Journal of Quantitative Economics, Vol. 12, No.2, July 2014

INTER-SECTORAL TERMS OF TRADE AND AGGREGATE SUPPLY RESPONSE INGUJARAT AND INDIAN AGRICULTURE

RAVINDRA H. DHOLAKIA[1]
AMEY A. SAPRE[2]

Abstract

This paper empirically investigates the role of inter-sectoral terms of trade in determining the growth performance of agriculture in Gujarat and All India during the period 1960-2011. Structural breaks endogenously identified in inter-sectoral terms of trade and phase wise growth performance in distinct periods in both Gujarat and all India is analysed. Empirical findings support the hypothesis that favourable terms of trade for agriculture lead to higher growth in agriculture. The results show a strong evidence for positive price elasticity of supply in agriculture and almost rules out the possibility of backward bending supply curve. The paper establishes favourable terms of trade as a major factor for achieving high growth in agriculture.

Keywords: Agriculture, Structural breaks, Supply elasticity, Terms of Trade, Indian economy, Gujarat

JEL Classifications: Q1, Q11, Q18

1. Introduction

In this paper we analyse the role of inter-sectoral terms of trade in leading to a growth momentum in agriculture at a state and the national level. It is a well-known fact that, agricultural output at a state level fluctuates more than the national level due to several regional factors. Determinants of agricultural output are often considered in terms of price and several non-price factors. Few studies such as Bapna, 1980; Tyagi, 1987; Ghosh, 1988; Raghavan, 2004; Alagh, 2004; and Deb, 2005 among others have considered the price response of agricultural supply. However, at the regional or state level, there have been limited efforts (except Singh, 1989, Sapre, 2014) to estimate the supply response to price or the inter-sectoral terms of trade for agriculture. A probable reason for neglect of price factors at the regional level may have been the conventional belief that prices do not vary considerably across regions within a nation. High fluctuations in regional agricultural output were, therefore, attributed only to the non-price factors. Conversely, variations in the inter-sectoral terms of trade can, however, be significantly different

[1] Corresponding Author: Professor of Economics, Indian Institute of Management, Ahmedabad, 380 015, India, Email: rdholkia@iimahd.ernet.in

[2] Indian Institute of Technology, Kanpur, 208 016, India, Email: amey@iitk.ac.in

We are thankful to an anonymous referee of this Journal for comments and suggestions on improving the paper.

at a regional and the national levels. Aggregate supply response of agriculture to terms of trade may also vary across states and on margin may contribute significantly to its determination.

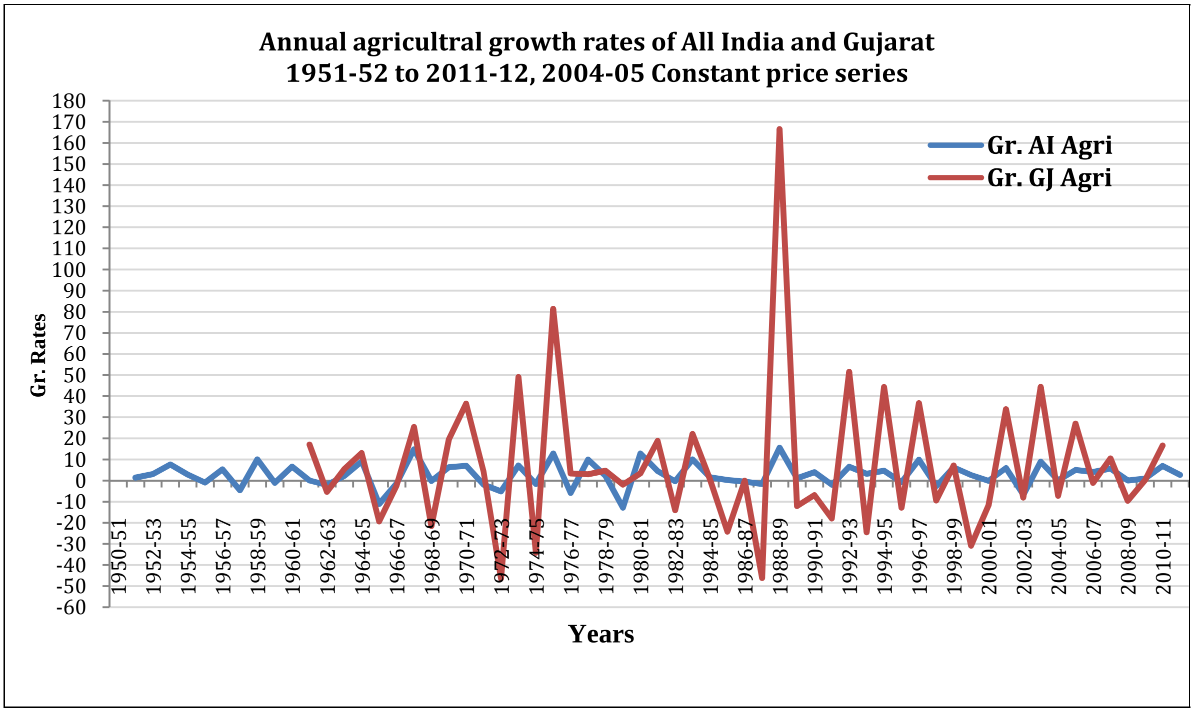
On this premise, we begin first by comparing the agricultural growth performance in India and of the state of Gujarat. In making this comparison we select Gujarat in particular for the following reasons: (i) the state historically experienced high fluctuations in agricultural output leading to overall growth fluctuations within the state economy; (ii) with economic reforms in 1991-92, it has been on the forefront in the India’s growth story not only for the economy as whole but also in agriculture (see Dholakia, 2009) and (iii) agricultural growth in the state during the last decade has been more than twice the national average. Recent studies such as, Gulati *et al.* 2009, Shah *et al.* 2010, and Dholakia & Datta, 2010, attempted to provide some explanations for this rapid growth of agriculture in the state, but did not consider the price response of agricultural supply. Theoretically, terms of trade reflect the price incentives that producers in the respective sectors face which in turn determines competitiveness and their savings and investment decisions. This paper extends the earlier work by explicitly estimating the price response of agricultural supply at the state and national level thereby establishing it as a significant determinant of growth and structural change in the economy.

The paper is organized in five sections. Section 2 briefly discusses the trends of agricultural growth in Gujarat and all India. Section 3 empirically investigates whether variations in regional and national inter-sectoral terms of trade are statistically the same or different. Subsequently structural breaks are endogenously identified in the long term trend of the inter-sectoral terms of trade in both Gujarat and all India thereby providing direct evidence on the nature of relationship between movements in terms of trade and output growth. Section 4 estimates the degree of price responsiveness of agricultural output to terms of trade at the state and the national level. The last section summarises the main findings with concluding remarks.

2. Trends of aggregate income in agricultural sector

State income (Gross State Domestic Product or GSDP) originating in agriculture including animal husbandry (Agri+AH henceforth; agriculture) at factor cost is the most aggregate and comprehensive measure of economic activities in the sector within the state boundaries. Corresponding aggregate at the national level is the GDP in agricultural and allied sectors. In India, the back series of aggregate incomes of all sectors are available from 1950-51 to 2010-11 at 2004-05 prices for the nation and from 1960-61 to 2010-11 for Gujarat. (For basic data, see Appendix).

Graph 1 plots the agricultural growth series of all India and Gujarat over the past five decades and depicts that both series show large fluctuations, but the state series fluctuates far more as compared to the national series. Thus, agriculture as business in Gujarat shows relatively high degree of risk and uncertainties than in the nation on an average. Agricultural income in the state has also been adversely affected by several drought years where the growth has nosedived. At the national level fluctuations are not severe as it represents aggregation of all states thereby cancelling out such individual state level fluctuations.



Graph 1: Annual growth rates of Agriculture (including allied activities) of All India (AI) and Gujarat (GJ), 1950-51 to 2010-11 at 2004-05 constant prices

Further, growth trends and fluctuations are more clearly brought out by taking a decadal view of the growth performance. Table 1 provides the average annual growth rate, coefficient of variation of annual growth rates and the decadal trend rates for agriculture at the state and national level during the past five decades.

Table 1. Growth statistics for five decades of Gujarat and All India Agriculture (2004-05 constant price series)

Agriculture (including Animal Husbandry)							
	Average Gr. rate		Coeff. Of Variation		Trend rate		
Period (years)	**Gujarat**	**All India**	**Gujarat**	**All India**	**Period (years)**	**Gujarat**	**All India**
2001-02 to 2010-11	10.67	3.19	179.75	143.21	2000-01 to 2010-11	8.00*	3.08*
1991-92 to 2000-01	3.25	2.84	928.3	145.33	1990-91 to 2000-01	2.43	3.17*
1981-82 to 1990-91	10.48	3.52	556.39	154.88	1980-81 to 1990-91	-0.53	3.12*
1971-72 to 1980-81	6.67	1.83	547.37	475.20	1970-71 to 1980-81	3.62	1.81*
1961-62 to 1970-71	6.86	2.54	277.4	283.19	1960-61 to 1970-71	2.29	2.01*

* indicates statistically significant at1%.Source: Department of Economics and Statistics, Government of Gujarat and Economic Survey 2011-12, Government of India, February 2012.

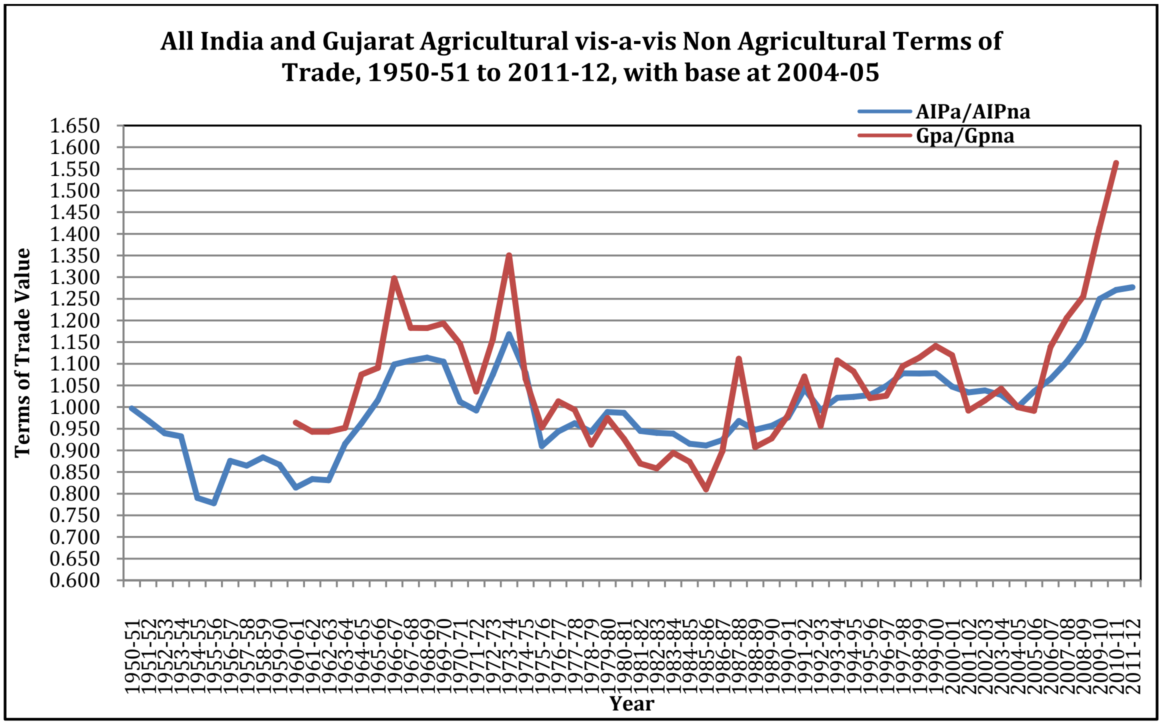
The table shows that the extent of fluctuations measured by coefficient of variation in the annual growth rates was high and kept increasing during the first four decades (1960-61 to 2000-01) in Gujarat agriculture. At the all India level, however, the extent of variations has been lower and falling consistently over the last four decades (1970-71 to 2010-11).During the last decade (2000-01 to 2010-11), variations in Gujarat have sharply fallen and are similar to the national level. The trend growth rate obtained by fitting a log-linear time-trend on the income series shows that Gujarat did not experience a statistically significant growth in agriculture except during the last decade. On the other hand, agriculture at the national level grew at a statistically significant rate during all past decades. However, comparison of the performance of agricultural income during the last decade between Gujarat and all India almost reverses the story of the earlier decades. The decade of 2001-11showsthe first statistically significant growth performance of agriculture in the state. The average growth rate is about 10.6% per annum and a statistically significant trend growth rate of 8% was registered in the state during this period compared to only 3.1% at the national level. This period also shows a considerable decline in growth fluctuations. Furthermore, the remarkable growth story in Gujarat agriculture in the recent decade is more or less intact even after two consecutive droughts in the last two years in the state.

Given such substantially different growth paths of agricultural income in the state and the nation, could the possible explanation be only in terms of non-price factors? Or could price factors and differential price responsiveness of agricultural supply also be playing an important role in the explanation? Are the price factors and responsiveness of agricultural supply likely to be identical for a state and the country? We explore these questions in the subsequent sections.

3. Structural breaks in inter-sectoral terms of trade

Empirically, the inter-sectoral terms of trade (ToT) in a state economy is best measured with the help of GSDP data by sectors at current and constant prices. From this, the implicit GSDP deflators by sectors are computed which show the relative prices that producers face in respective sectors[1]. It is customary to divide the economy into agriculture and the non-agriculture sectors for the purpose of examining inter-sectoral ToT between them over time. We therefore compute the GSDP deflators and use them to arrive at the agriculture vis-à-vis non-agricultural terms of trade, i.e.$(ToT)_{A/NA}$=[Deflator for Agriculture/Deflator for Non-Agriculture]. Graph 2 shows the inter-sectoral terms of trade in Gujarat and All India over the past five decades.

At the state level it can be observed from the above graph that the series fluctuates considerably over time and shows a consistent rise in favour of agriculture only after 2005-06.Although the fluctuations at the state level are more pronounced, the series for the state and the nation appear to follow a similar pattern. However, it is imperative to investigate whether the structure and trend of relative prices follow the same pattern for the state as for the nation. To investigate this, we conduct an empirical test to determine whether or not the terms of trade series are statistically same for the state and the nation.



Graph 2: Inter-sectoral terms of trade for agriculture vis-à-vis non-agriculture for All India (AI) and Gujarat (GJ)

Empirically this is done by regressing Gujarat To Ton All India To Tor vice versa in a linear equation and then testing the following hypotheses: Intercept $(\beta) = 0$ and slope coefficient $(\beta) = 1$. Based on the regression parameters, the two series would have a similar trend structure only when$(\alpha) = 0$ and $(\beta) = 1$. Alternatively, if both the series were different, we would expect statistically (α) to be different from 0 and (β) to be different from 1. We evaluate these hypotheses using the data for the period 1960-61 to 2010-11 for Gujarat ToT and All-India ToT. Table 2 reports the result.

Table 2: Test of similarity ininter-sectoral terms of trade for Gujaratand All India. Estimated equation: GJPa/Pna = α + β(AIPa/Pna)+v

Intercept (α)	Coefficient (β)	$t_{value}(\alpha = 0)$	$t_{value}(\beta = 1)$	R^2	F
–0.338 SE (0.113)	1.375 SE (0.111)	–2.991*	3.376*	0.757*	153.037

Notes: SE is standard error; * indicates value significant at 1% level of significance; No. of observations =51.By definition, the reverse regression of the above has the same R^2, statistically significant positive intercept and slope coefficient to be significantly less than unity.

Table 2 reveals that both (a) and (b) are statistically significantly different from (0) and (1) respectively. It provides empirical evidence that trends of terms of trade at the regional level and national level are not the same as they have different trend structure in terms of level and slope. The difference in trends of both series suggests differential response to several factors thereby indicating a need for a separate analysis of the two series. Also, apart from price factors, a host of non-price factors by their nature are likely to differ substantially by regions. Thus, growth performance of agriculture at a state and the national levels can, therefore, differ widely and so also the aggregate supply response to relative prices for agricultural output. This proposition is explored more in detail as follows.

Theoretically, we expect a uni-directional relationship between inter-sectoral ToT and growth of agricultural output in an economy. This is because inter-sectoral ToT is the ratio of relative prices faced by producers in the respective sectors which reflects the incentives for production and investment. Therefore, when the output response to changes in relative prices differs between a state and the nation, it could be because: (i)price factors differ; (ii) price elasticity of supply differs; or (iii)both price factors and supply elasticity differ. It is interesting to note that even if the output response or the growth does not differ between a state and the nation, price factors and supply elasticity may differ in an off-setting way. We may, therefore, obtain direct evidence on output response or growth with respect to the behavior of inter-sectoral ToT before estimating price elasticity of supply for the state and the nation.

Following a descriptive view of growth trajectories we next conduct an empirical exercise to investigate the points of structural breaks in the time paths of inter-sectoral terms of trade for the state and the nation. As the direction of causation can be established through expectations from theory, once the distinct phases of inter-sectoral ToT are identified, growth rates of agricultural output during the corresponding phases can be computed. This is expected to provide direct evidence on broad associations between the growth of output and behaviour of inter-sectoral terms of trade both at the state and the national levels.

For endogenously identifying structural breaks in a series, the method proposed by Bai-Perron (1998, 2003) and computationally operationalized by Zelileiset al (2005) and Wang (2006) is followed[2]. The Bai-Perron method explicitly allows for detecting multiple break dates, but is sensitive to selection of the length of segment (Dholakia &Sapre, 2011). Computationally, we calculate multiple break-dates by varying the length of the segment (h) for the regression over various partitions. Therefore, we iterate using the length (h) from h=6 to 9 and consider the set which is invariant to the choice of length of segment. Upon identifying the break dates, subsequently we fit a piecewise regression using the break-dates as cut-off years to identify different turning points in the series.

The break-date is computed in the level of ToT and a trend equation with year dummies for break-dates is fitted as follows:

$$\ln Y_t = \beta_0 + \beta_1 t + \beta_2 (t - t_1^*) D_1 + \beta_3 (t - t_2^*) D_2 + v_t \qquad ... (1)$$

where $D_1 = 1$for $t > t_1^*$; and$D_2 = 1$for $t > t_2^*$ are two dummy variables and $t_1^*$and t_2^* are estimated break-dates. This equation is fitted for both the state and the nation series. The results of the break-dates estimation are as follows:[3]

1. Gujarat Terms of Trade series (base 2004-05)

(a) Corresponding break-date years in (m) regimes:

m = 1			2002		
m = 2		1974	1992		
m = 3		1974	1990	2002	
m = 4	1967	1975	1990	2002	
m = 5	1967	1975	1986	1994	2002

(b) Criteria of BIC for corresponding regimes:

m	0	1	**2**	3	4	5
BIC	-43.6688	-46.2875	**-49.3049**	-47.6153	-40.0591	-32.558

(c) Confidence interval for break dates

1 1972 **1974** 1981
2 1984 **1992** 1994

2. All India Terms of Trade series (base 2004-05)

(a) Corresponding break date years in (m) regimes:

m = 1 1995
m = 2 1966 1995
m = 3 1966 1974 1990
m = 4 1966 1974 1990 2003
m = 5 1966 1974 1989 1996 2003
m = 6 1966 1974 1981 1989 1996 2003

(b) Criteria of BIC for corresponding regimes:

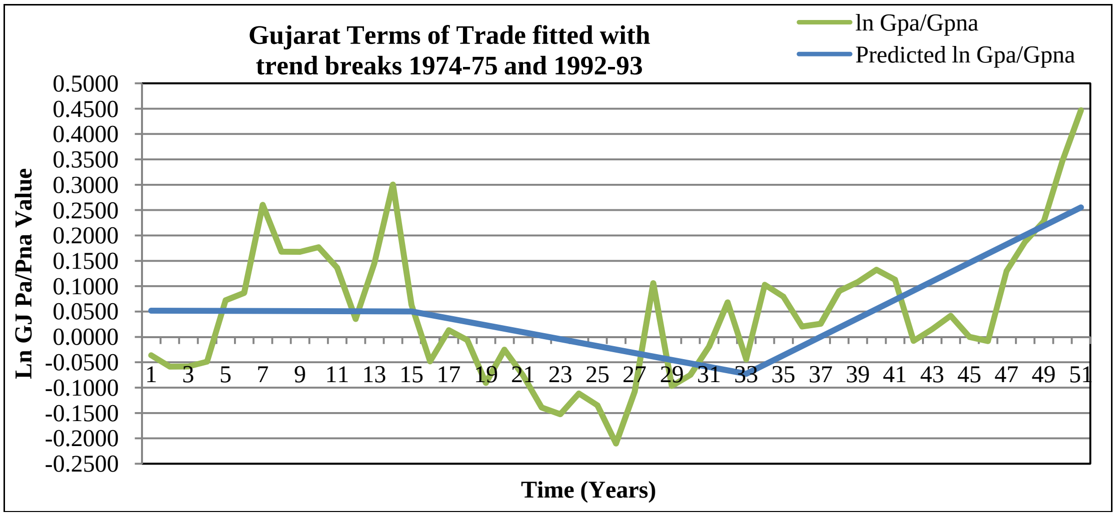
m	0	1	2	**3**	4	5	6
BIC	-92.270	-99.905	-98.271	**-108.767**	-108.205	-100.704	-93.178

(c) Confidence interval for break dates

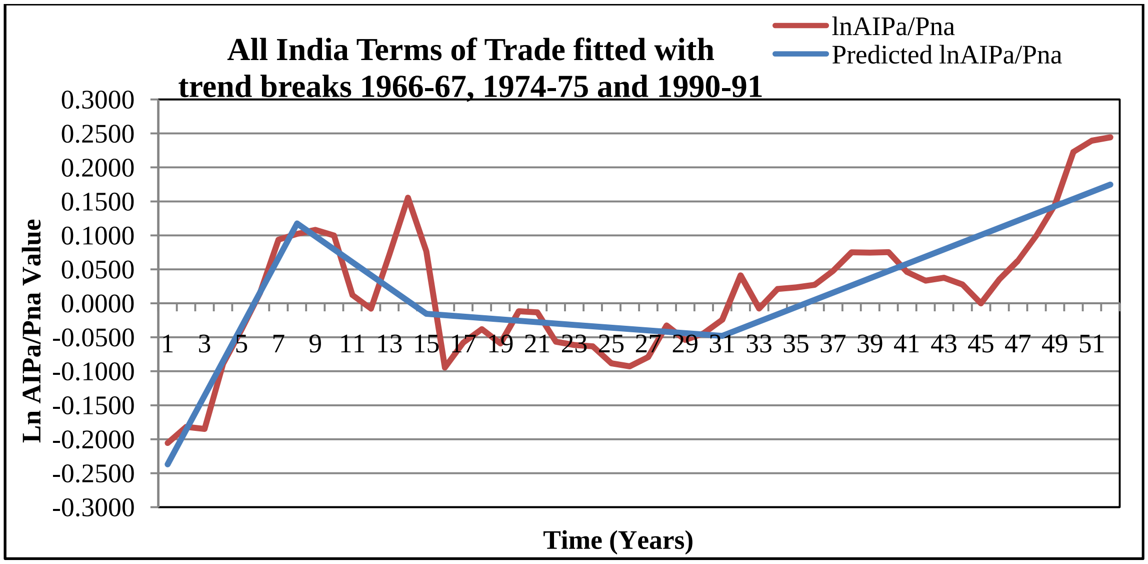
1 1965 **1966** 1972
2 1973 **1974** 1976
3 1986 **1990** 1991

The results show two breaks for Gujarat, viz. 1974 and 1992, representing the years of 1974-75 & 1992-93.Correspondingly for all India, the break-dates are 1966-67, 1974-75 and 1990-91. The findings indicate that the turning points of ToT in Gujarat and all-India are similar but not identical, except the one at 1974-75. Distinct phases of ToT in the state and the nation, therefore, largely but not completely overlap. In Gujarat, three distinct phases of long term behavior of ToT appear: (i) 1960-74, when P_A/ P_{NA} was almost constant;(ii) 1974-1992, when the P_A/ P_{NA} was declining; and (iii) 1992-2011, when P_A/ P_{NA} was rising. Given the two break dates for Gujarat, we fit a piecewise regression on ToT to separate out the threephases[4]. Graph3 shows the three distinct phases of trend of inter-sectoral terms of trade in the state.

On calculating the compound annual growth rate (CAGR) of agricultural GSDP for the three phases of ToT, we find that during the first phase of 1960-61 to 1974-75 when ToT was highly fluctuating, the trend rate was 2.2% (statistically not different from zero). During the second phase when ToT was fluctuating but around a falling trend, the agricultural CAGR was 2%(again statistically not significant). However, during the third phase when the agricultural terms of trade were sharply rising, the agricultural CAGR was statistically significant and at 3.8%, which rose to 8.0% in the latter half. It is equally evident that prior to 1992-93, the terms of trade were rising for the non-agricultural sector and post 1992-93; the same were declining. Thus, agriculture was relatively losing before 1992-93 and was economically gaining after 1992-93 in Gujarat. This change of regime seems to have spurred a positive and significant growth of agriculture in the state after 1992-93, which is reflected in table 1 above. Similarly, at the national level we observe four distinct phases of terms of trade regimes, viz. 1950-51 to 1966-67; 1966-67 to 1974-75;1974-75 to 1990-91; and the last phase 1990-91 to 2010-11. Graph 4 plots the phase wise trend of terms of trade for All India agriculture.



Graph 3: Piecewise regression for inter-sectoral terms of trade for agriculture vis-à-vis non-agricultural sector in Gujarat 1960-61 to 2010-11 with base at 2004-05.



Graph 4: Piecewise regression for Inter-sectoral terms of trade for agriculture vis-à-vis non-agricultural sector for All India 1950-51 to 2010-11 at 2004-05 constant prices

The pricewise regression shows similar trend behavior at the all India level, particularly in the last two phases where ToT was fluctuating around a falling trend during 1974-75 to 1990-91 and then sharply rising one in favor of agriculture during the last two decades, 1991-2011. During the last two distinct phases of ToT movements at the national level, the CAGR for agricultural income for the nation are: 2.7% during 1974-75 to 1990-91; and 2.9% during 1990-91 to 2010-11, both being statistically significant.

4. Terms of Trade and agricultural supply response

Direct evidence based on the association of the growth rates of agricultural output during different phases of ToT indicates that inter-sectoral terms of trade have a significant bearing on agricultural growth performance. The evidence is sharper for the state than for the nation. It is possible to argue that a strong favorable upward trend in the terms of trade for agriculture would lead to agricultural growth, prosperity and subsequently to a higher growth in the state. This happens because, other things remaining the same, when prices of agricultural commodities rise, farmers are encouraged to supply more value by changing cropping pattern in favor of high value crops, bring more area under cultivation, increase cropping intensity, increase investments in modern inputs and machinery, expand irrigation facilities, or take more risks for better technology, marketing, and storage among others. In order to model the agricultural supply function along this logic, we need to recognize that the expected supply of agricultural output depends on the expectations about relative prices, besides other non-price variables.

Theoretically, the formation of price expectations in the supply curve is modeled using either an adaptive expectation or a partial adjustment mechanism. These models have been used as standard specifications following the initial works of Nerlove (1958), Muth (1961), Mills (1961) among several others. Specifically, if we take(P_t^e) as the expected price of the output at a given time period, the conventional supply curve can be specified as:

$$X_t^e = \beta_0 + \beta_1 P_t^e + \sum_j \gamma_j V_{jt} + v_t \qquad \text{... (2)}$$

where(X_t^e) is the desired or expected output, (P_t^e) is expected price, (β_i, γ_j) are coefficients and $(V_j's)$ are set of independent variables. If price expectations are adaptive in nature, then the expectation formation mechanism can be written as; $P_t^e - P_{t-1}^e = \lambda(P - P_{t-1}^e)$ where (P_t^e) now can be considered as the current expectation of next period's price, (P_{t-1}^e) is the current period's price that was expected last year and (P) is the actual price in the given period. The coefficient of adaptation is given by $(\lambda;\ 0 < \lambda < 1)$ which captures the extent of correction that takes place in the formation of expectations each period. To simplify and make it empirically operational, if expectations are realized and output is at its expected level, we have, $(X_t^e = X_t)$ and $(P_{t-1}^e = P_{t-1})$ as the estimate of the expectation variables. Making this substitution for all periods, we have a simplified version of equation (2) as;

$$X_t = (\beta_0 \lambda) + \beta_1 \lambda P_{t-1} + (1-\lambda) X_{t-1} + \sum_j \gamma_j V_{jt} + v_t \qquad ;\forall t \qquad \text{... (2A)}$$

where actual output (X) is a function of lagged prices, lagged output and other covariates(V_j). Empirically, the equation gets transformed into an autoregressive structure and the log-log version directly provides the elasticity estimates of the concerned variables. Equation 2A is a general form of the conventional supply curve. We use this structure and augment it further by including the price and non-price variables. With regard to output, at the state level, GSDP in India is measured at factor cost and corresponds to the income originating within the geographical boundary of the state. This practically reflects the supply side of the economy rather than the demand side. Similarly at the national level, sectoral GDP such as agricultural GDP and non-agricultural GDP are also reported at the factor cost based on the income originating concept and hence directly represent the supply side.

Further, in order to derive the specification of an agricultural supply function at the macro level, we consider its two multiplicative components, namely: (i) gross cropped area(GCA) and (ii) yield per hectare of area(Y). Theoretically, we expect the yield per hectare during a year to be determined largely by the non-price factors like extent of irrigation (Irri), average rainfall, average fertilizer consumption (Fert), use of high yielding variety of seeds (HYV), changes in cropping pattern (CCP), etc., besides the yield obtained last year (Y_{-1}).Moreover, some of the non-price factors such as application of high yielding varieties of seeds (HYV) and changes in cropping pattern (CCP) are likely to be determined by the relative prices prevailing in the market last year (ToT_{-1}) and rainfall. On the other hand, the decision about area under cultivation by farmers during a year is likely to be based on the area cultivated last year (GCA_{-1}), besides the relative prices prevailing in the market last year, extent of irrigation and rainfall. We may, therefore, represent the system of functional relationships as follows:

$$Y = f\ (Irri, Rainfall, Fert, HYV, CCP, Y_{-1})$$

where; $HYV = h(ToT_{-1}, Rainfall)$

and $CCP = \ c(ToT_{-1}, Rainfall)$

Combing the relations, we have;

$$Y = f(Irri, Rainfall, Fert, ToT_{-1}, Y_{-1})$$

and$GCA \ = g(Irri, Rainfall, ToT_{-1}, GCA_{-1})$

Since agricultural output or income at constant prices (X) is given by the multiplication of two components,(Y)and (GCA), i.e. yield per hectare times the cultivated area, in logarithmic form, we can denote it as:$\ln(X) = \ln(GCA) + \ln(Y)$.These two components can be specified separately as a function of their determinants, such as;

$$\ln(GCA) = \alpha_0 + \alpha_1 \ln(Irri) + \alpha_2 \ln(Rainfall) + \alpha_3 \ln(GCA_{-1}) + \alpha_4 \ln(Tot_{-1}) + e \qquad (3)$$

and

$$\ln(Y) = \beta_0 + \beta_1 \ln(Irri) + \beta_2 \ln(Fert) + \beta_3 ln(Rainfall) + \ \beta_4 \ln(Y_{-1}) + \beta_5 \ln(ToT_{-1}) + v \qquad ... (4)$$

where irrigation and fertilizer are measured respectively as percentage of gross irrigated area in GCA and fertilizers used by farmers per hectare of GCA; rainfall is measured in average millimeters of rain; subscript of (–1) denotes last year’s value; (e) and (v) are random error terms; and α_i andβ_i’s are parameters. Adding equations (3) and (4), we get:

$$\ln(\mathrm{GCA}) + \ln(\mathrm{Y}) = \ln(X) = (\alpha_0 + \ \beta_0) + (\alpha_4 + \beta_5) \ln(ToT_{-1}) + (\alpha_2 + \beta_3)\ln\ (Rainfall)$$
$$+(\beta_1 + \alpha 1) \ln(Irri) + \beta_2 \ln(Fert) + \ \alpha_3 \ln(GCA_{-1}) + \beta_4 \ln(Y_{-1}) + (v + e) \qquad ... (5)$$

In equation (5), if $\alpha_3 = \beta_4$ then the respective two terms collapse into $\ln(X_{-1})$based on the definition of output(X).The equation finally reduces to:

$$\ln(X) = \psi_0 + \psi_1 \ln(ToT_{-1}) + \psi_2 \ln(Rainfall) + \ \psi_3 \ln(Irri)$$
$$+\psi_4 \ln(Fert) + \ \psi_5 \ln(X_{-1}) + \eta \qquad (5A)$$

where $(\psi_i's)$ are the reduced form coefficients from the structural equations of the model and correspond to the conventional supply function given in equation (2A) above. For estimation, we consider the period from 1974-75 to 2010-11 for Gujarat and 1974-75 to 2009-10 for all India covering the last two phases of the trend behavior of ToT in both Gujarat and all India. This period also satisfies the constraints on availability of data on all relevant variables at the state and the national level. Out of all variables considered as per equation (5A), we finally retain the variables with *t-values* exceeding unity in the regressions. Inclusion of the left out variables in the regression would only reduce the effective explanation power (adjusted R^2) and goodness of the fit (F-value). With all variables specified in natural logarithm, we estimate this equation for both Gujarat and All India agricultural series. The results are as follows[5]:

I Gujarat

Dep. Var	Constant	Coefficients			
Ln(X)	2.66	$+0.544 \ln(ToT)_{-1}$	$+ 0.549 \ln(Rain)$	$+ 0.249 \ln(Fert)$	$+ 0.309 \ln(X)_{-1}$
SE:		(0.269)	(0.086)	(0.076)	(0.104)
p value:		(0.052)**	(0.000)*	(0.003)*	(0.006)*

R^2 =0.856 \| Adj.R^2 = 0.837 \| N= 36
Durbin's H test p-value =0.250
Breusch-Godfrey LM test p-value =0.217

*X is agricultural output; ToT is terms of trade; Rain is Rainfall (mm);Fert is fertilizer used per hectare of GCA; * and ** indicate value significant at 1% and 5.5% respectively.*

This result for Gujarat shows no evidence of any estimation problem and is also a good fit on the data. All variables in the regression are statistically significant as given by their p-values and show elasticity of agricultural supply with respect to corresponding variables with positive sign. The short-run elasticity of agricultural output with respect to the inter-sectoral Terms of Trade turns out to be +0.54, whereas the long-term elasticity is +0.79 (i.e.0.544/(1–0.309)).Similarly, the short-run and long-run rain elasticity of agricultural supply is respectively +0.55 and +0.79; the corresponding figures of fertilizer elasticity of agricultural supply are respectively +0.25 and +0.36.Next, we describe the result for the all-India series.

II All India

Dep. Var	Constant	Coefficients			
Ln(X) =	0.358	$+ 0.625 \ln(ToT)_{-1}$	$+ 0.384 \ln(Rain)$	$+ 0.103 \ln(Fert)$	$+ 0.750 \ln(X)_{-1}$
Std. Error:		(0.162)	(0.084)	(0.047)	(0.096)
p values:		(0.001)*	(0.000)*	(0.037) **	(0.000)*

R^2 = 0.985 \| Adj.R^2 = 0.982 \| N =35
Durbin's H test p-value = 0.843
Breusch-Godfrey LM test p-value = 0.828

*X is agricultural output; ToT is terms of trade; Rain is Rainfall (mm); Fert is fertilizer used per hectare of GCA;*and** indicate value significant at 1% and 5% respectively*

The regression best fitting the data in the case of agricultural output at all India level is structurally similar to the one for Gujarat. The estimates also do not show any estimation problems and the goodness of fit is even better. All parameters showing the elasticity of the agricultural supply with respect to the corresponding variables are statistically significant with a positive sign. Our estimate of the short-run elasticity of agricultural supply with respect to the inter-sectoral terms of trade in India is +0.625, but in the long-run it is as high as +2.5. Short-run and long-run rain elasticity of agricultural supply is respectively +0.38 and +1.5; and the short-run and long-run fertilizer elasticity is respectively +0.1 and +0.4.

The above results suggest that while the short-run rain and fertilizer elasticities of agricultural supply are higher, the corresponding long-run price elasticities are lower in Gujarat than in the nation. The fertilizer elasticity in the long-run is similar in the state and the nation, but the other two long-run elasticities for rain and prices are substantially lower in Gujarat than at all India level. The agricultural supply in the state even in the long-run continues to be relatively price inelastic but at the all India level it turns out to be price elastic. The absolute supply response in the state agriculture could still be relatively high as the average agricultural price in the state may change relatively more than in the nation. This is because the average agricultural price is the weighted average of crop prices with the corresponding cropping pattern as the weights. If the cropping pattern of a state differs substantially from the nation, we may find higher aggregate absolute supply response to agricultural prices in a state than in the nation even when the price elasticity in the state is lower than in the nation.

Empirically, our findings here corroborate those of past studies that estimated aggregate supply response functions for the nation for different time periods. Alagh (2004) reported a positive lagged price elasticity of agricultural supply of +0.91 for the period 1950-1997. However, when Alagh (2004) considered a break date of 1980-81 on account of changes in economic policy and re-computed the elasticities for the two sub periods, they turned out to be positive but statistically insignificant. With updated data, Alagh (2011) obtained a positive and significant elasticity of+1.35 for all India agriculture for the period 1981-2004.Our result for the period 1974-2010shows a higher magnitude of +2.5.Bapna (1980) argued with strong evidence that aggregate agricultural supply elasticity of production had been positive. Although coefficients of price elasticity differed depending on the specification of supply functions, they were found to be positive but low in magnitude. The study argued that with a short series for estimation and given the nature of traditional agriculture and adverse conditions, supply elasticities of 0.24 would be considered plausible. Higher and significant elasticity values were found for individual crops under varied agro-economic conditions. Our results for Gujarat and all-India are directionally similar but higher in magnitude perhaps because it covers longer period with equal length of pre and post reforms phases.

Our results are also comparable with Gulati &Bathla (2001) who have used similar version of supply function with lagged terms of trade. Their elasticity estimates from standard log-linear specifications lie within the range of +1.8 to +2.8 for different set of covariates and interactive coefficient terms. Misra (1998) estimates a similar version of supply response with price and non-price factors which has both lagged price and output variables among other covariates. Using variants in models, the study finds ToT as a positive and significant determinant of agricultural output supply. The elasticity estimate in our case is directly comparable with previous estimates at the national level. Thus, our estimates of the price responsiveness of agricultural supply at both the state and national level are credible and usable for policy purposes.

The findings also have some important policy implications. Firstly, relative prices described by the inter-sectoral terms of trade are not uniform across states and hence they can be influenced by separate policies. Second, aggregate supply response to relative prices also varies in magnitude across states. Third, agriculture at a state level is likely to respond effectively to price policy thereby augmenting production if a right set of price incentives is provided.

Finally, our results here also help us take a view and revisit the debate regarding backward bending supply curves for marketable surplus in the Indian agriculture. Kothari (1998) showed that a backward bending supply curve for the self-consumed commodity would arise only if the elasticity of substitution is numerically smaller than the income elasticity of demand of that product, thereby making the price elasticity of the self-consumption positive. Dholakia (1999), however, demonstrated that even with a positive price elasticity of self-consumption, a backward bending supply curve for marketable surplus would not arise if the supply of the product is sufficiently price elastic. Our findings here show that price elasticity of agricultural supply is likely to be substantial and hence the possibility of backward bending supply curve for marketable surplus at the aggregate level is rare.

5. Summary and Conclusion

In this paper we have investigated the role of inter-sectoral terms of trade in leading to a higher growth momentum in agriculture at a regional and the national level. Inter-sectoral terms of trade are introduced to capture the price incentives that producers face in agricultural sector. This has implications on the supply of agricultural output and investments in the economy. We show that terms of trade (ToT) series at a state and the national levels are statistically different thereby making a case for a separate analysis of ToT at the two levels. The paper examines the hypothesis that favorable ToT for agriculture leads to higher growth of agricultural output in the economy.

Break-dates in ToT series are identified endogenously at the state and the national levels to get direct evidence on growth performance in distinct phases. At the state level, the empirical findings show three distinct phases of ToT for Gujarat. Correspondingly, the all India series shows three break-dates and four different regimes. Significant acceleration in Gujarat agriculture is associated with sharply rising ToT in favor of agriculture–a factor most studies have not considered while explaining the success story of Gujarat agriculture. Prior to 1992-93, the terms of trade had been falling for the agricultural sectorwhile post 1992-93, the same were rising.Thus, agriculture was relatively losing before 1992-93 in the state and as ToT changed favorably, it spurred significant growth of agriculture. Supply elasticity of agricultural output with respect to ToT was also estimated for the state and the nation considering the non-price factors also. The price elasticity of agricultural supply is positive and statistically significant, indicating the positive role of price incentives in influencing agricultural supply. Thus the hypothesis of favorable terms of trade of agriculture is empirically supported, both at the state and the national levels.

Several policy implications follow from our findings. Since relative prices revealed by the inter-sectoral terms of trade are not uniform across states, they can be influenced by state policies. Aggregate supply response to relative prices also varies in magnitude across states and therefore states can follow the price incentives best suited to their circumstances. Sectoral price policies may be effective for initiating overall growth promoting policies if agriculture is driving the economy. In such cases, the effect of relative prices on the total income in the economy could be much more in general than on agricultural supply. Thus, they can be used to promote employment and address poverty in the economy. Finally, our findings on the price elasticity of agricultural supply suggest that policy makers need not worry about any possibility of a backward bending supply curve in agriculture.

Notes:

1. In analyzing ToT, there are alternative price indices available at the national level, but GDP deflators perform equally well (Raghavan, 2004). At the state level, alternate price indices are either not available or are not reliable. Use of GSDP deflators by sectors is, therefore, the only effective alternative to examine trends in inter-sectoral terms of trade at the state level.

2**.** The methodology of the endogenous model following Bai-Perron (1998, 2003), Perron& Zhu (2005) uses a multiple regression model which estimates (*m*) parameters for (*m*+1) regimes. The break points say ($t_{1..}...t_m$) are treated as unknown and the goal is to determine the location and number of breakpoints (t_j) for j=1…..*m*. The estimation is based on the principle of ordinary least squares which gives the (*m*) parameters after minimizing the sum of squared residuals (RSS) over each partition or segment. The computational effort is to derive a triangular Residual Sum of Square (RSS) matrix which gives the RSS for a segment starting at observation (*j*) and ending at *j'* with $j < j'$. This is achieved through a dynamic programming algorithm which estimates the breakpoints (t_1…..t_m) as given by the outcome of the function (t_1…..t_m)= *arg min* $S_t(t_{1.}...t_m)$ where $S_t(t_1.....t_m)$ is the RSS for a given (*m*) partition and that the minimization is done over all partitions. (See, Dholakia &Sapre, 2011; Ghosh, 2010). Computationally, the method allows for a choice of length of segment (*h*) on which the regression would be estimated. Thus for 51 observations, a value of *h*=6 allows a possibility of detecting up to 8 breaks in the series.

3. The break dates for Gujarat inter-sectoral terms of trade with varying size of the segment (h) are:
h=6 – 1974-75 and 1992-93
h=7 – 1974-75 and 1992-93
h=8 – 1974-75 and 1992-93
h=9 – 1974-75 and 1992-93

Correspondingly, for All India inter-sectoral terms of trade, the break dates are:
h=6 – 1965-66, 1974-75, 1990-91 and 2004-05
h=7 – 1966-67, 1974-75, 1990-91
h=8 – 1995-96
h=9 – 1995-96

4. The estimated equation for piecewise regression is:
Gujarat:
$\ln(GJ\ Pa/Pna) = 0.051 - 0.0001\,(t) - 0.0067\,(t-t_1^*)D_1 + 0.00250\,(t-t_2^*)D_2$
P value: (0.984) (0.383) (0.000)
R^2 0.343, n=51

All India:
$\ln(AI\ Pa/Pna) = -0.287 + 0.050\,(t) - 0.0696\,(t-t_1^*)D_1 + 0.0169\,(t-t_2^*)D_2 + 0.0126\,(t-t_3^*)D_3$
P value: (8.24E-10) (3.08E-08) (0.000) (7.25E-05)
R^2 0.744, n=52

5. Empirically, the check for stationarity was carried out using the Augmented Dickey Fuller (ADF) test for all the series. We find that all series have a unit root and are stationary only in first differences, i.e. I[1]. In estimating elasticities using non-stationary variables, dynamic models with lagged and differenced variables have been discussed in Wickens and Breusch (1988) and Banerjee et al. (1993). They show that dynamic models can be estimated using OLS when variables are non-stationary and consider cases where the series are of the same order of integration and that a combination of such variables is I[0] or stationary. (See: pp. 7, 73, 77 and the cases of estimation of series of same and different order) Thus in the present case, since all variables are integrated of the same order I[1], the linear combination is stationary of the order I[0] and the coefficients can be interpreted as elasticity estimates, in absence of any other empirical problem.

References:

Alagh, Munish (2004), "Aggregate Agricultural Supply Function in India", *Economic and Political Weekly*, Vol. 39, No. 2 (Jan. 10-16, 2004), pp. 202-206

Alagh, Munish (2011), "Agricultural Economy of India and Macro-Economic Effects: Some empirical results and a research agenda based on the literature",*IIMA Working Paper, WP-2011-09-01, Indian Institute of Management, Ahmedabad.*

Bai, J. and P. Perron(1998), "Estimating and testing linear models with multiple structural changes", *Econometrica*, vol.66, pp. 817-58

Bai, J. and P. Perron(2003), "Computation and analysis of multiple structural change models", *Journal of Applied Econometrics*, vol. 18,pp.1-22

Banerjee, A, Dolado, J.J, Galbraith, J.W. and Hendry, D.F. (1993), *Co-integration, error correction, and the econometric analysis of non-stationary data*, Oxford University Press, New York

Bapna, S L (1980), *Aggregate Supply Response of Crops in a Developing Region*, Sultan Chand and Sons, New Delhi

Deb, Surajit (2005), "Terms of Trade and Supply Response of Indian Agriculture: Analysis in Co-integration framework", *Indian Economic Review,* New Series, Vol. 40, No. 1 (January-June 2005), pp. 65-92

Dholakia, Ravindra H. (1999), "Sufficient condition for a backward bending supply curve", *Indian Economic Journal,* Vol. 47, No. 4, pp.58-61

Dholakia,Ravindra H.(2009), "Regional sources of growth acceleration in India", *Economic and Political Weekly,* 21st November, pp.67-74

Dholakia, Ravindra H. and Samar K. Datta (Eds.)(2010), *High Growth Trajectory and Structural Changes in Gujarat Agriculture,* MacMillan, New Delhi

Dholakia, Ravindra H. andAmeyA. Sapre (2011), "Estimating Structural Breaks Endogenously in India's Post-Independence Growth Path: An Empirical Critique", *Journal of Quantitative Economics,* Vol. 9, No.2, July, pp. 73 – 87

Ghosh, Jayati (1988), "Intersectoral Terms of Trade, Agricultural Growth and the Pattern of Demand", *Social Scientist,* Vol. 16, No. 4, Four Decades of Economic Development II (Apr. 1988),pp. 9-27

Ghosh, Madhusudan (2010), "Structural Breaks and Performance in Indian Agriculture"*Indian Journal of Agricultural Economics*, Vol. 65, No.1 Jan-March

Govt. of India (2012), *Economic Survey 2011-12,* Government of India, Oxford University Press, New Delhi

Gulati, Ashok and SeemaBathla (2001), "Capital formation in Indian agriculture: Revisiting the debate", *Economic and Political Weekly,* Vol. XXXVI, No. 20, pp. 1697-1708

Gulati, Ashok, Tushaar Shah, and Ganga Shreedhar (2009), *Agriculture performance in Gujarat since 2000: Can it be a divadandi (Lighthouse) for other states?* IWMI and IFPRI, Delhi, May, 2009

IITM (2010), *Monthly data on Indian summer monsoon rainfall during 1871-2008 database* Indian Institute of Tropical Meteorology, Pune

Kothari, V.N (1998), "Elasticity of demand for self-consumption of own product", *Indian Economic Journal,* Vol. 46, No.2, pp.140 -142

Muth, John (1961)"Rational Expectationsand the Theory of Price Movements", *Econometrica,* 9.3:315–35

Mills, E (1961), "The Use of Adaptive Expectations in Stability Analysis: Comment", *Quarterly Journal of Economics,* 75:330–35

Misra, V.N (1998), "Economic Reforms, Terms of Trade, Aggregate Supply and Private Investment inAgriculture: Indian Experience", *Economic and Political Weekly, Vol. 33, No. 31, pp. 2105-2109*

Nerlove, M (1958), "Adaptive Expectationsand Cobweb Phenomena", *Quarterly Journal of Economics*, 73:227–40

Raghavan, M.(2004) "Terms of Trade between Agriculture and Non-Agriculture in India, 1950-51 to 2000-01", *Social Scientist*, Vol.32, N0.3-4, March-April, pp. 16-29

Sapre, Amey (2014), "Madhya Pradesh: Does Agriculture Determine the State's Growth Trajectory?",*Margin—The Journal of Applied Economic Research*, SAGE Publications, Vol. 8:1 (2014): pp. 39-57

Shah,Tushaar, Ashok Gulati, Hemant P., Ganga Shreedhar, & R.C. Jain (2010), "Secret of Gujarat's agrarian miracle after 2000", in Commissionerate of Information: *Agriculture miracle of Gujarat*, Government of Gujarat, Gandhinagar, February, 2010

Singh, J.P. (1989), "Terms of Trade in Punjab Agriculture", *Indian Economic Review*- New Series, Vol. 24, No. 2 (July-December), pp.263-276

Tyagi, D. S (1987), "Domestic Terms of Trade and Their Effect on Supply and Demand for the Agricultural Sector', *Economic and Political Weekly, Review of Agriculture*, March 1987, p.A33

Wang, Z.(2006), "The Joint determination of the numbers and the type of structural changes", *Economic letters*, Vol.93, pp.222-227

Wickens, M.R. and Breusch, T.S (1988), "Dynamic specification, the long-run and the estimation of transformed regression models", *Economic Journal*, Vol. 98, pp. 189-205

Zelileis, Achim, F.Leisch, K. Hornik and C. Kleiber(2005), "Strucchange: An R package for structural change in linear regression model", *R-project, 2005*

♦♦♦