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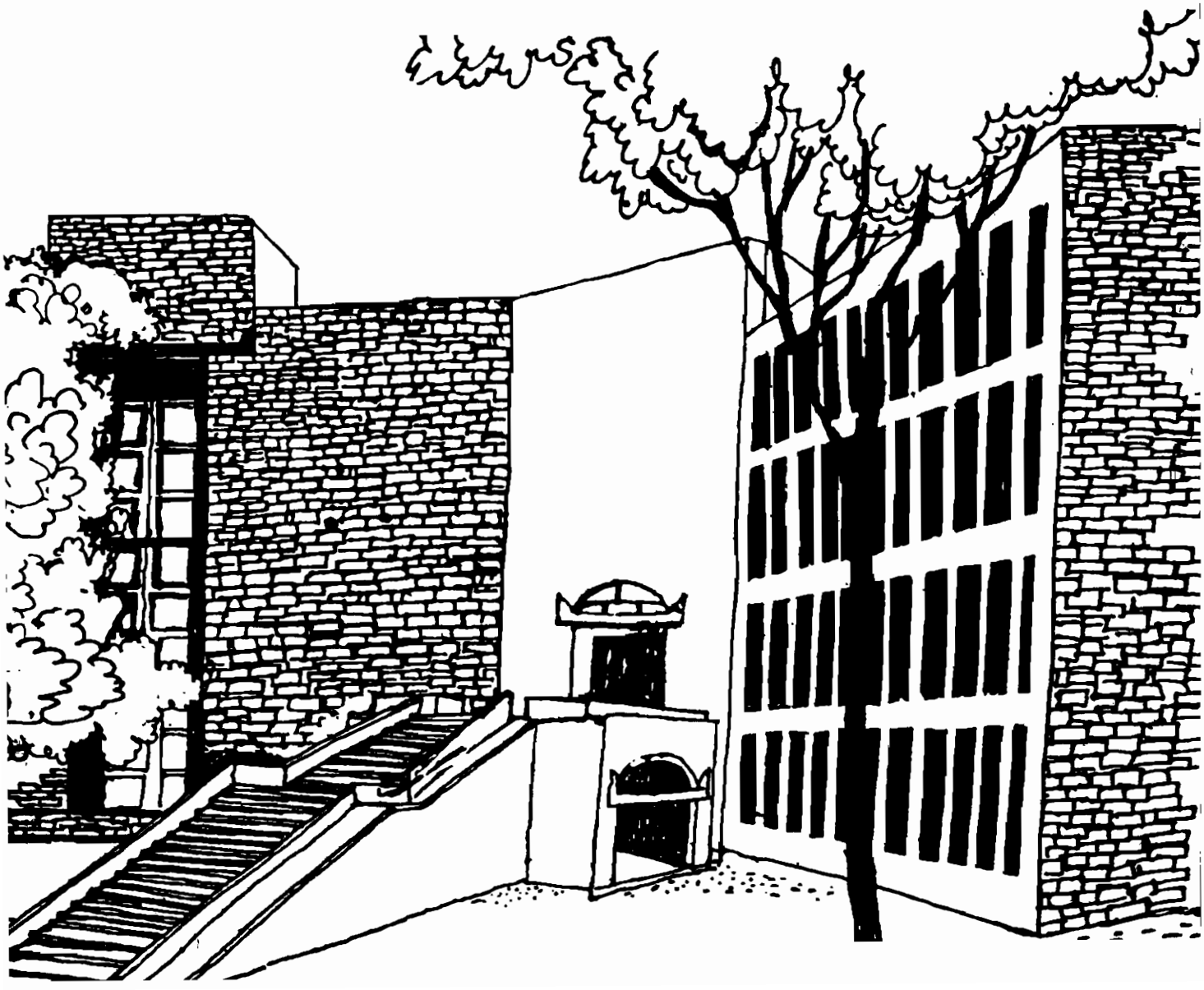

INVESTMENT BEHAVIOUR IN INDIAN AGRICULTURE: A THEORETICAL AND EMPIRICAL INVESTIGATION

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Introduction

Investment behaviour is a phenomenon that has been difficult to determine in the context of developing economies. Very little definitive work is available on this, particularly in the context of agriculture. Yet, it is clearly recognized that a healthy rate of investment is critical for sustained growth in the agriculture sector. In this context, there has been substantial concern in the last 5 to 10 years about a reduction in the growth of agricultural investment in India (see for instance Bhagwati and Srinivasan (1993) and Gulati & Bhide (1993)). Even though some studies have appeared investigating this (see Ram, Gill, Mishra and Chand, Dhawan and Yadav), the causes behind this decline have not been systematically examined within a comprehensive framework. In light of the large number of factors influencing investment, the examination needs to be done through a comprehensive model which should be based on the economic theory of investment behaviour.

Internationally, investment behaviour is an important economic relation that has been difficult to determine in the context of developing economies (see Sundarajan and Thakur (1980), and Blejer and Khan (1984)). This is principally because of the long-term and complex nature of the relationship, difficulties on account of imperfections and interventions in developing country markets, and often the non-availability of the required data. Relationships concerning consumption, money demand, imports and exports have been explored within a number of theoretical models and the empirical findings indicate some convergence of views on them. Theoretical models on investment behaviour, however, are few and their applications in

developing countries are nearly non-existent. As a result not only is investment behaviour in developing countries poorly understood but investment functions are often treated in most simplistic forms in developing country models. Since the government plays an important role in capital formation in many developing countries, investment is often treated as a policy variable rather than a behavioural one. Such approaches, although indicating the importance of the relationship between public and private investment, grossly disregard the fact that the major component of investment in developing countries is usually private investment.

The theoretical literature from developed countries on investment behaviour is rich and has yielded a well defined class of models of the flexible accelerator type first proposed by Chenery (1952) and Koyck (1954). The most popular of these are the neoclassical models of investment behaviour associated with Jorgenson (1963, 1967a, 1967b, 1971), and variants of these have been applied with a good degree of success to manufacturing in several industrial countries (for example, see Abel (1980)). A few applications have also appeared for agriculture of developed countries - Fisher (1974) and Waugh (1977a-b) for Australian agriculture, and Girao, Tomek and Mount (1974) and Hrubovcak and Le Blanc (1985) for U. S. agriculture. There is, however, a very large gap between the theory of investment behaviour and the study of the behaviour in developing countries. Some exceptions are recent efforts by Sundarajan and Thakur (1980), Tun Wai and Wong (1982), and Blejer and Khan (1984), in applying some features of the investment behaviour theory, such as the flexible accelerator principal and the neoclassical determination of capital stock, to behaviour of total investment in developing countries, (see Gandhi (1986) for a review). The empirical results have been varied, often

constrained by data limitations, but encouraging in confirming some of the features of the theory. However, hardly any studies are available towards examining and understanding the behaviour of agricultural investment in developing countries using the theory of investment behaviour. An important contribution to the study of investment has come from Binswanger, Khandkar and Rosenzweig (1989) which uses cross-district panel data from India to examine associations between different district characteristics/ variables, and private investment in a few types of assets in Indian agriculture. This, however, excludes many types of investments, such as, the bulk which is in physical construction works, and is also not directly based on the theory of investment behaviour. Another contribution is the work of Gandhi (1990) which develops a model based on the theory of investment behaviour to examine private investment behaviour in Indian agriculture upto 1980. The present study also based on the theory of investment behaviour seeks to examine the nature of investment behaviour from the 1950's to the early 1990's.

The Background and Determinants

Investment

Before the late 1970's comprehensive figures for investment in agriculture were not available. Since the late 1970's figures on capital formation by industry of use are being published by the Central Statistical Organization (CSO), Ministry of Planning, with agriculture defined as one of the industries. However, this included change of stocks, which needs to be separated to obtain the gross domestic fixed capital formation, which is the same as investment. Further, in late 1980's, the CSO published a new series on national accounts, and all the figures for the 80's as well as from 1950/51 onwards were revised under a new/changed methodology

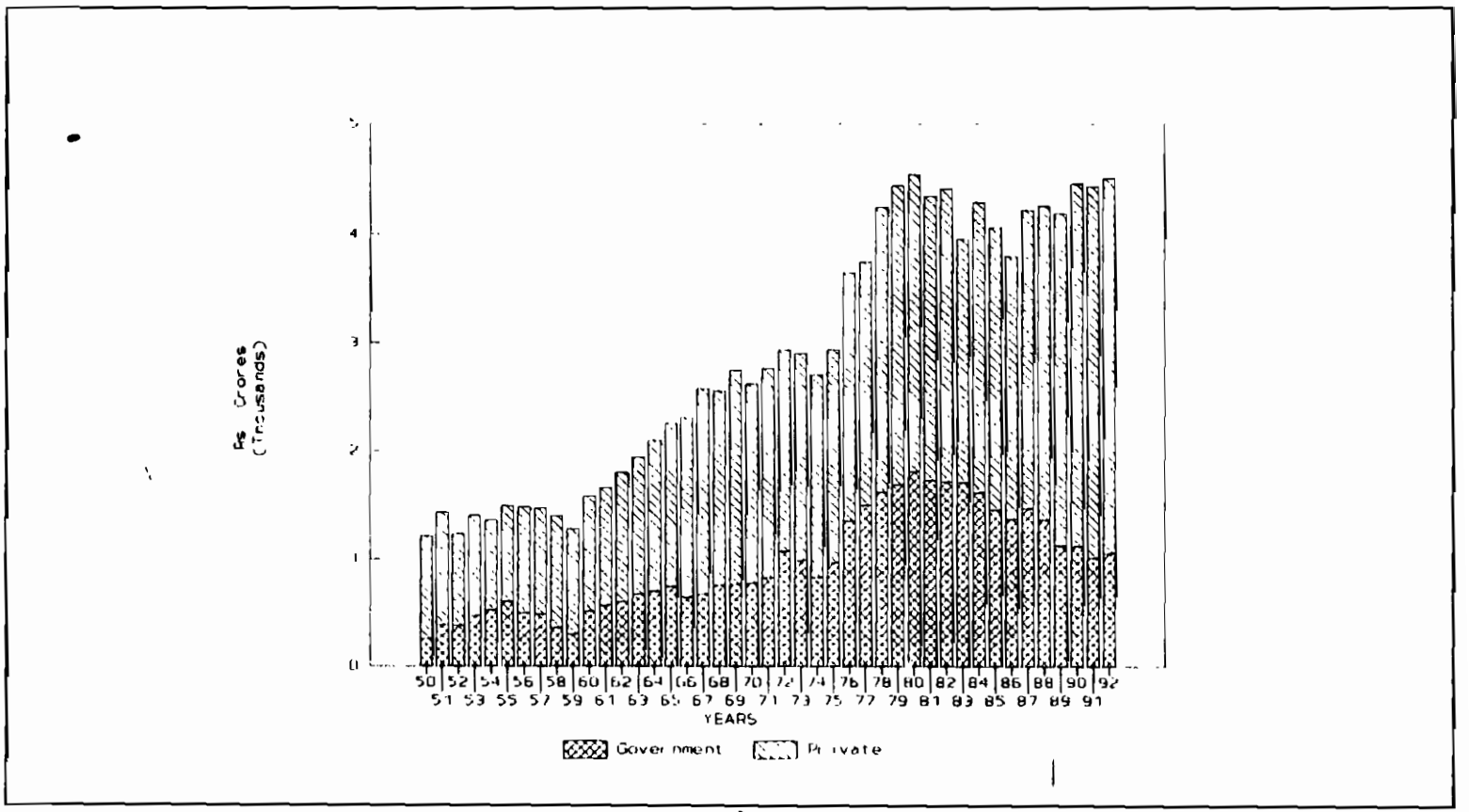
adopted. Subsequently, a new series on capital formation was also published, as a result, revising all the earlier data.

Total investment has two major components: private investment and government (or public) investment which need to be separated for any study of investment behaviour. Private investment is typically considered a behavioural or endogenous variable, and government investment a policy or exogenous variable. (Data and data sources and methods are discussed in Appendix 1).

An examination of the investment estimates (CSO, and Chaturvedi and Bagchi (1984)) shows that, despite massive developmental investment by the government, over 70 percent of the agricultural investment in the country is private investment (late 1970's). This is in many different forms such as land improvement, buildings/ construction (non-residential), agricultural implements, machinery and equipment, transport equipment, and farm animals.

Figure 1 shows depicts the levels of private, public and total investment in agriculture from 1950/51 to 1992/93 in constant 1980/81 prices. The figures show that there is considerable variation from year to year in private and public investment and more in the total investment. Private investment has always been the bigger component, and its proportion appears to have grown, especially in the second half of 80's and the 90's. Total investment shows growth, but with considerable fluctuations. There is a slow down in the late 50's, followed by growth through-out the 60's. There is a slow-down again in the early to mid 70's followed by a major

Figure 1 : Total Private and Government Investment in Agriculture (Gross Domestic Fixed Capital Formation in Agriculture) (in Constant 1980/81 Prices)



spurt which lasts all the way until the early 80's. After this there is a major decline during the eighties, but there is some recovery in the early 90's.

Figure 2 which separately depicts private and public investment indicates considerable variation in both the investments. The 80's however, show some distinct patterns. Public investment shows an absolute decline which continues into the 90's. This long a period of decline is unprecedented in the entire series, indicating a structural change. Note, that this has started much before the liberalization. The private investment shows fluctuations as well as some decline upto mid-80's. However, after this it shows a spurt which takes it to substantially higher levels into the early 90's. This is again unprecedented and is also indicative of a structural change. The two series are moving in completely opposite directions over sustained periods of time.

Table 1 which gives the levels at selected points (as earlier, in constant prices) in time also indicated these changes. Note that the total investment rises from Rs. 1224 crores in 1950/51 to Rs. 2580 crores in 1967/68 at the beginning of the green revolution. From this it again nearly doubles to Rs. 4537 crores in 1980/81. After this it shows an absolute decline to Rs. 3797 crores in 1986/87. From this there is a mild recovery taking it only to Rs. 4507 crores in 1990, still less than the 1980/81 level.

Table 2 gives the respective annual growth rates based on the entire time series. The early period growth rates are, of course, influenced by the starting magnitudes being very small.

Figure 2 : Private and Government Investment in Agriculture

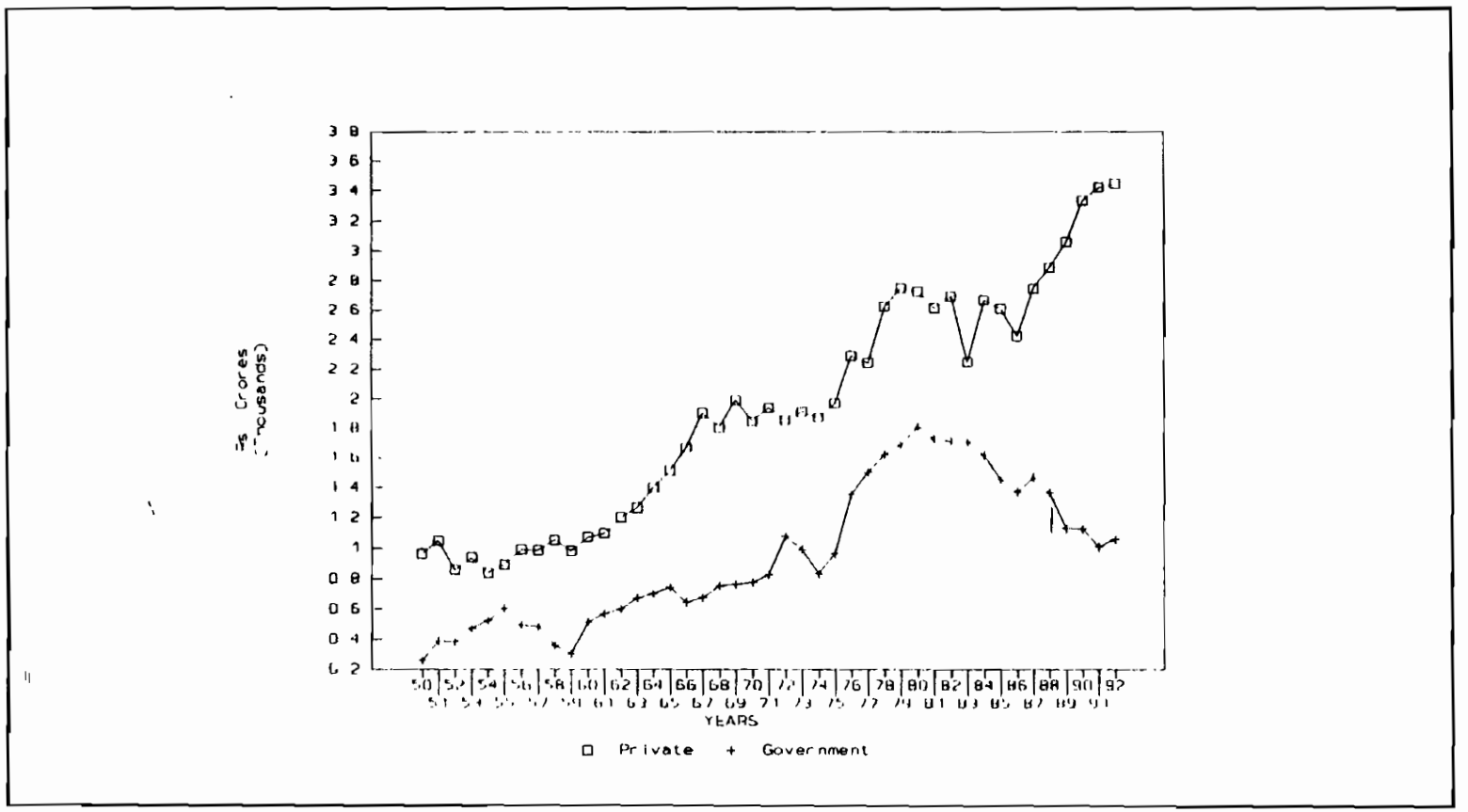


Table 1: GROSS DOMESTIC FIXED CAPITAL FORMATION (INVESTMENT) IN AGRICULTURE AT 1980/81 PRICES

YEAR	INVESTMENT TOTAL	INVESTMENT GOVERNMENT	INVESTMENT PRIVATE
50-51	1224	259.14	964.86
67-68	2580	675.25	1904.75
80-81	4537	1811.20	2725.80
86-87	3797	1373	2424
92-93	4507	1057	3450

Table 2: GROWTH RATES IN AGRICULTURAL INVESTMENT DURING DIFFERENT DECADES				
Particular	1950/51-67/68	1967/68-80/81	1980/81-86/87	1986/87-92/93
Total Investment	3.83	4.64	-2.48	2.35
t-statistics	8.40	7.97	3.40	3.97
Public Investment	4.11	7.70	-4.40	-6.17
t-statistics	4.26	9.71	6.12	4.84
Private Investment	3.78	3.11	-1.30	5.85
t-statistics	7.09	5.66	0.99	8.66

The figures indicate a considerable spurt in the public investment following the green revolution - the growth rate rises from 4.1 percent to 7.7 percent (1950/51-1967/68 and 1967/68-1980/81). Following this, there is a sharp fall to -4.4 percent between 1980/81 to 1986/87, and further decline to -6.2 percent in 1986/87 to 1992/93.

The private investment shows a substantially different pattern. The growth rate is 3.1 percent between 1967/68 and 1980/81. From this it falls to -1.3 percent in 1980/81-1986/87, but this is statistically not significant ie. no different from zero. From this it rises sharply to 5.9 percent in 1986/87-1992/93. This is unprecedented. It is this which overcomes the negative growth rates of public investment and turns around the growth rate of total investment from -2.5 percent in 1980/81-1986/87 to 2.4 percent in 1986/87-1992/93. However, this is still lower than the growth rate of 3.8 percent in 1950/51-1967/68 and 4.6 percent in 1967/68-1980/81 for total investment.

Private investment should be critically related to profitability and past literature suggests that this would be associated with several factors such as output demand/ prices, input use/ prices, the cost of capital including interest rates, government investment, and the availability of own savings and credit. The theoretical relationship between them and private investment is being examined in the next section. In the Indian setting, there have been a large number of policies that have influenced these determinants and these could in turn influence private investment in agriculture.

Agricultural Output

In the neo-classical models of investment, output is an important determinant of investment. This is what is referred to as the accelerator, since it is believed that output which reflects capacity utilization and the output demand, accelerates investment. This has been an important concept in the business cycles literature. Figure-3 shows the growth in agricultural output. The figure shows that the output has substantial growth and also considerable fluctuation. Particularly notable are the declines in 1965/66-1966/67 period of major drought and again in 1979/80 for the same reason. The output has remained nearly unchanged from 1983/84 to 1986/87, but this is followed by a huge jump both the bumper crop of 1987/88 continual growth since.

Output and Input Prices

Since profitability is fundamental to investment, output and input prices clearly become important determinant of investment. Low output prices depress investment and high input prices could have an adverse effect on investment if they substantially depress the profitability.

Figure 4 show the agricultural output price index (wholesale) and the fertilizer price index. It may be noted that these are both of base 1980/81 = 100 and therefore are relative to their respective 1980/81 price levels. The figure indicates that the two move fairly close together up to 1981/82. The fertilizer index is slightly higher until mid-60's and the output price index is slightly higher upto early 70's. The oil shock changes the balance in 1973/74-74/75 with the fertilizer prices shooting up substantially. However, subsidies bring these prices down and by 1977/78, fertilizer index dips below the output index.

Figure 3 : Output : Agricultural Output
(in Constant 1980/81 prices)

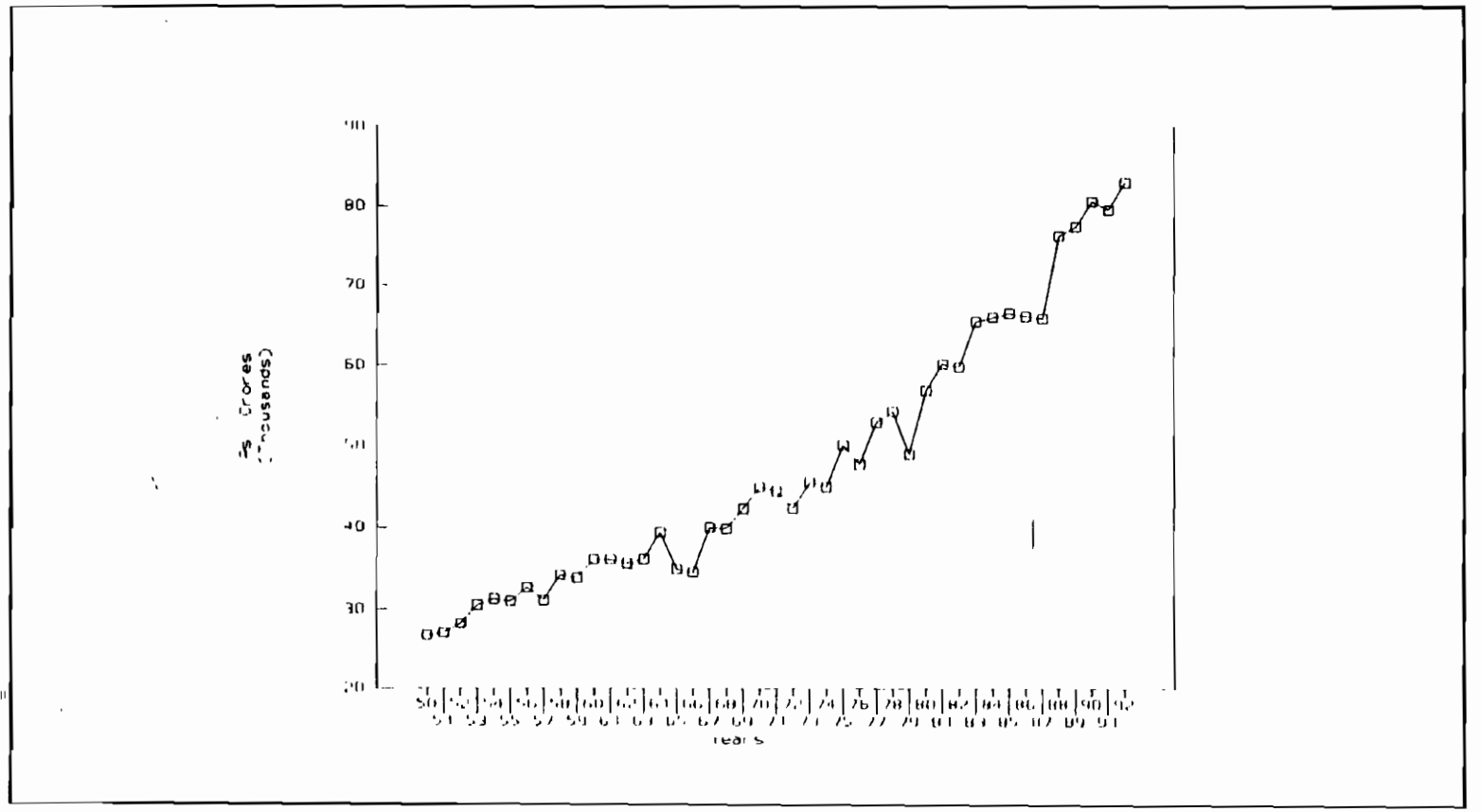
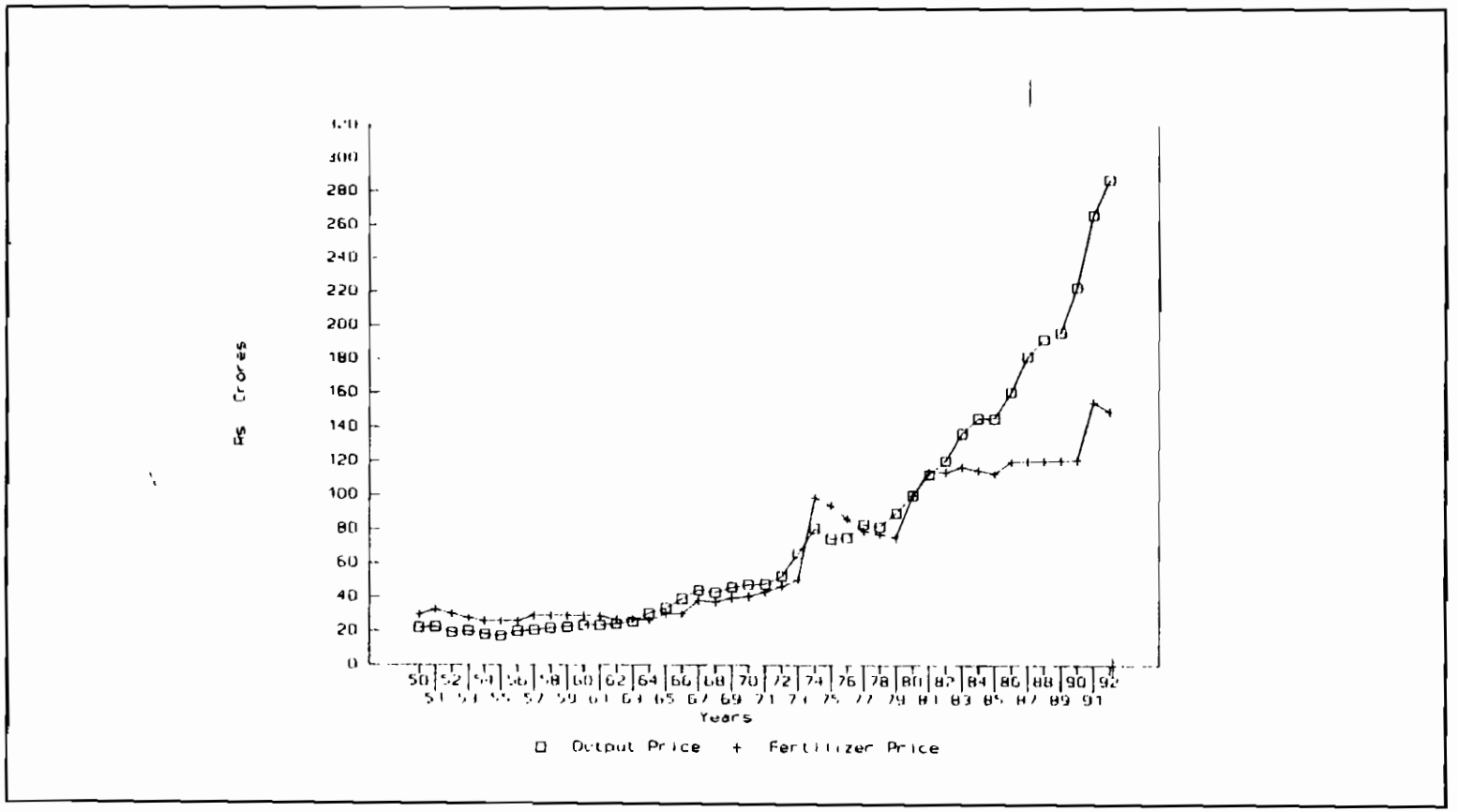


Figure 4 : Prices : Agricultural Output Price Index and Fertilizer Price Index (1980/81 = 100)



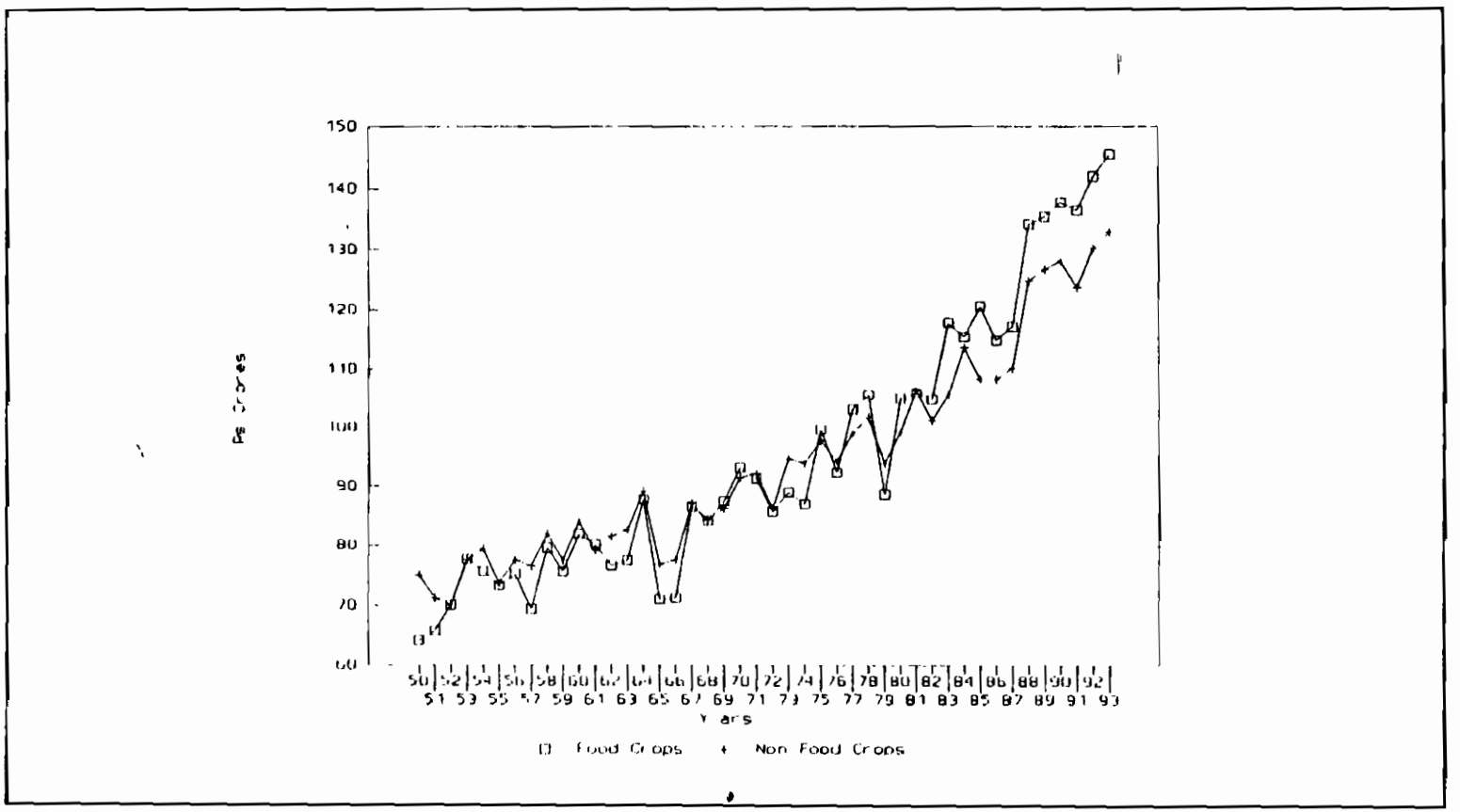
The major divergence commence after 1981/82 with the fertilizer index remaining nearly constant from 1981/82 to 1990/91 whereas the output price index continues its upward trend with an acceleration in the early nineties. There is a small rise in the fertilizer index in the early nineties but this is not sustained. These indices are indicative of a healthy environment for agricultural investment in the eighties and nineties.

Yields/ Productivity

Fertilizer use is one of the indicators of technological change, and it is well-known that technological change through the advent of research and high yielding varieties has played a major role in the growth of agricultural production in India. The production comprises of food and non-food crops. What has been the impact and record of this with respect to the yields of crops?

Figure-5 gives the yield indices for food and non-food crops. The figures indicate substantial fluctuations but a close match between the two. The fluctuation in the food index appears to be greater. The non-food crops index is almost always higher upto beginning of the green revolution (1967/68), and subsequently the food index is frequently higher. The consistent divergence starts only from 1981/82 after which the food yield index is higher in all years. Even though the non-food index also rises considerably, the food index remains higher throughout the late eighties and early nineties. Thus, the yield improvement is substantial in both food and non-food crops with the food crops showing a better growth.

Figure 5 : Yield Indices : Food and Non-Food Crops (1980/81 = 100)



Credit

When investment is an attractive proposition, credit often becomes a significant constraint. Given the seasonality in agriculture, the partly subsistence nature of the activity, small farm sizes and low incomes the availability of cash for investment typically becomes major constraint. The availability of institutional credit could therefore have a major impact on investment.

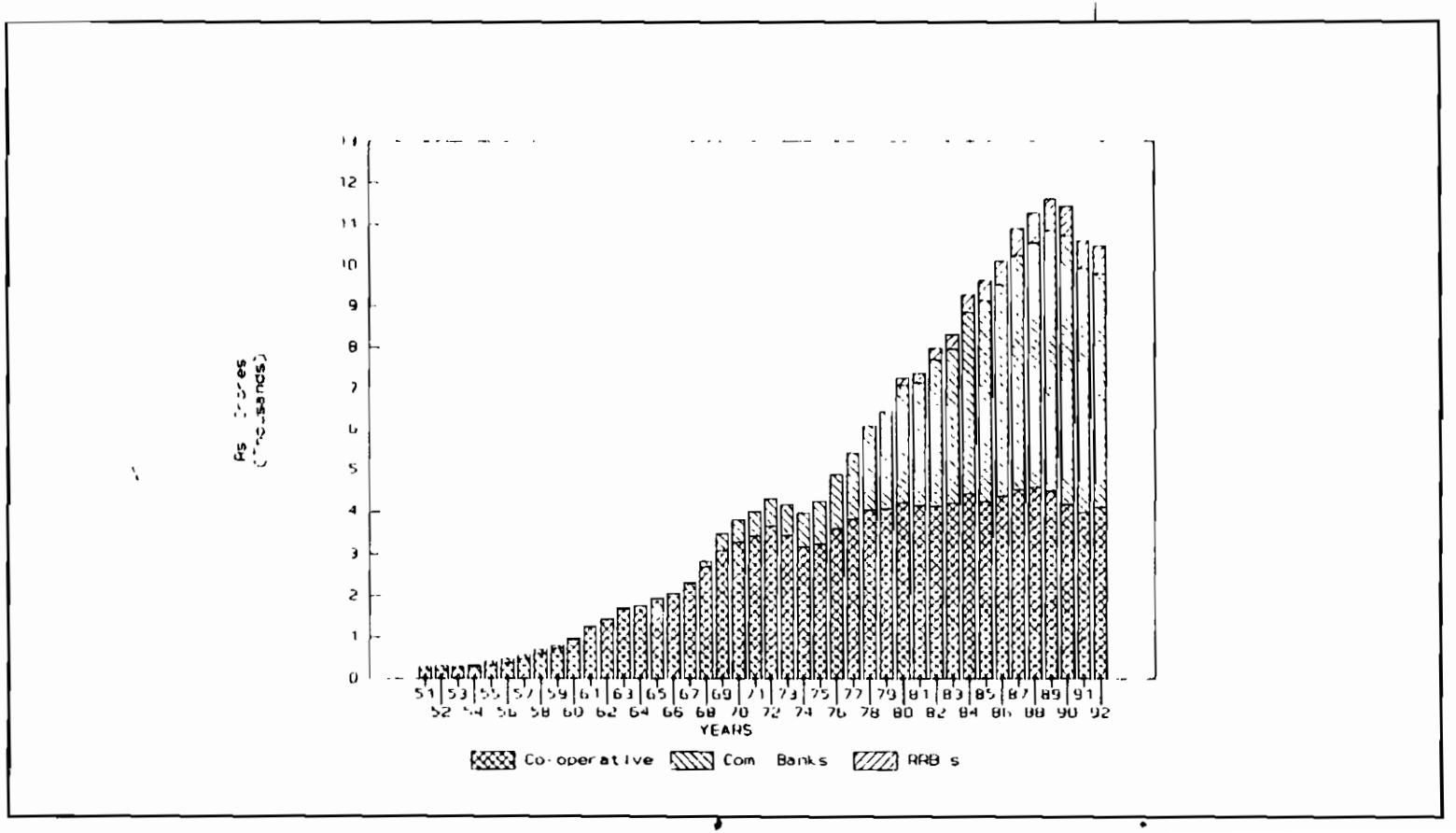
In India, institutional credit is made available principally through 3 channels:

1) Cooperatives
2) Commercial Banks
3) Regional Rural Banks

Figure 6 shows the movement of outstanding credit to agriculture from these three sources, as well as of the total credit (in constant 1980/81 prices). The figure shows that there has been a considerable buildup of credit in the 70's and 80's. An acceleration is seen in the late 60's with the coming in of commercial banks to agricultural credit in a significant way. There has, however, been some decline in the total credit in the mid-seventies especially cooperative credit. Following this growth of credit continue until 1989/90 with substantial expansion in the commercial bank credit and addition of Regional Rural Banks.

The proportion of commercial Banks becomes larger than that of cooperatives by the late 80's. However, cooperative credit does not show much real expansion in the 80's and actually shows a decline by the early 90's. The total credit outstanding to agriculture also shows a decline after 1989/90, with a considerable fall in 1991/92 and 1992/93. This may have significant implications for investment.

Figure 6 : Credit : Cooperative, Commercial Bank and Regional Rural Bank Credit Outstanding
(Deflated : 1980/81 prices)



Interest Rates

The cost of credit could have important implications for investment behaviour since it is an important determinant of the user cost of capital - the net cost of using capital. The nominal average rate of interest for institutional agricultural finance is shown in Figure 7. The figure indicates substantial growth in the interest rates, which has apparently taken place through 3 steps. One major step increase took place in the mid-sixties with the rates rising from around 8 percent to around 10 percent. This might have been related to inflationary pressures arising from food shortages in the mid-sixties - and the monetary policy response to checking this inflation. The second major step took place in the wake of the oil shock in 1973/74 with an increase to around 13 percent - possibly again as a result of inflationary pressures. The third step is seen in the early 80's taking them to around 14 percent possible in response to inflationary pressures from the second oil shock. In the mid-80's the interest rates show a slight declining trend, followed by a rise again in the early 90's with the new economic policies. However, the figure shows, that the rates haven't risen or fallen substantially since the early 80's.

Wages

Wages can have an impact on investment through capital labour substitution. High wages may lead to substitution away from labour using and towards capital using technology. However, high wages might also discourage more labour intensive investments such as in land improvement and 'Kutcha' construction. Figure 8 shows the average nominal agricultural wages for ploughing from a national survey of agricultural labourers. The figures indicate a rising trend

Figure 7 : Interest Rates : Interest Rates for Institutional Finance to Agriculture

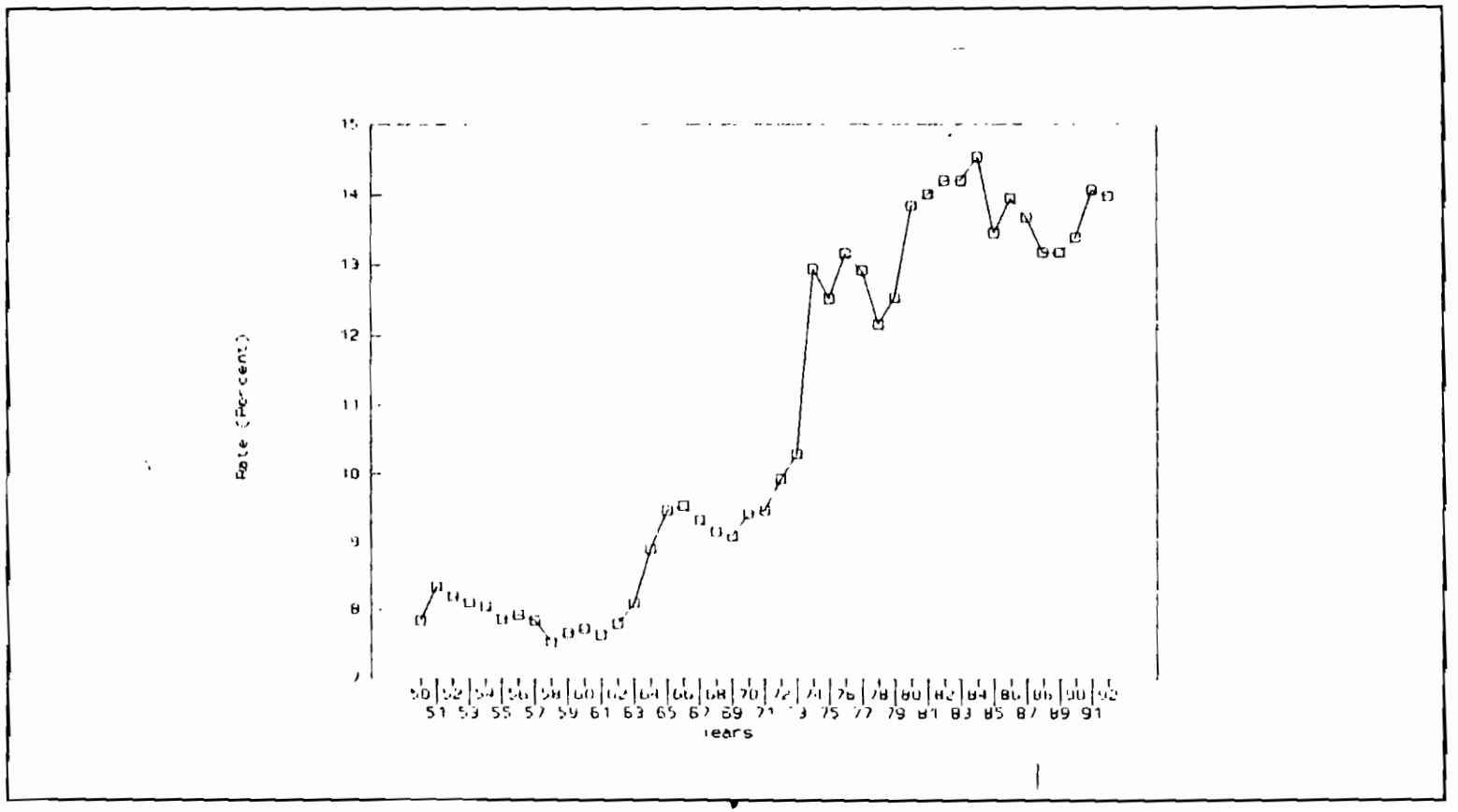
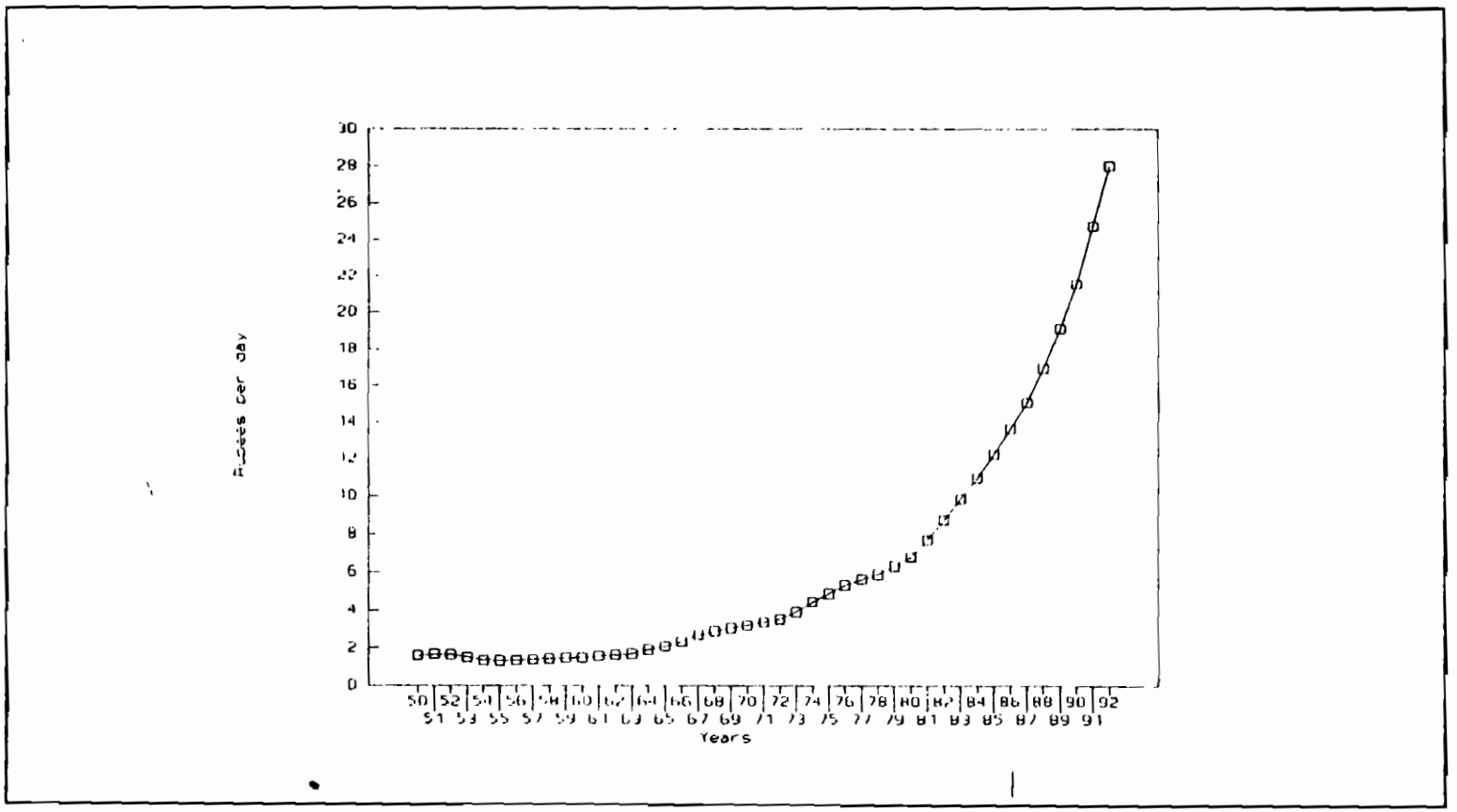


Figure 8 : Wages - Agricultural Wages (Rs.per day), Average



but the rise is less sharp until the early 80's. From the early 80's an accelerating rise is seen - almost on an exponential growth path. This may be partly inflation driven but may be partly indicative of increasing scarcity of farm labour in the recent years. This has been reported especially in peak seasons in several areas of the country. This would encourage labour-substituting investment.

Development of the Theoretical Model

In economic theory, investment is defined to be the periodic addition to the capital stock. Major theories of investment behaviour consider investment to takes place in response to a gap between the actual level of capital stock and the desired level of capital stock (see Gandhi (1986) for a review). The adjustment from the actual to the desired may, however, be partial in any given period and it may depend on the patterns or relationships of adjustment behaviour. Based on these foundations of the theory of investment behaviour, investment would depend on the actual (past) capital stock, the new desired capital stock (related to its determinants), and on factors affecting adjustment from the actual to the desired.

Following the theoretical work of Jorgenson (1967b) and of Gandhi (1990), the desired level of capital stock may be considered to be a behavioural outcome of the objective of maximizing the net return over time, or the net present value. This can be expressed as:

Maximize :

$$Net\ present\ value = \int_0^{\infty} e^{-rt}[P(t)F[KP(t),\ L(t),\ FR(t)]$$

$$- W(t)L(t) - PF(t)FR(t)$$

$$- PK(t)[KP(t) + \delta KP(t)]]dt$$

where,

P	=	price of output,
F(.)	=	production function,
KP	=	private capital stock,
KG	=	government capital stock,
L	=	labour use,
FR	=	fertilizer use,
W	=	wage
PF	=	price of fertilizer,
PK	=	price of capital,
K°P	=	dKP/dt,
δ	=	rate of depreciation
r	=	interest rate, and
t	=	time

Assuming a general inflation rate of π, and for notational simplicity dropping the t's, but keeping in mind that all the input and price variables are functions of time, Equation (1) can be rewritten as :

Maximize

$$Net\ present\ value = \int_0^{\infty} e^{(r-\pi)t}\ [PF[KP, KG, L, FR] - W\,L \qquad (2)$$

$$-PF\ FR - PK[\dot{KP} + \delta KP]]dt$$

Now integration by parts can be applied on the following lines:

$$\int_a^b v\,du = uv]_a^b - \int_a^b u\,dv$$

$$= u(b)\ v(b) - u(a)\ v(a) - \int_a^b udv \qquad (3)$$

One part of Equation (2) is the following expression :

$$\int_0^\infty e^{(r-\pi)t}\,\dot{K}P\ dt.$$

Now in Equation (3), let

$$v = e^{(r-\pi)t}$$

and let

$$du = \dot{K}P\ dt.$$

Then

$$dv = -(r-\pi)\,e^{-(r-\pi)t}$$

and

$$u = KP.$$

Therefore,

$$\int_0^\infty e^{-(r-\pi)t}\dot{K}P\ dt = KP\ e^{-(r-\pi)t}]_0^\infty + \int_0^\infty KP(r-\pi)\,e^{-(r-\pi)t}\,dt$$

$$= -KP(0) + \int_0^\infty KP(r-\pi)\,e^{-(r-\pi)t}\,dt \qquad (4)$$

Now, substituting Equation (4) into (2) and rearranging, gives

$$NPV = \int_0^{\infty} e^{-(r-\pi)t}[P\,F[KP, KG, L, FR] - WL - PF\,FR$$

$$- PK[KP(r-\pi) + \delta KP]]\,dt + PK\,KP(0)$$

which can be rewritten as

$$NPV = \int_0^{\infty} e^{-(r-\pi)t}\,[P\,F[KP, KG, L, FR] - W\,L - PF\,FR$$

$$- \underline{KP}\,PK[r + \delta - \pi]]\,dt + PK\,KP(0)\,. \qquad (5)$$

Maximization for Equation (5) is equivalent to maximizing the expression within the square brackets, since the last term is unimportant for maximization. The first-order conditions for this maximization are:

$$PF_{KP} = PK(r + \delta - \pi) \qquad (6)$$

$$PF_{L} = W, \qquad (7)$$

$$PF_{FR} = PF, \qquad (8)$$

where, F. is the derivative of the production function with respect to the subscripted input. Condition (6) could be interpreted as stating that the farmers would desire to build capital stock until the expected discounted return from the last additional unit of capital is (as it works through the production process) equal to the implicit user cost of capital. The government capital stock and prices are considered exogenous.

Deriving a specific expression for the desired level of capital stock requires selection of a specific form for the production function. The Cobb-Douglas functional form is superior to the linear but, as for most forms has restrictions. However, Jorgenson and his associates (1967a, 1971), have used the Cobb-Douglas form extensively in their sector level investment models. Further, in a study by Yotopoulos, Lau and Somel (1970) using Indian Farm Management Studies data, the estimated value of the elasticity of substitution was not found to be significantly different from one. Under this assumption, other forms such as the CES production function reduce to the Cobb-Douglas form. Some other studies such as by Bardhan (1971), Srivastava and Heady (1973), and Binswanger (1974) have come to varying conclusions, but the Cobb-Douglas function continues to hold the advantage in simplicity of form and parsimony of parameters.

The following Cobb-Douglas functional form is assumed:

$$Q = A(KP)^{\alpha_1} KG^{\alpha_2} (L)^{\beta_1} (PR)^{\beta_2}, \qquad (9)$$

where Q is the real output. Differentiating the production function with respect to the private capital stock gives

$$\frac{\delta Q}{\delta KP} = F_{KP} = \beta_1 A (KP)^{\alpha_1 - 1} (KG)^{\alpha_2} (L)^{\beta_1} (PR)^{\beta_2}. \qquad (10)$$

Now differentiating Equation (9) with respect to L, gives

$$F_L = A\beta_1 KP^{\alpha_1} KG^{\alpha_2} L^{\beta_1 - 1} PR^{\beta_2}.$$

Substituting Equation (9) back into the above equation gives

$$F_L = \frac{\beta_1 Q}{L}.$$

Substituting the above into the first-order condition Equation 7 gives

$$\frac{P\beta_1 Q}{L} = W$$

Therefore,

$$L = \frac{P\beta_1 Q}{W}. \tag{11}$$

Similarly differentiating Equation (9) with respect to FR gives

$$F_{FR} = A\beta_2 KP^{\alpha_1} KG^{\alpha_2} + L^{\beta_1} + FR^{\beta_2 - 1}.$$

Now substituting the above equation into the first order condition Equation (8) gives

$$\frac{P\beta_2 Q}{FR} = PF.$$

Therefore,

$$FR = \frac{P\beta_2 Q}{PF}. \tag{12}$$

Now substituting Equations (11) and (12) into (10) gives

$$F_{KP} = \alpha_1 A (KP)^{\alpha_1 - 1} (KG)^{\alpha_2} \left[\frac{P\beta_1 Q}{W}\right]^{\beta_1} \left[\frac{P\beta_2) Q}{PF}\right]^{\beta_2} = PK(r+\delta-\pi) \tag{13}$$

Substituting Equation (13) into the first-order condition (6) gives

$$P\alpha_1 A (KP)^{\alpha_1 - 1} (KG)^{\alpha_2} \left[\frac{P\beta_1 Q}{W}\right]^{\beta_1} \left[\frac{P\beta_2) Q}{PF}\right]^{\beta_2} = PK(r+\delta-\pi)$$

Letting

$$UC = PK(r+\delta-\pi),$$

$$KP = (constant)\, P^{\left[\frac{\beta_1+\beta_2+1}{1-\alpha_1}\right]} Q^{\left[\beta_1+\frac{\beta_2}{1-\alpha_1}\right]} KG^{\left[\frac{\alpha_2}{1-\alpha_1}\right]}$$

and transposing, gives

$$KP = (constant)\, P^{\left[\frac{\beta_1+\beta_2+1}{1-\alpha_1}\right]} Q^{\left[\beta_1+\frac{\beta_2}{1-\alpha_1}\right]} KG^{\left[\frac{\alpha_2}{1-\alpha_1}\right]}$$

$$UC^{-\left[\frac{1}{1-\alpha_1}\right]} W^{-\left[\frac{\beta_1}{1-\alpha_1}\right]} PF^{-\left[\frac{\beta_2}{1-\alpha_1}\right]}. \qquad (14)$$

This represents the desirable or profit-maximizing level of capital stock, given (or as influenced by) the product price, input prices, level of government capital stock, the input-output relationships, and the desired level of output. The output and the user cost of capital may be considered conventional determinants from standard neoclassical and flexible accelerator models. Besides these, the price of output, the government capital stock, the wage rate and the fertilizer price appear as incorporated in this model. The price of output is relevant for capturing the effect of price support policy on the desired level of capital stock. Introduction of wages help to capture the impact of wages on investment through capital-labor substitution. Besides it would also indicate the impact of wages (through the opportunity cost of labor), on direct labor investment which is an important component of investment in agriculture of developing countries, as shown by Levi (1979), Alamgir (1976). The effect of government capital stock on investment behaviour has been discussed earlier, and fertilizer price would indicate the influence of fertilizer price policy on investment.

After the work of Chenery (1952) and Koyck (1954), it is well recognized that the actual capital stock will not usually adjust fully to the desired capital stock in a period but lags are involved and the adjustment is generally partial. However, the specification of this adjustment process has remained somewhat ad hoc in a majority of studies, including those of Chenery,

Koyck and of Jorgenson (1967a). In most of these cases a lag distribution structure is imposed, and the parameters of this distribution are empirically estimated so as to provide the best fit to the data. Koyck uses the well known Koyck-lag distribution in which the weights decline geometrically over time. Jorgenson uses a rational lag distribution in which the weights can increase first and then decline over time, depending on the parameters. Jorgenson (1971) reviewing different lag distributions used in investment models finds that whereas the finite lag distributions generally tend to underestimate the lag, the Koyck lag distribution tends to greatly overestimate the lag, and the rational lag distribution comes close to industry estimates. All these distributions, however, remain largely empirical and without an explicit base with respect to behaviour or theory.

Blejer and Khan (1984) have indicated that in developing countries financial constraints might be more crucial in explaining adjustment behaviour than arbitrary implementation lags. This appears plausible given the scarcity of credit in most developing countries and, in the case of agriculture, the relatively smaller units and projects that may make up private agricultural investment. In developing countries, credit is usually in short supply and the financial markets are not very deep. Rural financial markets are highly dualistic and the price of credit from the unorganized market is often prohibitively high. The available sources of finance for productive investment are usually, to a large extent, own resources and finance from the organized credit markets/agencies. It is therefore assumed that these would play a major role in the adjustment from actual capital stock to the desired level of capital stock. In the case of India, development oriented financial interventions have been very large after independence, first through the cooperatives and after the late 60's through the commercial banks. The finance variable for

India can be broken down to rural savings (representing own finance), cooperative credit, and commercial bank credit (representing two modes of institutional finance). It is desirable to separate these sources of finance since they are usually tied in differing ways and degrees, and therefore may not be considered perfect substitutes. Besides, note that they do not represent the only sources of liquidity and therefore do not constitute a binding constraint.

The next section develops the second part of the model that determines whether and the extent to which the change in desired capital stock is translated into actual investment. The partial adjustment model can now be developed as follows. Let

$$KP_t - KP_{t-1} = b_t(KP_t^* - KP_{t-1}) \tag{15}$$

where b_t is the adjustment coefficient and * indicates "desired." Following methodology developed by Coen (1968), b_t can be expressed as

$$b_t = b_0 + b_1\frac{RS_t}{KP_t^*-KP_{t-1}} + b_2\frac{CRCP}{KP_t^*-KP_{t-1}} + \frac{CRCB}{KP_t^*-KP_{t-1}}, \tag{16}$$

where RS is rural savings, CRCP is cooperative credit to agriculture, and CRCB is commercial bank credit to agriculture.

Gross investment can be expressed as

$$IP_t = (KP_t - KP_{t-1}) + \delta KP_{t-1}, \tag{17}$$

where IP is gross private investment in agriculture and "small delta" is the rate of depreciation. Now substituting equation (15) into (17) gives

$$IP_t = b_t(KP_t^* - KP_{t-1}) + \delta KP_{t-1} \tag{18}$$

Substituting Equation (16) into (18) gives

$$IP_t = [b_0 + b_1[\frac{RS_t}{KP_t^*-KP_{t-1}}] + b_2[\frac{CRCP_t}{KP_t^*-KP_{t-1}}] + b_3[\frac{CRCB_t}{KP_t^*-KP_{t-1}}]]$$

$$(KP_t^* - KP_{t-1}) + \delta KP_{t-1}.$$

Therefore,

$$IP_t = b_0 KP_t^* + b_1\ RS_t + b_2\ CRCP_t + b_3\ CRCB_t + (\delta - b_0)\ KP_{t-1}. \tag{19}$$

Substituting Equation (14) for KP* into (19), gives the complete model :

$$IP = (constant)\ P_t^{[\frac{\beta_1+\beta_2+1}{1-\alpha_1}]}\ Q_t^{[\frac{\beta_1+\beta_2}{1-\alpha_1}]}\ KG_t^{[\frac{\alpha_2}{1-\alpha_1}]}\ PF_t^{[\frac{\beta_3}{1-\alpha_1}]} \tag{20}$$

$$+ b_1\ RS_t + b_2\ CRCP_t + b_3 CRCB_t + (\delta - b_0)\ KP_{t-1}$$

It may be noted that the model has a linear and a nonlinear component and therefore cannot be simplified by taking logarithms. The function for estimation can be stated as:

$$IP = (constant)\, P_t^{\gamma_1} Q_t^{\gamma_2} KG_t^{\gamma_3} UC_t^{\gamma_4} W_t^{\gamma_5} PF_t^{\gamma_6}$$

(21)

$$+ b_1 RS_t + b_2 CRCP_5 + b_3 CRCB_t + b_4 KP_{t-1} + u_t,$$

where U_t is a disturbance term. This form clearly requires a nonlinear estimation procedure. An alternative is to assume a simplified linear form (common in the literature; see Tun Wai and Wong, 1982, and Blejer and Khan, 1984), that gives

$$IP_t = d_0 + d_1 P_t + d_2 Q_t + d_3 KG_t + d_4 UC_4 + d_5 W_t + d_6 PF_t$$

(22)

$$+ d_7 RS_t + d_8 CRCP_t + d_9 CRCB_t + d_{10} KP_{t-1} + v_t,$$

where V_t is a disturbance term. Equations (21) and (22) are the two alternative functions for estimation.

Data for Empirical Testing

The data for empirical estimation is obtained through numerous official sources. Specific details on sources, background and assumptions are given in Appendix - 2. A relatively reliable and long time-series on investment in Indian agriculture is required. A time-series was essential to the application of the theory due to the long-term nature of investment behaviour and the importance of expectations in investment decisions. The Central Statistical Organization (CSO), Ministry of Planning, Government of India, provides a carefully worked out 30 year time-series on gross domestic capital formation in India by industry of use, agriculture being one of the

"industries". The agriculture series is put together by working on disaggregates of capital formation (ie. investment) consisting of major forms such as "Pucca" (brick and cement) construction, "Kutcha" (earth and mud work including land improvement) construction, machinery and equipment, and livestock. This is pursued by developing estimates for each of them with all available information. Apart from various annual surveys, on both the production/supply of investment goods as well as their acquisition and stocks, the major check points for the series are the large decennial All India Debt and Investment Surveys conducted by the Reserve Bank of India, having large randomized samples of as many as 100,000 rural households. More details about the measurement of capital formation are given in Appendix-3. Details on sources and derivation of other variables are given in Appendix-2.

Results

The linear model was estimated using ordinary least squares. Econometric issues and details are discussed mainly in Appendix-4. Note, for instance, that since this is time-series estimation some issues of simultaneity do not affect estimation here. Government investment and institutional credit are separate institutional policies in India and are not systematically related over time. The relationship between savings and investment fits into a recursive framework and therefore is amenable to single equation estimation. Output is, as here and in Jorgenson's (1967a, 1967b, 1971) work, determined by existing capital stock and other determinants, and therefore contemporaneously, the relation between output and investment might be considered mainly one-way from output to investment.

The linear model results are given in Table-3. For the period 1952 to 1980, the model provides a good fit with an R-squared of 0.98. The price of output variable is highly significant with an elasticity of 0.91 indicating a strong response of investment to output prices. The government capital stock variable is also highly significant, with a high elasticity of 1.43, indicating a strong inducement effect of government capital stock on private investment. The cooperative credit variable is also highly significant with a coefficient of 0.81 indicating a high impact on investment. The lagged private capital stock variable is significant and negative as consistent with the model. Among those somewhat less significant are wages with a positive sign indicating capital-labour substitution, and fertilizer prices with a negative sign indicating a negative effect of high fertilizer prices - or a positive effect from fertilizer subsidies. The impact of interest rates through the user cost of capital is negative but not significant.

The estimates from 1980 to 1992 are very different but are affected substantially by a lack of degrees of freedom. They do however seem to indicate a different behaviour pattern. This is brought out in the 1952 to 1992 estimates, which are very different from the 1952 to 1980 estimates. In the 1952 to 1992 estimates the output price variable turns out to be non-significant. The government capital stock coefficient is negative and significant. A study of the series indicates that a fall in the government investment in the last decade has been accompanied by a compensatory rise in the private investment in the recent years. This structural change would give a negative sign - and this does not indicate a negative impact of government investment. The rural savings variable emerges to be positive and significant, indicating that it is a major determinant. With a switch in importance to private investment, this indicates that

Table 3: LINEAR REGRESSION RESULTS

VARIABLE	1952-80			1980-92			1952-92		
	ESTIMATED COEFFICIENT	T-RATIO	ELASTICITY AT MEANS	ESTIMATED COEFFICIENT	T-RATIO	ELASTICITY AT MEANS	ESTIMATED COEFFICIENT	T-RATIO	ELASTICITY AT MEANS
PAGD	14.484	2.545	0.9059	-37.26	-0.1817	-1.3333	-2.181	-0.3095	-0.1116
QAT	-0.0055	-0.5224	-0.1383	-0.0095	-0.1422	-0.2326	-0.0147	-1.2469	-0.3649
KG	0.2032	3.4128	1.4288	-0.0558	-0.0766	-0.5761	-0.0936	-2.7974	-0.7953
UCD	-0.7148	-0.1375	-0.0033	23.772	0.1849	0.0722	-2.4952	-0.4016	-0.0098
WAGD	85.537	1.6741	0.3614	-619.74	-0.1561	-1.8448	95.096	1.492	0.353
PFD	-2.5427	-1.492	-0.1729	19.233	0.2131	0.5128	-2.8612	-1.3853	-0.1435
PEDD	-0.4789	-0.6053	-0.0652	-12.407	-0.2498	-0.3529	2.1938	2.0839	0.198
RSD	0.0186	0.2273	0.0293	0.2749	0.3804	0.6775	0.2161	4.4822	0.4253
CRCID	0.8139	2.7139	0.143	0.5478	0.1081	0.07369	0.2434	0.7231	0.0383
CRBID	0.0832	0.2003	0.0068	0.351	0.3	0.08364	0.0531	0.3233	0.0078
KPL	-0.1797	-2.1274	-3.5431	0.7353	0.5454	10.729	0.2431	4.0341	4.2661
CONSTANT	3283.4	1.6561	2.0477	-19326	-0.4578	-6.8094	-5634.2	-2.8476	-2.8635
D-W STAT	2.8213			2.7322			1.8798		
R SQ	0.98			0.89			0.97		
NO. OF OBS	29			13			41		

privately funded investment is assuming greater importance. The positive and significant sign on lagged private capital stock indicates that higher the private capital stock, more the private investment. This indicates a increased importance of private wealth and replacement investment in determining private investment.

The results of estimation of non-linear model estimation through the iterative Gauss-Newton optimization procedure are given in Table-4. These results appear to be affected by the uneven nature of the objective function over which the optimization is attempted. The results for 1952-1980 indicate a negative impact of government capital stock, a positive impact of commercial bank credit, and a positive impact of private capital stock. A weak negative impact of the user cost of capital is also indicated. The 1980-1992 results are affected by a lack of enough degrees of freedom. The 1952-1992 results are considerably different from the 1952-1980 results, indicating a change in the behaviour. The 1952-1992 results indicate a positive impact of cooperative credit and of lagged private capital stock. A negative impact of rural savings is indicated. The non-linear results are influenced by the inherent instability in the non-linear optimization function and procedure.

Discussion and Conclusions

The study has sought to examine aggregate behaviour of private investment in agriculture in the period 1952/53 to 1992/93. The results are constrained by data limitations as well as the ability of the econometric optimization procedures to search for correct solutions. Therefore, it is considered inappropriate to draw substantial implications at this stage until further

Table 4: RESULTS OF NON-LINEAR MODEL ESTIMATION

VARIABLE	1952-80		1980-92		1952-92	
	ESTIMATED COEFFICIENT	T-RATIO	ESTIMATED COEFFICIENT	T-RATIO	ESTIMATED COEFFICIENT	T-RATIO
PAGD	-0.2552	0.729	-1.6311	-1.69	0.1332	0.1383
QAT	-1.9044	-0.2653	-5.3108	-6.8225	-1.0462	-1.3584
KG	-1.5519	-2.4572	-4.8246	-5.9194	-0.8485	-1.0381
UCD	0.3363	-1.866	-0.3306	-0.3335	0.5527	0.5582
WAGD	0.4746	0.3398	-0.1925	-0.1939	0.6195	0.6239
PFD	-0.2871	0.4777	-1.4748	-1.5216	0.1533	0.1589
PEDD	-0.3985	-0.2991	-1.5218	-1.5721	0.1089	0.1134
RSD	-0.0101	-0.4183	-0.0415	-0.3573	-0.1371	-3.6028
CRCID	1.422	-0.3369	-1.4386	-2.3802	0.9773	2.5861
CRBID	1.3206	6.4552	-0.3622	-1.2765	0.4034	1.7513
KPL	0.0343	6.6426	-0.0919	7.3573	0.0662	8.6443
CONSTANT	0.7277	5.7764	0.4321	0.4328	0.8125	0.8139
ML Estimate of Sigma SQ	17379		56224		84705	

investigation. The results indicate substantial departures in the nature of investment in the post-1980 period. Government investment which was almost continuously rising earlier shows a decline which continues beyond 1986 on to 1992. Private investment fluctuates substantially between 1980 to 1986 and also shows some decline. However, after 1986, the private investment starts rising and continues to rise quite sharply. It compensates for the decline in the government investment, making the growth of total investment positive. However, the level of total investment in constant prices remains lower than that seen early 80's.

The results indicate a considerable change in the investment behaviour between 1952-1980 and 1980-1992 periods. The strong role of output prices in encouraging private investment in the earlier period is not seen in the later period. The strong positive impact of government capital stock on private investment in the earlier period turns into a negative empirical relationship between the two in the later period, apparently due to a compensatory shift from public to private investment. The strong role of credit, particularly cooperative credit in enhancing private investment is not seen in the later period. Instead, own resources through rural savings become more important as a source for funding private investment. Lagged private capital stock shows a positive association with investment in the later period, indicating, possibly the increased importance of wealth and also replacement investment in determining private investment.

APPENDIX 1. - DATA AND DATA SOURCES

1. Central Statistical Organization (CSO), Ministry of Planning, Government of India has revised and published its earlier (1970/71) series for the period 1950/51-1979/80 in both nominal and 1980/81 prices in its 1989 issue of National Accounts Statistics (NAS)(new series). Data for total gross fixed capital formation (investment) in agriculture for the period 1950/51 to 1979/80 both in nominal and real (1980/81 prices) terms are taken from this source. Data from 1980/81 to 1992/93 are taken from NAS 1995 issue obtained from CSO office. Data for gross fixed capital formation in agriculture in nominal terms by the government (government investment in agriculture) for the period 1950/51 to 1980/81 are taken from "Transactions of the Public Sector" parts of NAS (India, CSO, 1983). This is deflated to real terms (1980/81 prices) using the implicit deflator for total gross fixed capital formation in agriculture. Data for gross fixed capital formation in agriculture by government for the period 1981/82 to 1992/93 are calculated from gross domestic capital formation in public sector in agriculture after adjusting it for changes in inventory in capital stocks.

   Gross fixed capital formation in agriculture by private sector (private investment in agriculture) are obtained by deducting the gross fixed capital formation in agriculture by government from the total gross fixed capital formation in agriculture.

   Data on gross domestic product (GDP) total and for agriculture sector both in nominal and 1980/81 prices for the period 1950/51 to 1979/80 are obtained from "National

Accounts Statistics - Disaggregated Statements" (India, CSO, 1992), a special issue. Data for the period 1980/81 to 1992/93 are taken from NAS 1995 obtained on diskette from CSO office. The GDP price both for total economy and agriculture sector are derived as an implicit deflator from the real and nominal values of GDP from the same sources.

3. The series of agricultural output is the gross value of output of agriculture (including livestock) in real terms and is obtained from the same source as given in 2. The agricultural output price index is derived as an implicit deflator from the real and nominal values of output from the same sources. However, nominal values for years earlier than 1960 were not available in this source.

4. Agricultural wage data for the period 1950/51 to 1992/93 are calculated from the daily wage rates of unskilled agricultural labour (field labour/ploughman), which are reported monthly from over a hundred different rental centres all over the country to the ministry of agriculture. Average wage rates are obtained for each state by simple average over different centres and months in the state. A weighted average,then, is calculated using average agricultural income of the state as a weight for the respective states and is converted into an index. Data on statewise annual average of daily wages of ploughman or field labour (men) are available since 1952/53 in "Agricultural Wages in India" and is, therefore, taken directly and converted in to weighted index for the country using the same weights as above for each state. The basic source is "Agricultural wages in India" (India, Ministry of Agriculture, 1950-).

5. Calculation of user cost of capital required data on the price of capital, interest rate, the depreciation, and the rate of inflation, which were obtained as follows:

a. Data on price of capital is the implicit deflator from real and nominal values of investment as given in 1.

b. Data on interest rate for the period from 1950/51 to 1979/80 is the weighted average lending rate of Primary Agricultural Credit Cooperative Societies. where a range was given, a simple average was used. Where there was a choice available between short term and medium term rates, the medium term rate was used. A weighted average was calculated over the states for each year, using the amount of loans issued in that year in each state as the weight. Data on interest rate for the period from 1980/81 to 1989/90 is taken as simple average of interest rates for all the institutions financing the rural credit. The source for above data is "Statistical Statements Relating to Cooperative Movement in India published by Reserve Bank of India/ National Bank for Agricultural and Rural Development (1950-1990). Data on interest rate for the period 1990/91 to 1992/93 is taken as interest rates on commercial advances of scheduled commercial banks (Reserve Bank of India annual report 1994/95). Interest rates for these three years were adjusted to match with the series relating to period 1980/81 to 1989/90.

c. Assuming expected life spans of approximately 50 years for concrete constructions, 20 years for mud and indigenous construction, 15 years for machinery and equipment, and 10 years for livestock, assuming a declining balance method of depreciation (with 10 percent of initial value as residential) and

making adjustments based on the discussion of Yotopoulos (1967) and Grilliches (1960) given in the text, the following rounded depreciation rates were calculated: concrete construction, 2 percent; mud and indigenous construction, 6 percent; machinery and equipment, 8 percent; and livestock, 10 percent. A weighted average was calculated using the capital stocks in 1960/61 in these different forms as weights, and this gave an overall depreciation rate of 4 percent for capital in agriculture. The absolute accuracy of this depreciation rate is not very crucial for the estimation of the model, given the estimation procedure.

d. The rate of inflation was calculated as follows:

$$p(t) = P(t) - P(t-1)/P(t-1).$$

using the implicit investment deflator in agriculture as in a.

6. The price of agricultural inputs diesel, electricity and fertilizer for the period 1960/61 to 1992/93 are taken as implicit deflator from real and nominal values of diesel charges, electricity charges and chemical fertilizers from "value added from agriculture and allied activities" statement of National Accounts Statistics- Disaggregated statement (India, CSO, 1992) and NAS 1995. The prices of these inputs for 1952/53 to 1959/60 period are taken as wholesale price index from "India-Database", a compilation by Chandok (1990) after converting the base from 1970/71 to 1980/81. Data for 1950/51 and 1951/52 periods are not available in these sources, and therefore wholesale price index of the group "fuel, power, light & lubricants" for diesel and electricity and the wholesale price index of the group "chemical and chemical products" for fertilizer series were used to extend backward up to 1950/51.

7. The rural savings figures are estimated on the basis of Krishna and Raychaudhury (1980). This series is obtained as 25 percent of the domestic household savings. These figures are deflated by the implicit investment goods deflator for agriculture from 4a. The series on domestic household saving is obtained from NAS - new series (India, CSO,1989) and NAS 1995.

8. The cooperative credit data consists of credit outstanding to agriculture from the Primary Agricultural Societies (PACS) and the Central Land Development Banks (CLDB). Data from 1950/51 to 1989/90 on credit outstanding to agriculture from PACS is compiled from "Statistical Statements Relating to Cooperative Movement in India" published annually by RBI. Data for the period 1990/91 to 1992/93 is loans outstanding from the cooperatives as direct institutional finance to agriculture and allied activities, and is taken from "Report on Currency and Finance", 1993/94 published by RBI. The data on loan outstanding from CLDB for the period from 1950/51 to 1959/60 is obtained from "Basic Statistics Relating to Indian Economy" published by Centre For Monitoring Indian Economy Pvt. Ltd. (August 1994). This data for the period from 1960/61 to 1989/90 is obtained from "Statistical Statement Relating to Cooperative Movement in India" published by RBI. The above data on CLDB for the period 1990/91 to 1992/93 is taken from "Report on Currency and Finance, vol.2" published by RBI. The figures are adjusted to the uniform April to March financial year. Then the series is deflated by the implicit investment goods deflator from 4a.

9. The bank credit data are loans outstanding of commercial banks and regional rural banks to agriculture. From 1968 onward these data are available in various issues of the RBI's "Report on Currency and Finance". Data from 1950 to 1964 were obtained from RBI's "Supplement to Banking and Monetary Statistics of India, Part 1 (1964). Figures for 1965 to 1967 were obtained from Sharma(1974). All figures were deflated by the implicit investment goods deflator for agriculture from 4a.

10. Data on capital stock in agriculture is taken as net fixed capital stock in agriculture at 1980/81 prices from NAS which was published for the period 1951 to 1980 as a special statement in 1990 by CSO. Data for the later periods are obtained from different issues of NAS after 1980.

11. Total area under high yielding varieties for the period from 1966/67 to 1992/93 is obtained from various issues of "Economic Survey" (India, Ministry of Finance).

12. Index numbers of yields of foodgrains, non-foodgrains and all crops are obtained from "Agricultural Statistics at a Glance" published annually by Directorate of Economics & Statistics, Ministry of Agriculture, Govt. of India.

APPENDIX 2: MEASUREMENT OF CAPITAL FORMATION/INVESTMENT

In arriving at an estimate of gross capital formation for agriculture, it is firstly necessary to define its scope and coverage. In the case of India this definition is based on the United Nations, publication, 'A System of National Accounts - Studies in Methods' (Series F, No.2, Rev.3) (1968). Relevant description of the scope and coverage for agriculture is briefly given below:

1. Non-residential buildings: Value of work put in place on buildings and structures which are entirely, or primarily for industrial or commercial use; outlays on major alterations in, and additions to, these buildings and structures, and transfer and similar costs in respect of purchases of existing non-residential buildings.

2. Land improvement: Outlays on all land reclamation and land clearance, irrespective of whether or not it represents an addition to total land availability; irrigation and flood control projects, and dams and dikes which are part of these projects; clearance and afforestation of timber tracts and forests; and transfer costs of transactions in land, farms, and concessions.

3. Transport equipment: Purchasers value of new tractors for road haulage, carts. Outlays on major alterations and improvements in existing transport equipment of this type owned. Dealer margins, transport and other transfer costs in respect of purchase (sale) of such secondhand assets.

4. Agricultural machinery and equipment: Purchasers' value of new agricultural machinery and equipment such as harvesters, threshers, ploughs, harrows and other cultivators and tractors other than for road haulage; outlays on major alterations and improvements in such machinery and equipment; and dealers' margins, transport and other transfer charges in respect of purchase of secondhand agricultural machinery and equipment.

5. Breeding stock, draught animals, dairy cattle and the like: Value of additions to, less disposal of, breeding stock, draught animals, dairy cattle, sheep etc.

Several methods can be used for actual estimation of the different components of capital formation or investment described above (Lal (1977)). A few frequently used methods are: Income method, Expenditure method, Commodity flow method, and Inventory method.

The income method involves estimation of the number of workers employed in construction or other capital creation activity, the number of days they are employed and their average daily income. From this, the value of capital formation in terms of factor income earned in the process of capital creation can be calculated. In the expenditure method of estimation, data is collected on the actual expenditure of different industries on the creation of capital. This method provides easy industrial classification of the capital formation but the estimates are likely to be influenced by accounting conventions used by different industries which may lead to some lack of uniformity. The commodity flow approach is based on estimation of the domestic production of capital goods - which is then appropriately adjusted

for changes in stock, imports, and exports. Transport costs, dealer margins and indirect taxes need to be added to arrive at the purchasers' value. Finally, the inventory method requires estimation of the stock of capital goods annually or at different points in time, and the difference between two consecutive values give an estimate of the net capital formation in that period. The choice between these different method is dictated by the type of goods in question and also the availability of data. Major reliance is commonly placed on the expenditure and the commodity flow approaches.

The Central Statistical Organization of the Ministry of Planning, Government of India, has recently (National Accounts Statistics, 1976-) estimated and published time series on capital formation by industry of use, which begin from the year 1950. Its estimates of fixed capital formation for each of the industrial categories are prepared following primarily the expenditure approach, and also the commodity flow approach for some components. Specific details are given in CSO (1980).

APPENDIX 3: ESTIMATION TECHNIQUES

The linear model for estimation consistent with the theory is given by equation (22). This is estimated by ordinary least squares regression. OLS is considered valid for estimating this equation on the standard assumptions for the error term.

It is further assumed that explanatory variables and the error term are independent. Under these conditions OLS is the best linear unbiased estimator and also the maximum likelihood estimator.

The nonlinear model for estimation is given by equation (21). It is estimated using a nonlinear model optimization procedure: an iterative least squares method. The criterion function Q is the sum of squared residuals. It is assumed here that the error in the model is additive and is normally distributed, and under these conditions minimizing Q is equivalent to maximizing the likelihood function.

Q is a function of the vector of parameter estimates B, $Q = Q(B)$ and d is a direction vector such that Q decreases in the direction defined by d. The Gauss method (same as the Gauss-Newton method) is used for optimization and this is based on easier approximation of the Hessian matrix when the objective function is of the usual form (see Judge et.al 1985).

The Gauss algorithm works through a sequence of linear regressions in which at each stage least squares estimators are computed for a linear approximation of the nonlinear model. A generalization of this method has been developed by Berndt, Hall, Hall and Hausman (1974). It is possible to show that the coefficients in the linearized regression will be zero if and only if the current parameters are at a local minimum of Q. The covariance matrix of the regression

coefficients from the last OLS is asymptotically equivalent to the covariance matrix of the nonlinear least squares estimates of the parameters of the equation. This allows the testing of the statistical significance of the parameter estimates. Judge et. al. (1985) caution that only the asymptotic properties of the parameter estimators for nonlinear models are generally available, and this is only under certain regularity conditions which, however, are not too restrictive. Therefore the usual estimators or confidence regions are only asymptotically valid. Judge et. al. report that Monte Carlo experiments have been carried out in order to evaluate the small sample properties but they have limited generality. Despite some of these limitations of interactive optimization, nonlinear models are now widely employed.

A mention may be made here about simultaneous equations since a question of simultaneity exists between private investment and output. Whereas private investment may depend on current output, output can validly be assumed to depend only on private capital stock already in place, and therefore relatively independent of current investment. Thus contemporaneously, the dependence can be assumed to be one way. Another such question is about the simultaneity between private investment and rural savings, since both of them can be considered to be determined at the same time by output. Moreover, private investment also depends on rural savings. This inter-relationship can, however, be cast in a recursive system framework.

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