Responsiveness of Indian Agriculture to Price Changes

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Agricultural pricing policies in most of the developing countries were based on the assumption that aggregate production is not very responsive to price changes and market forces were not important. Following the early development literature, policy makers in these developing countries presumed that the prices of factors of production such as wages were institutionally determined. Consequently, these ideologies led to increasing concern about measures that reduce farm incomes and incentives in such developing countries (Brown 1981). However, recently there are a few studies which report that farmers in the developing countries do respond to changing prices (Yotopoulos and Lau, 1979, Khan and Maki, 1979 and Sidhu, 1974). An attempt has been made in this paper to examine the responsiveness of Indian agriculture to price changes, in the light of the existing agricultural pricing policies.

Like many other Asian countries, India seeks self sufficiency in domestic rice consumption. By most measures the Government has been successful in this effort. Rice production increased from 22.99 million tonnes in 1952-53 to 52.70 million tonnes in 1977-78 (Rao and Thamarajakshi 1978). The increase in output was accelerated by a combination of factors such as farmer adoption of high yielding varieties, increased use of chemicals including fertilizer, and the development of sound location-specific research.

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Nevertheless, only a few of states have undergone such a qualitative change which helped the country to overcome the scarcity trap. On the other hand, the progressive agricultural scenario has brought about complex problems of production success. Grain stocks were used by the government as a buffer stock measure to stabilize or to lower consumer prices, while not much attention was given to the rising costs of production. Farmers who were squeezed between retail price stabilizations and the sharply rising costs demand higher guaranteed prices, along the lines of the EEC's common agricultural policy.

Though India has a system of support prices, it actually applies to only about 15% of total farm sales.[1] The rest of the farm output usually is sold in the market. It is argued that even these support prices are not 'fair' prices, because family labor is not counted as a cost of production in deciding support prices. From the mid-1970, Indian prices have been well below world prices. If the domestic lower prices are due to reductions in real costs of production, it is possible for agricultural incomes and incentives to be growing with the declining agricultural prices. On the other hand, if the lower domestic prices are due to price controls and food subsidies, then it would turn the domestic terms of trade against agriculture. This twisting of the terms of trade against agriculture is indirectly supported by the assumption that agricultural production is not very responsive to price changes. It is in this context that studies based on decision making of individual farmers are significant.

Because of the interlinked nature of demand for various inputs and output, it is appropriate to incorporate these interlinked market mechanisms while estimating the supply responses. This can be achieved by analyzing the output supply and factor demand equations not separately but as one system of equations. The profit function approach (Yotopoulos and Lau 1979) enables us to derive these systems of output supply and factor demand equations while incorporating the reality that prices, technology and resource endowments may vary among farmers.

1. The support prices are deteriorated by a central body called the Agricultural Price Commission. The states, however, can raise these prices further if they need to.

I. The Normalized Profit Function and Demand Functions

The normalized profit function is specified as expressing the maximized real current profit of farmers as a function of real prices of inputs and the quantities of fixed endowments for a given technical production function (Yotopoulos and Lau 1979). The model is (basically) static in the sense that the behaviour of individual farmers remains stable over the time period analyzed, and decreasing returns to scale in the variable inputs as a whole exists.

The general form of the normalized profit function for a given production function:

$$(1) \qquad y = f(x_1, x_2, \ldots x_n; z_1, z_2, \ldots z_n)$$

is as follows

$$(2) \qquad \pi^* = \frac{\pi}{P_o} \; g(p_1^*, p_2^*, \ldots p_n^*; z_1, z_2 \ldots z_n)$$

where

y = total output
x_i = the quantity of i^{th} variable input
z_j = quantity of j^{th} fixed input
π = maximized profit of individual farmers defined as current revenue less current variable costs
P_o = output price
π^* = normalized maximized current profit
p_i^* = normalized (real) price of variable input i

The profit function defined in (2) is connected to the underlying production function (1) by a set of dual transformations (McFadden 1970) through which the variable factor demand functions and the output supply functions are derived respectively as:

$$(3) \qquad x_i = -\frac{\partial \pi^*}{\partial p_i^*} \qquad i = 1, 2, \ldots n.$$

and

$$(4) \qquad y = \pi^* = \sum_{i=1}^{n} \frac{\partial \pi^*}{\partial p_i^*} p_i^*$$

II. Output Supply and Input Demand Elasticities

Since the parameters of functions (2) and (3) are estimated simultaneously assuming a functional form, then the elasticities of output supply and variable input demands with respect to the real prices of output and inputs and fixed endowments of farmers can be directly worked out.

Rewriting the output supply function (4),

$$y = \pi^* - \Sigma \frac{\partial \pi^*}{\partial p_i^*} p_i^*$$

the supply elasticity with respect to the price of the output is calculated as below:

$$\eta_{yp_o} = \frac{p_o}{y} \cdot \frac{\partial y}{\partial p_o} = \left[\frac{\partial \pi^*}{\partial p_o} - \Sigma \frac{\partial}{\partial p_i^*} \left(\frac{\partial \pi^*}{\partial p_i^*} p_i^*\right)\right] \frac{p_o}{y}$$

The supply elasticity with respect to the price of the i^{th} variable input is

$$\eta_{yp_i} = \frac{p_i^*}{y} \cdot \frac{\partial y}{\partial p_i^*} = \left[\frac{\partial \pi^*}{\partial p_i^*} - \Sigma \frac{\partial}{\partial p_i^*} \left(\frac{\partial \pi^*}{\partial p_i^*} p_i^*\right)\right] \frac{p_i^*}{y}$$

The supply elasticity with respect to the fixed input z_i is

$$\eta_{yz_i} = \frac{z_i}{y} \cdot \frac{\partial y}{\partial Zi} = \left[\frac{\partial \pi^*}{\partial Zi} - \frac{\partial}{\partial Zi} \left(\frac{\partial \pi^*}{\partial p_i^*} p_i^*\right)\right] \frac{Zi}{y}$$

Now, the own and cross price elasticities of demand for variable input x_i are calculated as follows:

Rewriting the factor share equations (3),

$$x_i = -\frac{\partial \pi^*}{\partial p_i^*} \qquad i = 1, 2, \ldots n$$

the own – price elasticity demand for x_i is

$$\eta_{ii} = \frac{p_i^*}{x_i} \; \frac{\partial x_i}{\partial p_i^*} = \left[\frac{\partial}{\partial p_i^*}\left(-\frac{\partial \pi^*}{\partial p_i^*}\right)\right]\frac{p_i^*}{x_i}$$

The demand elasticity for variable input x_i with respect to the real price, p^*_j is

$$\eta_{ij} = \frac{p_j^*}{x_i} \cdot \frac{\partial x_i}{\partial p_j^*} = \left[\frac{\partial}{\partial p_j^*}\left(\frac{\partial \pi^*}{\partial p_i^*}\right)\right]\frac{p_j^*}{x_i}$$

The demand elasticity for variable input x_i with respect to the output price p_o is

$$\eta_{io} = \frac{p_o}{x_i} \cdot \frac{\partial x_i}{\partial p_o} = \left[\frac{\partial}{\partial p_o}\left(-\frac{\partial \pi^*}{\partial p_i^*}\right)\right]\frac{p_o}{x_i}$$

Finally, the elasticity of demand for variable input x_i with respect to the fixed input z_k is

$$\eta_{ik} = \frac{z_k}{x_i} \cdot \frac{\partial x_i}{\partial z_k} = \left[\frac{\partial}{\partial z_k}\left(\frac{\partial \pi^*}{\partial p_i^*}\right)\right]\frac{z_k}{x_i}$$

III. Empirical Normalized Profit and Factor Share Functions

The most frequently empirically estimated form of profit functions is the Cobb-Douglas. Very recently Sidhu and Baanante (1980) estimated a trans-log profit function using cross section data from the Indian Punjab. Trans-log functions are more flexible than the usual Cobb-Douglas, CES or quadratic functions in the sense that the values of the elasticity of substitution at any point in input space is not restricted and there is no strong separability assumption. In the special case of constant returns to scale, the fulfillment of the conditions for global separability implies that the trans-log function is a Cobb-Douglas function (Corbo and Meller 1979).

The demand elasticity for variable inputs when derived from a Cobb-Douglas type of profit function suffers from the following major limitation. The demand for variable inputs is always calculated to be price-elastic and the cross price elasticity of input i is worked out to be the same with respect to the price of any other inputs. Drawing conclusions about demand for variable inputs based on such estimates, therefore, will not be useful for policy makers. This limitation can be overcome by using a more general type of profit function such as trans-log function.

Data collected during 1977-1978 from a random sample of 73 irrigated rice farmers drawn from Coimbatore District in South India[2] (Table 1) were used to empirically estimate the following trans-log profit function:

$$(5) \quad \ln \pi^* = \alpha_o + \Sigma_i \beta_i \ln p_i^* + \Sigma_i \alpha_i \ln z_i + ½ \Sigma_i \Sigma_j \gamma_{ij} \ln p_i^*$$

$$\ln p_j^* + \Sigma_i \Sigma_j \delta_{ij} \ln p_i^* \ln z_j + ½ \Sigma_i \Sigma_j w_{ij} \ln z_i \ln z_j + u_1$$

As mentioned earlier, by using Shepherd's lemma, the following factor demand functions for variable inputs — labor, fertilizer,

2. Detailed informations about the study area are given in PEO and ANU (1977). Coimbatore district is one among the few districts in India which had a better performance of the high yielding paddy variety in terms of input applications and output achievements during the survey period.

pesticides and animal power — are written. For a transcendental logarithmic profit function, it is interesting to note that the demand functions are semi-logarithmic functions in the parameter estimates of the trans-log profit function, normalized variable prices, and the quantities of fixed endowments.

$$(6) \qquad \frac{-p_1 x_1}{\pi} = \beta_1 + \sum_{j=1}^{4} \gamma_{ij} \ln p_j^* + \sum_{j=1}^{2} \delta_{ij} \ln z_j + u_2$$

$$\frac{-p_2 x_2}{\pi} = \beta_2 + \sum_{j=1}^{4} \gamma_{2j} \ln p_j^* + \sum_{j=1}^{2} \delta_{2j} \ln z_j + u_3$$

$$\frac{-p_3 x_3}{\pi} = \beta_3 + \sum_{j=1}^{4} \gamma_{3j} \ln p_j^* + \sum_{j=1}^{2} \delta_{3j} \ln z_j + u_4$$

$$\frac{-p_4 x_4}{\pi} = \beta_4 + \sum_{j=1}^{4} \gamma_{4j} \ln p_j^* + \sum_{j=1}^{2} \delta_{4j} \ln z_j + u_5$$

where, x_i's are quantities of the variable inputs and u_i's are the usual random disturbances. Further, it is assumed that the covariances of the disturbances of any two of the equations for the same observation is not zero, but the covariance of the disturbances of any two equations corresponding to differenct observations are zero. With these assumptions, the above system of equations (5) and (6) were estimated simultaneously by using Zellner's asymptotically efficient method of estimation.

IV. Results and Discussions

As mentioned earlier, the assumption of profit maximization by the sample farmers was tested as explained below. The test consisted of examining whether the parameters derived from the trans-log profit functions (5) and the corresponding parameters derived from the factor demand equations (6) coincide (Yotopoulos and Lau 1979, pp. 15-16). This is equivalent to test whether:

$$\beta^{\pi}_{i} = \beta^{D}_{i}, \quad \gamma^{\pi}_{ij} = \gamma^{D}_{ij}, \quad \delta^{\pi}_{ij} = \delta^{D}_{ij},$$

$$(i = 1, 2, 3, 4; \; j = 1, 2)$$

where the superscript π and D respectively represent the profit function and demand functions. Along with these the symmetry conditions

$$(\gamma_{13} = \gamma_{31}, \gamma_{14} = \gamma_{41}, \gamma_{23} = \gamma_{32}, \gamma_{34} = \gamma_{33},$$

$$\delta_{12} = \delta_{21}, \delta_{13} = \delta_{31}, \delta_{14} = \delta_{41} \text{ and } w_{12} = w_{21})$$

were also imposed.

The computed F statistic works out to be 1.82 and the corresponding tabulated F-value is 2.93. Thus, the null hypothesis of the equalities mentioned above cannot be rejected at the 5% level of significance. This implies that the sample, on average, maximizes short term profits given their technology and resource base (Table 1).

With the equality restrictions being valid, the restricted parameter estimates of the normalized profit function and variable factors demand functions are presented in Table 2. Almost all the coefficients have the expected sign and are statistically significant.

As mentioned earlier, the elasticity estimates of paddy output supply and variable input demands were derived from the estimates of the profit and factor demand functions[3] and are reported in Table 3. Output supply is fairly sensitive to wage rate, its own price and operational holding, though it is inelastic. For a 10% increase in the price of paddy, however, the output supply will be increased by approximately 10%. Output supply seems to be sensitive to changes in the price of fertilizer, but not to changes in the price of pesticides. The supply elasticity with respect to fixed inputs indicates the *mutatis mutandis* effect (Yotopoulos and Lau 1979). This means that the supply response to a change

3. Sidhu and Baanante (1980) have provided a detailed derivation of the elasticity estimates.

Table 1

TYPICAL RICE PRODUCTION SYSTEM, COIMBATORE DISTRICT, SOUTH INDIA

	Physical units		Value (Rs unit)	
	Unit/ha	Level	Mean(Rs)	cv(%)
Rice area	ha	1.57	–	–
Output				
Paddy (rough rice)	t	5.90	1,407	11
Input				
Fertilizer	kg	230	1.52	9
Pesticides	kg a.i.	1	130.58	28
Bullock	hours	58	1.48	26
Labor[a]				
Establishment	days	26	8.20	15
Maintenance	days	32	9.30	13
Harvest	days	28	b	b
Total	days	86	–	–
Sample size	n	73		

[a]The value of family labour imputed at the equivalent cost to hire that service.
[b]This payment is in kind, one-sixth to one-seventh of the gross yield, (PEO-ANO, 1977)

in the operational holding would increase considerably, holding prices of output, variable inputs and quantities of other fixed inputs constant, but allowing output and variable inputs to adjust optimally. Supply response is less sensitive to the capital flow.

The demand for labour with respect to real wage is inelastic. The demand for labour, on the other hand, is elastic with respect to the price of output. A rightward shift in the supply function of agricultural labour, it means, could not be absorbed with only a

Table 2

ESTIMATES OF RESTRICTED NORMALIZED TRANS-LOG PROFIT FUNCTION AND SEMI-LOG FACTOR DEMAND FUNCTIONS FOR SOUTH INDIA, 1977-78

Variable / Function	Parameter Estimates									
	α_0	β_1	β_2	β_3	β_4	α_1	α_2	γ_1	γ_2	γ_3
Trans-log Profit function	7.872 (3.276)	−0.423 (0.118)	−0.384 (0.123)	−0.455 (0.276)	−0.213 (0.143)	−1.217 (0.652)	0.988 (0.432)	−0.307 (0.124)	−0.142 (0.071)	0.264 (0.096)
Semi-log Labor dd. fn.		−0.423 (0.102)						−0.307 (0.103)		
Semi-log Fertilizer dd. fn.			−0.384 (0.114)						−0.142 (0.063)	
Semi-log Pesticides dd. fn.				−0.455 (0.216)						0.264 (0.096)
Semi-log Animal power dd. fn.					−0.213 (0.127)					

Table 2 (Contd.)

Variable / Function	Parameter Estimates									
	γ_4	δ_1	δ_2	δ_3	δ_4	δ_5	δ_6	ε_1	ε_2	ε_3
Trans-log Profit function	−0.189 (0.116)	0.063 (0.021)	−0.045 (0.032)	−0.035 (0.010)	0.037 (0.016)	0.012 (0.005)	−0.084 (0.027)	−0.391 (0.125)	−0.467 (0.213)	0.321 (0.127)
Semi-log Labor dd. fn.		0.063 (0.016)	−0.045 (0.023)	−0.035 (0.007)						
Semi-log Fertilizer dd. fn.		0.063 (0.016)			0.037 (0.012)	0.012 (0.003)				
Semi-log Pesticides dd. fn.			−0.045 (0.023)		0.037 (0.012)		−0.084 (0.019)			
Semi-log Animal power dd. fn.	−0.189 (0.116)			−0.035 (0.007)		0.012 (0.003)	−0.084 (0.019)			

Table 2 (Contd.)

Variables / Function	Parameter Estimates							
	w_1	w_2	w_3	w_4	w_5	w_6	w_7	w_8
Trans-log Profit function	−0.201 (0.083)	0.193 (0.092)	−0.103 (0.062)	0.154 (0.071)	0.210 (0.082)	0.263 (0.101)	−0.156 (0.076)	−0.141 (0.061)
Semi-log Labor dd. fn.	−0.201 (0.063)	0.193 (0.081)						
Semi-log Fertilizer dd. fn.			−0.103 (0.041)	0.154 (0.052)				
Semi-log Pesticides dd. fn.					0.210 (0.071)	0.263 (0.093)		
Semi-log Animal power dd. fn.							−0.156 (0.052)	−0.141 (0.037)

Note: Figures in parentheses are asymptotic standard errors of the estimates.

Table 3

DERIVED ESTIMATES OF OUTPUT SUPPLY ELASTICITIES AND OWN AND CROSS PRICE ELASTICITIES OF DEMAND

Characteristics	Output Supply	Labor Demand	Fertilizer Demand	Pesticides dd.	Animal Power dd.
Price of Labor	−0.703	−0.513	−0.426	−0.409	−0.373
Price of Fertilizer	−0.621	−0.253	−1.349	−0.137	−0.021
Price of Pesticides	−0.537	−0.261	−0.373	−1.434	−0.432
Price of Animal Power	−0.201	−0.134	−0.046	−0.593	−0.334
Price of Output	0.961	1.236	1.179	1.272	0.435
Capital	0.282	0.231	0.151	0.537	0.015
Land	0.801	0.810	0.763	0.913	0.009

small decrease in real wages; but could be absorbed considerably with the upward adjustment of output price. This means that the present agricultural pricing system is not flexible enough to absorb labour easily. Fertilizer, pesticides and animal power appear to be complements to labour. These results show that potential labour absorption is mainly an increasing function of output price and operational holdings.

The demand for fertilizer with respect to its own price is elastic. The fertilizer demand elasticity with respect to the output price is also elastic. The demand for pesticides is elastic with respect to its own price and also to the output price. Most farmers continue to own the animal which is used for the operations; mechanization is still a relatively recent and rare phenomenon.

The results indicate that within the range of price variability observed in the sample the complementary relationships among labour, fertilizer, pesticides and animal power are dominant over the possible substitution relationship. However, it must be stressed that a significant change in the price ratios (arising, say, from a steep rise in pesticides prices) is likely to change the situation. Substitution of labour for the use of pesticides, for example, may well become attractive; particularly for farmers who have limited working capital.

Summarizing the results, it is evident that the irrigated paddy farmers in South India respond to price changes.

V. Conclusions

While analyzing the significance of agricultural price policies in a country, detailed case studies of the effect of particular price policies, say rice price in this case, provide more important informations to policy makers than aggregate studies. It is in this context that the present study points out that policy makers should not presume that agricultural production is not very responsive to price changes and is flexible enough to absorb labour easily. Nor should policy makers assume that output price is not important for either creating the demand for labour, or increasing yields. Japanese agriculture provides a valuable example for the later case of linking output price and yield. The empirical findings of the study show that irrigated paddy, at least, is responsive to relative price changes and pricing policies favouring farmers have the tendency to increase agricultural production and demand for variable inputs in the South Indian irrigated agriculture. Higher agricultural prices, it is generally believed, would adversely affect low-income consumers who are mostly living in urban areas. Higher prices, however, have two different types of stimulating effects on production; one is that higher prices may increase production by increasing the use of inputs and the other effect is by improving existing production technologies to find lower-cost production frontier.

Although it looks like a paradox that higher prices lead to lower prices, it is possible by means of measures such as on-farm investment and technological advances. Thus, these effects of higher prices inducing infrastructural development would not only benefit farmers but also low-income urban consumers. Dantwala's (1978) conclusions that infrastructural development is an important condition to achieve food self sufficiency in the long run for India, are strongly conveying these views. On the other hand, artificially lowering agricultural prices by means of price controls and subsidies may reduce output and deteriorate development.

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