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**Resilience of Indian Agriculture to External Shocks: Analyzing
through a Structural Econometric Model**

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Abstract

Is Indian agriculture resilient to external shocks? This question has assumed considerable importance ever since macroeconomic reforms were implemented from the early nineties. As a result, the agricultural sector was exposed to sudden disturbances caused not just by the demand and supply conditions within the country, but also by volatility in world market price, exchange rate and surge in imports. This paper aims to evaluate the magnitude of sensitivity of agriculture to these factors and other changes, and explores policy options that may neutralize their adverse effects, maintain price incentives and stability. The analysis is based on three important tradable commodities. A structural econometric model is applied to each, separately under the exportable and importable scenarios from 1980-81 to 2002-03. Broad findings reveal agriculture to be increasingly driven by an incentive structure based on its linkages with world market price, exchange rate and other factors. Counterfactual simulation experiments indicate that due to trade and price policies, commodity prices and output tend to be much more resilient to various shocks compared to the exports and imports.

This paper is an abridged version of Chapter 7 in author's forthcoming book: "Trade Liberalization and Indian Agriculture". Thanks are due to two anonymous referees for their valuable suggestions in improving the draft.

I Introduction and Contextual Framework

The Structural Adjustment Programme initiated from 1991 and the subsequent implementation of the UR AOA has brought significant changes in the structure of agricultural trade in India. Agricultural exports account for nearly 7 percent of total output, constituting a major share of basmati rice, oil meals, sugar, tea, coffee and spices. Imports are driven by pulses, wheat, rice, vegetable oils (edible), cereal preparations and cashew nuts. Though agriculture exports and imports have experienced positive rates of growth from 1990-91 to 2007-08, the share of former in total national exports has declined from 18 percent to 10-12 percent during this period and that of the latter has hovered between 3 and 5 percent except in 1998-99 and 1999-2000 when the import share reached a peak of 8 percent. The overall net trade position is clearly one of a surplus with significant spikes and troughs, indicating that globalization and trade liberalization measures have, in effect, influenced agriculture over the period. Also, prices of several commodities are beginning to be in line with world market prices, suggesting a greater integration of domestic markets with world markets. But at the same time, this sector is exposed to drifts, which could be attributed to fluctuations in global commodity prices, growing competition, demand and supply conditions within the country and other unexpected exogenous impulses. The government is thus, bound to implement measures to (a) cope with volatility in international prices that often transcend to domestic markets, which may deprive millions of people from essential commodities, (b) maintain production and price incentives to encourage exports, and handle the situation if imports surge, and (c) deal with situations arising due to drought and other unforeseen situations arising within the economy.

In this context, the following questions have been raised. First, what is the impact of structural and macroeconomic policies on agriculture? Second, to what extent agriculture prices, trade and output is sensitive to untoward situations arising in a freer trade regime? Third, what is the relative importance of external factors viz. world market price, tariffs and exchange rate and internal factors viz. hike in oil price, low fertilizer subsidy and poor rainfall impacting agriculture? Fourth, which of the trade, macroeconomic and sector specific interventions would make agriculture more resilient to such likely disturbances? These issues assume importance as the proponents of trade liberalization strongly believe that implementation of liberal macro and sectoral policies would correct the 'neglect of agriculture' that is long due. Their arguments rest on reduction in protection to manufacturing sector and hence, an improvement in terms of trade in favour of agriculture, which in turn, would augment capital

formation, competitiveness at the global level, higher production exports and growth. A favourable incentive structure, along with better technology, irrigation and infrastructure would determine the level of acreage, output, exports and imports. Those who oppose new economic policies express a deep concern about the future of India's agriculture under the pressure of liberalization and multilateral trading rules, and their adverse impact on farmers' income, prices, food security, employment and poverty.

This study aims to test two hypotheses. First, trade and macroeconomic policy changes have positively influenced agriculture prices, trade, acreage and production, and second, output and hence growth is resilient to unexpected divergences in the macro conditions and external and internal factors. In all, five alternate scenarios of change to which Indian agriculture may be sensitive to are considered. These are variations in (a) world commodity price (b) exchange rate (c) tariffs (d) rainfall, and (e) support price. The analysis is based on three tradable commodities, viz. wheat, sugar and groundnut seed. The choice of these crops is determined by changes in their area share in gross cropped area and external trade over time. For each commodity, a structural econometric model is used, separately under the exportable and importable scenarios from 1980-81 to 2002-03. The structural econometric model is preferred over other models as it (i) can easily incorporate Nerlovian framework, (ii) enables to study inter-linkages between sector specific variables with other sectors, and (iii) is suitable for forecasts/simulations under alternate scenarios¹.

The model represents a simultaneous equation system of four behavioural equations and a few identities. The impact of key external factors viz. world price, exchange rate and tariffs along with other exogenous variables viz. production, support price, procurement, rainfall, irrigation, technology etc. is quantified on four endogenous variables viz. price, export-import, area and yield. The equations are estimated individually and simultaneously in double log form using OLS and 3SLS procedures. The estimates obtained are used to calibrate a simulation over the observed time period. Simulations are done by conceiving 'what would happen if' best and worst scenarios wherein one time change or multiple changes are introduced in the exogenous variables at a time and their impact on endogenous variables is examined. The hypothetical divergences are described under the optimistic (best) and pessimistic (shock) scenarios based on the maximum

¹ Since time series models usually suffers from the problem of multicollinearity, auto correlated error term, omitted variables and spurious regression due to non-stationarity of data, care has been taken to minimize such effects by appropriately specifying variables and improving estimation procedures.

and minimum annual percentage change in the selected exogenous variables in the past. In each case, the model is first validated. A change is then introduced and the predicted values of endogenous variables are estimated for 2000-01, 2001-02 and 2002-03 using the Gauss-Seidel method. The base run values of endogenous variables are compared with their respective simulated values to analyze the degree of resilience of agriculture to unexpected changes.

In what follows, section II explains the econometric model in terms of behavioral equations and identities followed by commodity-wise results on the impact of various factors on agriculture. Section III presents simulation model and results of validation exercise. Section IV describes various optimistic and pessimistic scenarios that may impinge upon the performance of agriculture in an open economy and analyses results obtained from simulation exercises. Section V summarizes key findings obtained and their implications.

II Quantification of Macroeconomic and Agriculture linkages

Theoretically, the linkages between agriculture and macroeconomic factors and policies can be analysed through world market price, global conditions, macroeconomic policies viz. exchange rate, trade (tariff and non-tariff barriers) and sectoral policies viz. support price, marketing and procurement (Schuh 1974; Chambers and Just 1981; In and Mount 1994; Mamingi 1996; Schiff and Valdes 1998). Though macroeconomic and sector specific policies are inter-linked, the effect of the former on producers' incentives is stated to be indirect and that of the latter direct. A quantification of the impact of macro conditions, policies and of several unforeseen situations on agriculture has been based on both economy wide macro modeling and time series econometric models (see among others, Narayana et al., 1987, Lassaad and Womack, 1998, Ardeni and Freebairn 2002; Bhattacharya and Kar, 2007; Bhanumurthy and Kumawat, 2010). Sector specific models have also been developed in assessing the growth performance of agriculture in totality and separately for foodgrains and non-foodgrains (Narayana 1989; Storm 1993; McKay, Morrissey and Vaillant 1998; Gulati and Kelley 1999; Kalirajan and Bhide 2003).

Some of the possible scenarios that have been considered from the supply as well as demand sides include deceleration in the volume of world trade, sudden capital outflow, hike in oil price, fiscal profligacy of the government, increase in price of fertilizer and food, exchange rate depreciation, tariffs and monetary shocks. Broad results provide evidence in favour of significant interactions between macroeconomy and agriculture over a period of time. However, the relative importance of various factors impacting agriculture differs across countries, sectors and

commodities, which could be due to different time periods considered, specification of variables and choice of the model. The findings indicate that the performance of agriculture, and also of the economy as a whole would not be the same in a situation of any change in exogenous factors, which in due course may also affect the overall economic system through various channels. Such exogenous impulses, if happen may positively influence growth as has happened in the case of technological breakthroughs or may have adverse impact in a situation of global recession or hike in international oil price. Such shocks often cause unpredictable changes in the aggregate demand and short run aggregate supply, thereby inducing fluctuations in the short run growth rate (Bhattacharya and Kar 2007).

The above theoretical and empirical linkages have provided a framework for analysis in this paper. The model that is used represents a simultaneous equation system of four behavioural equations and a few identities as follows.

For Exportable Commodity:

$$\begin{aligned} P_e &= P_w * \text{Exchange Rate} \dots\dots\dots(1) \\ P_d &= f(P_e, \text{MSP, Production, Procurement, Export}) \dots\dots\dots(2) \\ \text{Export} &= f(P_e/P_d, \text{Stock, Production, Procurement, World Income, Openness}) \dots\dots(3) \\ \text{Area} &= f(\text{Lagged } P_d/I_p, P_c, \text{Rainfall, Irrigation, Technology, Risk, Road Density,} \\ &\quad \text{Lagged Crop Area}) \dots\dots\dots(4) \\ \text{Yield} &= f(\text{Rainfall, Fertilizer consumption/GCA, Irrigation, Technology}) \dots\dots\dots(5) \\ \text{Production} &= \text{Crop Area} * \text{Yield} \dots\dots\dots(6) \end{aligned}$$

For Importable Commodity:

$$\begin{aligned} P_i &= P_w * \text{Exchange Rate} \dots\dots\dots(1) \\ P_{it} &= P_i * (1 + \text{Tariff}) \dots\dots\dots(1a) \\ P_d &= f(P_{it}, \text{MSP, Production, Procurement, Import}) \dots\dots\dots(2) \\ \text{Import} &= f(P_{it}/P_d, \text{Stock, Procurement, PDI, Openness, Dummy}) \dots\dots\dots(3) \\ \text{Area} &= f(\text{Lagged } P_d/I_p, P_c, \text{Rainfall, Irrigation, Technology, Risk, Road Density,} \\ &\quad \text{Lagged Crop Area}) \dots\dots\dots(4) \\ \text{Yield} &= f(\text{Rainfall, Fertilizer consumption/GCA, Irrigation, Technology}) \dots\dots\dots(5) \\ \text{Production} &= \text{Crop Area} * \text{Yield} \dots\dots\dots(6) \end{aligned}$$

Where,

Er is nominal exchange rate in Rs./Dollar;

Pw is the world reference price in US dollars;

Pi and Pe are world reference price in Rs./tonne and represents export (fob) price and import (cif) price of commodities;

Pd is wholesale commodity price in domestic markets in Rs./tonne;

Pc is price of competing crop in Rs./tonne;

Ip is input price represented by fertilizer (NPK) in Rs./tonne weighted by consumption of NPK;

Irrigation is represented by gross irrigated area under the crop (GIA) in 000' ha or irrigation ratio i.e. GIA under a crop/Crop Area;

Technology is represented by own crop yield, yield of competing crop (yieldc) in kg/hectare or relative yield i.e. ratio of own crop yield to competing crop yield (yieldc);

MSP/SMP is minimum support price as fixed by the government in Rs./tonne;
PDI is personal disposable income in India in Rs.;
Dummy represents non-tariff barriers and other factors not captured by specified variables;
Openness is captured indirectly through India's share in world trade and/or ratio of export + imports to GDP agriculture.

To begin with, domestic price of a commodity (P_d) under exportable/importable scenario is postulated to be determined by export/import price (P_e/P_i), which, in turn is taken to be exogenously influenced by world reference price, exchange rate and tariff in case of importables. Other factors that affect prices are support price, procurement, production and absolute volume of trade. Lags are used in some equations to incorporate the dynamic behaviour. Commodity export is determined by export price/domestic price indicating competitiveness, stocks with government, procurement, world income and openness of agriculture to world trade. Theoretically, all these variables are expected to have a positive sign. In the case of import function, the expected sign of relative price, stocks and procurement is expected to be negative and that of income to be positive. Dummy is specified to capture the effect of NTBs and other factors, if any². Since most of the restrictions got removed only from 1999 when India was asked by the WTO to replace QRs with tariffs, the value of dummy is taken as 1 from 1980-81 to 1998-99 and 0 from 1999-2000 to 2002-03. Its expected sign is negative, which implies that external trade will get a boost with decrease in QRs. As NTBs are to be replaced by tariffs, the tariff equivalents of NTBs were also tried as an explanatory variable in place of dummy. The results, however, remained unchanged.

Crop acreage is influenced by price incentives, which is explained by profitability, defined as ratio of output price to input price (fertilizer). Assuming that farmers are profit maximizers and also that trade, exchange rate and price policies have created a positive environment through increase in price, this variable is expected to be positive. An increase in price of competing crop is likely to yield a negative influence on acreage. Other factors, termed as non-price may exert positive influence on area. The variable risk is expected to bear a negative sign. Lagged dependent variable represents partial adjustment i.e., farmers respond slowly to changes in relative prices and other variables in the short run. However, in the long run certain desired levels of acreage and output may be achieved.

² NTBs could be obtaining permits/license, quota/quantitative ceilings, minimum export price, canalized and permitted through official agencies etc. Though most of these barriers got removed from 1999-2000, a few continue on grounds of health and food security.

Data on each variable is collected from Agriculture Statistics at a Glance, FAO Trade Statistics and Reports of Commission on Agricultural Cost and Prices. World prices are taken from International Financial Statistics, IMF. Price variables are specified in Rs./tonne and are converted into real prices at base 1993-94 using wholesale price index of all commodities. Since data on wholesale prices are available at state level, weighted average prices are taken to represent price at all India level. The weight is taken to be production of crop under question. The external reference price represents price prevalent at major trading centre in the world. Price series given in US dollar are converted into Rupees using appropriate exchange rate and is deflated for converting into real prices. The following section provides estimated results based on OLS.

II.1 Empirical Results on the Impact of various Policies and Factors on Agriculture

Tables 1a-c present results for selected commodities. It is evident that except wheat, prices of sugar and groundnut seed are significantly explained by their respective world reference prices. A statistically insignificant coefficient of world wheat price is explained by its lack of competitiveness in the global markets. Furthermore, wheat and sugar prices are highly influenced by their respective administered price³. The insignificance of exports/imports in determining wheat price is explained by lagged relationship between production and export. A high production in year t is followed by an increase in exports in the subsequent period (year), which also happens to coincide with lower prices. In many instances, domestic prices have influenced decision to go in for export and import rather than export/import being a lead factor in affecting domestic prices. If this kind of situation occurs, then the relationship between domestic price and exports turns out to be negative, which otherwise is expected to be positive.

Turning to export function, it is found that variations in wheat and sugar exports are not influenced by relative world and domestic prices primarily due to their higher domestic price than world price. Under import function, relative price has the expected negative sign but it is statistically significant for these two commodities. From early 2000, tariffs have been raised to control their imports. The acreage response shows price incentives, attributable to liberal measures have positively and significantly explained changes in the absolute area. However,

³ This, among other factors tends to suggest that though price policy, backed by procurement provides protection from unexpected plunge in world price, it may dissuade full price transmission from world to domestic markets and could also bring imbalances in the latter.

area price elasticity estimates are on the lower side i.e. 0.10 for wheat and 0.21 each for sugarcane and groundnut⁴. Other supply side factors stand equally important in influencing area. Rainfall appears to influence acreage the most, which is visible from the elasticity estimates at nearly 0.22. The final equation explains yield, which is taken to be influenced by rainfall, irrigation, technology (AHYV/GCA) and fertilizer consumption. Since most of the explanatory variables in area and yield equations overlap, the analysis was tried without specification of yield equation i.e. assuming yield to be determined exogenously. The results, however, did not vary much.

Table 1a: Wheat: Results from 1980-81 to 2002-03 at 1993-94 Prices

Exportable Scenario: Price	World Price	Support Price (MSP)	Export	Procurement	Production	Trend	Constant	R ²	D-W
	-0.063 (-0.86)	0.64* (3.86)	-0.007# (-1.21)	-0.17* (-2.69)	-0.56*# (-2.15)	0.02* (2.29)	10.97	0.69	2.6
Export	Pe/Pd	Stock	World Income	-	-	-	Constant	R ²	D-W
	3.52*** (1.71)	3.57*# (3.66)	2.58* (2.64)	-	-	-	-64.94	0.66	2.04\$
Area	Lagged Pd/Ip	Rain Index	Yield/ Yielde	Pc Rape seed- Mustard	Yield Risk	Lagged Area	Constant	R ²	D-W
	0.10** (2.08)	0.20* (3.28)	0.15* (2.17)	-0.06 (-1.42)	-0.004 (-1.5)	0.35** (2.09)	6.09	0.83	2.2
Yield	Fert.con /GCA	Technology	Trend	-	-	-	Constant	R ²	D-W
	0.05* (2.15)	0.94* (3.72)	0.003 (0.51)	-	-	-	8.83	0.97	2.5
Importable Scenario: Price	World Price	Support Price	Import	Procurement	Production	Trend	Constant	R ²	D-W
	-0.06# (-1.06)	0.77* (4.02)	0.0002# (0.04)	-0.17* (-2.85)	-0.59*# (-2.50)	0.02* (2.41)	10.19	0.78	2.8
Import	Pit/Pd	Stock	Procurement	Openness (share)	Dummy (NTB)	Constant	-	R ²	D-W
	-3.05* (-2.26)	-2.28* (-2.65)	-3.93* (-2.33)	5.78* (2.32)	-1.11 (-0.73)	65.06	-	0.70	1.62

⁴A low supply response may be attributable to (a) choice of time period, which pertains to both pre and post-reform (b) partial nature of economic reforms even after 1999 such as adhocism in exports-imports and trade through official agencies, (c) low market access of exports to other countries, (d) high volatility in world prices and lack of any mechanism to ensure stability in domestic prices, and (e) inadequate technological advancement, irrigation and other infrastructure.

Table 1b: Sugar/Sugarcane: Results from 1980-81 to 2002-03 at 1993-94 Prices

Exportable Scenario: Price	World Price	Support Price	Export	Production	Constant	R ²	D-W
	0.14*** (1.71)	0.98* (2.51)	0.04*# (2.83)	-0.33 (-1.56)	5.96	0.61	2.40\$
Export	Pe/Pd	Stock	Openness (trade flow)	Lagged Export	Constant	R ²	D-W
	1.82***# (1.71)	1.61* (2.50)	0.42*** (1.94)	0.29 (1.24)	-8.92	0.69	1.98\$
Area	Lagged Pd	Pc Rice-wheat	Yield/Yieldc	Lagged Area	Constant	R ²	D-W
	0.21** (1.84)	-0.19# (-0.62)	0.059 (0.197)	0.84* (4.02)	0.82	0.79	1.49
Yield	Rain Index	Fert.Cons./GCA	GIA/Area	Technology	Constant	R ²	D-W
	0.20*** (1.79)	0.05 (1.24)	0.52** (2.07)	0.22** (1.97)	10.59	0.69	1.55
Importable Scenario: Price	World Price	Support Price	Lagged Import	Production	Constant	R ²	D-W
	0.13** (2.01)	1.16* (3.47)	0.02* (-2.93)	-0.18 (-1.19)	3.16	0.65	2.4\$
Import	Pit/Pd	Stock	PDI	Openness (Trade flow)	Constant	R ²	D-W
	-6.29* (-2.39)	-5.78* (-4.07)	7.36* (3.12)	0.85*** (1.71)	-44.17	0.59	2.10

Table 1c: Groundnut: Results under Exportable Scenario from 1980-81 to 2002-03 at 1993-94 Prices

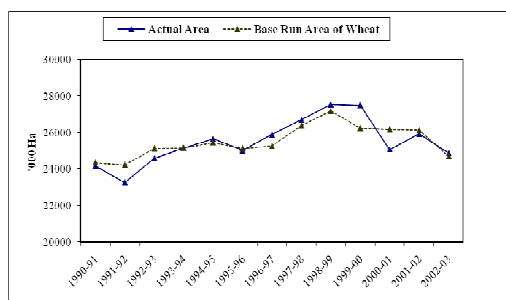
Price	World Price	Support Price	Export	Production	-	Constant	R ²	D-W
I	0.38* (2.18)	-0.38 (-0.85)	-0.05** (-1.99)	-0.18 (-1.50)	-	10.73	0.43	2.05\$
II	0.26** (1.98)	-	-0.04 (-1.49)	-0.18 (-1.59)	-	8.48	0.41	1.89\$
Export	Lagged Pe/Pd	World Income	Open-ness (share)	-	-	Constant	R ²	D-W
	2.54* (2.63)	0.22 (0.44)	3.06* (3.70)	-	-	-0.67	0.63	1.86
Area	Lagged Pd	Rain Index	Yield/Yieldc	Pc Jowar	Lagged Area	Constant	R ²	D-W
	0.21** (1.71)	0.29* (2.19)	0.09 (1.32)	0.07 (1.21)	0.58* (3.29)	-0.095	0.75	2.17
Yield	Rain Index	Fert.Cons./GCA	GIA/Area	-	-	Constant	R ²	D-W
	0.78* (2.23)	0.03 (0.33)	0.41#* (2.37)	-	-	4.06	0.51	2.3

Note: Figures in parentheses are t-values. *, ** & *** denote 1, 5 & 10% level of significance. # denotes one year lag. \$ specified using AR(1). The estimates are respective elasticities based on double log functional form. OLS estimates of area and yield equations remain same under the two scenarios.

III Simulation Model and Validation of Key Endogenous Variables

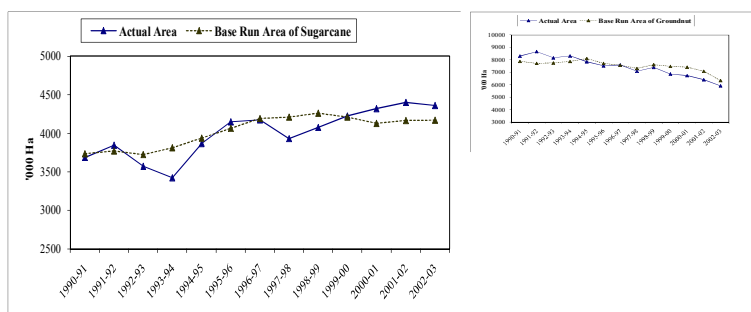
The behavioural equations determined by the use of OLS and 3SLS show estimates to be, by and large, consistent. Simulations are performed on OLS estimates as the estimated parameters also show robustness based on t-test and other tests. The actual estimates are used to calibrate a simulation over the period by introducing a hypothetical change in some of the exogenous variables. Before this, the effectiveness of the model in generating simulations is determined. Validation is done by comparing the actual past and base run simulated values of endogenous variables without introducing any change in exogenous variables. The base run simulated values are representative of equilibrium values that are generated on the basis of actual time paths of exogenous variables and given time paths of factors relating to trade, exchange rate and world prices. As shown in Fig. 1, a negligible difference between the actual and base run simulated values of acreage is found, indicating that the error is low and unbiased. In the case of sugar, deviations between actual and base run values of exports are identified during early 2000. Occurrence of such errors can be explained by both statistical and economic reasons⁵. It is important to mention that such distortionary changes, identified in some years cannot be quantified. However, broad economic variables in the model correctly elicit directional changes. After validation, a maximum or a minimum change is introduced in the exogenous variable at a given time to explain the magnitude of its impact on endogenous variables for 2000, 2001 and 2002⁶.

Fig.1: Actual and Base Run Estimates of Area



⁵ Some of these include (a) regression techniques that determine the behavioural equations have an inherent stochastic component that represents the random nature of variables, (b) techniques used in constructing and solving the model, (c) dynamic method used to do simulations/forecasts because the present values of impact variables are generated on the basis of forecasted past values rather than actual values of the past. Errors tend to be more in dynamic model compared to static model, (d) behavioural equations developed are based on theories with well developed market structures and hence may not explain conditions in the Indian context satisfactorily, (e) mix of sample period pertaining to pre- and post-reforms having year-to-year changes in tariffs and NTBs, (f) imposition of internal trade barriers may distort prices (Bhattacharya and Kar, 2007).

⁶ The choice of period is based on the fact that macroeconomic policies had already been adopted by this time and removal of NTBs and their replacement by tariffs was allowed to be implemented only from 2000-01.



IV Optimistic and Pessimistic Scenarios of Change and Resilience of Agriculture

This section presents plausible scenarios that are generated for carrying out counterfactual simulations along with the estimated results. Table 2 shows three years annual average percentage change in the base run and simulated values of price, exports, imports and acreage/production of commodities under each scenario.

World Price Volatility:

The first experiment relates to volatility in world market price of commodities. Commodity prices are subject to fluctuations due to changing demand and supply conditions. An increase in world market price may act as an incentive due to competitiveness of commodities and hence an increase in demand for export. On the contrary, a fall in it can have negative implications. In any situation, producers need to accommodate in their land and production decisions such price fluctuations that often arise in world markets (Nayyar and Sen 1994). For selected commodities, world market price is hypothetically changed within a positive range of 25 to 35 percent and a negative range of 20 to 45 percent based on the maximum and minimum change in price from 1991-92 to 2002-03.

Simulations show that unlike the case of wheat, world reference prices of sugar and groundnut seed are positive and significant in explaining variations in their prices. It shows a maximum increase of 30 percent and a decline by 20 percent in wheat; 35 percent each in sugar, and 30 and 45 percent in groundnut. Results show volatility on the higher side increases average domestic price. Acceleration in exports is the highest for wheat and sugar followed by groundnut seed. As expected, an increase in world price relative to domestic price brings the level of imports downward and raises acreage/production. Area under groundnut and sugarcane shows an increase only during 2002-03 and a fall otherwise. These results, though not strictly comparable with the estimates given in the literature due to use of different methodology and time period considered, are yet similar in demonstrating directional changes in price, output and

exports. Gulati and Kelly (1999) found the impact of an increase in domestic price in tune with international price on percentage change in price and supply to be 6.38 and 4.95 percent for wheat and 4.5 and -0.73 percent for sugar (cane) from base level during 1993-94. Wheat and sugar exports may increase to 5.1 and 0.34 million tons. In contrast, a pessimistic scenario, if it occurs, would negatively affect exports. The impact is also extensive in terms of import surge, which may badly affect area/production. A hike in tariff rates can be followed to counter this shock. Notably, the impact of world price shock on wheat area may not be severe as it is influenced more by MSP than by movements in world price. However, much would depend upon the magnitude of transmission between two price series.

Exchange Rate Fluctuations:

India undertook devaluation of currency once during 1991 and then twice in 1992-93. Since then, exchange rate is market driven and has an in-built mechanism that stabilizes its movements. From 1991-92 to 2002-03, nominal exchange rate has shown a maximum yearly increase of 30 percent and a minimum of 2 percent. For simulation, a hypothetical maximum and minimum change is introduced at a time from the existing level. Keeping in view the fact that exchange rate appreciated from 2003-04 with the result that the nominal rate came down from Rs. 48.5 per dollar in 2002-03 to Rs. 44 per dollar in 2005-06, another experiment is done by allowing the rate to appreciate annually by 5 percent from its existing level.

A depreciation of currency by 30 percent raises nominal exchange rate from Rs. 44.92, Rs.47.23 and Rs.48.49 per dollar to Rs.58.39, Rs.61.39 and Rs.63.04 respectively during 2000 to 2003. Similarly a minimum change of 2 percent increases it by Rs. 45.82, Rs.48.17 and Rs.49.45 respectively. In contrast, an appreciation of currency by 5 percent reduces nominal exchange rate to Rs.42.67, 44.87 and 46.07 per dollar from the existing level. Keeping other variables unchanged, maximum variations in exchange rate would increase exports and decrease imports through change in price structure. Impact of devaluation on percentage increase in price is positive in case of sugar and groundnut and negative in case of wheat. This is because prices of sugar and groundnut have responded positively and significantly to changes in their respective world prices.

The impact of exchange rate variations is directly visible on the volume of trade. It indicates that had India been more open to world trade during the eighties, average exports would have been higher by 170 percent in wheat, 74 percent in groundnut seed and 91 percent in sugar. The

impact of depreciation on area shows an average annual percentage increase by 0.64 for wheat. Groundnut shows a downfall of 2.22 percent per year, which is expected given that area shifts are taking place within the oilseed group. Similar is the case of sugarcane where trend growth rate of area has been falling over time. Estimates on area response (equation 4) have also indicated that technology and irrigation play significant role in inducing area along with price incentives. Under a scenario of a minimum depreciation of currency, price rises by maximum 2.73 percent, which is less than what is observed under an optimistic scenario. The situation also negatively affects area to be put under cultivation. Average wheat and sugar exports increase annually. Exports tend to fall under a scenario of currency appreciation by 5 percent from the existing level and imports remain negative. In case of a severe shock through appreciation of currency, average rate of imports increases. Currency appreciation would negatively affect prices, exports and area and hence production, implying lack of resilience of agriculture to this change. The impact is not severe on wheat as world price movements do not influence its price significantly.

Since exchange rate is now market determined, agriculture can be resilient to adverse impacts arising out of currency appreciation. Import surge caused by appreciation and also by world price shocks can be handled by keeping a check on imports and imposing higher tariffs. Price stability in domestic markets can also be maintained through storage as is done for wheat and rice. But this option may not work for all commodities in view of a limited capacity of storage. A variable tariff policy must synchronize with price policy in terms of fixation of MSP in accordance with conditions prevailing in domestic and world markets.

Changes in Tariffs and Elimination of NTBs:

Tariffs on imports have long been in place for sugar and were imposed for wheat only from 2000-01 onwards. For each commodity, tariff rates have been lower than the WTO prescribed bound rates, which indicates that there is further room for increasing import duties. The optimistic scenario represents a maximum increase in tariffs equal to the bound rates and the pessimistic scenario focuses on minimum or complete removal of tariffs⁷. The impact of change in tariff is carried out only for wheat and sugar as India hardly imports groundnut seed. For wheat, tariffs were 0 till 1999-2000 and got imposed at 92 and 108 percent during

⁷ The first scenario also takes care of the impact of removal of NTBs. The estimated tariff equivalents of NTBs quantified are found to be falling within the range of 2 to 56 percent for selected commodities (Bathla 2006). Since current rates are well below the bound rates, imposition of maximum tariff equal to bound rate will account for the effects of NTBs on imports.

2002-03. In the subsequent years, tariffs fell to 75 and 100 percent. The prescribed bound rate for wheat is 100 percent. Sugar tariff was placed at 100 from 2000 to 2002 and the bound rate was 150 percent. Two simulations are, therefore carried out, one with maximum tariff equal to bound rate and second with minimum or zero tariff. An increase in tariff equal to bound rate also takes care of complete elimination of NTBs. The tariff equivalents of NTBs estimated vary from 3 to 14 percent for cereals and 9 to 43 percent for sugar from 2000 to 2003.

The optimistic scenario reveals an increase in domestic price. Import of wheat is stable and does not show a significant increase. Sugar imports are hard hit by increase in tariffs. As expected, the impact of hike in tariff, though positive on price, may not be high enough to accelerate or decelerate growth in acreage. In a situation of no tariff i.e. shock, results reveal that had we not raised tariffs in wheat and sugar from 2000, the impact would have been extensive in terms of import surge and fall in prices. Finally, sugarcane area is found to be decelerating annually. Wheat acreage is resilient to tariff shock as average percentage change in it is estimated to be 0.88 percent. A flexible tariff rate policy is, therefore, desirable.

Variations in Rainfall:

Despite advancements in major and minor irrigation in India, agriculture continues to be dependent on weather. A less than normal rainfall (index=100) affects production and hence overall growth due to inter-sectoral demand and supply linkages. The extent to which rainfall shock affects area is studied under an optimistic scenario, which depicts above normal rainfall, taken to be 15 percent during the last more than 10 years. The pessimistic one depicts below average normal rainfall i.e. drought, which is observed to be 20 percent in 1987 and 2002. Rainfall index is assumed to be the maximum at 106.08, 106.9 and 91.31 and minimum at 73.8, 74.36 and 63.52 compared to the actual values of 92.25, 92.96 and 79.4 respectively during 2000, 2001 and 2002. An above normal rainfall is expected to increase production whereas a below normal rainfall represents drought conditions, which negatively affects output. Bhattacharya and Kar (2007) found that due to rainfall shock, agricultural growth rate fell substantially from 3.3 percent to -1.7 percent in the short run and from 2.6 to 2.0 percent in the long run. Results estimate an average fall in area between 2 and 12 percent per year. In both the situations, domestic prices of sugar and groundnut seed are negatively affected. A small impact of rainfall on wheat price could be due to fixation of MSP backed by procurement, which stabilizes its prices. There is not much variation in trade as a result of

change in rainfall. The shocks arising due to drought can be countered on its own as rainfall has tendency to follow a cyclical pattern.

Changes in Minimum Support Price (MSP):

Government fixes MSP of essential commodities and undertakes procurement of a few in order to provide incentives to farmers and bring price stability through open market sales. The issue is highly debatable because the policy is argued to suffer from regional and crop bias as it acts as a floor price mainly for wheat and paddy/rice that too in states where procurement operations are undertaken. Besides, many think that it is inflationary in nature, distort the process of market mechanism and bring demand-supply imbalances (Chand 2009). Further, due to opening up of markets, opportunities to export cereals have been growing. The degree of sensitivity of price, export-import and output as a result of changes in support price is estimated. The exercise is done for wheat and sugar (cane) as support price is found to be positively and significantly explaining variations in prices of these crops. The maximum and minimum (negative) variations observed in support price from 1991 to 2003 are: +20 and -8 percent for wheat and +8 and -1 percent for sugarcane respectively. MSP of wheat under an optimistic scenario is Rs. 4701.35, Rs. 4621.12 and Rs. 4581.82 per tonne respectively and the same under pessimistic scenario is Rs. 3604.37, Rs. 3542.86 and Rs. 3512.73 per tonne respectively. For sugar, SMP varies between a maximum and a minimum range of Rs. 3537.57 and 3111.75 per tonne in the year 2001, between Rs. 3555.28 and 3127.33 per tonne in 2002 and between Rs. 3534.55 and 3109.09 per tonne in 2003 respectively. Based on these, the existing price in each year is changed.

Results reveal that with a hike and fall in MSP of wheat, price increases/decreases by a maximum 13/4.45 percent per year, indicating a not so elastic response. Clearly, under an optimistic scenario, production gets a boost but exports decline. Average imports of wheat and sugar may rise annually by 7.87 and 66.71 percent respectively. In contrast, a decline in support price may bring down price and raise average exports of wheat and sugar by 21 and 12 percent per year and turn down their imports. The effect of this shock on wheat goes against the expectation showing an average yearly increase in area by 0.21 percent. Price shock, in the case of sugarcane, may bring down area by 1.53 percent annually. The impact is not found to be large as variations in support price do not indicate much change in yield. Overall results indicate resilience of area under wheat to a given change in MSP.

Table 2: Impact of Variations in various factors on Agriculture (Annual %age Change)

Commodity	Price	Export	Import	Area/Production	Price	Export	Import	Area/Production
World Price:	Max.: +25% to 35%				Min.: -20% to -45%			
Wheat	-1.53	172.83	-60.48	0.64	-0.83	-57.53	80.48	0.63
Sugar	3.76	107.77	-77.22	-0.38	-10.18	-55.36	737.70	-2.70
Groundnut Seed	7.45	74.50	-	-2.22	-15.57	-68.58	-	-5.96
Exchange Rate:	Max.: +30%				Min.: +2%			
Wheat	-1.53	172.89	-60.49	0.64	0.38	7.72	-15.63	0.89
Sugar	2.99	91.81	-72.57	-0.51	-1.83	14.85	-9.24	-1.28
Groundnut Seed	7.46	74.53	-	-2.22	0.39	6.86	-	-3.30
					Min.: -5%			
Wheat	-	-	-	-	0.95	-17.93	5.40	0.96
Sugar	-	-	-	-	-3.20	-1.11	28.80	-1.51
Groundnut Seed	-	-	-	-	-1.59	-7.34	-	-3.61
Tariffs:	Max.: +100% to 150%				Min.: 0%			
Wheat	-1.72	-	-2.90	0.53	1.37	-	747.99	0.88
Sugar	4.12	-	-66.70	2.39	-12.70	-	2955.10	-0.54
Rainfall:	Max.: +15%				Min.: -20%			
Wheat	0.54	-0.15	-10.23	4.63	0.54	-0.15	-10.23	-4.76
Sugar	-2.22	10.16	-1.19	3.21	0.07	1.83	0.26	1.83
Groundnut Seed	-0.17	2.68	-	3.79	-0.17	2.68	-	-13.80
Support Price:	Max.: +8% & 20%				Min.: -5% & -8%			
Wheat	13.18	-34.40	7.87	2.45	-4.75	20.99	-16.25	0.21
Sugar	5.20	-2.67	66.71	0.07	-3.15	12.01	-6.38	-1.53

Note: Minimum variation in sugar is 40%

Table 3 shows relative as well as total impact of selected policy, price and natural factors on agriculture. For each commodity, the sum total of each of the percentage changes corresponding to various factors under two scenarios is presented. It is clear that changes in world price, exchange rate and tariffs have a relatively stronger positive/negative effects compared to those in rainfall and support price. Rainfall shock has a significant impact on impeding growth in area. Only exceptional case is that of sugar/sugarcane, which shows resilience to drought. Furthermore, a change in support price has a considerable impact on wheat price than on its trade and area. The movements in world market price and tariffs have relatively stronger effects on both prices and trade.

Table 3: Relative Impact of Changes in Various Factors						
	Exchange Rate	Tariff Rate	World Price	Support Price	Rainfall	Total
Wheat: Optimistic Scenario:						
Price	-1.53	-1.72	-1.53	13.18	0.54	8.93
Exports	172.89	-	172.83	-34.40	-0.15	311.18
Imports	-60.49	-2.90	-60.48	7.87	-10.23	-126.23
Area/Production	0.64	0.53	0.64	2.45	4.63	8.90
Pessimistic Scenario:						
Price	0.95	1.37	-0.83	-4.75	0.54	-2.72
Exports	-17.93	-	-57.53	20.99	-0.15	-54.63
Imports	5.40	747.99	80.48	-16.25	-10.23	807.38
Area/Production	0.96	0.88	0.63	0.21	-4.76	-2.08
Sugar/Sugarcane: Optimistic Scenario:						
Price	2.99	4.12	3.76	5.20	-2.22	13.85
Exports	91.81	-	107.77	-2.67	10.16	207.07
Imports	-72.57	-66.70	-77.22	66.71	-1.19	-150.96
Area/Production	-0.51	2.39	-0.38	0.07	3.21	4.78
Pessimistic Scenario:						
Price	-3.20	-12.70	-10.18	-3.15	0.07	-29.16
Exports	-1.11	-	-55.36	12.01	1.83	-42.63
Imports	28.80	2955.10	737.70	-6.38	0.26	3715.48
Area/Production	-1.51	-0.54	-2.70	-1.53	1.83	-4.44
Groundnut Seed: Optimistic Scenario:						
Price	7.46	-	7.45	-	-0.17	14.74
Exports	74.53	-	74.50	-	2.68	151.70
Imports	--	-	-	-	-	--
Area/Production	-2.22	-	-2.22	-	3.79	-0.65
Pessimistic Scenario:						
Price	-1.59	-	-15.57	-	-0.17	-17.34
Exports	-7.34	-	-68.58	-	2.68	-73.24
Imports	-	-	-	-	-	--
Area/Production	-3.61	-	-5.96	-	-13.80	-23.37

V Key Findings and Implications

An attempt is made to examine the impact of macroeconomic and sector specific policies and factors on Indian agriculture and the extent to which agriculture is resilient to shocks caused by policies, price and other factors. The analysis is undertaken for three important tradable commodities viz. wheat, sugar and groundnut seed. A structural econometric model is applied to individual commodities, separately under the exportable and importable scenarios from 1980-81 to 2002-03. Five counterfactual simulations experiments are carried out to quantify the magnitude of sensitivity of agriculture to exogenous impulses and explore options that may neutralize their adverse effects.

The empirical results indicate that performance of agriculture has been increasingly driven by an incentive structure based on its linkages with trade, exchange rate, world market price, irrigation, infrastructure and technology. Sudden disturbances caused by fall in world price, currency appreciation and tariffs are relatively more pervasive than support price and rainfall in changing the incentive structure, trade and acreage. Effects of such shocks on land allocation and production decisions can be countered by following an appropriate tariff structure. A situation of drought can be moderated through increase in public investment in irrigation. The impact of shocks arising due to various policy variables, though significant in bringing down prices, does not lead to much change in area, especially of wheat. Only exceptional case is that of rainfall shock that brings down wheat acreage. Further, there are considerable tradeoffs involved, viz. a hike in support price may increase market price and acreage but may dissuade higher exports. Finally, commercial crops may be more vulnerable to shocks compared to cereals as these are relatively more responsive to incentives arising out of liberal policies and a greater openness of domestic markets to international trade. On the other hand, wheat, though open to trade and somewhat responsive to incentives, is backed by MSP and procurement, which provide cushion against shocks caused by an unexpected plunge in world price. Overall results indicate that Indian agriculture is sensitive to exogenous impulses caused by external conditions. Nonetheless, due to macro, trade and price policy measures, commodity prices and output tend to be much more resilient to various shocks compared to the exports and imports. Appropriate and timely adjustments in tariffs together with changes in support price may help to counter the adverse effects of likely divergences, maintain incentive structure and price stability in a market driven economy.

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