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ROLE OF TERMS OF TRADE IN INDIAN AGRICULTURAL GROWTH: A NATIONAL AND STATE LEVEL ANALYSIS

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ABSTRACT

Using time series data, this paper analyses the relative contributions of terms of trade and non-price variables in explaining agricultural growth in recent decades in India. Agricultural growth is largely explained by expansion of irrigation, (which in the model is also a proxy for HYVs and other capital investments), and, until the 1970s, by increases in the net cultivated area. Agricultural output is inelastic, and is becoming increasingly more so over time. The terms of trade was not an important factor in explaining past growth. Even during the late 1960s and early 1970s when the terms of trade improved by 18 percent for agriculture, they only accounted for 15 percent of the growth in output. Increases in agricultural output are also found to worsen the terms of trade for agriculture, despite government attempts to control prices. The results highlight the importance of further investments in agricultural research, extension, irrigation and other supply-enhancing inputs if the ongoing policy reforms in India are to translate into more rapid and sustained agricultural growth.

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1. INTRODUCTION

Much of the current policy debate in India is focused on agricultural policy reforms that are designed to "get prices right." But how important is this for agricultural growth? Can agriculture respond to improved market incentives if adequate investments in other determinants of agricultural output, such as rural infrastructure, irrigation, and agricultural research and extension are not already in place?

This paper seeks to answer this question through analysis of past patterns of agricultural growth in India. The impact of the domestic terms of trade on aggregate agricultural output is quantified, while controlling for the influence of other supply-side determinants. Unlike previous studies of this issue in India (e.g. Thamarajakshi, 1977, 1994; Sidhu and Singh, 1979; Krishna, 1982; and Parthasarthy and Mudahar, 1976), this paper a) uses state as well as national data which, amongst other things, helps to overcome multicollinearity problems, and b) specifies the terms of trade as endogenously determined with agricultural supply. As Bautista (1989) has shown in a cross-country study, allowing for feedback effects from agricultural output to the terms of trade can significantly affect the estimated supply response elasticity.

The econometric results are used to estimate aggregate supply response elasticities to changes in the terms of trade, and to unravel the relative contributions of terms of trade and non-price supply shifter variables in explaining agricultural growth in India. The results lead to some conclusions about the importance of price and nonprice factors for future agricultural growth.

HISTORICAL CONTEXT

Following independence in 1947, India deliberately turned the terms of trade against agriculture in the pursuit of industrialization goals. This led to low productivity growth in agriculture prior to 1964/65, and to growth in total agricultural output that depended heavily on increases in the gross cropped area (Table 1). This in turn depended on public investments in irrigation.

Table 1—Changes in agricultural performance and key structural variables over time

	Terms of Trade[1]	Average Annual Percentage Change[2] Gross Cropped Area	Productivity	Value Production[3]	Irrigated Area (%)[4]	HYVs (%)[5]	Net Fixed Capital/Ha.[6] (Rs)
1952/53 - 1964/65	98.1	1.39	2.04	3.50	18.0	0.0	2550
1967/68 - 1977/78	115.3	0.87	3.45	4.46	23.9	13.1	3439
1978/79 - 1988/89	98.1	0.49	2.84	3.48	30.3	28.4	4670

[1] Barter terms of trade as defined by Kahlon and Tyagi (1980).
func{(X sub t~-~X sub {t-1})/X sub {t-1}~ TIMES ~100%.}
[2] Calculated as the average over time of
[3] Total value of agricultural crop output measured in constant 1980/81 prices.
[4] Irrigated area as a percentage of the gross area sown.
[5] HYVs as a percentage of the gross cropped area of wheat and rice.
[6] Net fixed capital stock (buildings, plant and machinery, public and private irrigation, farm transport, land improvements, and farm stocks and assets) per hectare of net area sown in constant 1980/81 prices.

therefore important to understand the relative roles of technology and investment policies vis-a-vis correct pricing for achieving acceptable rates of agricultural growth.

MEASURING THE TERMS OF TRADE

The Commission for Agricultural Costs and Prices (CACP), formerly the APC, bases in recommendations on a barter terms of trade index. This index is a weighted price ratio of a basket of 21 agricultural commodities sold to a basket of 32 commodities purchased by agricultural households (17 for consumption purposes, 7 for farm inputs, and 8 for farm investment). The merits of this index are discussed in Kahlon and Tyagi (1980). The index is only available at the national level.

An alternative terms of trade index that can be computed for individual states is the ratio between agricultural and non-agricultural GDP deflators. This can be calculated from state income accounts as follows:

$$TT = \frac{GDP\ ag\ (current)}{GDP\ ag\ (constant)} \div \frac{GDP\ nonagr\ (current)}{GDP\ nonagr\ (constant)} \times 100\%$$

This index is often called the 'gross' terms of trade.[1]

Figure 1 shows the relationship between the barter and gross terms of trade at the national level over the period 1950 to 1990. There is a close correspondence: the correlation coefficient is 0.87 and there is a good match on the turning points.

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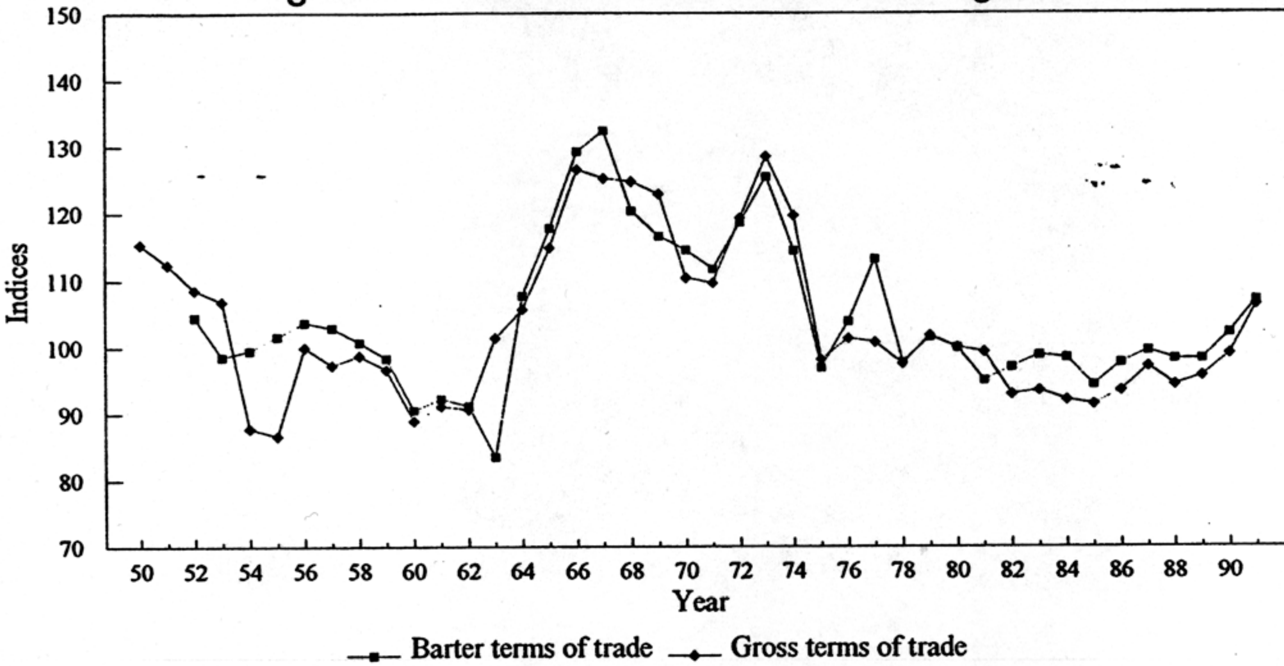
[1]In principle, the gross terms of trade is better because it measures the relative returns to investing resources in the two sectors, and it corrects for increases in productivity in both sectors.

Figure 1. Trends in terms of trade for agriculture



Moreover, as will be shown, econometric results for a national model are not much affected by choice of either of these indices. We assume that a similarly close correspondence occurs at the state level, though this assumption cannot be tested because data are not available to compute the barter terms of trade for individual states.

Past econometric analyses of the effects of terms of trade on agricultural output have often been confounded by multicollinearity problems. We overcome this problem by pooling time-series data for individual states. However, the success of this approach depends on there being sufficient variation in the terms of trade across states. Without wishing to display the full data set, the following statistics are indicative of considerable cross-sectional variation. During 1971 to 1988, the coefficient of variation over time of the gross terms of trade varied from 6.6 percent in Maharashtra to 21.2 percent in Uttar Pradesh. Moreover, of 91 possible different correlations between the fourteen states for which data are available, 47 were less than 0.5 and 11 were negative. Only 11 of the 91 correlations (12 percent) were greater than 0.8. These low correlations arise in large part because different states grow different crops, and hence different commodities are used in calculating the state GDP deflators.

2. THE MODEL

We first specify the national time-series model, and then show how it was modified for the pooled cross-state, time-series analysis.

The two structural equations of interest are those determining agricultural output (Q_t) and the terms of trade (TT_t). These are as follows:

$$Q_t = f(TT_t{}^*, \hat{IRR}_v, \hat{NA}_v, R_v, PD_t) \tag{1}$$

$$TT_t = f(Q_v,\ \hat{IRR}_v,\ POP_v,\ Y_t) \qquad (2)$$

where variables marked with hats are endogenous to the model in addition to Q_t and TT_t.

Agricultural output is hypothesized to depend on the anticipated terms of trade (TT*) and a number of non-price factors that shift the aggregate supply.[2] Assuming farmers forecast prices on the basis of past prices, the anticipated terms of trade in year t is defined as a moving average of the observed terms of trade in the immediately preceding three years. It is intended to capture producers' forecasts about the terms of trade at the time they allocate resources to agricultural production each year.

The non-price factors are irrigation (IRR_t) measured as the percentage of the gross cropped area that is irrigated; the net area sown (NA_t) in millions of hectares; annual rainfall

(R_t) in millimeters; and a policy dummy variable (PD_t) that is equal to unity during 1967/68-1988/89 and zero during 1952/53-1966/67.

Irrigation is expected to have a positive impact on production in its own right. Additionally, irrigation is used as a proxy for other kinds of capital investment in agriculture, and for technological change. While time-series data on HYVs and the net capital stock are available, they are so highly correlated with irrigation that severe multicollinearity problems arise when more than one of the three variables are included.

Agricultural output should increase with the net area sown, and with rainfall. We use net rather than gross cropped area to capture the effect of bringing new land into production,

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[2]Direct production inputs, such as fertilizer, labor and draftpower, are not included in the output function. These inputs are also determined by the terms of trade and the non-price shifter variables, and therefore drop out of the semi reduced-form supply function that is estimated here.

and not the effect of changes in the gross cropped area that arise from increased multiple cropping on existing land as a result of new irrigation investments and quicker growing crop varieties.

The policy dummy is designed to capture the affects of government regulation and procurement policies implemented in the mid-1960s. While any terms of trade effects arising from these interventions should be captured by the TT variable, the procurement and regulatory interventions of parastatals such as the Food, Cotton and Jute Corporations may have had additional effects on the efficiency and competitiveness of agricultural markets. The current policy debate about the need for market reforms in the agricultural sector suggests that the policy dummy will have a negative affect on agricultural output.

The terms of trade is hypothesized to depend on agricultural output (Q_t), irrigation (IRR_t), and two demand shifting variables; population (POP_t) and per capital income (Y_t).

If the terms of trade are truly fixed by government policy, then output should not have a statistically significant effect on the terms of trade. However, we hypothesize that there is sufficient market determination of most producer prices in India that increases in output lead to a contemporaneous reduction in the terms of trade. Moreover, these domestic terms of trade effects may have been strengthened by restrictions on foodgrain exports.

Irrigation is included in the terms of trade equation to capture two effects. The first is the effect of any increase in demand for capital goods arising from irrigation investments; by bidding up the price of capital goods, irrigation investments should worsen the terms of trade for agriculture. The second effect arises from use of the irrigation variable as a proxy for technological change. Technological change is expected to reduce unit costs of production, and hence it should lead to a decline in the terms of trade. Since both of the expected irrigation effects are negative, the irrigation variable should have a combined negative effect on the terms of trade.

Growth in population and per capita income expand the demand for agricultural output. But since they also increase the demand for nonagricultural output, the net effect on the terms of trade will depend on which of the two types of demand grows fastest, and on the supply elasticities of the two sectors. The outcome is indeterminate a priori, though a positive outcome seems most likely give India's low per capita income and high average budget share and income elasticity of demand for food.

For comparative purposes, it is desirable to use the same model specification for the national and state analyses. But two changes proved necessary at the state level. First, to correct for any missing state-level variables when pooling time-series and cross-section data, state dummies (SD_i, where i denotes states) were included in the output and terms of trade equations. Second, since state data were only available beginning in 1971/72, the policy dummy (PD_t) had to be deleted.

With these changes, and using i subscripts to denote states, the state model is:

$$Q_{it} = f(TT_{it}{*},\ \widehat{IRR}_{it},\ \widehat{NA}_{it},\ R_{it},\ SD_i) \qquad (3)$$

$$TT_{it} = f(\widehat{Q}_{it},\ \widehat{IRR}_{it},\ POP_{it},\ SD_i) \qquad (4)$$

ESTIMATION METHOD

Agricultural output and the terms of trade are not the only endogenous variables in the system. We expect that irrigation and the net area sown are also jointly determined with the terms of trade. Several authors (see Binswanger (1990) for a review) have argued that improvements in the terms of trade have powerful shift effects on agricultural supply in the longer-run because they lead to increased investments in irrigation and other farm capital. Accordingly, the two models were estimated by two-stage least squares, and the variables marked with hats in equations (1) to (4) were replaced by predicted values obtained from reduced-form equations including the lagged terms of trade.[3] In addition to the exogenous variables already indicated, we included one other variable in the reduced-form equations. This is the lagged capital stock in agriculture, which we postulate to be an explanatory variable in the structural equation for irrigation. The anticipated terms of trade (TT*) was also treated as a predetermined variable because it is calculated from lagged values of TT.

DATA

Data on the barter terms of trade were obtained from Tyagi (1987) for 1952/53 to 1978/79 and updated using various annual reports from the Commission for Agricultural Costs and Prices, Ministry of Agriculture. All other data were obtained from national and state incomes accounts published by the Central Statistical Organization (CSO), Department of Statistics, Ministry of Planning and Programme Implementation, Government of India. Agricultural output is measured as the total value of crop output. The time series data for the analysis cover the period 1952/53 to 1988/89 at the national level, and 1971/72 to 1988/89 at the state level.

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[3]The results from the reduced-form equation for irrigation do not support the argument that improvements in the terms of trade lead to increases in investments in irrigation and other farm capital. The coefficient on the terms of trade variable in the irrigation equation was positive but statistically insignificant when estimated with national data, and significant but negative when estimated with state data. These results probably reflect the dominance of public-sector investments in Indian agriculture, and the fact that public investment is not driven primarily by terms of trade considerations.

Data were available for fourteen states: Andhra Pradesh, Bihar, Gujarat, Haryana, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Orissa, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh and West Bengal. Taken together, these 14 states account for 95 percent of national foodgrains production, and 85 percent of national agricultural output.

3. RESULTS

NATIONAL RESULTS

The estimated structural equations for agricultural output and the terms of trade at the national level are reported in Table 2. Three alternative estimates of the output equation are shown. It makes little difference to the results whether the equation is estimated by OLS or 2SLS (compare columns (1) and (2)), or whether the barter rather than the gross terms of trade is used (compare columns (2) and (3)).

All the coefficients in the output equations have the expected signs, and all are statistically significant at the 10 percent level or better (one-tail tests) except those on the terms of trade variable. The lack of significance of the terms of trade variable is indicative of the weak and often contradictory results found in similar studies using national Indian

Table 2—National results, 1952 to 1988

	Agricultural Supply (Q)			Gross Terms of Trade (TT)
	(1)	(2)	(3)	(4)
	OLS	2SLS	2SLS	2SLS[1]
Constant	-80,349.0	-89,660.0	-102,690.0	112.3
	(3.91)	(2.59)	(2.28)	(14.56)
Anticipated Terms Trade (TT*)				
Barter			57.6	
			(0.70)	
Gross	61.9	82.7		
	(1.01)	(1.25)		
Irrigation (IRR)[2]	2,204.9	2,267.2	2,170.5	0.012
	(11.62)	(11.54)	(10.38)	(0.13)
Net Area Sown (NA)[2]	402.6	449.7	577.1	
	(3.23)	(1.91)	(1.87)	
Rainfall (R)	81.9	81.02	80.8	
	(3.67)	(3.45)	(3.27)	
Policy Dummy (PD)	-6,800.8	-7,906.1	-7,447.0	
	(2.63)	(2.49)	(2.04)	
Agricultural Output (Q)[2]				-0.000084
				(1.99)
Population (POP)				-0.00000058
				(0.18)
Per Capita Income (Y)				-0.0041
				(1.92)
R^2	0.97	0.97	0.97	0.05
Degrees Freedom	32	32	30	33
Durbin-Watson	1.15	1.64	1.61	1.26

[1] Corrected for multicollinearity using ridge regression method with k=1.
[2] Variables that were replaced by predicted values in the 2SLS estimation.
Note: Figures in parentheses are absolute values of t statistics.

data. This is probably because of multicollinearity problems, and which are managed in the present model by deleting several important variables.[4]

Estimation of the terms of trade equation proved more troublesome. All the explanatory variables were highly collinear (correlations of 0.95 or greater) and a ridge-regression method that corrects for multicollinearity was used. The results are not very satisfactory, but agricultural output does have a significant and negative effect on the terms of trade (column (4) in Table 2). This suggests that market forces may still be important in determining agricultural prices, despite government attempts to determine prices through market intervention policies.

STATE RESULTS

The state level results are reported in Table 3. In this case it makes an important difference as to whether OLS or 2SLS is used to estimate the output equation. In particular, the sign on the terms of trade variable is negative when OLS is used but positive when 2SLS is used. Bautista (1989) obtained a similar result in his pooled time-series cross-country analysis, and he concluded that output and the terms of trade are jointly determined.

All the coefficients in the 2SLS output equation have expected signs and all are significant, except the coefficient on the net sown area which is negative but not significant. The significance of the terms of trade variable is a distinct improvement over the results from the national model, and shows the advantage of working with disaggregated data.

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[4] Multicollinearity problems are pervasive if HYVs or the net capital stock are included in addition to irrigation, or if some of the potentially interesting interaction terms (e.g. between irrigation and the terms of trade) are included.

Table 3—State results, 1971 to 1988.

	Agricultural Output (Q)		Terms of Trade (TT)	
	(1)	(2)	(3)	(4)
	OLS	2SLS[1]	OLS	2SLS
Constant	-1,308.0	-60,041.0	126.3	337.6
	(0.40)	(5.81)	(8.91)	(4.91)
Anticipated Terms of Trade (TT*)	-86.2	58.4		
	(6.72)	(3.23)		
Irrigation (IRR)[2]	165.0	799.7	-0.13	-3.4
	(6.01)	(13.20)	(0.64)	(3.18)
Net Area Sown (NA)[2]	1.55	-0.28		
	(5.01)	(0.10)		
Rainfall (R)	1.17	3.41		
	(1.90)	(2.17)		
Agricultural Output (Q)[2]			-0.0000019	-0.0000042
			(3.76)	(2.47)
Population (POP)			-0.00032	0.0014
			(1.46)	(2.06)
Per Capita Income (Y)			-0.001	0.02
			(0.35)	(2.70)
R^2	0.91	0.95	0.44	0.43
Degrees Freedom	232	232	232	232
Durbin-Watson	1.18	1.08	1.24	1.35

[1] Corrected for autocorrelation using the first order Cochrane - Orcutt method.
[2] Variables that were replaced by predicted values in the 2SLS estimation.
Notes: State dummies were included but the results are not reported here for brevity.
Figures in parentheses are absolute values of t-statistics.

Contrary to the national model, multicollinearity was also not a problem in estimating the terms of trade equation at the state level.[5] The coefficient on agricultural output is still significant and negative, confirming that market forces do help determine the terms of trade. The coefficient for irrigation is also negative as expected and it is statistically significant in the 2SLS results. Population and per capita income have significant and positive effects on the terms of trade in the 2SLS results, reflecting the continuing importance of food in India's consumer expenditure patterns.

SUPPLY ELASTICITIES

The 2SLS estimates of the output equations were used to calculate the supply response elasticities in Table 4. They were calculated using the sample means for the periods indicated for all the variables in the two models. Since the anticipated terms of trade is defined as a three-year moving average of past terms of trade, then an exogenous increase in the terms of trade takes three years to achieve its full impact on agricultural output. The elasticities in Table 4 show the cumulative effects, and since the model is linear, the elasticities increase in equal increments over the three years.

The state-level model gives elasticities that are nearly three times larger than those obtained from the national model. Since the terms of trade variable was not statistically significant in the national model (Table 2), more credence should be given to the elasticity estimates from the state model. Even so, the range in the elasticity estimates between the two models when using the full sample period estimates (0.06 to 0.17 in the first year, and 0.18 to

[5]All but one of the correlation coefficients between the right-hand side variables were less than 0.45. The exception was the correlation between rainfall and one of the state dummies; this coefficient was 0.75.

0.50 by year three) seem reasonable for aggregate agricultural output.[6] The elasticities are declining over time. In the national model, the supply elasticities are 60 percent smaller in 1986-88 than in 1952-54. The decline between 1971-73 and 1986-88 is 30 percent in the state model, and 45 percent in the national model. These reductions may reflect diminishing returns in Indian agriculture as the limits of the productivity gains from the Green Revolution technologies are approached, and as new land and water resources become increasingly scarce.

These calculations of the supply elasticities assume an exogenous and permanent shift in the terms of trade. But since output has been shown to have a negative effect on the terms of trade, the initial increase in the terms of trade may be hard to maintain. How large are these feedback effects, and what is their longer-term effect on supply?

To answer these questions, we used the estimated 2SLS results for the state-level model (columns (2) and (4) in Table 3) to simulate the impact of a 10 percent increase in the intercept of the terms of trade equation. The results were obtained by (i) initializing

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[6] Comparable estimates of the aggregate supply response of Indian agriculture are 0.13 (Binswanger et al, 1993), 0.28-0.29 (Chibber, 1988), and 0.2-0.3 (Krishna, 1982).

Table 4—Supply response elasticities to changes in terms of trade

	National Model [1]			State Model [2]		
Period	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3
1952-1988	0.08	0.15	0.23	n.a.	n.a.	n.a.
1971-1988	0.06	0.12	0.18	0.17	0.33	0.50
1952-1954	0.13	0.26	0.38	n.a.	n.a.	n.a.
1971-1973	0.09	0.18	0.27	0.19	0.38	0.57
1986-1988	0.05	0.10	0.15	0.13	0.27	0.40

[1] Calculated using estimated equation (2) in Table 2.
[2] Calculated using estimated equation (2) in Table 3.
Note: n.a. means not applicable.

all variables to their sample means for 1971-88 in the output and terms of trade equations; (ii) increasing the intercept of the terms of trade equation by 10 percent and then solving the output and terms of trade equations simultaneously for Q_t and TT_t; (iii) updating the anticipated (lagged) terms of trade TT* for year t+1; (iv) re-solving for Q_{t+1} and TT_{t+1}; and (v) repeating steps (iii) and (iv) until the results converged. The error terms were set at zero in all the calculations.

The adjustment in output over time is shown in Figure 2. For comparative purposes, the trajectory for output when the feedback effects between output changes and the terms of trade are ignored is also shown (i.e. the terms of trade is treated as exogenous, not endogenous).

Without feedback effects, output increases in three equal increments to achieve a new level that is 20 percent larger than the base value. However, when feedback effects are introduced, the initial output increase is moderated in years 2 and 3 by induced reductions in the terms of trade (Figure 3). This is followed by a modest decline in output in years 4 to 7 before output stabilizes at a value 16.7 percent greater than its base value. Comparing the equilibrium values from the two trajectories, the output increase is 3.1 percent lower when feedback effects are considered. The feedback effects are not, therefore, very substantial in affecting supply response.

DECOMPOSITION OF THE SOURCES OF GROWTH IN OUTPUT

This section attempts to unravel the relative importance of the terms of trade from various supply-side shifter variables in explaining recent agricultural growth in India.

Given a linear output equation of the form:

$$Q_t = \alpha_0 + \alpha_1 TT_t + \sum_i \beta X_{it}, \qquad (5)$$

where X_i denotes the ith shifter variable, then changes in Q between any two periods can be expressed as:

Figure 2. Simulated value of output

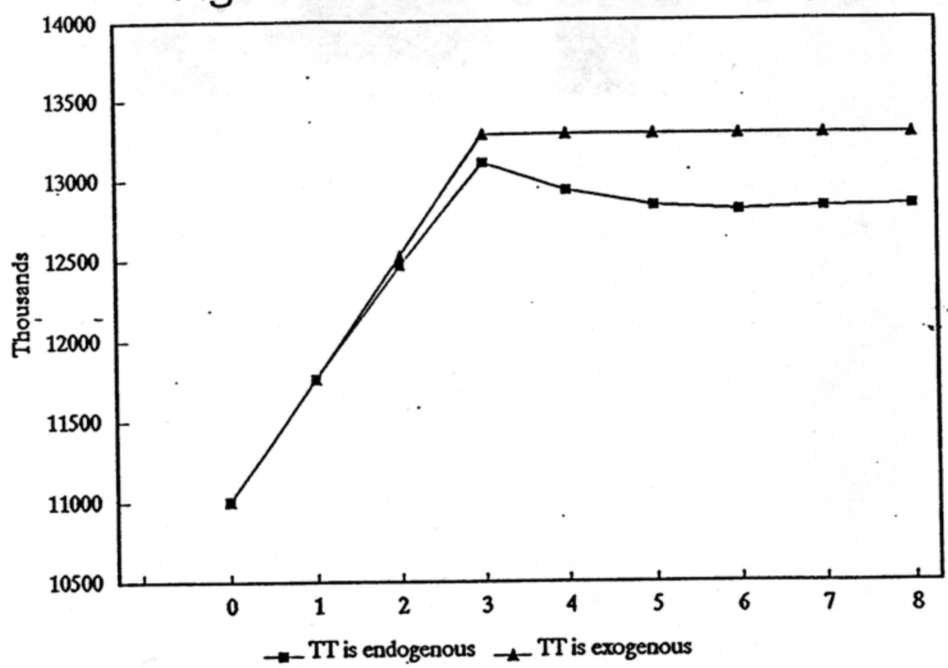
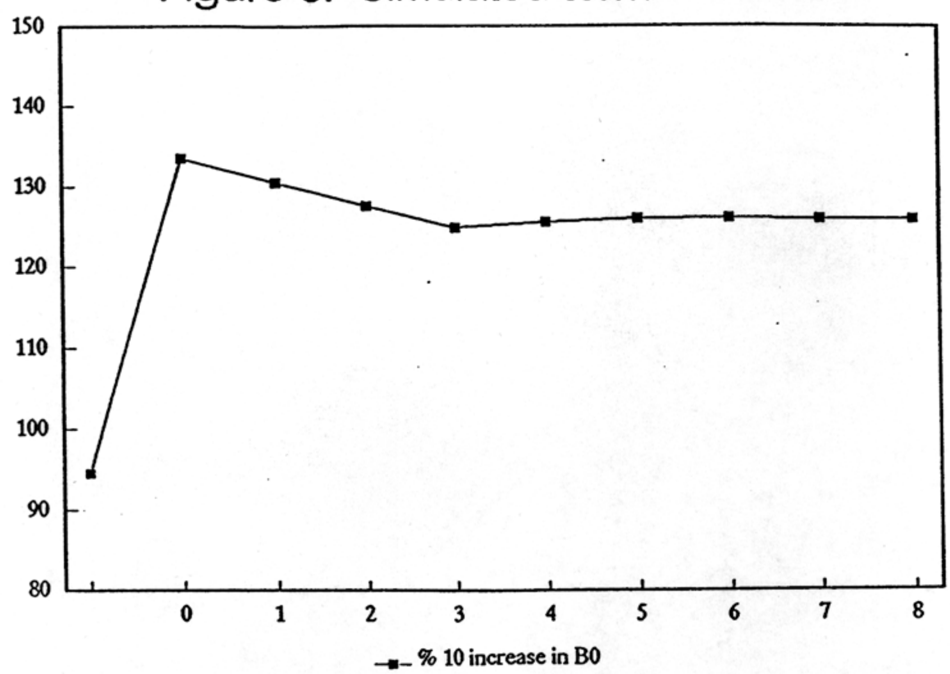


Figure 3. Simulated terms of trade



$$\Delta Q = \alpha_1 \ \Delta TT + \sum_i \beta_1 \Delta X_i \qquad (6)$$

Using the 2SLS regression estimates for agricultural output from the national and state-level models (Tables 2 & 3), the changes in agricultural output between 1957-59, 1971-73 and 1982-84 (the midpoints of the periods defined in Table 1) were decomposed into their source components. Changes in the means of the relevant variables and the associated decomposition results are given in Table 5.

Irrigation, explained earlier, is also used as a proxy for technological change and capital investment in agriculture, increased rapidly between the selected periods and proves to be the dominant source of agricultural growth. This is true in the national and state-level results, and between all the time periods considered. The terms of trade were a relatively minor factor. Even between 1957-59 and 1971-73 when the terms of trade increased by 18 percent at the national level, they only accounted for 15 percent of the total increase in agricultural output.

The net sown area was also an important source of growth between 1957-59 and 1971-73, but was less important thereafter. The policy dummy variable in the national model, which captures some of the effects of government regulations and parastatal operations in agricultural markets, had a strong negative impact on agricultural growth, especially between 1957-59 and 1971-73. The size of the negative effect (-71.4 percent) more than offsets the positive terms of trade effect (15.4 percent) that the market interventions were helping to implement, suggesting that their net impact may have been

Table 5—Decomposition of sources of growth in agricultural output between selected periods[1].

Period[2]	Terms of Trade	Irrigation	Net Area Sown	Rainfall	Policy Dummy	Total
			(Percent)			
National Model						
I:II	15.4	125.4	31.6	-1.0	-71.4	100
	(17.9)	(38.3)	(6.5)	(2.8)	(100)	
II:III	-11.6	110.7	0.4	0.5	n.a.	100
	(-22.0)	(27.8)	(1.1)	(0.9)		
I:III	1.0	117.5	14.9	-0.2	-33.2	100
	(-8.1)	(76.8)	(7.6)	(3.7)	(100)	
State Model						
II:III	-13.7	121.7	0.9	-8.9	n.a.	100
	(-20.4)	(23.1)	(0.7)	(-9.8)		

[1] Figures in parentheses are the percentage change between periods in the source variable. The value of agricultural output grew by 37% between periods I and II, by 40% between periods II and III, and by 93% between periods I and III.
[2] Periods are defined by 3-year averages as follows: Period I is 1957-59, period II is 1971-73, and period III is 1982-84. Changes are measured between these three-year averages.
Note: n.a. means not available.

negative over the period studied. However, some caution is warranted in accepting this result because the terms of trade variable was not statistically significant in the national model results.

4. CONCLUSIONS

National and state level data are used in this study to estimate the aggregate supply elasticity for Indian agriculture and to unravel the relative contributions of the domestic terms of trade and non-price supply-shifter variables in explaining agricultural growth since the early 1950s. As expected, the state level model is less prone to multicollinearity problems than the national model, and the results for the terms of trade variable are statistically stronger.

The results from the national and state level analyses are very similar, and show that aggregate supply is inelastic, and is becoming increasingly more so over time. Moreover, both levels of analyses show that growth in agricultural output in India in recent decades is largely attributable to increased irrigation, which in the model is also a proxy for technological change and other farm investments. Expansion of the net cultivated area was also important until the early 1970s, but has become less so since then.

The terms of trade is not a major factor in explaining past agricultural growth. This partly reflects the inelastic nature of aggregate supply, but also the fact that the terms of trade did not change very much over the period studied. The terms of trade improved by 18 percent between 1957-59 and 1971-73, (though it accounted for only 15 percent of the total increase in agricultural output between those two periods), but then they declined again during the 1980s, and detracted from agricultural growth.

The analysis stops short of the recent policy reforms in India, and it is possible that the terms of trade will play a larger role in contributing to agricultural growth in the 1990s. This could happen because a) the terms of trade may improve more substantially for agriculture, and b) the liberalization of agricultural markets may lead to additional efficiency gains that benefit agriculture. The latter is suggested by a negative coefficient obtained in the national model for a dummy variable that represents the introduction of market regulation and parastatals in the mid-1960s.

Although the policy reforms may induce further rounds of agricultural growth, the results presented in this paper caution against relying on the reforms as the principal source of growth for the future. Aggregate supply response to the terms of trade is inelastic, and it is becoming increasingly inelastic over time as supplies of new land and water become scarcer. Given also the dominating importance of non-price factors in explaining past growth, the results imply that future agricultural growth will become increasingly dependent on public and private investments in agricultural research and extension, irrigation, and other supply-enhancing investments.

Statel-level data are also used in this paper to estimate the determinants of the terms of trade for agriculture. A key results is that increases in agricultural output have an immediate and negative impact on the terms of trade. While the size of this feedback effect is not very large, it does show that the government has not been able to regulate the terms of trade as tightly as often thought. This feedback effect is likely to diminish with the current policy reforms if trade restrictions are reduced and grain surpluses are allowed to move more freely within India and into export markets.

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