use of an econometric model that allows price modeling with time varying risk premia so that economic agents command larger risk premia in more turbulent periods.

This study is organized as follows. In the next section different modeling approaches are discussed and evaluated, which is followed by a description of theoretical and empirical model. The last two sections present a detailed discussion of results, and a summary of major findings and recommendations.

Methodology and Data

Literally, volatility can be modeled as a conditional variance in the GARCH framework. A number of studies have employed this methodology to address price volatility for various commodities (Yang, Haigh, and Leatham; Yang and Brorsen; Jayne and Myers). Nevertheless there is well-established evidence suggesting that monthly data usually does not have GARCH effects, and whenever these effects are detected, they are usually due to structural break of unconditional variance (Baillie and Borlerslev).

An alternative set-up to the GARCH model is a stochastic volatility (SV) model. A complication with SV is that its density function has no closed form and hence neither does the likelihood function, even for the simplest form. Contemporary approaches suggest that the model can be estimated through the construction of its fully likelihood function or simply through approximation. This model has been extensively used in financial markets (Friedman and Harris; Pitt and Shephard). Overall, direct estimation of the SV model is often very difficult.

Another approach is to use a Lagrange Multiple test for ARCH process proposed by Engle. This approach assumes that conditional variances follow a fixed form over the sample period. However, the assumption might not hold in all cases and conditional variances might be asymmetric. Thus, a threshold-ARCH model has been frequently used to account for asymmetric conditional variances. The threshold-ARCH model tests whether observed price variance depends on past prices in a non-linear fashion. The model is estimated through permitting changes in the structural parameters of the ARCH process conditional on previous information. Shively gives details regarding conceptualization and estimation of the threshold-ARCH model. Nevertheless, the model assumes a change in regime is triggered by a price change in excess of a defined threshold value.[3]

The empirical model in this study draws on Engel, Lilien, and Robins that refine the ARCH-in mean (ARCH-M) model to allow price modeling with time varying risk premia. The choice for this model was motivated by three reasons. First, there exists a theoretical belief that all storable commodities have ARCH processes because current price volatility transmits itself into future period by creating volatility in inventory carryover. When there is an ARCH effect, market participants can forecast the variance, which affects their inventory holding decision if they are risk-averse. In summary theory suggests that if a commodity is storable and the production lag is one period, then there is an ARCH process of order one (Beck). The second reason is that ARCH-M allows conditional volatility to directly influence the conditional mean and it captures the expectation that agents command a larger risk premium in more turbulent periods. The third reason is that data limitations and estimation difficulties precluded the adoption of alternative specifications. The theoretical model was specified as:

$$
\begin{aligned}
& Y_t \mid X_t, \Psi_t \sim N\left(\beta' X_t + \delta h_t^{1/2}, h_t\right) \\
(1) \qquad & h_t = h\left(\varepsilon_{t-1}, \ldots, \varepsilon_{t-p}, X_t, \ldots, X_{t-p}, \alpha\right) \\
& \varepsilon_t = Y_t - X_t \beta
\end{aligned}
$$

In equation (1), X_t is a vector of weekly exogenous and lagged dependent variables included in the information set Ψ_t, h_t represents a variance function and β is vector of corresponding parameters. $\varepsilon_{t-1},\ldots,\varepsilon_{t-p}$, represent lagged disturbances, where p is the order of the autoregressive process appropriate for the ARCH-M model and α is a vector of unknown terms.

To achieve the study objectives four separate analytical models were specified and estimated.

$$\begin{aligned} \ln P_{it} &= \beta_0 + \beta_1 \ln P_{it-1} + \beta_2 TR_t + \beta_3 \ln RE_t + \sum_{t=1}^{3} \pi_t S_t + \sum_{i=1}^{r} \Phi_i R_i + \delta_1 h_{it}^{1/2} + \varepsilon_{it} \\ h_{it} &= \alpha_0 + \alpha_1 \varepsilon_{it-1}^2 + \gamma_1 \ln P_{it-1} + \tau_1 TR_t + \beta_4 \ln RE_t + \sum_{t=1}^{3} \xi_t S_t + \sum_{i=1}^{r} \psi_i R_i + \varphi REG_t \end{aligned} \tag{2}$$

$$\begin{aligned} \ln P_{it} &= \beta_5 + \beta_6 \ln P_{it-1} + \beta_7 TR_t + \beta_8 \ln RE_t + \sum_{t=1}^{3} \lambda_t S_t + \sum_{i=1}^{r} \theta_i R_i + \delta_2 h_{it}^{1/2} + \varepsilon_{it} \\ h_{it} &= \alpha_2 + \alpha_3 \varepsilon_{it-1}^2 + \gamma_2 \ln P_{it-1} + \tau_2 TR_t + \beta_9 \ln RE_t + \sum_{t=1}^{3} \Omega_t S_t + \mu_i DEV_i \end{aligned} \tag{3}$$

$$\begin{aligned} \ln P_{it} &= \beta_{10} + \beta_{11} \ln P_{it-1} + \beta_{12} TR_t + \beta_{13} \ln RE_t + \sum_{t=1}^{3} \rho_t S_t + \sum_{i=1}^{r} \phi_i R_i + \delta_3 h_{it}^{1/2} + \varepsilon_{it} \\ h_{it} &= \alpha_4 + \alpha_5 \varepsilon_{it-1}^2 + \gamma_3 \ln P_{it-1} + \tau_3 TR_t + \beta_{14} \ln RE_t + \sum_{t=1}^{3} \eta_t S_t + \zeta_i MILLS_i \end{aligned} \tag{4}$$

$$\begin{aligned} \ln P_{it} &= \beta_{15} + \beta_{16} \ln P_{it-1} + \beta_{17} TR_t + \beta_{18} \ln RE_t + \sum_{t=1}^{3} \Gamma_t S_t + \sum_{i=1}^{r} \Theta_i R_i + \delta_4 h_{it}^{1/2} + \varepsilon_{it} \\ h_{it} &= \alpha_6 + \alpha_7 \varepsilon_{it-1}^2 + \gamma_4 \ln P_{it-1} + \tau_4 TR_t + \beta_{19} \ln RE_t + \sum_{t=1}^{3} \lambda_t S_t + b_i BORDER_i \end{aligned} \tag{5}$$

In the above equations P_{it} is the real maize price in region i and month t, and P_{it-1} is its previous month's value. *TR* represents a monthly trend variable and *RE* stands for real exchange rate calculated as a ratio of Tanzanian Shilling to United States dollar deflated by their respective consumer price indices (CPI). *S* represents dummy variables for the second through fourth quarters of a year, and *R* is a region-specific dummy variable. ε stands for normally, independently, and identically distributed error term.

REG represents market reforms dummy variable, which takes a value of one for liberalized period and a value of zero for pre-liberalized period. *DEV* represents a dummy for regional population and development, which takes a value of one for regions that are classified as towns and a value of zero for regions that are either classified as cities or municipals. *MILLS* is a dummy variable for maize milling activities that takes a value of one for regions dominated by small mills and a value of zero for regions that have large-scale commercial mills. *Border* is a dummy for informal cross-boarder maize trade that takes a value of one for non-boarder regions and zero otherwise.

The models were estimated in a system framework using SAS program.[4] The first model (equation (2)) was estimated twice to obtain estimates for each regime. Equations (3) through (5) are specified to test regional differences in price volatility with respect to population and economic development, commercial milling activities, and cross-boarder trade linkages. Literally, the three last models could be lumped into one equation. However this is avoided because variables that appear last in these equations are highly correlated and collapsing them into one equation induces serious multicollinearity problem. Regional dummy variable is omitted in variance equation of equations (3) through (5) to avoid the perfect collinearity.

Prices series are monthly wholesale prices of each location for years 1983-1998. The data were collected from the Ministry of Agriculture and Cooperatives Development in Tanzania. Maize prices for each region, measured in Tanzanian Shillings per Kilogram (Tshs/Kg) were deflated by food CPI.

Regions included in the analysis are Arusha (AR), Morogoro (MR), Dodoma (DO), Singida (SI), Mbeya (MB), Iringa (IR), and Ruvuma (SO). Out of these regions Arusha is the only city that has large-scale maize mills. MR, DO, MB, and IR are municipals.[5] Regions that have notable inter-country cross-boarder trades are AR and MB. Overall AR, DO, MB, IR and SO are among the six regions that account for over 50 percent of the maize produced. The major consumer market is Dar es Salaam city followed by the other cities and municipals. Among the regions included in the analysis IR, MO and DO are well-connected to Dar es Salaam. MB is well-connected to Dar es Salaam and has access to cross-border trade opportunities, AR city is well-linked to Kenya, thus, it is also potential for cross-border trade.[6] SO is a region that is linked to Dar es Salaam via IR. The region that is least connected to Dar es Salaam and cross-border market is SI.

The estimation proceeds through pooling regional prices into one panel data structure, which permits estimation of aggregate effects of market reforms on spatial price volatility and to test whether the volatility is attributable to identified region-specific factors.

Results and Implications

Estimated results for the first model are summarized in table 1. Values in this table are useful for making inferences on the relative changes of the mean prices and their variances across regimes. This comparison is done through computing mean values of explanatory variables (assuming all dummies and residual terms are equal to zero) and then substituting the calculated mean-values and their corresponding parameter estimates in the original equations. This analysis indicates that both mean prices and price variances are higher in liberalized markets than in pre-liberalized markets, which is consistent with Barrett's findings. On the other hand the first order autocorrelation term fell from 0.82 to 0.47, which indicates that the effects of structural shocks to the maize price takes shorter to play themselves fully in the free market system than in the autarkic market arrangement. Results also show that there has been a significant depreciation in real exchange rate, which is expected because the country has switched from a fixed to floating exchange rate.

On the other hand, visual inspection of regional dummies suggests that the differences in mean prices and variances between regions included in the analysis and a reference region (AR) are slightly smaller in the post-reform period than in the pre-reform period. Similar effects are observed for seasonal prices. This might signify that the freedom accorded to traders through revamping restrictions on maize movement has permitted inter-regional maize trade thereby slightly reducing spatial and temporal price volatility. Coulter and Golob have indicated that liberalization has been a success in terms of improving efficiency of resource allocation and stimulating private entrepreneurship.

Another interesting discussion is about the ARCH-M risk term δ, which is a measure of the relative risk premia ($\delta h^{1/2}/P_t$). The risk term can be interpreted as a portion of observed price attributable to a risk premium. The short-term risk premium is a necessary gain demanded by an existing agribusiness for assuming price risk. Long-term risk premium represents general equilibrium effects on structure of a commodity market and it captures long-term market effects such as entry, exit and investment.[7] A negative value of long-term risk premium in staple food pricing can be interpreted as consumer's dedication to maintain diet and food preparation habit around the staple (Barrett). Domowitz and Hakkio point out that risk-averse investors normally demand greater compensation in period of above average uncertainty, thus a negative value for a long-term risk premium may signify that investors are better off investing in alternative industries with higher interest rates to guarantee their returns.

Results in table 2 indicate that the short-run and long-run risk premia for maize prices are different for both regimes. The positive sign on the long-term risk premium for the post-reform period suggests that equilibrium prices probably compensate suppliers for bearing price risk, which is not the case for pre-reform period. However this does not necessarily means that markets are efficient.[8]

Based on the discussion of results presented in table 1 it is hard to explain the cause of the increased price volatility because test statistics show that market reforms have reduced the degree of spatial and temporal volatility. However, sometimes it is difficult to identify such effects in disaggregated data, a problem common in panel data. Therefore it was thought intuitive to regroup the data based on geographical, social and institutional differences and assess whether the grouping could change the inferences. The grouping was done with respect to differences in population and economic development, commercial milling activities, and cross-boarder trade linkages and results are discussed below.

Parameter estimates for equation (4) presented in table 3 does not give evidence to support that maize prices in a region that has large-scale maize milling operations (AR) are less volatile than prices in other regions. This might suggest that the economy had not yet attained sufficient scale economies in maize milling to alter pricing patterns across supply chains. Existing information indicates that small-scale dry and wet mills are scattered all over the country, and most of the maize flour sold at retail level comes from small-scale millers.

On the other hand results obtained from third model (table 4) indicated that maize prices for a group of regions that include municipals (MR, DO, IR, and MB) and Arusha city were less volatile than prices in a group consisting of towns (SI and SO). The reason is that often times price adjustment up and down is slower in less populated and less developed markets. Gordon cited in Coulter and Golob observed that seasonal price adjustments, both up and down, were faster in rural markets (3 months) than in urban markets (five to six months).

This constitutes a possible avenue that policy makers can explore to reduce further spatial volatility of the maize price. In view of the empirical results it seems logical to invest in infrastructure to promote trade linkages between Singida and Dodoma, Dodoma and Iringa, and Singida and Arusha. The linkages have potentials to increase the volume of trade between the regions and the resulting trade effects might be transmitted further to neighboring regions hence stabilizing maize prices in regions where they are more volatile.

According to results obtained from the last mode that are appended in table 5.0, prices in regions that were potential for informal cross-boarder trade were not statistically less volatile than prices in other regions. This suggests that the informal maize trade was probably not substantial.[9] In general, a ban on maize exportation was still in place at least for the entire period of 1983-1998 in spite of the fact that agricultural markets were liberalized in 1991. The ban was imposed for food security reasons although economists expressed dissatisfaction with the policy. Therefore, while the trade effect could have reduced the volatility of maize prices in some regions based on comparative trade advantages, the ban might have muted completely such trade effects.

Conclusion

The main objective of this paper was to investigate whether the liberalization of maize marketing in Tanzania has exacerbated the degree of spatial price volatility and to identify if spatial price volatility might be attributable to factors such as population and local development indices for urbanization, commercial milling capabilities, and cross-boarder trade.

The objectives have been investigated in the ARCH-M modeling approach. A preference for this approach is based on three factors. The first reason is a theoretical belief that storable commodities have an ARCH process because current price volatility transmits itself into future period by creating volatility in inventory carryover. Second, the model allows conditional volatility to directly influence the conditional mean and it captures the expectation that agents command a larger risk premium in more turbulent periods. Third, data limitations and modeling difficulties precluded the adoption of alternative specifications.

The analysis entailed identifying the effects of reform policy on the mean and variance of maize price and associated changes in risk premia over the two regimes. Results provided evidence that agricultural liberalization policy has increased mean prices and the volatility of maize prices in the country. Estimated risk premia for the post-reform period indicated that equilibrium prices might be adequate to compensate suppliers for bearing risk, which is not the case for pre-reform period. However, the fact that prices were generally more volatile in the post-reform period than in the pre-reform period is something worrisome to rural producers. Minten has indicated that the switch from fixed to liberalized prices in agricultural markets in many developing economies has significantly influenced households welfare after reforms as the presence of infrastructure determines how the benefits or costs from a liberalized environment are shared between producers, transporters, middlemen and consumers.[10] What appears to be shocking is the declining trend in real producer prices that was observed in earlier phases of market liberalization (Santorum and Tibaijuka).

Preliminary analysis also showed that spatial and temporal volatility were less pronounced in the post-reform period than in the pre-reform period, this was partly contrasted when volatility was investigated using panel data that allowed regions with similar socio-economic characteristics to be grouped together. Extension of the spatial price volatility analysis to regions classified on the basis of differences in commercial milling capabilities and potentialities for informal cross-boarder trade did not suggest that the volatility was different. However, the analysis of spatial volatility on the basis of population and development indices revealed that maize prices in Arusha city and municipals (MR, DO, IR and MB) were less volatile than prices in towns (SI and SO). This constitutes a possible avenue that can be explored to reduce further spatial volatility of the maize price. This could be achieved through infrastructure development to link the two categories of regions, which has potential to increase the volume of trade between the region-classes thereby offsetting price swings that result from low supply or scarcity.

Previous studies have identified some of the major problems that constrain traders' stockholding ability, which include lack of commercial storage structures in market places, capital constraints and uncertainties regarding theft and fire losses. In addition to these problems, seasonal variability is also exacerbated by weather variability because most of the rural-urban roads are not paved and periods of much higher transfer cost is always envisaged. Programs that strengthen traders' entrepreneurial and capital management skills, and access to formal loans constitute a reasonable course of action to reduce seasonal volatility of maize price. Issues related to fire and theft damages could probably be minimized through development of credible insurance system.

Footnotes

1. This approach has two major disadvantages. First, consumer subsidy can make production unprofitable, thereby encouraging transfer of resources from food production to other sectors of the economy. Second, subsidized food production may drive wage for farm workers and the real exchange rate, thus making the country less competitive in international trade and slowing the overall economic growth through raising production cost in non-agricultural sector (World Bank).

2. Lack of agricultural credit curtails private transportation and storage capacity in Tanzania, this coupled with the problem of poor infrastructure discourages most traders to buying crops from remote areas, thus rural markets are generally very uncompetitive.

3. A grid search is conducted to identify a relevant value of a threshold. Also the order of the proper lag structure is based on the assumption that orders obtained from autocorrelation functions (ACFs) and partial autocorrelation functions (PACFs) in linear models provide a rough upper bound on non-linear autoregressive orders.

4. Prior to estimation data were tested for stationarity using Augmented Dickey-Fuller test. Results indicated that test statistics were below 5 percent critical value leading to rejection of the null hypothesis that the time series exhibits unit root. The order of the ARCH model was determined through assessment of statistical significance generated from the Lagrange Multiplier (LM) test with a lag length of 20. Results suggested that an autoregressive order of one was appropriate for the data. Empirical evidence suggests that misspecification of the variance equation may impact on the consistency of estimators of the mean parameters. Thus, attempts were made to model for alternative

forms such as linear and square root. However, results were not sensitive to the functional form of the error terms.

5. City is relatively more populated and highly developed than municipal or town. A town is a least populated and least developed.

6. Iringa and Ruvuma share boarders with other countries, however there are no direct infrastructure links to facilitate cross-boarder trade.

7. Mathematically, long-term risk premium is calculated as $\frac{RP_s}{1-\mu}$, where RP_s is a short-term risk premium and μ is a parameter estimate for lagged price (P_{t-1}) in the mean equation.

8. Efficiency is a very broad term. It encompasses a number of measures related to structure, performance and conduct.

9. Analysts had acknowledged the presence of informal cross boarder trade in the country, however the actual volume was not known during data collection.

10. This problem has not been addressed and it needs further investigations.

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Table 1: ARCH-M Estimate for Model 2 (Dependent: Mean P_{it} ; Variance h_{it})

	Pre-reform period		Post-reform period	
Variable	Mean	Variance	Mean	Variance
Constant	0.0701 (0.0090)**		-1.2326 (0.0740)**	
TR	0.0003 (0.0004)	0.0000 (0.0000)	0.0140 (0.0019)**	0.0000 (0.0000)
P_{it-1}	0.8196 (0.0077)**	0.0000 (0.0000)	0.4737 (0.0229)**	0.0163(0.0052)**
RE	-0.0024 (0.0131)	0.0000 (0.0011)	-0.0172 (0.0484)	0.0000 (0.0000)
δ_1	-0.2232 (0.0296)**		0.6668 (0.1674)**	
α_0 and α_1	0.0007 (0.0006)		0.0000 (0.0000)	
α_2 and α_3	1.0233 (0.0958)**		0.5502 (0.0890)**	
REG				
SI	-0.0071 (0.0079)	0.0000 (0.0000)	0.0836 (0.0387)*	0.0334 (0.0116)**
MR	0.0117 (0.0064)*	0.0000 (0.0000)	0.0787 (0.0578)	0.0798 (0.0094)**
DO	-0.0003 (0.0154)	0.0155 (0.0036)**	0.0222 (0.0297)	0.0033 (0.0078)
IR	-0.0987 (0.0197)**	0.0266 (0.0066)**	0.0298 (0.0267)	0.0000 (0.0000)
MB	-0.0472 (0.0221)*	0.0224 (0.0057)**	0.0725 (0.0288)**	0.0000 (0.0000)
SO	-0.0687 (0.0214)**	0.0324 (0.0086)**	-0.0474 (0.0303)*	0.0077 (0.0088)
S				
Jan-Mar	0.1144 (0.0164)**	0.0370 (0.0042)**	0.3567 (0.0280)**	0.0000 (0.0000)
Apr-Jun	0.0324 (0.0083)**	0.0000 (0.0000)	0.2115 (0.0396)**	0.0000 (0.0000)
Jul-Sep	0.0351 (0.0075)**	0.0342 (0.0022)**	-0.0485 (0.0255)*	0.0026 (0.0055)
N	665		665	
R^2	0.8030		0.8722	

Values in parentheses are asymptotic standard errors. ** Means statistically significant at 5% probability level. *Means statistically significant at 10% probability level.

Table 2: Relative Risk Premia for Maize

Period	Short-term risk premia	Long-term risk premia
Pre-reform	-0.27701642**	-1.535567737**
Post-reform	3.408819744**	6.476951822**

Values are calculated at mean-values of each period.

Table 3: Parameter Estimates for Model 4 (Dependent: Mean P_{it} ; Variance h_{it}).

Variable name	Mean	Variance
Constant	-1.1797 (0.0675)**	
TR	0.0108 (0.0013)**	0.0000 (0.0000)
P_{it-1}	0.4872 (0.0238)**	0.0180 (0.0051)**
RE	0.0740 (0.0410)*	0.0000 (0.0000)
Regional dummies		
SI	0.1346 (0.0292)**	
MR	0.0205 (0.0300)**	
DO	0.0394 (0.0267)	
IR	0.0364 (0.0299)	
MB	0.0814 (0.0332)**	
SO	-0.0460 (0.0255)	
δ_3 (risk term)	0.4685 (0.0943)	
α_4		0.0000 (0.0000)
α_5		0.8791 (0.0907)**
Seasonal dummies		
Jan-Mar	0.3272 (0.0251)**	0.0000 (0.0000)
Apr-Jun	0.1885 (0.0271)**	0.0000 (0.0000)
Jul-Sep	-0.0639 (0.0217)**	0.0119 (0.0048)**
MILLS		0.0000 (0.0000)
N	665	
R^2	0.8722	

Table 4: Parameter Estimates for Model 3 (Dependent: Mean P_{it} ; Variance h_{it}).

Variable name	Mean	Variance
Constant	-0.0314 (0.0265)	
TR	0.0027 (0.0005)**	0.0002 (0.0000)**
P_{it-1}	0.8660 (0.0093)**	0.0000 (0.0006)**
RE	-0.0122 (0.0165)*	0.0000 (0.0000)
Regional dummies		
SI	-0.0293 (0.0263)	
MR	0.0466 (0.0241)*	
DO	-0.0330 (0.0255)	
IR	-0.0818 (0.0235)**	
MB	-0.0116 (0.0263)	
SO	-0.0460 (0.0255)*	
δ_2 (risk term)	-0.2685 (0.0659)**	
α_2		0.0124 (0.0025)**
α_3		0.6933 (0.0617)**
Seasonal dummies		
Jan-Mar	0.2058 (0.0210)**	0.0396 (0.0054)**
Apr-Jun	0.0292 (0.0141)**	0.0000 (0.0000)
Jul-Sep	-0.0457 (0.0164)**	0.0118 (0.0030)**
DEV		0.0127 (0.0040)**
N	665	
R^2	0.9299	

Table 5: Parameter Estimates for Model 5 (Dependent: Mean P_{it} ; Variance h_{it})

Variable name	Mean	Variance
Constant	-1.1815 (0.0676)**	0.0000 (0.0000)
TR	0.0107 (0.0014)**	0.0181 (0.0051)**
P_{it-1}	0.4866 (0.0238)**	0.0000 (0.0000)
RE	0.0788 (0.0410)*	0.0000 (0.0000)
Regional dummies		
SI	0.1346 (0.0292)**	
MR	0.2005 (0.0300)**	
DO	0.0394 (0.0267)	
IR	0.0364 (0.0299)	
MB	0.0814 (0.0332)**	
SO	-0.0332 (0.0247)	
δ_4 (risk term)	0.4652 (0.0934)**	
α_6		0.0000 (0.0000)
α_7		0.8692 (0.0898)**
Seasonal dummies		
Jan-Mar	0.3252 (0.0251)**	0.0000 (0.0000)
Apr-Jun	0.1867 (0.0271)**	0.0000 (0.0000)
Jul-Sep	-0.0641 (0.0217)**	0.0118 (0.0048)**
BORDER		0.0000 (0.0000)
N	665	
R^2	0.8722	