Ind. Jn. of Agri. Econ.
Vol.59, No.1, Jan.-March 2004

Aggregate Agricultural Supply Response in Andhra Pradesh

N. Chandrasekhara Rao*

I

INTRODUCTION

The economic reforms initiated in 1991 aim at accelerating agricultural production through improvement in terms of trade[1] (Ahluwalia, 1996; Desai, 2002; Gulati, 1998; Mishra, 1998; Singh, 1995). Price related interventions to the relative exclusion of non-price interventions characterised the strategy for agricultural development in the nineties (Sen, 2001). A growth rate of about 4-5 per cent in agriculture is targeted to overcome the ' Hindu rate of growth' in the economy and achieve 7 per cent growth in gross domestic product (GDP). Higher agricultural growth can be realised only when agricultural production is highly responsive to increased prices (Bhalla, 1994). The impact of economic reforms on rural employment also depends on the extent of supply response in agriculture (D'Souza, 2001). Against this background, it is necessary to have an estimate of aggregate agricultural supply response to changes in agricultural terms of trade. If the aggregate supply response is small, then the current structural adjustment programmes cannot rely exclusively on price instruments for bringing about structural change in agriculture (Palanivel, 1995). The index of terms of trade of the agricultural sector during the eighties generally remained adverse, but staged a steady recovery and turned favourable in the nineties albeit with minor fluctuations (Government of India, 2003). Private capital formation in agriculture increased during the nineties at a good pace, while the public capital formation continued to decline and the gross capital formation in agriculture increased at a trend rate of 2.14 per cent per annum (Chadha, 2003). However, the growth rate in the production of all crops declined to 2.56 per cent from 3.19 per cent in the eighties (Government of India, 2002). Thereby the validity of the assumption of the new growth strategy that 'getting prices right' will spur growth in agriculture becomes doubtful.

* Faculty Member, Centre for Economic and Social Studies, Hyderabad - 500 016 (Andhra Pradesh).

This paper is a part of the author's doctoral dissertation completed at the Centre for Economic and Social Studies, Hyderabad. The author is grateful to his research supervisors S. Mahendra Dev and S. Galab and an anonymous referee of the Journal for useful comments. Further, he is also grateful to G. K. Mitra for carefully going through the draft for corrections.

II

METHODOLOGICAL SURVEY

The earlier studies viewed the supply response in terms of relationship between rates of growth in production and those in prices[2] (for e.g., Narain, 1960). Subsequently, Nerlove's reformation of Cagon's adaptive price expectation model has almost become a standard tool for estimation of supply functions. This methodology has been extended even to estimating aggregate supply response with respect to terms of trade (Tyagi, 1987). Initially, many studies were confined to individual crop response to prices (Krishna, 1963; Nerlove, 1958). Later, many studies used Nerlovian framework to study the impact of prices on aggregate agriculture. Most of these studies came to the conclusion that aggregate agricultural supply is relatively inelastic to relative prices for agriculture and that the non-price factors are comparatively more important for agricultural growth (Bapna, 1980; Dantwala, 1962,1967,1978 and 1986; Krishna, 1982; Mellor, 1966, 1976 and 1978; Narain, 1977).

Aggregate agricultural supply response at the country level with terms of trade representing relative prices is a relatively less researched area. The calculation of series of terms of trade data by Thamarajakshi in the late sixties facilitated these studies. Most of these studies were undertaken in Nerlovian framework (Desai and Namboodiri, 1997; Krishna, 1982, 1984; Mungekar, 1997; Palanivel, 1995; Shankar and Mythili, 2001; Sidhu and Singh, 1979; Thamarajakshi, 1994) except a few studies, which were in linear functional form (Mishra, 1998; Mishra and Hazell, 1996; Thamarajakshi, 1977). Most of these studies used net barter terms of trade as the indicator for relative prices, while studies by Mishra and Hazell (1996), Mishra (1998), Shankar and Mythili (2001) and Mishra and Rao (2003) used gross terms of trade. [3] Tyagi (1987) questioned the use of Nerlovian lagged adjustment model for supply response. He argued that this method does not give reliable results. He held that it ought to be appreciated that by simply regressing agricultural output on terms of trade completely ignoring the impact of institutional innovations/ reforms and of changes in agricultural technology, etc., one is likely to get fairly misleading results. [4] Besides employing supply response of Nerlovian type, Mungekar (1997) compared the compound rates of growth in the indices of terms of trade along with those of area, production and productivity to find the impact of terms of trade. [5] Among the scholars using net barter terms of trade, Thamarajakshi, Mungekar and Palanivel used series constructed on their own, while Desai and Namboodiri used series of Thamarajakshi. Though there are some studies on aggregate agricultural supply response at the state level (Bapna, 1980; Bapna *et al*., 1984; Herdt, 1970), none of them used series of net barter terms of trade at the state level. This is mainly because of lack of efforts to construct series of net barter terms of trade data at state level, just as Thamarajakshi (1969), Kahlon and Tyagi (1980), Mungekar (1992), Government of India (1995) and Palanivel (1999) did at the all-India level.

The regression coefficients in the above studies were mostly negative and non-significant for the period prior to 1970[6] (Desai and Namboodiri, 1997; Mungekar, 1997; Sidhu and Singh, 1979; Thamarajakshi, 1977). However, the regression coefficients were positive and non-significant for the later period involving the seventies and the eighties[7] (Desai and Namboodiri, 1997; Sidhu and Singh, 1979; Thamarajakshi, 1994) except Mungekar (1997). Palanivel (1995) also found significant and positive impact of terms of trade on aggregate output. [8] However, the elasticity with respect to technology variables is 3-4 times higher than price variable. In a recent study to find the existence of long-run functional relationship underlying the supply response model through co-integration analysis and error correction framework, the results indicated that agricultural terms of trade are econometrically exogenous in the vector error correction (VEC) version of agricultural supply response model, i.e., the short-run deviations in terms of trade from its long-term trend do not bear any direct causality for the long-run output adjustments in agriculture. However, changes in terms of trade create short-run adjustments in the other variables (technology adoption in agriculture as captured by gross irrigated area), so that the long-run growth of agricultural output in India is determined by the dynamic interplay of terms of trade and technology variables (Deb, 2002). Further, supply response equations estimated by using autoregressive integrated moving average (ARIMA), Prais-Winsten and OLS methods revealed that the gross terms of trade have significantly positive coefficient[9] (Mishra and Rao, 2003).

It was also hypothesised that the impact of barter terms of trade on aggregate supply in agriculture is indeterminate in its direction, *a priori.* The aggregate impact of a rise in the terms of trade is two-fold- self-consumption may rise or fall, and labour supply may rise or fall. Therefore, this has to be established empirically (Desai, 2002; Desai and D'Souza, 1999). Further, the negative sign of the interaction term between terms of trade and technology in Mishra (1998) was interpreted to mean that the two policies- terms of trade and technology are substitutive policies and technology has higher response coefficient[10] (Desai and D'Souza, 1999). However, it was argued that prices and non-price factors are complements rather than substitutes from the survey of aggregate agricultural supply response in developing countries (Schiff and Montenegro, 1997). Similar results were reported from a study in Punjab also (McGuirk and Mundlak, 1991). This means that a high level of irrigation and other public investment created infrastructure raises the impact of prices on output and vice versa (Dev and Ranade, 1998). Further, the overall agricultural picture at the all-India level conceals the regional variations (World Bank, 2000).

Therefore, the aggregate agricultural supply response in different regions may not be in line with that at the all-India level. In India, the public investments during the past three to four decades were relatively higher and the level of infrastructure in general and irrigation in particular is also high in some states like Punjab, Haryana, Uttar Pradesh and Andhra Pradesh (Hirashima, 2000). Further, some regions may be having very favourable terms of trade while others face unfavourable situation at any particular point of time (Reddy, 1994), even though there may be favourable terms of trade at the all-India level. Against this background, a study was conducted to find out the aggregate agricultural supply response in Andhra Pradesh. It is one of the states to implement economic reforms vigorously, particularly after 1995 and the level of infrastructure in the state is closer to that in all-India level (Dev and Ravi, 2003). Besides, the novelty of the study is that agricultural terms of trade for the state were constructed for the period 1980-1981 to 1999-2000. This was not done for any state except Punjab prior to nineties[11] (Singh, 1989). The farmers' decisions on what to produce, how to produce and how much to produce depend not only on output prices but also on input prices. In fact, output-input price ratio is the most relevant in this context (Johl and Kapur, 1987). Therefore, output-input price ratio represented by agricultural terms of trade is more relevant in finding aggregate agricultural supply response (Palanivel, 1995).

III

METHODOLOGY

The supply response is brought out by a regression model in the basic Nerlovian partial adjustment framework. It is assumed that one- year lagged relative prices viz., terms of trade represents the farmers' expected price. The aggregate supply response model is specified as below in log-linear form:[12]

$$Q_t = A_{0\,t} + A_1 P_{t-1} + A_2 R_t + A_3 T_t + A_4 Q_{t-1}$$

Q_t and Q_{t-1} are agricultural outputs in year's t and t-1 respectively,
P_{t-1} = Index of net barter terms of trade in year t-1,
R_t = State average annual rainfall in mm in year t,
T_t = Technological progress in year t represented by irrigation ratio (GIA/GSA *100) and / Index of TFP based on Tornquist- Theil Index,
A_is = Short-run supply elasticities,
Long run supply elasticity= A_i/ 1-A_4.

The model is estimated by using ordinary least squares method. The supply response for aggregate agricultural output (includes livestock), crop output, foodgrain output and non-foodgrain output in real terms have been estimated by the above regression model with two types of price variables (index of terms of trade and the ratio of index of prices received to the index of prices paid for inputs used in farm production) and technology variables.

The index of net barter terms of trade, which is the ratio of index of prices received to the index of prices paid for final consumption, intermediate consumption and capital formation is calculated taking 1988-1991 as the base. The indices of barter terms of trade are constructed based on Laspeyre's index and Paasche's index. Totally, 102 products are identified to have been exchanged between agriculture and non-agriculture, to make the indices of prices received and those paid by agriculture representative and comprehensive enough.[13] The farm harvest prices are used to construct the index of price received for items sold and rural retail prices are taken to represent the prices paid by the farmers for items purchased for final consumption, intermediate consumption and capital formation.[14] Two types of price variables are used for the study. Besides the index of net barter terms of trade, the ratio of index of prices received to the index of prices paid for inputs used in farm production is also used.

The irrigation ratio is generally used to represent technology in many studies on agricultural supply. In this study, index of total factor productivity based on Tornquist-Theil Index is also taken as technology variable alternatively. Total factor productivity is the ratio of index of aggregate output to an index of aggregate input. This productivity variable captures the changes in technology and management as well as fluctuations in productivity induced by weather. [15]

The TFP growth is measured from the Tornquist-Theil TFP indices (Desai, 1994). Expressed in logarithmic form, the Tornquist-Theil TFP index is

$$Ln\,(TFP_t/TFP_{t-1}) = ½ \sum_j (R_{jt}+R_{jt-1})\,Ln\,(Q_{jt}/Q_{jt-1}) - ½ \sum_i (C_{it}+C_{it-1})\,Ln(X_{it}/X_{it-1})$$

where R_{jt}= Share of output j in revenues in year ‘t’,
Q_{jt}= Output ‘j’ in the year 't’,
C_{it}=Share of input ‘i’ in total input cost in year ‘t’,
X_{it}=input ‘i’ in period ‘t’,
R_j and C_i are in current prices,
Q_j and X_i (which are in monetary values) are in 1993-94 prices.

For calculating the index, 34 products of crop and livestock sector and 10 inputs are considered. The ten inputs are seeds, chemical fertilisers, pesticides, wages paid, interest rate, electricity, diesel, land revenue, water charges and livestock feed. The Tornquist-Theil indices are calculated for aggregate agriculture, crops sector, foodgrain crops and non-foodgrain crops for use in the regression equations.

Regressions have been carried out and the following null hypotheses are proposed to be tested

$$H_0:\ A_1=A_2=A_3=A_4=0 \qquad ….(1)$$

This null hypothesis is a joint hypothesis that A_1, A_2, A_3, A_4 are jointly or simultaneously (and not individually or singly) equal to zero. In other words, this hypothesis states that the four explanatory variables together have no influence on Y. This is the same as saying

$$H_0:\ R^2=0 \qquad ….(2)$$

This hypothesis states that the four explanatory variables explain zero per cent variation in the dependent variable. These two hypotheses are tested by taking ‘F’ ratio with 4 and 15 degrees of freedom at one per cent. The regression equations, where the above hypotheses have been rejected are presented in Table 1 along with other relevant ratios. As the equations are of autoregressive nature and the usual ‘d’ statistic cannot show the serial correlation for these equations, calculating ‘h’ statistic is necessary to test for autocorrelation (Gujarati, 1992). These are also presented in Table 1.

TABLE 1.ESTIMATES OF AGGREGATE AGRICULTURAL OUTPUT FUNCTION IN ANDHRA PRADESH FOR THE PERIOD 1980-81 TO 1999-2000
(OLS ESTIMATES)(LOG-LINEAR FORM)

Equation		Intercept	Coefficients								D-W	F ratio	H
			Price 'a'	Price 'b'	Irrigation ratio	Index of TFP	Rainfall	Lagged output	R^2	2	statistic		statistic
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1.1	Aggregate agricultural	3.381	0.202		0.984	--	0.178	0.0327	0.662	0.566	2.1	6.86	0.109
	output	(1.665)	(0.434)		(2.34*)		(1.289)	(0.113)					
1.2	-Do-	3.24	0.207		0.984	--	0.182	0.0411	0.670	0.575	2.04	7.094	0.373
		(1.616)	(0.712)		(2.368*)		(1.371)	(0.156)					
1.3	-Do-	2.792	--	0.293	0.909	--	0.186	0.0731	0.691	0.603	2.112	7.840	0.135
		(1.406)		(1.236)	(2.233*)		(1.456)	(0.298)					
2.1	Crop output	-4.356	0.499		--	0.837	0.135	0.709	0.74	0.666	2.275	9.953	-0.707
		(-1.986)*	(1.32)			(3.821)*	(0.929)	(3.475)*					
2.2	-Do-	-4.188	0.249		--	0.823	0.171	0.794	0.728	0.650	2.308	9.352	-0.159
		(-1.872)*	(1.020)			(3.682*)	(1.194)	(4.299*)					
2.3	-Do-	-3.896	--	0.304	--	0.736	0.194	0.762	0.747	0.674	2.157	10.318	-0.073
		(-1.839*)		(1.473)		(3.308*)	(1.412)	(4.238*)					
3.1	Foodgrain output	-3.619	0.390		--	0.854	0.125	0.650	0.696	0.610	2.161	8.026	-0.329
		(-1.559)	(1.021)			(4.305*)	(0.934)	(3.073*)					
3.2	-Do-	-3.625	0.383		--	0.854	0.122	0.657	0.708	0.625	2.205	8.490	-0.783
		(-1.629)	(1.284)			(4.413*)	(0.931)	(3.332*)					
3.3	-Do-	-3.520	--	0.352	0.794	--	0.117	0.699	0.721	0.641	2.037	9.035	0.409
		(-1.651)		(1.536)	(4.2180*)		(0.918)	(3.832*)					
4.1	Non-foodgrain output	-5.44	0.337		--	0.935	0.122	0.859	0.827	0.778	2.372	16.766	-0.878
		(-3.101)*	(1.032)			(5.725*)	(0.848)	(5.376*)					
4.2	-Do-	-5.273	0.182		--	0.926	0.151	0.903	0.824	0.773	2.424	16.353	-0.781
		(-3.022)*	(0.871)			(5.638*)	(1.078)	(6.210*)					
4.3	-Do-	-4.748	--	0.257	--	0.779	0.196	0.845	0.835	0.788	2.226	17.690	-0.281
		(-2.912)		(1.324)		(4.160*)	(1.447)	(5.523*)					

Notes: All variables are expressed as logarithms of the original values. Hence all the coefficients are also elasticities. Figures in parentheses are the calculated t values. The asterisk values of t imply the significance at 10 per cent or lower levels. A value of 'h' below 1.645 indicated the absence of serial correlation.

Price a is the index of prices received for all agricultural products divided by the index of prices paid for items used in family living, production and capital formation.

Price b is the index of prices received for all agricultural products divided by the index of prices paid for intermediate use, viz., items used in production only.

IV

RESULTS

All the regression coefficients have the expected signs according to economic logic. It can be observed from the table that the partial regression coefficients of terms of trade with respect to aggregate agricultural output, crop, foodgrain and non-foodgrain are not statistically significant. However, they are positive. Therefore, it can be concluded that the response of aggregate agricultural output (includes livestock, crop, foodgrain and non-foodgrain output) to changes in terms of trade is positive and non-significant. On the other hand, technology variables represented by irrigation ratio and total factor productivity are significant and positive in case of aggregate agricultural output, crop output, foodgrain output and non-foodgrain output. The coefficients for technological variable are quite higher than those for terms of trade. Therefore, it can be concluded that the elasticity of output with respect to technological change variable is substantially higher than that with respect to price variable. This suggests that unit change in the technology variable will yield much greater growth in agricultural output than a unit change in the price (terms of trade variable).

In case of aggregate agricultural output, irrigation ratio is found to exert significant positive impact. On the other hand, total factor productivity is found to impact crop, foodgrain and non-foodgrain output significantly and positively.

The results seem to indicate that TFP index captures not only the effect of technological change in agriculture but also a part of the effect of rainfall on agricultural output. This may be a reason for the non-significant coefficient for rainfall. Although the 't' ratios are more than one for aggregate agricultural output, they have declined for crop, foodgrain and non-foodgrain output due to substituting of irrigation ratio with TFP. The coefficient for lagged output is statistically significant and positive for crop, foodgrain and non-foodgrain output and non-significant and positive for aggregate agricultural output. The coefficient of lagged output increases substantially when irrigation ratio is replaced with the TFP index. Similar results were reported by Palanivel (Palanivel, 1995).

A 10 per cent increase in terms of trade increases aggregate agricultural output by 2.0 to 2.9 per cent; crop output by 2.5 to 5.0 per cent; foodgrain output by 3.5 to 3.9 per cent and non-foodgrain output by 1.8 to 3.4 per cent. On the other hand, a 10 per cent increase in irrigation ratio increases aggregate agricultural output by 9.1 per cent to 9.8 per cent. Further, a 10 per cent increase in the index of total factor productivity increases aggregate crop output by 7.4 per cent to 8.4 per cent; foodgrain output by 8.5 per cent and non-foodgrain output by 7.8 per cent to 9.4 per cent. A 10 per cent increase in rainfall increases aggregate agricultural output by 1.8 to 1.9 per cent; crop output by 1.4 to 1.9 per cent; foodgrain output by 1.2 to 1.3 per cent and non-foodgrain output by 1.20 to 2.0 per cent.

Short and Long-Run Elasticities: The short and long-run elasticities are presented in Table 2. It can be observed from the table that the short-run elasticities of output with respect to terms of trade for aggregate agriculture are 0.20 to 0.29.

TABLE 2. SHORT-RUN AND LONG RUN ELASTICITIES OF AGGREGATE AGRICULTURAL SUPPLY IN ANDHRA PRADESH, 1980-81 TO 1999-2000

Equa-tion No.	Dependant variable	Short-run elasticities						Long-run elasticities			
		Price 'a'	Price 'b'	Irrigation ratio	Index of TFP	Rainfall	Partial adjustment coefficient	Index of NBTT	Irrigation ratio	Index of TFP	Rainfall
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
1.1	Aggregate agricultural output	0.20		0.98	-	0.18	0.97	0.21	1.01	--	0.19
1.2	-Do-	0.21		0.98	-	0.18	0.96	0.22	1.02	--	0.19
1.3	-Do-	-	0.29	0.91	-	0.19	0.93	0.31	0.98	--	0.20
2.1	Crop output	0.50		-	0.84	0.14	0.29	1.72	--	2.9	0.48
2.2	Crop output	0.25		-	0.82	0.17	0.21	1.19	--	3.9	0.81
	-Do-	-	0.30	-	0.74	0.19	0.24	1.26	--	3.11	0.80
3.1	Foodgrain output	0.39		-	0.85	0.13	0.35	1.11	--	2.43	0.37
3.2	-Do-	0.38		-	0.85	0.12	0.34	1.12	--	2.5	0.35
3.3	-Do-	-	0.35	0.79	-	0.12	0.30	1.16	2.62	--	0.40
4.1	Non-foodgrain output	0.34		-	0.94	0.12	0.14	2.83	--	6.71	0.86
4.2	-Do-	0.18		-	0.93	0.15	0.1	1.8	--	9.3	1.5
4.3	-Do-	-	0.26	-	0.78	0.20	0.16	1.68	--	5.03	1.29

Note: The long-run elasticities are computed by dividing the estimated coefficient by one minus the coefficient of lagged output.

In the case of crops sector, the short-run elasticity of 0.50 is from the equation where the price variable is terms of trade with Laspeyre's index and the other equations have terms of trade with Paasche's index as the price variables. Since indices of terms of trade constructed with Paasche's index, which uses current year weights are more appropriate in capturing the change in trading and consumption pattern and the ones with Laspeyre's indices are not good because of only base year weights (Kahlon and Tyagi, 1980), the short-run elasticity of 0.50 for the crops sector need not be taken seriously.

The long-run elasticities of non-foodgrain output with respect to terms of trade are 1.68 to 2.83 and are relatively high. The short-run and long-run elasticities of output with respect to total factor productivity for all these outputs are 2-3 times higher than those for terms of trade. The long run elasticities of non-foodgrain output with respect to total factor productivity are the highest at 5.03 to 9.3.[16]

Elasticities in Different Studies: The econometric estimates of aggregate agricultural price response in some of the other studies in India are presented for comparison in Table 3.

TABLE 3. SOME ECONOMETRIC ESTIMATES OF AGGREGATE AGRICULTURAL PRICE RESPONSE IN INDIA

Country/ Region (1)	Period (2)	Short-run elasticities (3)	Long-run elasticities (4)	Notes/Sources (5)
Punjab	1907-1946	0.6-0.17	-	Herdt (1970)
Rajasthan	1956-57-1973/74	0.24	-	Bapna (1980)
Semi-arid tropics	1955/56-1973/74	0.09	-	Bapna and others (1984) (Used panel data)
85 districts	1961/62-1981/82	0.13	-	Binswanger and Rosenzweig (1989) as quoted in Palanivel, 1995
All-India	1952/53 -19878/8	0.18	0.30	Krishna (1982)
All-India	1954/55 -1977/78	0.2-0.3	0.2-0.3	Chhiber (1988)
All-India	1951/52 -1987/88	0.05-0.19	0.09-0.79	Aggregate agricultural output
(Palanivel,	- Do -	0.09-0.23	0.17-0.83	Aggregate crop output
1995)	- Do -	0.07-0.19	0.14-0.72	Gross value added in agriculture
All-India	1950-51 -1994-95	0.2381	-	Shankar and Mythili (2001)
All-India	1950-51 - 1964-65	-0.1647	-	Sidhu and Singh (1979)
	1965-66 - 1975-76	0.1114	-	Do
All-India	1967/68 - 1990/91	-0.02	-	Foodgrains (Mungekar, 1997)
(Mungekar,		-0.07	-	Non-foodgrains (Mungekar, 1997)
1997)		-0.03	-	All crops (Mungekar, 1997)
All-India	1951/52 - 1965/66	-0.27	-	Desai and Namboodiri, 1997
(Desai and Namboodiri, 1997)	1966/67 - 1989/90	0.01	-	-Do-
All-India	1978-79 - 1999-2000	0.28 - 0.34	-	Mishra and Rao, 2003
Present Study for Andhra Pradesh				
Andhra Pradesh	1980-81 to 1999-2000	0.20-0.29	0.21-0.31	Aggregate agricultural output
	- Do-	0.25-0.0.50	1.19-1.72	Crop output
	- Do-	0.35-0.39	1.11-1.16	Foodgrain output
	- Do-	0.18-0.34	1.68-2.83	Non-foodgrain output

Most of the estimates of supply response using terms of trade as price variable indicate negative relationship except Krishna, Palanivel and Shankar and Mythili and also Desai and Namboodiri for post-green revolution period. The short-run elasticities for aggregate agricultural output; crop, foodgrain and non-foodgrain output and long-run elasticity for aggregate agricultural output of the present study go well with the results of other studies. However, the short-run elasticities are slightly higher than those in the other studies. The lower range starts from 0.20. While the long-run elasticity in Palanivel's study for crop output was 0.17- 0.83, the present study found it to be 1.19-1.72 for Andhra Pradesh during 1980-81 to 1999-2000. The long-run elasticity for foodgrain output is 1.11-1.16 and 1.68-2.83 for non-foodgrains in Andhra Pradesh in the present study. This may be because the present study covers much of the reform period and also because the state is one of the leading states in regard to commercialised agriculture.

IV

CONCLUSION

The regression coefficients for terms of trade for aggregate agriculture, crop sector, foodgrain crops and non-foodgrain crops were positive and statistically non-significant whereas the regression coefficients for technology variable indicated by irrigation ratio and total factor productivity are statistically significant and far higher than those for price variables. A 10 per cent increase in terms of trade, *ceteris paribus*, increases aggregate agricultural output by 2.0 to 2.9 per cent; crop output by 2.5 to 5.0 per cent; foodgrain output by 3.5 to 3.9 per cent and non-foodgrain output by 1.8 to 3.4 per cent. On the other hand, a 10 per cent increase in irrigation ratio, *ceteris paribus,* increases aggregate agricultural output by 9.1 per cent to 9.8 per cent. Further, a ten per cent increase in the index of total factor productivity, *ceteris paribus,* increases aggregate crop output by 7.4 per cent to 8.4 per cent; foodgrain output by 8.5 per cent and non-foodgrain output by 7.8 per cent to 9.4 per cent. The results indicate that non-price factors are the more important determinants in aggregate agricultural supply than price related factors in the state of Andhra Pradesh. Therefore, there is a case for stepping up public investment in irrigation, research, extension, marketing infrastructure, rural roads, etc., in the state for higher growth in agricultural production.

Received November 2003. *Revision accepted March 2004.*

NOTES

1. On the other hand, institutional reforms like abolition of intermediaries and other land reforms and technological changes dominated interventions of Government of India in agriculture during the fifties to mid-sixties and mid-sixties to eighties, respectively (Radhakrishna, 2002; Rao, 1996). During the entire period prior to nineties, modernization of agriculture through large-scale investment in irrigation and power and creation of infrastructure such as credit institutions, regulated markets, roads and extension as also research institutions supplemented the main form of interventions in agriculture.

2. Significant among these studies is the study by Narain (1960). It covered a longer period 1900 to 1939 and made a systematic investigation into price-acreage relationship for a number of crops in different parts of the country. The study included crops like rice, and wheat and non-food crops like cotton, jute, sugarcane and groundnut. His analysis clearly showed a positive relationship between acreage under competing crops and their prices. Further, according to him, non-food crops respond more to prices and food crops are influenced more by weather.

3. The gross terms of trade, as estimated and used by these scholars is a ratio between agricultural and non-agricultural GDP deflators. It does not represent the prices at which quantities

were traded and measures the relative valuation of agricultural and non-agricultural products. According to Desai and D'Souza (1999), such a concept is somewhat akin to income terms of trade rather than barter terms of trade, since it has underneath it production volume gains implied. And it has therefore an obvious positive association with aggregate output, marketed surplus.

4. Tyagi (1987) says that, in these analysis what is missed is that movement of terms of trade whether in favour or against the agricultural sector is not the same thing as relative prices moving in favour of or against a crop. The impact of terms of trade on aggregate output depends also on the stage of production possibility curve and elasticity of output with respect to input. He contends that in a situation when most farmers are sing some inputs where the mvp is greater than the cost of these inputs, the application of variable inputs may continue to increase despite terms of trade moving against the agricultural sector.

5. He did this exercise for the period 1952-53 to 1990-91. From this, he concluded that the terms of trade seemed to be a very weak variable as its movements were not very relevant to the increase in the production of both food grains and non-food grains, while they are some what positively related to the production of all crops.

6. The study period was 1951-52 to 1973-74 for Thamarajakshi (1977); 1950-51 to 1964-65 for Sidhu and Singh (1979); and 1951-52 to 1965-66 for Desai and Namboodiri (1997). Mungekar (1997) studied for the period 1970-71 to 1990-91. The regression coefficient was –0.1647 in Sidhu and Singh (1979); -0.03 in Mungekar; -0.27 in Desai and Namboodiri (1997). In Desai and Namboodiri (1997), the dependent variable is marketed surplus.

7. The study period was 1967-68 to 1990-91 for Thamarajakshi (1994); 1965-66 to 1975-76 for Sidhu and Singh (1979); and 1966-67 to 1989-90 for Desai and Namboodiri (1997). The regression coefficient was 0.1114 for Sidhu and Singh (1979) and 0.01 for Desai and Namboodiri (1997).

8. Palanivel (1995) constructed a series of net barter terms of trade for the period 1951-52 to 1987-88 and studied aggregate supply response in India. He also used total factor productivity indices for technology, besides irrigation ratio as independent variables along with rainfall index and lagged output in Nerlovian framework.

9. Mishra and Rao (2003) specified a log-linear model contrary to Mishra and Hazell (1996) and Mishra (1998). They introduced lagged gross terms of trade, total net fixed capital stock, index of rainfall, net area sown, total employment in agriculture and total fertilizer use as independent variables. With regard to the criticism by Desai and D'Souza (1999), they defended use of gross terms of trade by showing that both gross and barter terms of trade move in the same direction, though there is no one to one correspondence. They worked out the correlation coefficient between the two series for the period 1978-79 to 1999-00 to be 0.91. In view of the difficulties in calculation of barter terms of trade at state level and wide coverage of the gross terms of trade, they felt use of gross terms of trade is justified, despite some limitations.

10. Mishra (1998) has tried to show that the negative sign for the coefficient of the terms of trade with respect to aggregate output/marketed surplus is obtained in other studies probably because they could not either capture the main force, i.e. the idea of sharing the gains of the new technology between producers and consumers operationalised through the terms of trade by the government of India using the agricultural price policy or incorporate various rigidities operating in the system along with important factors directly related to production in their explanatory framework. He interpreted the significant negative coefficient for the interaction term to mean that the gains of technology have not been allowed to be kept by the producers themselves. An attempt has been made to share the gains with consumers through terms of trade. This is the most harmonious approach adopted by the Government of India in the price policy formulation. Desai and D'Souza (1999) objected to this by saying that a simple linear regression equation cannot capture such effects, which requires a system of equations that incorporates explicitly the relationship between these variables. Further they maintained that the purpose of an interaction term in a regression is to estimate whether there is a complementarity of substitutability between two variables.

11. Singh (1989) constructed net barter terms of trade for Punjab for the period 1971-72 to 1980-81 and concluded that the net barter terms of trade moved against agriculture since the mid-seventies. He further said that the series could not be extended beyond that period because of non-availability of data on certain items.

12. The detailed derivation from Nerlove's model can be seen in Palanivel (1995).

13. Other things remaining the same, accuracy and correctness of inter-sectoral terms of trade necessitate that, as many products as possible from those actually exchanged between the sectors are included in the study (Kahlon and Tyagi, 1980).

14. Farm harvest prices represent the prices received by the farmers for the products sold by them better than the wholesale prices (Mungekar, 1993). Many studies showed that the use of wholesale prices for the items purchased by the farmers give erroneous results in calculation of terms of trade for agriculture (Palanivel, 1999), as they are generally less than what the farmers actually pay. 34 items for items sold by agriculture to non-agriculture; 45 items as purchased from non-agriculture for final (family) consumption, 10 items for intermediate consumption and 13 for capital formation were taken in the study. Detailed methodology of terms of trade calculation was given in Rao (2003).

15. Tornquist-Theil index is a superlative index for calculating total factor productivity (Rosegrant and Evenson, 1994). The Tornquist-Theil index provides consistent aggregation of inputs and outputs under the assumptions of competitive behaviour, constant returns to scale, Hicks neutral technical change and input-output separability. They provide consistent aggregation across a range of production structures (Desai, 1994).

16. The long-run elasticities are probably questionable and should not be used for policy analysis (Binswanger, 1990).

REFERENCES

Ahluwalia, M. (1996), "New Economic Policy and Agriculture: Some Reflections", *Indian Journal of Agricultural Economics*, Vol.51, No.3, July-September.

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

Bapna, Shanti L.; Hans P. Binswanger and Jaime B. Quizon (1984), "Systems of Output Supply and factor Demand Equations for Semi-Arid Tropical India", *Indian Journal of Agricultural Economics*, Vol.39, No.2, April-June.

Bhalla, G. S. (1994), "Policy for Food Security in India", in G.S.Bhalla (Ed.)(1994), *Economic Liberalisation and Indian Agriculture*, Institute for Studies in Industrial Development, New Delhi.

Bhalla, G.S.(1995), "Globalisation and Agricultural Policy in India", *Indian Journal of Agricultural Economics*, Vol. 50, No.1, January-March.

Binswanger, H. (1990), "The Policy Response of Agriculture", in Proceedings of the World Bank Annual Conference on Development Economics, 1989, also supplement to the *World Bank Economic Review* and *World Bank Research Observer.*

Chadha, G.K. (2003), "Indian Agriculture in the New Millennium: Human Response to Technology Challenges", *Indian Journal of Agricultural Economics*, Vol. 58, No.1, January-March.

Chhiber, A (1988), "The Aggregate Supply Response in Agriculture: A Survey", in S. Commander (Ed.)(1988), *Structural Adjustment in Agriculture,* James Curry Publishers, London.

Dantwala, M. L. (1962), "Price Policy for Agricultural Development: Rapporteur's Report and Summary of Group Discussion", *Indian Journal of Agricultural Economics,* Vol.17, No.4, January-March.

Dantwala, M. L.(1967) "Incentives and Disincentives in Indian Agriculture", *Indian Journal of Agricultural Economics*, Vol.22, No.2, April-June.

Dantwala, M. L. (1978), "Future of Institutional Reform and Technological Change in Indian Agricultural Development", *Economic and Political Weekly,* Vol. 13, Nos. 31, 32 and 33, Special Number, August.

Dantwala, M. L. (1986), "Technology, Growth and Equity in Agriculture", in John W.Mellor and Gunvant M.Desai (Eds.)(1986), *Agricultural Change and Rural Poverty: Variations on a Theme by Dharm Narain*, Oxford University Press, Delhi.

Deb, Surajit (2002) *Terms of Trade and Supply Response of Indian Agriculture: Analysis in Cointegration Framework,* Working Paper No.115, Centre for Development Economics, Delhi School of Economics, Delhi.

Desai, B.M. (1994), "Contributions of Institutional Credit, Self-Finance and Technological Change to Agricultural Growth in India", *Indian Journal of Agricultural Economics*, Vol. 49, No.3, July-September.

Desai, B. M. (2002), “Policy Framework for Reorienting Agricultural Development”, *Indian Journal of Agricultural Economics*, Vol. 57, No.1, January-March.

Desai, B. M. and Errol D’ Souza (1999), “Economic Reforms, Terms of Trade, Aggregate Supply and Private Investment in Agriculture”, *Economic and Political Weekly*, Vol. 34, No.20, May 15.

Desai, B.M. and N.V. Namboodiri (1997), “Price and Non-Price Determinants of Aggregate Agricultural Supply”, in B.M.Desai (Ed.)(1997), *Agricultural Development Paradigm for the Ninth Plan Under New Economic Environment*, Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.

Dev, S. Mahendra and Ajit Ranade (1998), “Rising Food Prices and Rural Poverty: Going Beyond Correlations”, *Economic and Political Weekly,* Vol. 33, No.39, September 26.

Dev, S. Mahendra and C.Ravi (2003), “ Macroeconomic Performance and Policies”, *Economic and Political Weekly,* Vol.38, Nos.12,13, March 22-29.

D’Souza, Errol (2001), “Rapporteur’s Report on Impact of Economic Reforms on Rural Employment”, *Indian Journal of Agricultural Economics,* Vol. 56, No.3, July-September, pp.605-611.

Government of India (1995), *Report of the Task Force on Terms of Trade between Agriculture and Non-Agricultural Sectors*, Directorate of Economic and Statistics, Ministry of Agriculture, New Delhi.

Government of India (2002), Economic *Survey 2001-2002,* Ministry of Finance, New Delhi.

Government of India (2003), *Report of the Commission for Agricultural Costs and Prices for the Crops Sown During 2002-2003,* Ministry of Agriculture, New Delhi.

Gujarati, Damodar (1992), *Essentials of Econometrics,* McGraw-Hill, Inc, Singapore, pp.365-378.

Gulati, Ashok (1998), “Indian Agriculture in an Open Economy: Will it Prosper?”, in I.J.Ahluwalia and I.M.D.Little (Eds.)(1998), *Indian Economic Reforms and Development Essays,* Oxford University Press, Delhi.

Herdt, R. W. (1970), “A Disaggregated Approach to Aggregate Supply”, *American Journal of Agricultural Economics*, Vol. 52, No.4.

Hirashima, S. (2000), “Issues in Agricultural Reforms: Public Investment and Land Market Development”, *Economic and Political Weekly,* Vol.35, Nos.43 and 44, October 28.

Johl, S. S. and T. R. Kapur (1987), *Fundamentals of Farm Business Management,* Kalyani Publishers, Ludhiana.

Kahlon, A. S and D.S Tyagi (1980), “Intersectoral Terms of Trade”, *Economic and Political Weekly*, Vol.15, No.52.

Krishna, Raj (1963), “Farm Supply Response in India-Pakistan: A Case Study of the Punjab Region”, *Economic Journal*, Vol.73, No.291.

Krishna, Raj (1982), Growth, Price Policy and Equity, *Food Research Institute Studies,* Vol. 18, No.3.

Krishna, Raj (1984), “Price and Technology Policies”, in Carl K.Eicher and John M.Staatz (Eds.)(1984), *Agricultural Development in the Third World,* The Johns Hopkins University Press, London, U.K.

McGuirk and Mundlak (1991), *Incentives and Constraints in the Transformation of Punjab Agriculture,* International Food Policy Research Institute Research Report, No.87, Washington, D.C., U.S.A.

Mellor, John W. (1966), *The Economics of Agricultural Development,* Cornell University Press, Ithaca, New York, U.S.A.

Mellor, John W. (1976), *The New Economics of Growth*, Cornell University Press, Ithaca, New York, U.S.A.

Mellor, John W. (1978), “Food Price Policy and Income Distribution in Low Income Countries”, *Economic Development and Cultural Change,* Vol.27, October.

Mishra, V.N. (1998), “Economic Reforms, Terms of Trade, Supply and Private Investment in Agriculture: Indian Experience”, *Economic and Political Weekly*, Vol.33, No.31, August 1.

Mishra, V.N. and M. Govinda Rao (2003), “Trade Policy, Agricultural Growth and Rural Poor; Indian Experience, 1978-79 to 1999-2000”, *Economic and Political Weekly,* Vol.38, No.43, October 25, pp.4588-4603.

Mishra, V.N. and Peter B.R.Hazell (1996), "Terms of Trade, Rural Poverty, Technology and Investment: The Indian Experience, 1952-53 to 1990-91", *Economic and Political Weekly*, Vol. 31, No.13, March 30.

Mungekar, B. L. (1992), *The Political Economy of Terms of Trade*, Himalaya Publishing House, Mumbai.

Mungekar, B.L. (1993), "Intersectoral Terms of Trade: Issues of Concept and Method", *Economic and Political Weekly*, Vol. 28, No.39, September 25.

Mungekar, B. L. (1997), "Terms of Trade, Technology and Agricultural Development", in B. M Desai (Ed.)(1997), *op cit.*

Narain, Dharm (1960), "Impact of Price Movements on Areas under Crops in India, Cotton: A Case Study", *Indian Economic Review,* Vol.5, No.2, August.

Narain, Dharm (1977), "Growth of Productivity in Indian Agriculture", *Indian Journal of Agricultural Economics*, Vol.32, No.1, January-March.

Nerlove, M. (1958), *The Dynamics of Supply: Estimation of Farmers' Response to Price,* The Johns Hopkins University Press, London, U. K.

Palanivel, T. (1995), "Aggregate Supply Response in Indian Agriculture: Some Empirical Evidence and Policy Implications", *Indian Economic Review*, Vol.30, No.2.

Palanivel, T. (1999), "The Long Run Trends in the Terms of Trade between Agriculture and Non-Agriculture in India: Some Alternative Methods", *Indian Journal of Economics*, Vol.79, No.315, April.

Radhakrishna, R. (2002), *Agricultural Growth, Employment and Poverty: A Policy Perspective*, Presidential Address delivered at the 43rd Annual Conference of the Indian Society of Labour Economics at Bangalore on December 18-20.

Rao, N. Chandrasekhara (2003), *Economic Reforms, Terms of Trade, Output and Capital Formation in Indian Agriculture: The Case of Andhra Pradesh*, Ph.D Thesis submitted to Dr. B.R.A.O. University, Hyderabad, through Centre for Economic and Social Studies, Hyderabad.

Rao, V.M. (1996), "Agricultural Development with a Human Face: Experiences and Prospects", *Economic and Political Weekly,* Vol.31, No.26, June 29.

Reddy, V. Ratna (1994), Book Review on "The Political Economy of Terms of Trade by B.L.Mungekar", *Indian Journal of Agricultural Economics,* Vol.49, No.1, January-March.

Rosegrant, M.W. and Robert E. Evenson (1994), "Total Factor Productivity and Sources of Long Term Growth in Indian Agriculture", Paper submitted at IFPRI/IARI Workshop on *Agricultural Growth in India*, May 1-6,New Delhi.

Sankar, U. and G. Mythili (2001), "Indian Agricultural Economy: An Overview", in K.P.Kalirajan, G. Mythili and U. Sankar (Eds.)(2001), *Accelerating Growth through Globalisation of Indian Agriculture*, Macmillan Publishers.

Schiff, M. and C.E. Montenegro (1997), "Aggregate Agricultural Supply Response in Developing Countries: A Survey of Selected Issues", *Economic Development and Cultural Change,* Vol.45, No.2, January, pp.393-410.

Sen, Abhijit (2001), "A Whole Crop of Uncertainties", *Frontline*, February 2, Vol.18, No.2.

Sidhu, D.S. and A.J. Singh (1979), "Domestic Terms of Trade and Economic Development in India" *Indian Journal of Agricultural Economics*, Vol. 34, No. 4, October-December.

Singh, J.P.(1989), "Terms of Trade in Punjab Agriculture", *Indian Economic Review*, Vol. 24, No.2.

Singh, Manmohan (1995), "Inaugural Address", *Indian Journal of Agricultural Economics*, Vol. 50, No.1, January-March.

Thamarajakshi, R. (1969), "Intersectoral Terms of Trade and Marketed Surplus of Agricultural Produce, 1950/51 to 1965/66", *Economic and Political Weekly*, Vol. 4, No. 26, June 28.

Thamarajakshi, R. (1977), "Role of Price Incentives in Stimulating Agricultural Production in a Developing Economy", in D. Ensminger (Ed.)(1977), *Food Enough or Starvation for Millions,* TMH Publishing Company, New Delhi.

Thamarajakshi, R. (1994), *Intersectoral Relationships in a Developing Economy*, Academic Foundation, Delhi.

Tyagi, D.S. (1987), "Domestic Terms of Trade and Their Effect on Supply and Demand of Agricultural Sector", *Economic and Political Weekly*, Vol.22, No.13, March 28.

World Bank (2000), *India: Policies to Reduce Poverty and Accelerate Sustainable Development,* Washington, D.C., U.S.A.