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Effect of Trade liberalization on Volatility: The experience of Indian Agriculture

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Abstract

Trade liberalization in agriculture can be acceptable only if developing countries can be convinced of its benefits as this sector provides food security and livelihood to large sections. One of the serious apprehensions hampering negotiations is about the effect on market volatilities and the resultant implications for supply of products. In view of the contrary results suggested in theoretical and empirical literature, this study takes a different approach to model volatility of agricultural crop prices facing farmers using time series models to enquire whether trade liberalization has indeed increased unpredictability of prices. The EGARCH and EGARCH-M models were found to perform well in forecasting volatility, but food crops did not show any significant sign in this direction though two commercial crops were found to have shown increased volatility. A parallel analysis with supply responses also reinforces this finding by suggesting that responses to price variations have become more variable only for the same two commercial crops after trade liberalization in India.

Trade liberalization's effect on Volatility: The experience of Indian Agriculture

Nilabja Ghosh
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Agriculture has remained at the centre of the debacles at the World Trade Organization. This is a sector that provides food security and livelihood to large sections in the developing countries so that trade liberalization (TL)relating to agriculture can be acceptable only if these countries can be convinced of its benefits. The implications of TL for the developing countries therefore have called for scrutiny.

One of the serious apprehensions of the sceptics is about the effect of TL on market volatilities and the resultant implications for supply of products. As countries shed their barriers, global demand and supply increasingly get determined by a multitude of diverse forces emanating from different countries, each with its own domestic market realities, and the net effect coming as the market signal to the farmer is neither likely to persist nor is predictable in advance. The typically low elasticities of demand and supply of food articles could in principle enhance the chances of sharp changes occurring in price movements. The implication of volatility is especially serious for agriculture since crop production is largely resource and season specific and responding to short term and unexpected price movements cannot be easy for farmers. Further, to the extent that price becomes more important in guiding production, the supply responses reflect the volatilities of the market, creating severe challenges for the governments in the management of supplies and food security and even in macroeconomic planning. The possibility of volatility is undoubtedly an important factor behind the concerns of developing countries. On the contrary, Computable General Equilibrium Models (CGE) came out with more encouraging projections that the elimination of distortion by both developed and developing countries would increase international prices of agricultural products but bring down their variability (Anderson, 2004,2005). Indeed, the demand and supply curves facing a country could become more elastic with TL due to the responses coming from outside the domestic economy and these changes could reduce volatilities of prices. However in reality, there has been a widespread feeling that the Uruguay Round of multilateralism has not benefited the developing countries (World Bank, 2002, Grimwade, 2004 and Chand, 2002). The CGE models are also criticised for the poor underlying economic theory (Ackerman and Nadal, 2004, Ackerman, 2005, Jomo et al, 2008) and, with changes in certain assumptions, they can even imply contrary results like increased macroeconomic volatility and negative impacts on developing countries (Kraev, 2005). The recent negotiations in the Doha Development Round have therefore focused on issues of food and livelihood security, rural development and on Special Safeguard mechanisms (SSM) against import surges, price volatility and risk.

India is a large country in which agriculture is a critical component of the political economy. Not surprisingly, India has been an audible voice in the negotiations at the WTO. This paper examines on the basis of empirical evidence whether trade liberalization has indeed exacerbated the unexpected volatilities of agricultural (producer) prices in India and if so, what could be the likely time point of departure. This is done by systematic time series modelling of harvest time prices to look at the movement in price volatility. Further we also look at the supply responses in agriculture to enquire if the post-liberalization period witnessed a rise in the volatilities of supply. This is done by conventional econometric modelling of supply.

We have conducted the exercise on major crops raised in the main kharif (June to October) season when the country gets rainfall from southwest monsoon. These crops include the cereal rice which is the most important staple for food security, three coarse cereals jowar, bajra, and maize which are raised by poorer farmers in drier climates, a major oilseed crop groundnut grown in drier climates and cotton a representative important non-food crop. The last two crops are usually raised for commercial reasons but also enjoy considerable political significance. The data used cover wholesale price index with 1993-94 as the base, production, gross area under each of the crops, net irrigated area available for agriculture and rainfall and relate to the years 1975-76 to 2005-06.

Transitions in Indian agriculture

When India, a founding member, signed at the WTO to open up its market, the decision had expectedly created strong currents of arguments and dialogues. Quantitative exercises showed that India would have a comparative advantage in major crops including rice (Gulati et al , 1994). Although such projections were based on critical assumptions regarding the imperfection of markets and the intentions of competing countries (Sen, 1994), in retrospect, India did export rice in the initial period after the signing but subsequently also faced shortfalls resulting in import of the substitute crop wheat. Oilseeds were projected to be and in practice they proved to be importables. Other cereals (apart from main cereals rice and wheat) are only slightly traded and more dominantly exported in a minor scale.

India had a deeply interventionary agricultural policy since the 1960s a period, haunted by food crisis. The government was active especially in the food market and it administered prices and supported farmers through para-statal bodies[1] and the minimum support prices. External trade was severely restricted if not prohibited. The regulated regime did give way to a more market friendly and open agricultural economy that continues and also evolves today. What is the point of departure? Since the 1990s the economic regime in India has been undergoing a paradigm change. The year 1995 marked India's entry into the WTO and can be a natural answer to the question, but the rationale is not too easy to justify. In fact back in 1991 India had launched a domestic programme of stabilization and adjustment that promised to draw Indian agriculture closer to world prices. A series of measures leading up to 1995 such as abandonment of

[1] like Food corporation of India (FCI), National Agricultural Cooperative Marketing Federation Of India Ltd. (NAFED), Cotton Corporation of India (CCI), National Dairy Development Board (NDDB) etc.

canalization in case of exports, dismantling of quantitative restrictions for a large number of items and some adjustment of tariff rates could be the first signs of a new paradigm. While these policy changes were rudimentary to say the least, broad changes in external and macroeconomic policy especially in the regulation of foreign exchange and the dis-protection of the manufacturing sector could also have helped agriculture to move towards a new free market regime. The year 1995 saw the real opening up in terms of promise but even this year was just a beginning of another period of transformation. Domestic reforms continued over time (Government of India, Economic Survey, various) while countries over the world also worked for the dismantling of trade barriers as part of the WTO commitments. Moreover, the trade in cotton shifted from Multi Fibre Agreements to the transitory Agreement on Textile and Clothing (Sankar and Kalirajan, 2001) and towards the WTO disciplines in a phased timetable.

Framework

Agricultural commodities today serve both as assets and products incorporating the characters of both stocks and flows. As assets they are in many cases traded in the commodity and futures markets and are objects of speculations[2]. However, a sizeable part of demand for agricultural commodities is met from current production that enhances the carried over stocks. The dual nature can have its distinct influence on the dynamics of commodity prices. While in the case of stocks, the prices may be modelled on the basis of past information, current shocks impacting on the movements of crop prices can be significant. Production decisions of farmers in any growing season depend on their expectations which are again mostly made on the basis of the past realised prices. Farmers however have to allocate their resources among competing crops and take into account the prices of major inputs and even prices of other goods and services that enter into their cost of living. So, the relative prices rather than the absolute prices are important in their decisions. The weather performance can be seen as an important shock on the system. Given the price and the speculative stocks carried over from the earlier

[2] Such commodities need to be fairly durable and storable and this condition is satisfied in varying degrees by many agricultural products.

season, farmers undertake current production and add to the stocks to determine current supplies. The supply then interacts with demand from consumers and traders in the harvest period to determine the current price (P) and stock (Stock).

$$P_{t-1} \rightarrow (\text{Stocks}_{t-1} + \text{Production}_{t} - \text{Demand}_{t}) \rightarrow P_{t} \rightarrow \text{stock}_{t}$$

In this scheme, the linkage between the price with its previous value comes from not only stocks carried but also the current production and the government's responses. The harvest price is the representative price, so that the time period of our analysis is one year and decisions are viewed to be taken at annual intervals. There may however be continuity in consumption demand through the year but for simplicity we assume that all consumption demands are also met at the harvest period. This assumption can actually mean that consumers stock food at home (or storehouses) or that traders procure output immediately after harvest and sell from the stock (godowns) during the year.

Modelling volatility

While the standard deviation is often used in empirical studies to depict unpredictability, this inter-temporal statistic is a measure of instability over time and cannot fully convey the degree of risk involved. The unpredictability of the movements can be quantified when the component of the movement that is predictable on the basis of available information is factored out. The methodology for measuring volatility has undergone significant development in context of the literature on stock markets. Volatility of a risky asset is typically modelled in the literature on asset markets through the ARCH and the GARCH models (Engle, 1982) and their modified versions, in which past information is used to project the mean and also the variance around the mean price. The degree of deviation of such an informed prediction from the actually realised value is treated as news or innovation that becomes part of the information set for making future predictions. The entire class of time-series techniques shave been used extensively for modelling financial sector time series data which comes in high frequency but in this study we have used the same approach on annual data on agricultural prices for the sample period of 31 years to examine the effect of TL on price volatility. The frequency of data as used is necessitated by the compulsion of using harvest prices for the present purpose and the sample period commencing in the mid 1975 is decided taking into account the policy and technology paradigms in the country. So far, in literature such volatility models are not common in agricultural studies but despite the relatively shorter sample period and lower frequency of data, we have been able to show results that are not inconsistent with other supporting methods followed in this study.

Considering that the econometrician's information set is the set of past prices and innovations, the GARCH (p,q) model is expressed as Equations 1a and 1b in which for simplicity p=1, q=1.

Mean $Y_t = a0 + a1Yt - 1 + \varepsilon_t$ ….(1a)

Variance $\sigma_t^2 = b0 + b1\varepsilon_{t-1}^2 + b2\sigma_{t-1}^2$ ….(1b)

Although the ARCH and the GARCH models can estimate and forecast volatility of time series data, in practice the standard models are found inadequate in capturing some of the important features of the data. One interesting feature which is not considered by these models is the 'levarage effect', where conditional variance tends to respond asymmetrically to positive and negative shocks in errors. To solve this type of problem a dummy variable for cases of positive or negative past shocks has been used (Glosten et al, 1993, Zakoian, 1990, Rabemananjara and Zakoian, 2008). Alternatively, a non-linear GARCH model can also be used. For example, Nelson (1991) proposed an exponential GARCH or the so called EGARCH model based on the logarithmic expression of the conditional variability in the variable under study. Further, in the standard models the left hand side term in the variance equation is a squared term and necessarily needs to be positive (Bollershev, 1986, Patterson, 2000) so that, an unrestricted model may not be the best option. The EGARCH model in its appropriate specification is a suitable answer to the problem (Berument and Sahin, 2008) . The typical 'smile' effect of news as in the

ARCH model, may not hold true in real life, especially when governments intervene or when say a negative disturbance on returns (often termed as a 'bad' news to traders in the stock literature) has a greater effect of increasing variability in the subsequent period than a positive one. Theory is far from clear about the sign of the effect of news on volatility.

The E-GARCH model is presented in Equations 2a and 2b as

Mean $Y_t = a0 + a1Yt - 1 + \varepsilon_t$ …(.2a)

Variance $$\log\left(\sigma_t^2\right) = b0 + +b1\left|\frac{\varepsilon_{t-1}}{\sigma_{t-1}} - m\right| + b2\frac{\varepsilon_{t-1}}{\sigma_{t-1}} + b3\log\left(\sigma_{t-1}^2\right) \quad \ldots(.2b)$$

The asymmetry is captured by including the absolute term (the scaled disturbance minus the mean (m)). The parameter b_2 is a key coefficient which allows the positive or negative sign of the shock to incorporate news for the market over and above its magnitude and constitutes a leverage effect.

Another common question raised in the literature is the standard model's indifference to the well known risk-return tradeoffs, the possibility of risk aversion and the case of a risk premium (Golsten et al 1993). Higher volatility means greater risk for traders who would carry over inventory from one period to another and therefore demand greater premium. If such a period witnesses a rise of riskiness of multiple assets, a non-negative relation is possible. These possibilities are accommodated by the ARCH-M, GARCH-M or the EGARCH-M models in which the conditional variance or the measure of volatility enters the mean equation as a variable (Engle, Lilien and Robins, 1987). The GARCH-M model (not presented), and the EGARCH-M model (provided in Equations 3a and 3b) incorporate the time varying measure of risk in the mean equation of the relevant model.

Mean $Y_t = a0 + a1Yt - 1 + a3\left(\sigma_t^2\right) + \varepsilon_t$ …… (3a)

Variance $$\log\left(\sigma_t^2\right) = b0 + +b1\left|\frac{\varepsilon_{t-1}}{\sigma_{t-1}} - m\right| + b2\frac{\varepsilon_{t-1}}{\sigma_{t-1}} + b3\log\left(\sigma_{t-1}^2\right) \quad \text{......(3b)}$$

Modelling the crop prices

While modelling the crop prices, two distinctive features of this particular case are kept in view. First the commodities here are not simply assets carried over but are supplemented by current production as any flow variable. Like the stocks, the production decisions are also impacted by the known prices but such decisions are taken by producers who do not generally operate in the broader national and international markets, do little inventory planning (farmers hardly hold stocks for want of capacity) and have extremely limited access to information. The farmers' relevant price is generally the realised harvest price of the previous harvest. They typically sell in the period soon after harvest at the prevailing price and also plan production based on known price which could be the previous season's harvest price. Their production however is also influenced by other factors, most notably the weather, all of which is unknown before the on set of the sowing season. Such non price factors unfolding during the current growing period are treated shocks in this model.

A second feature that needs consideration is the important role often played by the government as a trader. Though an important objective of this particular trader is the achievement of national welfare rather than profit, government's trading decisions (purchases when price is low, sells when price is high, responds to expectations, stocks are larger when previous price was low and vice versa etc.) are not much different from the commercial trader. Thus under any argument in favour of a free market, the latter is viewed as a better mechanism to substitute the government so long as it is efficient. Nevertheless, it is useful to recognize that government intervenes purposively especially in food markets. It is also observed that government tends to act against price volatilities.

It has to balance the consumers' interest with the producers', the two often being contradictory (Mellor, 1966) to each other and the government tries to control inflation (to which prices of food articles act as inputs to protect farmers[3]. On the whole, a typical smile effect may not necessarily be expected in this case as large disturbances in price may be followed by active intervention on the part of government to bring down volatility. Further the presence of a downside or an upside bias cannot be ruled out in government interventions depending on policy priorities. The ' perceptions and responses can also vary in different situations.

Mean $Y_t = a0 + a1Yt - 1 + a2Yt - 1 + a3\left(\sigma_t^2\right) + a4\left(DTLM\right) + \varepsilon_t$ …… (4a)

Variance $\log\left(\sigma_t^2\right) = b0 + +b1\left|\frac{\varepsilon_{t-1}}{\sigma_{t-1}} - m\right| + b2\frac{\varepsilon_{t-1}}{\sigma_{t-1}} + b3\log\left(\sigma_{t-1}^2\right)\ b4\left(DTLV\right)$……(4b)

We have modelled the harvest period (October-February) prices with the ultimate objective of identifying any possible shift in volatility after the trade liberalization took place. This is done with the help of a dummy variable but in order to mark this point of shift, if any, the model must be well specified (Golsten et al, 1993). We have taken some care in specifying and estimating the model for price volatility. A generic form of the model is presented in equations4. In Table 1A in the appendix we have presented the standard GARCH model, the EGARCH model and the GARCH-M/EGARCH-M model in succession. Robust t-statistics are presented (Bollershev and Wooldridge, 1988, 1992). For estimating each model we have identified the lags based on the AIC and SBC criteria. For the selected specification in each case we have considered a shift for each year starting from 1991-92 and used a dummy variable (DTLV) for the ensuing years in the variance equation. Thus for a shift in 1995-96 the dummy takes a value of one for all the sample years starting with 1995-96 and zero in other years, and the for break in 1996-97, the dummy takes a value of one for the years 1996-97 onwards and so on. In all the

[3] The public distributions, open market sales and greater regulation on speculation and hoarding are some of the measures taken in times of soaring prices especially for the interest of the poorer classes and a hike in the procurement price and reinforced public procurement are not uncommon when prices fall.

alternative specifications we then looked at the significance levels of the coefficients of the shift variables. The earliest instance of continued significance of the dummy's coefficient is taken as the break point, making sure that the one time shift is sustained and care is taken to ensure there is no reversion during the post liberalization years. Thus short term pulse shifts are not what we looked for. In cases where no break was identified in the said manner, we moved to the next model reporting the basic model without a dummy. While the EGARCH and the GARCH-M/EGARCH-M model allow more flexibility, we have looked for the significance of the added variables in the variance equations at 10% level to decide our preference.

In each of the three models we studied the distributions of the errors reporting the skewness and kurtosis and also subjected the errors to the Sign and Size bias tests (Engle and Ng,1993) to make sure that no further asymmetric effects are there (Table 2A). The distribution test statistic we have reported is the probability based on Jarque-Bera (1980) test for normality. The auxiliary equations of the following form Equation 5 are estimated and the t-statistics of the coefficient of S-, e_ and e- and the F-statistics of the equations are reported as diagnostics.

$$v_t^{\,2} = \gamma_0 + \gamma_1 S^- + \gamma_2 \varepsilon^- + + \gamma_3 \varepsilon^+ \quad \ldots\ldots(5)$$

Where $S^- = 1$ if $\varepsilon_{t-1} < 0$ and

$=0$ otherwise

$\varepsilon^- = \varepsilon_{t-1} S^-$

$\varepsilon^+ = \varepsilon_{t-1} (1-S^-)$

and v_t^2 is the squared standardised (or scaled) residual.

Based on these diagnostic tests we have chosen a specification that appears to be the best. We also examined if there is a break in the mean equation in the same manner and accommodated it in the final model. The time point of shift of the mean (DTLM) may not be the same as that of the variance.

Results

Since the price series are likely to be stationary, the first differences (or returns) are considered for analysis. These series are stationary at 5% level. The mean of the transformed variable is highest for jowar and lowest for cotton but they are positive in all cases. The standard deviations are higher than the means in all cases indicating the frequency of negative absolute price movements. The variation measured by the coefficient of variation is highest for cotton and 4.63. The skewness is positive in all cases except maize and bajra but low in magnitude. The kurtosis is high for rice, jowar and groundnut (Table 1).

Table1: Descriptive statistics of the Prices (First differences) 1975-76 to 2005-06						
Descriptive	**Rice**	**Maize**	**Jowar**	**Bajra**	**Cotton**	**Groundnut**
Mean	4.95	5.95	7.20	6.20	3.97	4.93
Standard Deviation	6.00	17.20	20.38	21.66	18.40	12.00
Coeff. Of Variation	1.21	2.89	2.83		4.63	2.43
Skewnes	1.11	-0.11	0.15	-0.07	0.05	0.78
Kurtosis	4.14	3.01	5.14	2.79	2.99	4.49
Unit root test						
ADF-trend	-3.39	-7.17	-7.10	-6.31	-6.24	-5.67
ADF-no trend	-3.34	-7.23	-7.47	-6.36	-6.09	-5.52
Note: ADF statistic at 1% -3.66, 5% -2.96 1% 2.62						

In Table2 we examine if the prices have become more unstable after TL by comparing the coefficient of variation (CV) in the pre-TL period 1975 to 1995 and post TL period 1995-05. The CV has increased in all the crop cases and has even more than doubled for groundnut and cotton. Thus there is an indication that prices have become more unstable after TL, especially for the two commercial crops.

Table2: Instability of Price movements (First differences of Prices)						
1975-95	**Bajara**	**Maize**	**Jowar**	**Rice**	**Groundnut**	**Cotton**
Mean	6.08	5.76	6.68	4.64	5.72	6.01
Std.Dev.	15.358	15.38	17.61	4.74	10.07	15.86

Coeff. Variation	2.65	2.67	2.64	1.02	1.76	2.64
1995-2005						
Mean	7.49	5.60	8.49	5.63	3.44	-1.84
Std. Dev	30.18	20.37	24.77	7.81	14.87	22.59
Coeff. Variation	4.03	3.64	2.92	1.39	4.32	12.3

For each crop we have tried alternative specifications based GARCH, EGARCH, GARCH-M and EGARCH-M models. For food grain crops rice, jowar, bajra and maize the search for a shift in volatility was not fruitful. In the case of bajra a dummy for the period starting with 1991 gave a significant coefficient at 5% level for the EGARCH model only but since b_2 becomes insignificant and the specification fails the sign bias tests, we have not preferred the specification. The EGARCH-M model seems to perform the best as the coefficient a_3 is also significant. For jowar GARCH (2,1) is not satisfactory and the dummy specification does not work in any of the cases. The EGARCH is the best model again. For maize, the dummy specifications with a shift in 1991 both in mean and variance equation appear for both EGARCH and for EGARCH-M models but b_2 and the EGARCH coefficient b_3 are insignificant respectively, so we consider EGARCH-M with no dummy as the best. For rice the dummy is significant only for the GARCH-M model but the ARCH variable b_1 has an insignificant but negative coefficient and EGARCH with no dummy appears to be the best. For cotton the simple GARCH model does not produce a significant dummy but the dummy variable does have a significant coefficient in EGARCH model. In the EGARCH-M model coefficient b_2 is significant. Also for Groundnut the EGARCH with dummy is the best specification. The dummy has a significant effect in GARCH model and the EGARCH-M models but the GARCH effect becomes insignificant in the latter.

Thus on the basis of our selection of the best specifications in terms of significance of parameters and diagnostic tests of the errors, the commercials crops groundnut and cotton are found to have become more volatile in prices (as in the simple analysis with standard deviations in Table 1) but the food grains do not show this effect. The coefficients of the lagged conditional variance terms are less than one so that volatility is not explosive and those of lagged variables in the mean equations are usually negative suggesting a tendency for cyclical behaviour. It is interesting to note that the coefficient b1 is negative and b2 is positive in all cases indicating that past news brings down volatility so that the news effect curve is likely to be an inverted-U. Asymmetric slope effect is suggested in all cased so that negative innovations are likely to be associated with faster reduction of impending volatility brought about possibly by public intervention while positive innovations (good news to the traders) by slower reduction due to both interventions and contrary market speculations. The results would depend on the interactions between responses of the government and the traders. The coefficient of past volatility on expected returns measured by the parameter a_3 is negative in both cases where EGARCH-M specification is selected signifying a negative risk return relation.

Table3: Models specifications selected by comparison of the diagnostics			
Crop	**Model**	**Shift in Volatility**	**Year**
Bajra	EGARCHM	NONE	-
Groundnut	EGARCH	+	1997
Jowar	EGARCH	NONE	-
Cotton	EGARCH	+	1999
Maize	EGARCHM	NONE	-
Rice	EGARCH	NONE	-
Note: The specifications are provided in Appendix Table 1A			

Effects on supply responses

We now examine the changes in supply responses and significance of price signal in the time of liberalization. For this we first estimate econometric supply response functions assuming that expectations are based on the past. We have considered supply to be determined in two stages (Narayana and Parikh, 1981, 1987), the first being farmers' decision on area allocation to the crop and the second being the determination of the yield rate. Crop area is a function of past harvest price or revenue, available total irrigated area, fertilizer price of the sowing season and sowing season rainfall. The lagged area is retained to allow partial adjustment in the Nerlovian convention (Nerlove, 1958). Yield is a function of past crop price and fertilizer price that are viewed as influences on farmers' decisions on input use, irrigation intensity measured as irrigated area available deflated by the crop area (estimated area from the first stage is used to avoid endogeneity) and the growing season rainfall. Fertilizer is considered as the major input used. The variables used take into account the information that might be available to farmers at the time of decision taking. Prices are deflated suitably to arrive at the relative prices.

$A_t = \alpha_0 + \alpha_1 X1 + \alpha_2 X2 + \alpha_3 X3 + \alpha_4 X4 + \alpha_5 X5 + \alpha_6 X6 \ldots .6a$

$Y_t = \beta_0 + \beta_1 X7 + \beta_2 X8 + \beta_3 X9 + \beta_4 X10 + \beta_5 X11 \ldots .6b$

A=Crop area (in hectares)
Y=Crop yield rate per hectare (kg/ Hectare)
X1= Harvest price of crop (Lagged) deflated by wholesale price of all commodities
X2= Harvest price of substitute crop (Lagged) deflated by wholesale price of all commodities
X3= Fertilizer price of two growing months deflated by wholesale price of all commodities
X4= Irrigated area proxied by canal area
X5= Rainfall in sowing season
X6= Area under crop lagged
X7= Harvest price of crop (Lagged) deflated by fertilizer price
X8= Harvest price of substitute crop (Lagged) deflated by fertilizer price
X9= Irrigation intensity variable (deflated by the estimated area)
X10=Rainfall during growing months
X11= Square of the growing season rainfall.

The equations are linear in all variables except rainfall in which the quadratic term is allowed. The final specification is chosen on the basis of the significance levels and the signs of the variables. Finally supply is the product of area and yield.

$Q_t = A_t \times Y_t$ ….6c

The equations estimated are presented in Appendix tables 3A and 4A. The supply responses are expectedly positive to the crop prices and negative to substitute crop and input prices. We have then used the model to find out if price movements after liberalization have made a significant difference to supply in a positive way and to the volatility of supply. For this purpose we have first considered a fixed set of price levels. For convenience we considered the prices of products and fertilizer prevailing in the year 1995-96. Keeping these price levels unchanged and allowing the other variables to take the realized values we simulate the areas (A), yields (Y) and the resultant supplies (Q) using equations 7. Comparing the supplies simulated at constant prices with the estimated supplies we isolate the effects of the price variations. We then compute

$PSE_t = QE_t - QCP_t$ ….7a

And

$PSVE_t = (QE_t - QCP_t)^2$ ….7b

Where PSE is the effect of price variation, PSVE is its square, QE is the estimated supply (at actual variable values) and QCP is the simulated supply under constant price (1995-96). We consider three points of time A, B and C, where A= 1985-86, B= 1995-96 and C= 2005-06 and calculate the effect of price variations through the two eleven year periods i.e., A to B and B to C. The variable QE measures the series of supply estimated with our model in the sample period and QCP is a series of hypothetical supply that would have been estimated in the sample period if only the non-price factors varied. The deviations between the two series vary in sign depending on price movements. The means of PSE and PSVE in the two are reported in Table4. The two periods mark the pre and post trade liberalisation era if 1995-96 is treated as the watershed.

Table 4: Price Effect on supply and supply volatility				
	PSE		PSVE	
	Period 1 1985-86 to 1995-96	**Period 2** 1995-96 to 2005-06	**Period 1** 1985-86 to 1995-96	**Period 2** 1995-96 to 2005-06
Bajra	-0.060	0.065	0.356	0.282
Cotton	-1.216	-1.256	1.721	1.948
Groundnut	0.170	-0.596	0.367	0.532
Jowar	-.918	-0.148	1.416	0.138
Maize	0.174	-0.068	0.208	0.072
Rice	-.293	0.684	14.532	1.698

The negative deviations in supply PSE as for bajra, cotton, jowar and rice in the pre-TL period (period 1) signifies that estimated supplies fall short of those expected if 1995-96 prices prevailed. For bajra, the supplies expected with varying realised prices overshot those with 1995-96 prices on the average, so that the price effect was positive after TL. Comparing the signs and magnitudes in the two periods, the supply effect of price changes is found to be positive bajra, (-0.06 to 0.06), jowar (-0.92 to -0.15) and rice (-0.29 to 0.07) but TL could have witnessed an adverse impact through price on cotton, groundnut and maize. Comparing the PSVE, cotton and groundnut are the only two crops for which the variability of the supply effect could have increased between the two periods. For rice, there is substantial reduction.

Conclusion

A compelling argument stalling the trade negotiation at the WTO is that trade liberalization goes against the interests of the developing countries owing to its volatility enhancing effects on prices. A simple comparison of the standard deviations establishes the fact the prices of major agricultural products have become more unstable in India in the period following the signing of the WTO agreement. However, treating the agricultural products as risky assets in whose markets, the government also operates for welfare, when the predictable component of the price is corrected for and the deviations around the expected values are modelled carefully, price volatility estimated as the predictable variance is found to have increased after trade liberalization only in respect of two out of the six crops considered. These crops are commercial crops groundnut and cotton both of which are traded in the global market, while the foodgrain crops seemed to have maintained status quo. A further exercise in supply modelling provides reinforcing evidences. As in the case of prices, the trade liberalization period has seen an increase in the volatility of production in the cases of cotton and groundnut while the foodgrain crops became more stable. Thus trade liberalization in the present condition of the domestic policy regimes does not appear to have had an adverse effect on food security and food management. However, to the extent that farmers in dry areas and belonging to the poorer classes cultivate groundnut or cotton for a livelihood, trade liberalization's effect of welfare and poverty may be hard to defend.

APPENDIX TABLE 1-1A: Estimated Equations for Volatility with alternative Specifications: **Bajra**										
Crop **Bajra**	Model (GARCH)		Model2 (GARCH-Dummy)		Model3 (EGARCH)		Model 4 (EGARCH-Dummy)		Model 5 (EGARCH-M)	
	Coeff	Zstatistic	Coeff	Zstatistic	Coeff	Zstatistic	Coeff	Zstatistic	Coeff	Zstatistic
Mean Equation										
a0	7.26	4.24	13.12	6.31	17.009	5.77	7.04	9.72	45.26	4.99
a1	-0.56	-3.92	-0.74	-13.26	-0.754	-8.39	-0.66	-33.05	0.02	0.10
a2	-0.27	-1.91	-0.51	-4.33	-0.606	-7.48	-0.39	-6.32	-0.04	-0.21
a3									-0.14	-24.04
a4										
Year										
Variance Equation										
b0	-1.63	-0.27	208.31	1.94	11.06	14.95	7.29	4.16	4.66	34.39
b1	-0.24	-1.13	-0.19	-2.35	-0.98	-2.38	-2.26	-3.85	-0.22	-1.65
b2					-0.26	-1.38	0.60	2.57	0.35	2.71
b3	1.31	7.73	0.44	1.05	-0.81	-6.79	-0.26	-0.87	0.19	261.50
b4			104.77	1.84			2.46	3.78		
Year			1995				1995			
Log likelihood ratio	-124.25		-127.46		-127.22		-121.93		-129.16	
Note: For parameters in all Tables 1-1A to 1-6A see equations 4 in text. Parameter b_4 corresponds to the dummy for TL.										

TABLE1-2A : Estimated equations for Volatility using alternative specifications: **GROUNDNUT**

Parameters	Model 1 (GARCH)		Model 2 (GARCH-Dummy)		Model 3 (EGARCH-Dummy)		Model M4 (EGARCH-M-Dummy)	
	Coeff	Zstatistic	Coeff	Zstatistic	Coeff	Zstatistic	Coeff	Zstatistic
Mean Equation								
a0	4.98	3.89	4.24	2.46	10.23	20.09	9.75	19.84
a1								
a2								
a3							-0.24	-2.04
a4								
Year								
Variance Equation								
b0	-3.009	-1.12	3.47	8.89	4.28	9.03	4.94	9.55
b1	-0.198	-0.95	-0.20	-2.29	-1.81	-3.25	-1.55	-4.08
b2					0.48	2.13	1.21	3.85
b3	1.314	6.63	1.18	18.27	0.34	8.27	0.09	0.82
b4			50.71	3.01	1.37	4.60	1.09	3.01
Year			1997		1997		1997	
Log likelihood	-120.53		-116.12		-118.87		-119.24	

TABLE1-3A : Estimated equations for Volatility using alternative specifications- **JOWAR**

Parameters	Model 1 (GARCH)		Model 2 (EGARCH)		Model 3 (EGARCH-M)	
	Coeff	Zstatistic	Coeff	Zstatistic	Coeff	Zstatistic
Mean Equation						
a0	14.19	5.99	11.58	15.05	14.41	10.42
a1	-0.14	-2.28	-0.21	-9.71	-0.16	-5.95
a2	-0.45	-2.89	-0.60	-8.29	-0.56	-12.55
a3					-0.01	-8.28
a4						
Year						
Variance Equation						
b0	247.45	1.01	5.87	6.52	5.26	12.20
b1	-20	-1.52	-2.46	-2.72	-1.79	-4.22
b2			1.21	9.81	0.90	4.65
b3	0.46	0.83	0.26	20.31	0.29	4.71
b4						
Year						
Log likelihood	-129		-116.13		-122.05	

TABLE 1-4A : Estimated equations for Volatility using alternative specifications- **COTTON**						
Parameters	MODEL 1 (EGARCH)		MODEL 2 (EGARCH- Dummy)		MODEL 3 (EGARCH-M)	
	Coeff	Zstatistic	Coeff	Zstatistic	Coeff	Zstatistic
Mean Equation						
a0	4.25	2.97	5.03	10.25	-11.30	-1.67
a1	-0.23	-2.77	-0.16	-2.60	-0.43	-4.31
a2	-0.46	-5.33	-0.29	-4.41	-0.73	-5.64
a3					.104	2.70
a4						
Variance Equation						
b0	0.72	0.14	2.94	5.21	1.20	1.90
b1	-0.21	-0.94	-1.73	-2.88	0.66	4.57
b2			1.11	7.34	0.11	1.23
b3	1.29	6.42	0.64	17.64	0.67	6.89
b4			0.66	2.89		
year			1999			
Log likelihood ratio	-117.17		-113.60		-118.02	

TABLE1-5A : Estimated equations for Volatility using alternative specifications- **MAIZE**

Parameters	Model 1 (GARCH)		Model 2 (EGARCH)		Model 3 (EGARCH- Dummy)		Model 4 (EGARCH-M-Dummy)	
	Coeff	zstatistic	Coeff	zstatistic	Coeff	zstatistic	Coeff	zstatistic
Mean Equation								
a0	12.25	5.88	12.85	54.9	10.04	18.17	8.69	60.12
a1	-0.59	-8.03	-0.97	-36.75	-0.84	-23.83	-832	-84.76
a2	-0.39	-3.72	-0.48	-13.42	-0.59	-10.505	-0.61	-12.55
a3							0.02	1.39
a4					12.86	8.15	12.97	11.59
year					1991		1991	
Variance Equation								
b0	17.14	1.26	5.01	9.06	4.53	5.28	5.03	6.01
b1	-0.18	-1.92	-2.24	-3.78	-2.18	-2.08	-2.67	-2.95
b2			1.14	16.25	0.06	0.12	-0.86	-1.07
b3	1.10	9.81	.035	41.76	0.19	2.13	0.04	0.36
b4					1.55	9.09	1.76	4.81
year					1991		1991	
Log likelihood	-119.57		-111.9		-106.92		-105.19	

TABLE 1-6A : Estimated equations for Volatility using alternative specifications- **RICE**								
Parameters	Model 1 (GARCH)		Model 2 (EGARCH)		Model 3 (GARCH-M)		MODEL 4 (GARCH- Dummy)	
	Coeff	Zstatistic	Coeff	Zstatistic	Coeff	Zstatistic	Coeff	Zstatistic
Mean Equation								
a0	2.73	4.81	4.11	39.49	8.31	16.23	20.37	4.09
a1	0.45	3.75	0.16	2.61	0.51	4.01	0.32	1.59
a2								
a3					-0.19	-2.03	-0.58	-3.57
a4							-11.98	-3.06
year							2000	
Variance Equation								
b0	0.80	0.74	2.65	6.99	32.25	3.04	5.79	1.26
b1	-1.97	-0.91	-1.61	-3.37	0.29	1.88	-0.01	-0.24
b2			0.87	4.05				
b3	1.19	6.15	0.57	18.08	-0.52	-15.62	0.79	4.62
b4							-7.05	-1.97
year							2001	
Log likelihood ratio	-90.97		-82.97		-93.35		-88.96	

Appendix Table2: Diagnostic tests for selection of Volatility Equations							
Residual Test				**Sign Bias Test**			
BAJRA	**SKEWNESS**	**KURTOSIS**	**PROBABILITY (JB)**	**S^-**	**e^-**	**e^+**	**F-statistic**
GARCH	0.487	3.052	0.552	-089	0.48	-1.07	0.645
GARCH-Dummy	0.424	3.108	0.633	-1.84	-5.24	0.58	9.283
EGARCH	0.507	3.173	0.517	-0.35	-0.25	0.41	0.350
EGARCH-Dummy	0.351	2.954	0.734	-1.51	-0.98	-0.6 4	0.773
EGARCH-M	0.507	3.172	0.52	0.899	0.491	1.09	0.643
GROUNDNUT							
GARCH	1.022	4.445	0.015	-3.02	-1.25	-1.52	3.215
GARCH-Dummy	1.022	4.445	0.015	-0.07	-0.82	-0.05	0.301
EGARCH-Dummy	1.022	4.445	0.015	0.09	-0.06	0.55	0.111
EGARCH-M-Dummy	1.039	4.272	0.019	0.28	-037	-1.64	0.214
COTTON							
EGARCH	0.455	4.226	0.233	0.703	0.039	2.29	1.829
EGARCH-Dummy	0.332	3.735	0.542	-1.21	-4.351	0.001	6.753
EGARCH-M	-822	3.856	0.117	-0.198	0.016	0.475	0.216
JOWAR							
GARCH	0.491	2.961	0.547	-1.373	0.037	-0.909	0.849
EGARCH	0.759	2.608	0.215	0.089	1.191	-0.718	0.645
EGARCH-M	0.653	2.499	0.295	-0.537	0.652	-1.013	0.534
MAIZE							
GARCH	0.417	3.044	0.646	-1.659	-0.307	-0.695	1.326
EGARCH	-0.171	3.913	0.553	-0.491	0.004	0.507	0.525
EGARCH-Dummy	0.652	3.053	0.345	1.278	-0.869	-0.852	0.775
EGARCH-M-Dummy	-0.238	3.932	0.504	-0.767	0.0017	-0.205	0.335
EGARCH-M	0.899	3.442	0.120	0.436	0.688	0.305	0.87
RICE							
GARCH	0.436	4.986	0.048	-1.041	-0.332	-0.351	0.412
EGARCH	0.841	4.317	0.053	0.481	0.161	-0.369	0.303
GARCH-M	1.319	4.8202	0.001	-0.328	-0.61	0.463	0.207
GARCH-Dummy	0.646	4.081	0.159	-0.135	-0.469	0.063	0.087
Note: Probability is based on Jarque-Bera (JB) test for Normality. Normality test is based on ordinary residuals, sign test on standardised.							

Table 3A: Area equations for Supply responses									
	CONT.	**X1**	**X2**	**X3**	**X4**	**X5**	**X6**		**R^{-2}**
Bajra	1290.6	**3922**	**-2536**			14.98	0.45		0.59
	(.59)	**(3.51)**	**(-2.48)**			(3.34)	(3.61)		
Cotton	806.6	2246	- 888		0.03	4.93	0.62		0.79
	(0.84)	(5.33)	(-3.54)		(1.87)	(2.28)	(5.22)		
Groundnut	850.9	5452	- 1202			5.79	0.67		0.73
	(1.49)	(4.71)	(-3.59)			(2.94)	(8.12)		
Jowar	2275	**1033**	**-236**		- 0.14	- 2.17	1.02		0.98
	(1.93)	**(2.76)**	**(-1.4)**		(-3.45)	(-1.11)	(48.11)		
Maize	-1653.2	**529**	**-435**			3.25	1.18		0.89
	(-2.1)	**(1.78)**	**(-2.27)**	-236		(2.87)	(13.55)		
Rice	21862.5	1103.18	- 2691.03	(-1.42)	0.35	20.48	0.13		0.71
	(2.91)	(2.40)	(-1.83)		(2.10)	4.96)	(0.64)		

Table 3b: Yield equations for Supply responses						
	CONT.	**X7**	**X8**	**X9**	**X10**	**X11**	**R^{-2}**
Bajara	-914.58	336.74	- 218.20	150.91	3.41		0.61
	(-3.50)	(1.86)	(-1.65)	(5.17)	(3.15)		
Cotton	-921.48	153.93			14.19		0.82
	(-1.14)	(2.03)			(1.78)	(-1.79)	
Groundnut	-664.28	312.32	-312.32	102.49	4.39		4.39
	(-2.41)	(2.06)	(-1.71)	(4.68)	(3.73)		
Jowar	176.15	399.50		9.84	1.10		0.61
	(1.19)	(3.65)		(1.53)	(1.77)		
Maize	-4001.77	304.00			53.30	- 0.13	0.87
	(-3.19)	(2.22)			(4.81)	(-4.62)	
Rice	-51.57			1025.15	3.49		0.84
	(-0.25)			(3.80)	(4.08)		

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