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Abstract

In this paper we empirically investigate 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. Terms of trade reflects price signals and economic incentives for producers and hence could be a determinant of supply response and growth performance of agriculture and the whole economy. We identify structural breaks endogenously in inter-sectoral terms of trade and analyse phase wise growth performance in distinct periods in both Gujarat and all India. Empirical analysis supports the hypothesis that favourable terms of trade for agriculture lead to a higher growth in agriculture and the whole economy. The results show a strong evidence for positive price elasticities of supply in agriculture and almost rules out the possibility of backward bending supply curve. Favourable terms of trade for agriculture are an additional factor for the high growth trajectory of Gujarat agriculture not emphasized in the literature.

Keywords : Agriculture, Structural breaks, Supply elasticity, Terms of Trade, Indian economy, Gujarat, Backward bending supply curve

JEL Codes : Q1, Q11, Q18

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I Introduction

In this paper we analyse the role of agricultural terms of trade in leading to a growth momentum in agriculture and the overall economy at a state and the national level. It is a well-known fact that agriculture over time at a state level fluctuates more than at the national level. Determinants of the agricultural output at the national level are often considered in terms of non-price factors with only a few studies considering the price response of agricultural supply (Bapna, 1980; Tyagi, 1987; Ghosh, 1988; Raghavan, 2004; Alagh, 2004; and Deb, 2005). At the state level, however, there are few efforts (except Singh, 1989) to estimate supply response to the terms of trade for agriculture. A probable reason for ignoring price factors at the regional level may be the belief that prices may not vary across regions within a nation. High fluctuations of regional agricultural output could, therefore, be attributed only to the non-price factors. Variations in the inter-sectoral terms of trade can, however, be significantly different at a regional and the national levels. Aggregate supply response of agriculture to terms of trade may also vary across states.

We begin by comparing agricultural growth performance in all India and Gujarat state. We selected Gujarat for the following reasons: (i) It historically experienced high fluctuations in agricultural output leading to overall growth fluctuations in the state; (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 (Dholakia, 2009); and (iii) agricultural growth in the state during the last decade has been more than twice as compared to the national figure. Recent studies (Gulati *et al.* 2009; Shah *et al.* 2010; and Dholakia & Datta, 2010) have attempted to provide some explanations for this rapid growth of agriculture in the state, but have not considered price response of agricultural supply. The terms of trade reflect the price incentives that producers in the

respective sectors face determining their investments, savings and competitiveness.

The paper is organized in five sections. Section II briefly discusses trends of agricultural growth in Gujarat and the whole national economy. Section III conducts an empirical investigation to establish whether variations in the regional and the national inter-sectoral terms of trade are the same or different. It then endogenously identifies breaks dates in the long term trend of the inter-sectoral terms of trade in both Gujarat and all India. Section IV estimates the degree of price responsiveness of both the agricultural and total output at the state and the national level. The last section summarises main findings with concluding remarks.

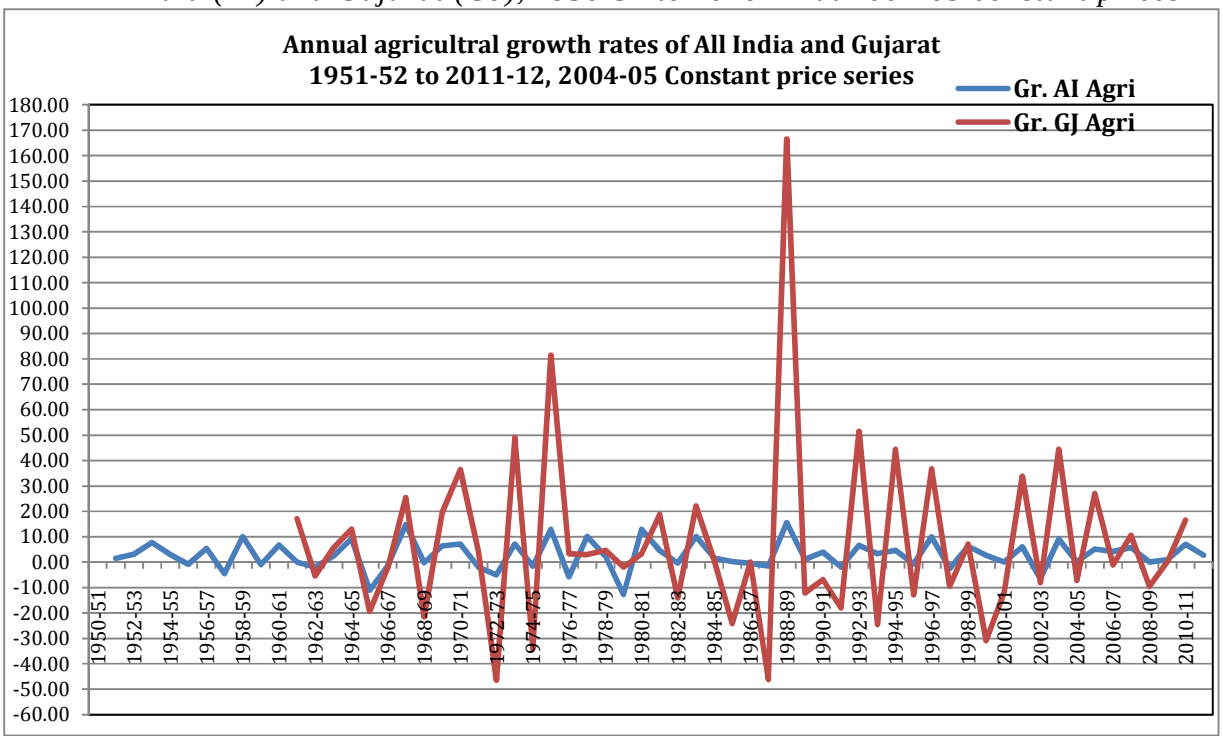
II Trends of aggregate income in agricultural sector

State income (GSDP) originating in agriculture including animal husbandry (Agri+AH) (henceforth agriculture) at factor cost is the most comprehensive measure of economic activities in the sector within the state boundaries. It takes into account the estimates of total production of all agricultural products & services net of all inputs used in their production in a given year. The production and inputs are valued at both current and constant base year prices to get respectively the nominal and real incomes over time. Correspondingly, similar aggregates are taken at the national level. 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. Graph 1 plots the annual growth of agriculture (including AH) of Gujarat and All India agricultural GDP including allied activities at constant prices for the period 1950-2011. (For basic data, see Appendix).

It can be seen from the graph that both the series show fluctuations over time, but the ones in the state is far more than in the nation. Thus, agriculture as

business in the state shows relatively high degree of risk and uncertainties than in the nation. Agricultural income in the state has also been adversely affected by several drought years when it has nosedived. At the national level the fluctuations are not so severe.

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



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

Table 1: Growth statistics for five decades of Gujarat and All India Agriculture and total Income (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*
Gross State Domestic Product (GSDP) and All India GDP							
	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	10.34	7.64	27.35	24.03	2000-01 to 2010-11	10.44*	7.91*
1991-92 to 2000-01	6.1	5.7	187.03	34.59	1990-91 to 2000-01	7.07*	6.09*
1981-82 to 1990-91	5.75	5.4	258.64	40.83	1980-81 to 1990-91	4.55*	5.28*
1971-72 to 1980-81	4.23	3.16	381.42	137.75	1970-71 to 1980-81	4.47*	3.43*
1961-62 to 1970-71	5.13	3.75	177.41	93.90	1960-61 to 1970-71	3.29*	3.48*

** indicates statistically significant at 1%. 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 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). Trend in fluctuations in the annual growth rates of total

income is found very similar in the nation and the state with the latter fast closing in with the former. It implies that growth in the total real income in the state became relatively immune to fluctuations in agricultural growth.

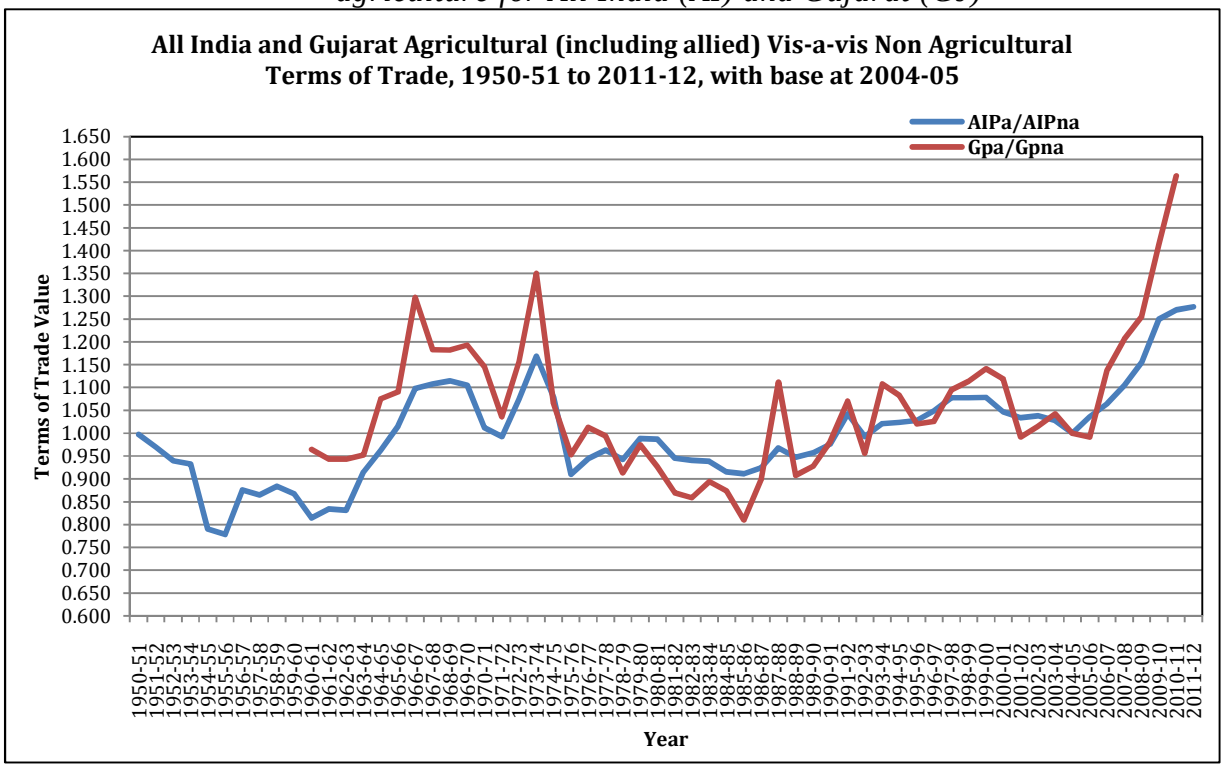
The trend rate of growth obtained by fitting a log-linear time-trend on the income series, shows that Gujarat did not experience a statistically significant growth in agriculture except during the last decade. On the other hand, agriculture in the nation grew at a statistically significant rate during all the past decades. Comparison of the performance of agricultural income during the last decade between Gujarat and all India, however, almost reverses the story of the earlier decades. The decade of 2001-11 shows the 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% in the nation. 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, is it possible to link and relate their explanation in terms of price factors? Are the price factors likely to be identical for a state and the country? We explore these questions in the next section.

III Structural breaks in agricultural 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[1]. From this, the implicit GSDP deflators by sectors are computed which show the relative prices that producers face in respective sectors. 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. It is customary to divide the economy into agriculture (including animal husbandry) 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.

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



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 favor of agriculture only after 2005-06 in the last decade. 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 structure and trend of relative prices follow a similar pattern for the state as for

the nation. To investigate this, we conduct an empirical test to determine whether the terms of trade series are statistically the same for the state and the nation.

Empirically this is done by regressing Gujarat ToT as the dependent variable and All India ToT as the independent variable and then testing the following hypotheses: Intercept (a)=0 and slope coefficient (b)=1. Based on the regression parameters, it implies that if the two series were to be the same, it would imply that (a)=0 and (b)=1. Alternatively, if the disparity or structural features of both series were different, we would expect (a) to be different from 0 and (b) to be different from 1 statistically. 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 of Gujarat agricultural terms of trade and All India agricultural terms of trade. Estimated equation:
GJPa/Pna = a + b(AIPa/Pna)

Dep. Var	**Intercept (a)**	**Coefficient (b)**	**t_{value} (a=0)**	**t_{value} (b=1)**	**R^2**	**F**
GJ.Pa/Pna	–0.338 SE (0.113)	1.375 SE (0.111)	–2.991 *	3.376 *	0.757	153.037

*SE is standard error; * indicates value significant at 1% level of significance. No. of observations =51*

It can be observed from Table 2 that both (a) and (b) are statistically significantly different from (0) and (1) respectively. This provides the empirical evidence that trends of terms of trade at the regional level and national level are not the same. Thus, the price factors operating at the state level are different from the ones at the national level. A substantially different growth performance of agriculture at a state and the national levels, moreover, indicates a possibility of even the aggregate supply response both for agricultural and overall output being different for the two spatial units.

Theoretically, we expect a uni-directional relationship between inter-sectoral ToT and overall growth of output as well as growth of agricultural output in the economy, because inter-sectoral ToT being the ratio of relative prices faced by producers in the respective sectors reflects the incentives for production and investment. Therefore, when the output response or the growth differs between a state and the nation, it could be because: 1. price factors differ; 2. price elasticity of supply differs; or 3. 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 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. Since the direction of causation is already established through expectations from the theory, once the distinct phases of inter-sectoral ToT are identified, growth rates of agricultural and overall output during the corresponding phases can be computed. This is expected to provide direct evidence on broad association 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 Zelileis *et 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, Bai-Perron this is achieved 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. In order to

empirically investigate the role of agricultural ToT we detect structural breaks and subsequently fit a piecewise regression using the break dates to identify different turning points in the series. The break date is computed in the level of ToT and subsequently, a trend equation with dummies for break dates is fitted as follows:

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

where $D_1=1$ for $t > t_1^*$, $D_2=1$ for $t > t_2^*$ are two dummy variables and t_1^* and t_2^* are estimated break dates. We fit this type of equation for ToT after identifying the break dates endogenously for both the state and the nation. As discussed earlier, the result of the endogenous is as follows: [3]

1. Gujarat Terms of Trade series (with base at 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 and RSS for corresponding regimes:

m	0	1	2	3	4	5
RSS	1.0870	0.8851	0.7150	0.6335	0.6297	0.6252
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 (with base at 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 and RSS for corresponding regimes:

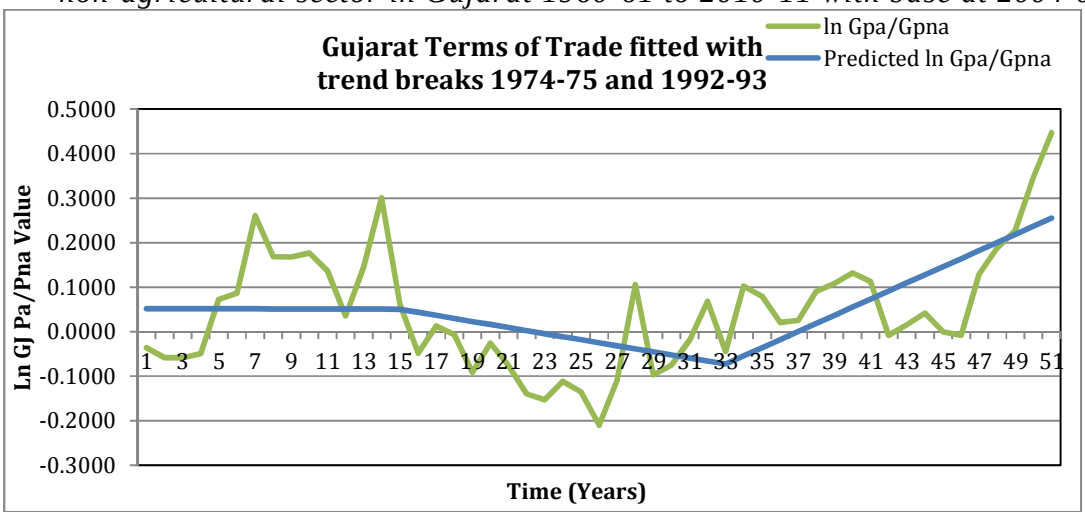
m	0	1	2	3	4	5	6
RSS	0.4191	0.309	0.273	0.190	0.165	0.164	0.163
BIC	-92.270	-99.905	-98.271	-108.767	-108.205	-100.704	-93.178

(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, viz. (i) 1960-75, when P_A/ P_{NA} was almost constant; (ii) 1975-1991, when the P_A/ P_{NA} was declining; and (iii) 1991-2011, 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 three phases[4]. Graph 3 shows the three distinct phases of trend of agricultural terms of trade in the state.

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.



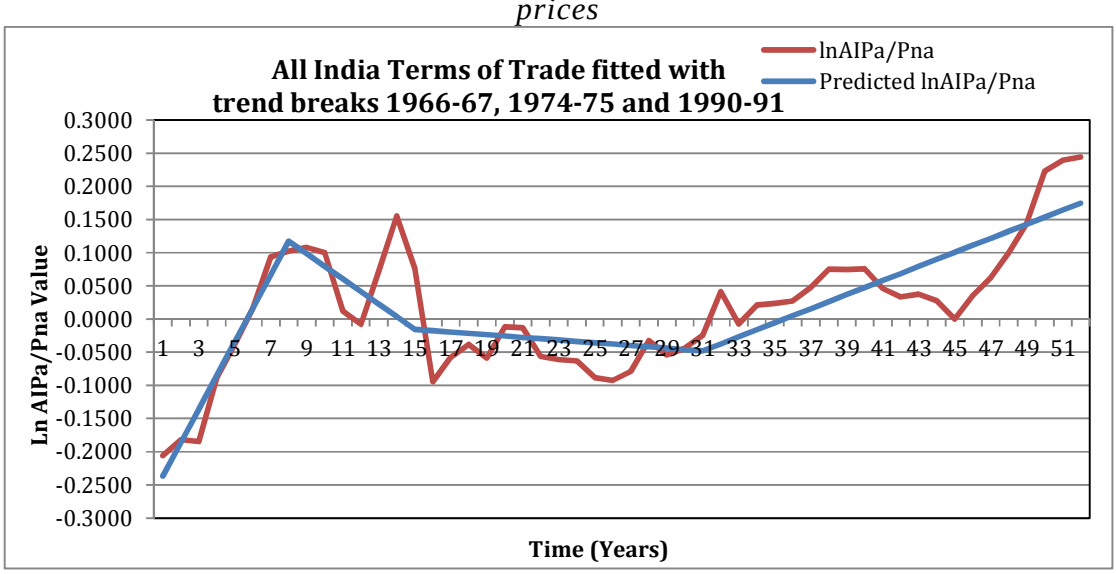
In order to understand the underlying changes in terms of trade, we first note from the decadal growth record that GSDP in Gujarat always registered a

positive and statistically significant annual growth throughout the period, while agricultural sector did not show statistically significant trend growth rate during the first four decades (Table 1 above). Evidently, the periods of low and high growth, particularly for agriculture, coincide with the fluctuations in the inter-sectoral terms of trade in the state.

When we calculate the compound annual growth rate (CAGR) of agriculture and total 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 agricultural trend rate was 2.2% (statistically not different from zero) while it was around 3% for total GSDP. During the second phase when ToT was fluctuating but around a falling trend, the agricultural CAGR was 2% (again statistically not significant) and 4.9% for total GSDP. However, during the third phase when the agricultural terms of trade were sharply rising, the agricultural CAGR was statistically significant at 3.8% and GSDP registered a CAGR of 7.60%, which later rose to 8.0% for agriculture and 10.4% for GSDP. It is equally evident that prior to 1990-91, the terms of trade were rising for the non-agricultural sector and post 1990-91; the same were declining. Thus, agriculture was relatively losing before 1990-91 and was economically gaining after 1990-91 in Gujarat. This change of regime seems to have spurred a positive and significant growth of agriculture in the state after 1990-91, which is borne out 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, 1967-68 to 1974-75 and 1975-76 to 1990-91 and the last phase 1991-92 to 2010-11. Graph 4 plots the phase wise trend of terms of trade for All India agriculture.

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- 1991 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 and total GDP for the nation are respectively: 2.7% and 4.6% during 1975-76 to 1990-91; and 2.9% and 6.8% during 1991-92 to 2010-11.

IV Terms of Trade and agricultural supply response

Direct evidence based on the association of the growth rates of agricultural output and total output during different phases of ToT indicates that agricultural terms of trade have a significant bearing on agricultural growth performance and on the overall economy. 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 (and hence unfavorable trend for non-agriculture) would lead to agricultural growth, prosperity and subsequently to a

higher growth trajectory for 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. However, given the movement of agricultural prices and output, this at best suggests a lagged relationship between prices and agricultural supply and thus forms the basis for an eventual increase in overall agricultural supply and hence overall state income.

On the other hand, if prices of non-agricultural products were to fall *ceteris paribus*, the total effect on the supply of non-agricultural products is likely to be on two counts: (i) the profitability of the product may decline under the assumption of closed economy with inelastic demand, and (ii) in an open economy with vibrant export market, the value of production may increase because, reduced prices point to competitive advantage in the market. If the demand for such products is elastic, the total value will rise. Since at the state level, GSDP is always measured at factor cost and corresponds to the income originating within the geographical boundary of the state, it invariably reflects the supply and not the demand aspects. Similarly at the national level, sectoral GDP such as agricultural GDP and non-agricultural GDP are also reported at the factor cost based on income originating concept and hence represent the supply side. We formulate two dynamic regression equations to estimate the responsiveness of growth of agricultural GSDP and total GSDP to changes in inter-sectoral ToT (P_A/P_{NA}). Since a lagged response is theoretically expected, the following equations are postulated in double log form:

(i) $\ln(Agri.+AH)_t = \alpha_0 + \alpha_1 \ln(P_A/P_{NA})_{t-1} + u$ (2)

(ii) $\ln(GSDP)_t = \beta_0 + \beta_1 \ln(P_A/P_{NA})_{t-1} + v$ (3)

where u and v are random errors and α_0 & $ß_0$ are intercepts, and α_1 & $ß_1$ are price elasticity parameters. The estimates of these equations using OLS regression for the entire period are as follows:[5]

Gujarat:

(1) $\ln(GJ.Agri.+AH)_t = 9.68 + 0.467 \ln(P_A/P_{NA})_{t-1}$
P value: (0.393) $R^2 = 0.015$, n=50

(2) $\ln(GJ.GSDP)_t = 11.15 + 1.27 \ln(P_A/P_{NA})_{t-1}$
P value: (0.173) $R^2 = 0.038$, n=50

All India:

(3) $\ln(AI.Agri.+AH)_t = 12.75 + 2.104 \ln(P_A/P_{NA})_{t-1}$
P value: (0.001)* $R^2 = 0.205$, n=50

(4) $\ln(AI.GDP)_t = 13.95 + 3.913 \ln(P_A/P_{NA})_{t-1}$
P value: (0.001)* $R^2 = 0.223$, n=50

Both the equations for Gujarat do not show a good fit for the 50 year period perhaps on account of substantial changes in the relationship between these variables over different phases. We re-compute the elasticity estimates as per the phases of terms of trade by separating the years from 1974-75 to 1992-93 and 1992-93 onwards. The estimated equation of agricultural output in Gujarat during 1974-75 to 1992-93 is:

(5) $\ln$ (GJ Agri. + AH) = $9.58 - 0.755 \ln(P_A/P_{NA})_{-1}$
P value: *(0.187)* $R^2 = 0.100$, n= 19

While for the period 1992-93 to 2010-11 the result is:

(6) $\ln$ (GJ Agri. +AH) = $10.04 + 1.15 \ln(P_A/P_{NA})_{-1}$
P value: *(0.093)** $R^2 = 0.156$, n= 19

Similarly, the re-estimated equations of total output (GSDP) in Gujarat for 1974-75 to 1992-93:

(7) $\ln$ (GJ GSDP) = $10.930 - 0.89 \ln(P_A/P_{NA})_{-1}$
P value: *(0.12)* $R^2 = 0.132$, n= 19

While for the period 1992-93 to 2010-11 the result is:

(8) $\ln$ (GJ GSDP) = $11.85 + 2.46 \ln(P_A/P_{NA})_{-1}$
P value: *(0.012)** $R^2 = 0.312$, n= 19

However, it may be argued that other than price factors, adverse supply shocks in agriculture may have a significant impact on output growth and prices. The impact of shocks such as droughts would be more significant at the regional level and may well explain a considerable variation in agricultural growth. In order to incorporate the impact of adverse supply shocks, we construct a dummy variable (D) for drought. The dummy takes value of (1) for years of 1972-73, 1974-75, 1987-88, 2000-01 and 2005-06 for drought years in Gujarat and (0) otherwise. We incorporate the dummy variable in both agricultural output and total output (or GSDP) equations and report the result for which the dummy was found significant. The result where the dummy variable was significant was for Gujarat agriculture for the period 1974-75 to 1992-93[6].

(9) $\ln(\text{Agri.} + \text{AH}) = 9.69 + 0.10 \ln(P_A/P_{NA})_{-1} - 0.772\ \text{D}$

P value: *(0.75)* *(9.76E-06)** $R^2 = 0.744$, n= 19

It can be seen from the above piece-wise regression results that during the period 1974-93, the elasticity in both the cases was negative and not significant, but during the latter period of 1992-2011, the elasticity in both the cases was positive and significant. This indicates a sharp contrast in the two phases such that the overall regressions for the whole 51 year period turned out to be statistically irrelevant. Moreover, the second phase of 1992-2011 has the expected sign of the elasticity estimate as compared to the earlier phase (1974-93) which has an opposite sign though statistically insignificant. Such a feature requires some explanation. The reason for expecting a positive sign of the price elasticity of aggregate supply is in terms of exports and competitiveness of non-agricultural products in the market. During 1974-93, however, there were serious restrictions on trade of even non-agricultural products because of quantitative restrictions and high tariff barriers. Moreover, during these years several prices were also administered and controlled. As a result, the underlying economic logic of price incentives to producers in the sector would not fully work during such period and would empirically lead to statistically insignificant results.

However, with economic policy reforms initiated during the early 1990s, several market distortions including the ones in export markets were reasonably corrected and the economic logic of price incentives started operating in a holistic sense. As a result, the hypothesis of favorable terms of trade to agriculture leading to growth of agriculture and hence the total state income appears to hold in Gujarat from the empirical evidence. It also provides us the estimates of aggregate price elasticity of supply for agricultural output to be +1.15 and for overall GSDP to be +2.46. These estimates suggest that the ToT as a policy parameter has a definite role to promote growth of agriculture and total income in the state; and the more favorable it is for agriculture, the more effective it would be. At the All India level, the corresponding results for the same time period as of Gujarat for agriculture and GDP are as follows. It may be noted that the drought dummy variable was found insignificant in all cases.

All India:
For the period 1974-75 to 1992-93 the result is:

(10) $\ln(\text{AI Agri.} + \text{AH}) = 12.64 - 0.58 \ln(AI\ P_A/P_{NA})_{-1}$
P value: *(0.355)* $R^2 = 0.050$, n= 19

While for the period 1992-93 to 2010-11 the result is:

(11) $\ln(\text{AI Agri.} + \text{AH}) = 13.09 + 1.86 \ln(AI\ P_A/P_{NA})_{-1}$
P value: *(0.003)** $R^2 = 0.403$, n= 19

Similarly, the re-estimated equations for All India GDP for the corresponding period are; for the period 1974-75 to 1992-93 the result is:

(12) $\ln(\text{AI GDP}) = 13.73 - 1.101 \ln(AI\ P_A/P_{NA})_{-1}$
P value: *(0.26)* $R^2 = 0.07$, n= 19

While for the period 1992-93 to 2010-11 the result is:

(13) $\ln(\text{AI GDP}) = 14.49 + 4.46 \ln(AI\ P_A/P_{NA})_{-1}$
P value: *(0.0035)** $R^2 = 0.402$, n= 19

The result shows a sharp contrast in comparison to the 51 year period where the supply elasticity was positive and significant. However, when the period is spliced in two different regimes of ToT, the result for the country as a whole is broadly similar to the one obtained for the state. The first phase (1974-93) supply elasticities are negative and statistically insignificant. However, the second phase (1992-2011) elasticities are positive and statistically significant.

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 without considering their nature and re-computed the elasticities for the two sub periods, they turned out to be positive but statistically insignificant. Updating the data, Alagh (2011) obtained a positive and significant elasticity of 1.35 for all India agriculture for the period 1981-2004. Our results for the period 1993-2011 are similar in sign but different in magnitude. Bapna (1980) argued with strong evidence that agricultural aggregate 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 during the post-reform period.

Our results have some important lessons. First of all, relative prices revealed by the inter-sectoral terms of trade are not uniform across states and they can be influenced by 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 the production if a right set of price incentives are provided. Fourth, the inter-sectoral terms of trade in favour of agriculture do not only increase the agricultural supply but also enhances total income in the economy. Fifth, the effect on the total income in the economy is likely to be much more (almost double) than on agricultural supply.

Finally, our results here also help us take a view on the debate regarding backward bending supply curves in 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 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 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 in the aggregate is rare.

V Summary and Conclusion

We have investigated the role of agricultural terms of trade in leading to a higher growth momentum in agriculture and the overall economy at a regional and the national level. Inter-sectoral terms of trade are introduced to capture the price incentives that producers face in agricultural and non-agricultural sectors. This has implications on the supply of agricultural and total output and investments in the economy. We have shown 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 favourable ToT for agriculture leads to higher growth of agricultural output and the total output in the economy.

Break dates in ToT series are identified endogenously at the state and 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 and the overall economy is associated with sharply rising ToT in favour 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 were falling for the agricultural sector and post 1992-93, the same were rising. Thus, agriculture was relatively losing before 1992-93 in the state and as ToT changed favorably, they spurred significant growth of agriculture.

Supply elasticity of both agricultural and total output with respect to ToT was also estimated for the state and the nation. The price elasticity of agricultural supply and total output supply were positive and statistically significant for the post-reform period, 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 level.

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 can be an effective overall growth promoting policies in the economy. Moreover, the effect of relative prices on the total income in the economy is likely to be much more (almost double) 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. The terms of trade series is arrived at by first calculating the deflators of both series taking the base year as 2004-05 i.e. Deflator for Agriculture = [GSDP in $Agri_{current\ price}$/GSDP in $Agri_{constant\ price}$] and similarly for the Non-Agriculture series. The terms of trade $(ToT)_{A/NA}$ is then given by [Deflator for Agriculture / Deflator for Non-Agriculture].

2. The methodology for estimating the trend breaks endogenously following Bai-Perron (1998 and 2003) and Perron & Zhu (2005) uses a multiple regression for estimating (m) parameters for (m+1) regimes. The break points in the trend given by (t_1, t_2….. t_m) are considered as unknown and we have to fix their location and the number. The principle is the same as OLS to obtain (m) parameters by minimizing the residual sum of squares (RSS) over each segment. The computations involved are in terms of generating an RSS matrix for segments starting at observation j and ending at j' such that j < j'. This is accomplished by a dynamic programming algorithm. Out of RSS for each partition, minimum is taken over all partitions. (See, Dholakia & Sapre, 2011; and Gosh, 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 agricultural 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 agricultural 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:

$\ln (AI\ Pa/Pna) = -0.287 + 0.050\ (t) - 0.0696\ (t-t_1^*)D_1 + 0.0169\ (t-t_2^*)D_2$

P value: *(8.24E-10)* *(3.08E-08)* *(0.000)*

$+ 0.0126\ (t-t_3^*)D_3$

(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 ToT, Agriculture and GSDP 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 only if the variables have the same order of integration and that combination of such variables is I[0] or stationary. Thus in this case, since all variables are integrated of the same order I[1] the coefficients of the lagged variables in the dynamic equation can be interpreted as elasticity estimates.

6. The dummy variable for controlling the effect of adverse supply shocks such as drought in the state was created by identifying years 1972-73, 1974-75, 1987-88, 2000-01 and 2005-06 as drought years. The years were identified on basis of the long term average and deviation of rainfall in India as published by the Indian Institute of Tropical Metrology (IITM, 2010). The same dummy variable was incorporated in both the agriculture and GSDP equation. The results are:

Gujarat Agriculture: 1992-93 to 2010-11

$\ln (Agri. + AH) = 10.05 + 1.14 \ln (P_A/P_{NA})_{-1} - 0.06\ D$

P value: *(0.112)* *(0.744)* $R^2 = 0.162$, n= 19

Gujarat GSDP: 1974-75 to 1992-93

$\ln (GSDP) = 10.97 - 0.58 \ln (P_A/P_{NA})_{-1} - 0.271\ D$

P value: *(0.339)* *(0.237)* $R^2 = 0.207$, n= 19

Gujarat GSDP: 1992-93 to 2010-11

$\ln (GSDP) = 11.84 + 2.49 \ln (P_A/P_{NA})_{-1} - 0.09\ D$

P value: *(0.014)** *(0.732)* $R^2 = 0.317$, n= 19

All India Agriculture: 1974-75 to 1992-93
ln (AIAgri. +AH) = 12.66 – 3.77 ln (AIPA/ PNA)$_{-1}$ – 0.103 D
P value: *(0.583)* *(0.449)* R^2 = 0.084, n= 19

All India Agriculture: 1992-93 to 2010-11
ln (AIAgri. +AH) = 13.07 + 1.92 ln (AIPA/ PNA)$_{-1}$ + 0.079 D
P value: *(0.003)** *(0.414)* R^2 = 0.428, n= 19

All India GDP: 1974-75 to 1992-93
ln (AIGDP) = 13.73 – 0.96 ln (AIPA/ PNA)$_{-1}$ – 0.06 D
P value: *(0.380)* *(0.748)* R^2 = 0.077, n= 19

All India GDP: 1992-93 to 2010-11
ln (AIGDP) = 14.48 + 4.60 ln (AIPA/ PNA)$_{-1}$ + 0.188 D
P value: *(0.004)** *(0.419)* R^2 = 0.427, n= 19

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Appendix

Figures of Agriculture (including allied activities) and GSDP in Gujarat, and All India Agriculture and Gross Domestic Product at Factor Cost (GDPFC) 1960-61 to 2010-11 at 2004-05 base year

	At Constant Prices (2004-05) Series Rs. Crore						At Current Prices (2004-05) Series Rs. Crore					
	Gujarat			All India			Gujarat			All India		
Year	Agri.+ AH	GSDP	Non Agri GSDP	Agri + AH	GDP	Non Agri GDP	Agri.+ AH	GSDP	Non Agri GSDP	Agri.+AH	GDP	Non Agri GDP
1960-61	8069	23180	15111	195482	410279	214797	314	925	610	7256	17049	9793
61-62	9452	25757	16305	195647	423011	227364	367	1039	672	7516	17992	10476
62-63	8946	25528	16582	191755	431960	240205	355	1054	699	7674	19238	11564
63-64	9439	27143	17704	196241	453829	257588	385	1144	759	9031	21986	12955
64-65	10674	29739	19065	214343	488247	273904	520	1385	865	11034	25686	14652
65-66	8607	27226	18619	190675	470402	279727	487	1452	965	11004	26895	15891
66-67	8404	27758	19354	187962	475189	287227	604	1676	1072	12801	30613	17812
67-68	10544	30804	20260	215914	513860	297946	754	1980	1225	16019	35976	19957
68-69	8273	27910	19637	215572	527270	311698	632	1902	1269	16512	37938	21426
69-70	9887	31326	21439	229428	561630	332202	792	2232	1440	18059	41722	23663
70-71	13496	36925	23429	245699	589786	344087	1088	2736	1648	18620	44382	25762
71-72	14073	38090	24017	241087	595741	354654	1061	2807	1747	19021	47221	28200
72-73	7544	29427	21883	228988	593843	364855	771	2706	1935	20921	51943	31022
73-74	11246	36461	25215	245479	620872	375393	1490	3964	2474	27570	63658	36088
74-75	7401	30611	23210	241740	628079	386339	979	3863	2884	30204	74930	44726
75-76	13430	40464	27034	272899	684634	411735	1497	4660	3163	29937	79582	49645
76-77	13884	42908	29025	257131	693191	436060	1760	5393	3632	30585	85545	54960
77-78	14300	45688	31388	282937	744972	462035	1883	6044	4161	36212	97633	61421
78-79	14970	48693	33723	289452	785964	496512	1859	6444	4585	37217	104930	67713
79-80	14678	48855	34177	252475	745083	492608	2182	7392	5210	38501	114500	75999
80-81	15176	50025	34849	285015	798506	513491	2515	8746	6231	48426	136838	88412
81-82	18034	55235	37201	298130	843426	545296	3226	10876	7650	54583	160213	105630
82-83	15496	53951	38455	297293	868091	570798	3001	11676	8675	58849	178985	120136
83-84	18918	63545	44626	327382	936269	608887	4104	14930	10826	70228	209356	139128
84-85	19031	64090	45058	332571	973357	640786	4232	15698	11466	75731	235113	159382
85-86	14429	61460	47031	333616	1013866	680250	3307	16609	13302	81160	262717	181557
86-87	14430	64903	50473	332250	1057612	725362	3918	19181	15264	87111	292924	205813
87-88	7771	57363	49593	326975	1094992	768017	2894	19511	16617	96905	332068	235163
88-89	20716	81041	60325	378113	1206243	828130	6281	26432	20151	119678	396295	276617
89-90	18219	79864	61645	382609	1280228	897619	6329	29411	23082	132264	456540	324276
90-91	16974	80712	63738	397971	1347889	949918	6876	33192	26316	154350	531813	377463
91-92	13926	75110	61184	390201	1367171	976970	7140	36440	29300	180313	613528	433215
92-93	21111	96748	75637	416153	1440503	1024350	10061	47755	37694	202219	703723	501504
93-94	15934	93494	77560	429981	1522343	1092362	9943	53619	43676	234566	817961	583395
94-95	23004	110685	87681	450258	1619694	1169436	15331	69308	53977	270107	955385	685278
95-96	20051	116161	96111	447127	1737740	1290613	13699	78036	64338	293701	1118586	824885
96-97	27410	133072	105661	491484	1876319	1384835	19628	93359	73731	353142	1301788	948646
97-98	24825	135726	110902	478933	1957031	1478098	19533	99249	79717	374744	1447613	1072869
98-99	26603	145392	118789	509203	2087827	1578624	22884	114596	91712	430384	1668739	1238355
99-00	18399	145905	127505	522795	2246276	1723481	16702	118110	101408	455302	1847273	1391971

2000-01	16230	138775	122545	522755	2342774	1820019	15435	119523	104088	460608	1991982	1531374
2001-02	21721	150896	129175	554157	2472052	1917895	19045	133212	114167	498620	2167745	1669125
2002-03	19964	162796	142831	517559	2570690	2053131	18928	152316	133388	485080	2338200	1853120
2003-04	28834	187249	158414	564391	2777813	2213422	28882	181100	152218	544667	2622216	2077549
2004-05	26746	203373	176627	565426	2971464	2406038	26746	203373	176627	565426	2971464	2406038
2005-06	33982	233776	199794	594487	3253073	2658586	35323	244736	209413	637772	3390503	2752731
2006-07	33616	253393	219777	619190	3564364	2945174	42075	283693	241618	722984	3953276	3230292
2007-08	37155	281273	244118	655080	3896636	3241556	51077	329285	278208	836518	4582086	3745568
2008-09	33592	300847	267255	655689	4158676	3502987	50132	367745	317613	943204	5303567	4360363
2009-10(P)	33677	331633	297956	662509	4507637	3845128	59180	429356	370176	1079365	6091485	5012120
2010-11(A)	39277	370032	330755	709103	4885954	4176851	80611	514750	434139	1269888	7157412	5887524

Note: (P) stands for provisional; (A) stands for advanced estimate. Source: Department of Economics and Statistics, Govt. of Gujarat, 2011 and Economic Survey, Govt. of India, 2012.

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