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**Savings, Investment, Foreign Inflows and Economic
Growth of the Indian Economy 1950-2001**

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SAVINGS, INVESTMENT, FOREIGN INFLOWS AND ECONOMIC GROWTH OF THE INDIAN ECONOMY 1950 – 2001*

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ABSTRACT

There is a large research literature on the roles of domestic savings and investment in promoting long run economic growth. This paper attempts to identify the major interdependencies between savings, investment, foreign capital inflows and real output for India since independence. An endogenous growth model is adapted to specify the possible complex interrelationships between the sectors of a growing economy.

The time series of real per worker household, private corporate and public savings and investment, per worker foreign capital inflows and GDP are tested for stationarity under structural change where the structural break is determined endogenously. The Johansen's FIML cointegration procedure is used to provide efficient long run and short run parameter estimates for the non-stationary variables in a simultaneous setting. The elasticity estimates provide robust evidence of the Solow proposition that household, and to a lesser extent private corporate, per worker savings have driven household per worker investment in the Indian economy from 1950 to 2001. There is also evidence of an inverse, crowding-out relationship between per worker household and public investment. Foreign capital inflow per worker is found to be unstable in the short run and residually determined by per worker household and private corporate savings and investment.

Despite the strong links between the sectors, there is little evidence that sectoral per worker savings and investment affect GDP in the long run. Whilst per worker GDP has significant but small effects on per worker household savings and investment in the short run, the feedbacks to GDP are non-existent in the long run and only small and imprecise in the short run. Whilst savings certainly affect investment, there are only weak links from investment to output. These findings do not support the Solow and endogenous growth policy prescriptions that it is necessary to increase household savings and investment in order to promote economic growth in India.

Keywords: Savings, investment, foreign inflows and economic growth.

JEL Classifications: F43, E21, E22, C22.

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1. Introduction

In recent years, there has been extensive empirical research on savings, investment and economic growth. The motivation for this interest is the growing concern over the falling savings rates in the major OECD countries, the growing divergence in saving and investment rates between the developing countries, and the increasing emphasis of the important role of investment in the more recent economic growth literature. Foreign capital inflows are also receiving attention because of their potential to finance investment and promote economic growth, although they can be problematic for developing countries such as India.

The major empirical studies on savings, investment and foreign inflows in promoting economic growth in India include Krishnamurty, Krishnaswamy and Sharma (1987), Laumas (1990), Pandit (1991), Ketkar and Ketkar (1992), Sinha (1996), Mühleisen (1997), Agrawal (2000), Mahambare and Balasubramanyam (2000), Athukorala and Sen (2002), Sandilands and Chandra (2003), Saggar (2003), and Seshaiyah and Sriyval (2005).

However, these studies provide only partial analyses of the possible relationships between savings, investment and economic growth. For example, Sinha (1996) considers the growth of private and gross domestic savings on economic growth; Mühleisen (1997) examines sectoral savings but not investment; Agrawal (2000) studies private and total savings and investment rates¹; Mahambare and Balasubramanyam (2000) analyse savings but not investment and economic growth; Sahoo, Nataraj and Kamaiah (2001) consider total savings only, whilst Sandilands and Chandra (2003) analyse private and public (total and fixed) investment, but not savings;.

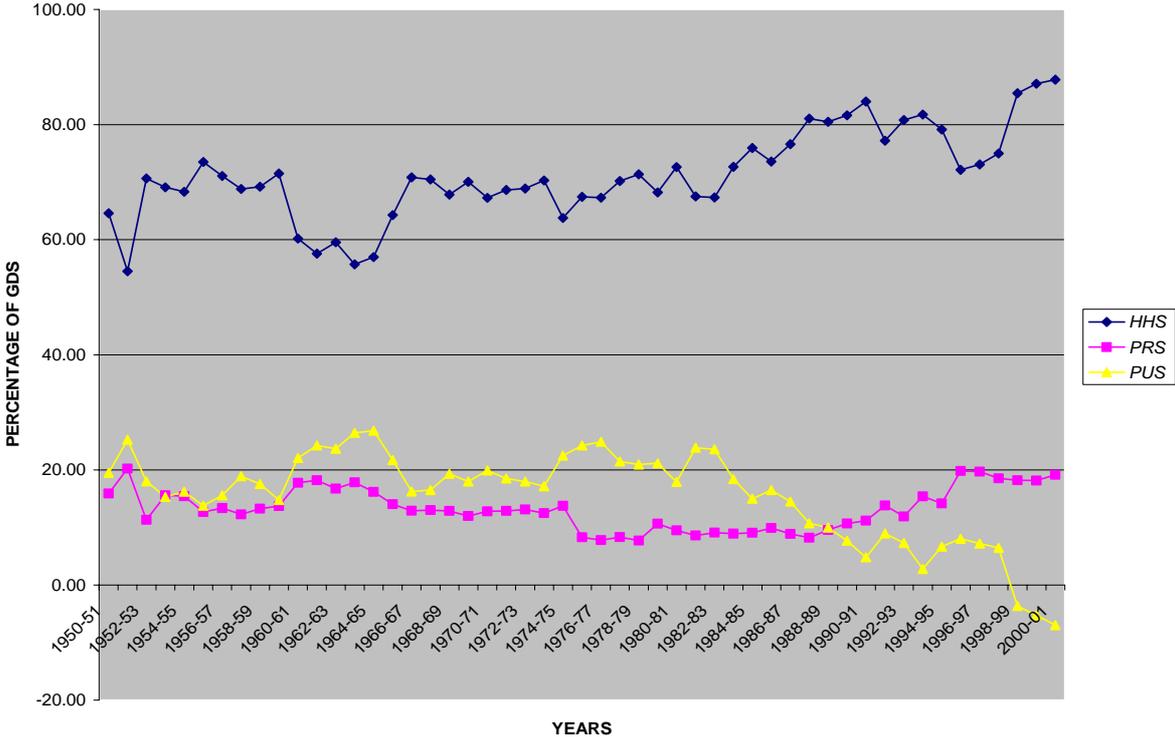
All of these studies do not examine the relationship between savings and investment, with the exception of Seshaiyah and Sriyval (2005), who only consider the measures in aggregate, and Saggar (2003). Saggar provides a detailed examination of all the sectors including the household sector, although his econometric estimation combines household and private corporate savings. It appears that there are no comprehensive studies available on the analysis of the interdependence between savings and investment for the household, private corporate and public sectors and GDP. This paper therefore intends to explore the important developments in household, private corporate and public savings and investment and their interrelationships since India gained independence.

Figures 1 and 2 show the household sector is very important in the Indian economy with household savings increasing to over 85 percent of total gross domestic savings and

¹ Whilst Agrawal (2000) considers private and total savings and investment rates, the Granger causality tests are limited to the growth rates in savings and GNP.

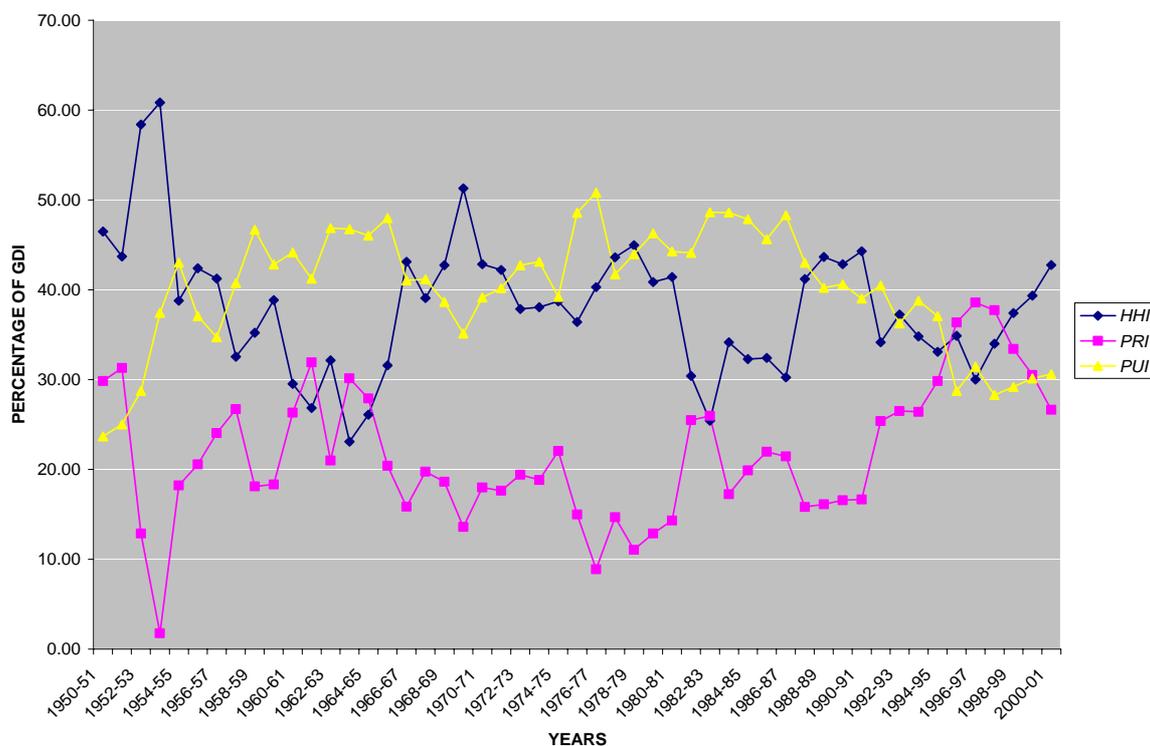
household investment contributing 30 to 40 percent of total gross domestic investment. Studies which do not explicitly detail the household sector in empirical analysis will not only miss these important effects, but the estimates will be subject to misspecification bias. Figure 1 also shows the relative sizes of the other sectors are varying over time with the share in public sector saving falling since the 1960s, reaching negative rates after 1998/99, reflecting the continuing deterioration in the fiscal position of the government. This contrasts with the increasing relative importance of household and private corporate savings. The variation in the relative sectoral investment shares is even higher according to Figure 2 and the contribution of public investment is also declining since the late 1980s. Note the reversal in the shifts for household and private corporate investment in the mid 1990s.

Figure 1
Components of Gross Domestic Savings
Percent



Source: National Accounts Statistics of India (2002) and Reserve Bank of India.
 Note: *HHS*: Household savings; *PRS*: Private corporate savings; *PUS*: Public savings.

Figure 2
Components of Gross Domestic Capital Formation
Percent



Source: National Accounts Statistics of India (2002)

Note: *HHI*: Household investment; *PRI*: Private corporate investment; *PUI*: Public investment.

The data shown in Figures 1 and 2 and Table 1 describe a dynamic process involving changing relative shares and growth rates across sectors over a fifty year period. The data show that the analysis needs to be in a growth context and a four sector open economy growth model with government is developed in the next section in order conceptualise and identify the possible complex interrelationships between the key variables and sectors.² The relevant variables are per worker household, private corporate and public savings and investment, foreign capital inflows and GDP. The variables are tested for non-stationarity under structural change in Section 3 because of the long time span 1950/51 to 2000/01 used in the analysis and the financial reforms in the early 1990s.³ The Johansen (1991, 1995) FIML cointegration estimation procedure provides efficient parameter estimates which allows us to distinguish between the long run and short run interdependencies. The final Section 4 summarises the key findings and brings out some policy implications.

² The overseas sector is modelled via the capital and financial account.

³ Allowing for Perron and Vogelsang (1992) endogenously determined structural breaks improves the reliability of the tests of non-stationarity.

Table 1
Savings, Investment, Foreign Capital Inflows and Real GDP
R's crore at constant 1993/94 prices

Years	Gross Domestic Savings	Gross Domestic Capital Formation	Foreign Capital Inflows	Gross Domestic Product
1950/51	13,931	17,398	2,000	148,503
1960/61	26,377	34,204	8,317	220,560
1970/71	48,164	53,255	10,954	326,925
1980/81	84,189	83,621	14,420	439,201
1990/91	177,482	184,564	57,834	771,295
2000/01	312,290	304,642	170,490	1,316,340

Source: National Accounts Statistics of India (2002) and Reserve Bank of India.

2. The Model

The private sector is disaggregated into two sectors, namely households and private corporate firms. All variables are real, and consistent with growth models, expressed in per worker terms in order to keep the maths simple. A typical household supplies labour services for a real per worker wage rate, w , to produce real per worker household output via the production function, $f_h(k_h)$, where k_h represents the households capital per worker.⁴ Households also arbitrage their supply of their labour to private corporate firms, which equilibrates the per worker wage, w , across the two sectors. Households own the real capital used in production by private corporate firms, k_p , in the form of share purchases, \dot{b}_p , with real return, rb_p (all in per worker terms). The household pays net per worker taxes to the government, τ_h and purchases government debt, \dot{b}_g , with real per worker return, rb_g . Consumption goods, c , again expressed in per worker terms are also purchased by households from private corporate firms.⁵ Household investment per worker, \dot{k}_h , returns

⁴ The household's production function is assumed to have properties: $k_h(0) = k_0$, $f'_{k_h} > 0$, $f''_{k_h} < 0$, $\lim_{x \rightarrow 0^+} f'_{k_h} = \infty$ and $\lim_{x \rightarrow \infty} f'_{k_h} = 0$ where $f'_{k_h} = \partial f / \partial k_h$, $f''_{k_h} = \partial^2 f / \partial k_h^2$.

⁵ Households may receive transfer payments from the government which are included in net taxes.

rk_h , based on the assumption that the real returns, r , are arbitrated and therefore equal across sectors. The budget constraint for the representative household is given by:

$$c + \dot{b}_p + \dot{b}_g = (w + rb_p + rb_g + \dot{k}_h) - \tau_h \quad (1)$$

where the right hand side represents total per worker household disposable income, which is spent on purchases of consumption goods, c , and shares, \dot{b}_p , from private firms, and government bonds, \dot{b}_g .⁶

The household selects the time path of per worker consumption which maximises intertemporal utility, $U(c) = \int_{t_0}^{\infty} u[c(t)] e^{-\rho t} dt$, where $u(c)$ is a concave instantaneous utility function.⁷ The utility maximising growth in household per worker consumption can be determined by substituting out the costate variable in the Hamiltonian maximisation:

$$H = u(c) e^{-\rho t} + \mu (\dot{b}_p + \dot{b}_g) \quad (2)$$

where: $\dot{b}_p + \dot{b}_g = w + rb_p + rb_g + \dot{k}_h - \tau_h - c$, to give the well known result for the utility maximising growth in consumption, $\dot{c} = \theta(r - \rho)$.⁸ Integrating forward with respect to time gives the accumulated value of the utility maximising consumption per worker, $c(t) = e^{\int_0^t \theta(r(s) - \rho) ds}$.⁹ The optimal household savings path, s_h , can be derived from this result by defining household per worker gross (pre-tax) income as, $y_h = w + rb_p + rb_g + \dot{k}_h$. Assuming household taxes are a proportion of household per worker income, $\tau_h = \alpha_h y_h$, substituting in (1) and collecting like terms gives, $s_h = \dot{b}_p + \dot{b}_g = \alpha y_h - c$, where $\alpha = 1 - \alpha_h$. Substituting $\dot{c} = \theta(r - \rho)$ derives the time path of savings which maximise household intertemporal utility:

$$s_h = \dot{b}_p + \dot{b}_g = \alpha y_h - e^{\int_0^t \theta(r(s) - \rho) ds} \quad (3)$$

The second component of savings in (3) is the bonds purchased by household from the government, \dot{b}_g . Assuming government debt is only held by households, the government budget constraint is given by:

⁶ In order to keep the model tractable, it is assumed that households do not borrow or lend overseas.

⁷ The utility function has the standard properties: $u(0) = 0$, $u(c) > 0$ and $u'(c) = \partial u(c) / \partial c < 0$.

⁸ The elasticity of marginal utility with respect to consumption term is specified as, $-1/\theta = u''(c)/u'(c)$.

$$\dot{k}_g = (\tau_h + \tau_p) + (\dot{b}_g - rb_g) \quad (4)$$

where receipts comprise taxation per worker received from households and private corporate firms $(\tau_h + \tau_p)$ plus net borrowings from households $(\dot{b}_g - rb_g)$. Outlays are in the form of government purchases of capital goods from firms, expressed in per worker terms, \dot{k}_g .¹⁰ Government per worker budget (dis)savings are therefore defined as:

$$s_g = -(\dot{b}_g - rb_g) = (\tau_h + \tau_p) - \dot{k}_g \quad (5)$$

The other component of household savings in the form of shares, \dot{b}_p in (3) involves the private corporate sector. The representative firm employs household labour and household owned capital per worker, k_p , to competitively produce per worker output according to the production function, $f_p(k_p, k_g, A)$.¹¹ This specification assumes that government capital per worker, k_g promotes production and parameter A represents total per worker factor productivity.

As mentioned earlier, the corporate firm pays households the real per worker wage rate for their labour services, w and distributed earnings in the form of the real per worker return to capital owned, rb_p . The firm is able to borrow capital from overseas, \dot{b}_f in per worker terms and pays interest on the outstanding debt per worker, rb_f . The typical firm also pays per worker tax, τ_p to the government, which purchases per worker capital goods, \dot{k}_g from firms. Households also purchase per worker consumer goods, c , from the firms. Total per worker cash inflows therefore comprise receipts, $c + \dot{k}_g$ from households and the government, and borrowings, $\dot{b}_p + \dot{b}_f$ from households and overseas. Cash outflows are, $w + rb_p + rb_f + \tau_p$, giving the firm's cash flow constraint:

$$c + \dot{k}_g + \dot{b}_p + \dot{b}_f = w + rb_p + rb_f + \tau_p. \quad (6)$$

⁹ The initial value of consumption is standardised at unity, ie. $c_0 = 1$

¹⁰ Government expenditure will include consumption spending on goods and services, broadly defined to include public service wages. In order to keep the model simple, assume government spending is in the form of purchases of capital from private corporate firms.

¹¹ The firm's production function is assumed to have the well behaved properties: $\forall x \in \{k_p, k_g, A\}$

$x(0) = x_0, f'_x > 0, f''_x < 0, \lim_{x \rightarrow 0^+} f'_x = \infty$ and $\lim_{x \rightarrow \infty} f'_x = 0$ where $f'_x = \partial f / \partial x, f''_x = \partial^2 f / \partial x^2$.

Per worker savings by firms, s_p are given by:¹²

$$s_p = -(\dot{b}_p + \dot{b}_f) = \beta y_p - y_h + rb_g - rb_f. \quad (7)$$

with the substitutions, $y_p = c + \dot{k}_g$ and $y_h - rb_g = w + rb_p$, and defining the company tax rate to be a fixed proportion of corporate income, $\tau_p = \beta_p y_p$, so that, $\beta = 1 - \beta_p$. Equation (7) can also be rearranged to determine the endogenous overseas borrowings in the form of foreign capital inflows:

$$\dot{b}_f = -\beta y_p + y_h - \dot{b}_p - rb_g + rb_f \quad (8)$$

The representative competitive firm accumulates capital to maximise the intertemporal net present value of the per worker savings, $s_p(k_p)$:

$$S_p(k_p) = \int_{t_0}^{\infty} s_p[k_p(t)] e^{-\rho t} dt \quad (9)$$

where the constant discount rate, ρ is assumed to be the same for households. For the Hamiltonian, $H = s_p(k_p) e^{-\rho t} + \mu [-(\dot{b}_p + \dot{b}_f)] e^{-\rho t}$, it is convenient to define the costate variable μ as the net present value of Tobin's q at the current time period, t , that is, $\mu = \xi q_p e^{-\rho t}$. The Hamiltonian for this frictional system becomes:¹⁴

$$H = s_p(k_p) e^{-\rho t} + \xi q_p [-(\dot{b}_p + \dot{b}_f)] e^{-\rho t} \quad (10)$$

and the costate equation $\dot{\xi} = -H_{k_p}$ gives the result: $\dot{q}_p = r q_p - \beta y'_{p,k_p} + y'_{h,k_p}$, where: $y'_{p,k_p} = \partial y_p / \partial k_p$ and $y'_{h,k_p} = \partial y_h / \partial k_p$ represent the per worker marginal products of the firm's and household's capital. This solves for q_p , to give the well known result:

¹² In order to ensure model stability it is necessary to constrain private, government and overseas borrowing. We restrict total borrowings $(\dot{b}_p + \dot{b}_g + \dot{b}_f)$ to be less than capital formation, $(\dot{k}_h + \dot{k}_p + \dot{k}_g)$ in net present value terms. That is: $\int_t^{\infty} [\dot{b}_p(t) + \dot{b}_g(t) + \dot{b}_f(t)] e^{-\rho(s-t)} ds < \int_t^{\infty} [\dot{k}_h(t) + \dot{k}_p(t) + \dot{k}_g(t)] e^{-\rho(s-t)} ds$.

¹³ To the extent that firm's rely on selling shares to households and bonds to overseas, then these are dissavings, $-(\dot{b}_p + \dot{b}_f)$. Additional savings by the firm can be easily included in terms of the depreciation of capital δk_p .

¹⁴ Capital formation in this system will involve costs of adjustment. We will not explicitly define these costs here and assume that investment, \dot{k}_p is net of these costs, which are used up in production (*vide*: Wilson and Chaudhri (2000)).

$$q_p(t) = \int_t^{\infty} (\beta y'_{p,k_p} - y'_{h,k_p}) e^{-\rho(s-t)} ds. \quad (11)$$

which clearly shows that Tobin's q_p is the sum of the weighted net present values of all future per worker marginal products, $\beta y'_{p,k_p} - y'_{h,k_p}$. Since q_p represents the marginal valuation of capital relative to its replacement cost when frictions are present, then values of $q_p > 1$ will encourage investment by firms according to the per worker investment function:

$$\dot{k}_p = \phi(q_p - 1) \quad \text{with} \quad \phi' > 0. \quad (12)$$

When $q_p = 1$, investment will be zero, $\dot{k}_p = 0$, and when $q_p < 1$, there will be disinvestment $\dot{k}_p < 0$. Using (10) to substitute for q_p in (11) gives the required result for per worker capital formation as a function of the net present value of the marginal products of per worker capital used in production:

$$\dot{k}_p = \phi \left[\int_t^{\infty} (\beta y'_{p,k_p} - y'_{h,k_p}) e^{-\rho(s-t)} ds - 1 \right]. \quad (13)$$

Tobin's q can also be used to determine the optimum time path of household investment, \dot{k}_h . Modifying the Hamiltonian (2) to:

$$H = u(c) e^{-\rho t} + \mu (\dot{b}_p + \dot{b}_g) \quad (14)$$

where $\mu = \xi q_h e^{-\rho t}$ and $\dot{b}_p + \dot{b}_g = \alpha y_h - \tau_h - c$, and maximising gives the equivalent result, $\dot{q}_h = r q_h - \alpha y'_{h,k_p}$. This solves to, $q_h(t) = \int_t^{\infty} y'_{h,k_p} e^{-\rho(s-t)} ds$, which determines optimal household investment:

$$\dot{k}_h = \phi \left[\int_t^{\infty} \alpha y'_{h,k_p} e^{-\rho(s-t)} ds - 1 \right] \quad (15)$$

The endogenous growth model, comprising equations (1) to (15), indicate high degrees of interdependence between the variables and relationships. Equations (3) and (15) show that household per worker savings and investment are determined by households who select the time path of consumption and capital which maximise intertemporal utility. The government constraint with endogenous public investment in (5) shows the government sector per worker (dis)saving (4) as a function of household savings and tax receipts paid by households and private corporate firms. Private sector per worker savings (7) and investment (13) are determined by competitive firms maximising intertemporal savings of firms who may borrow from overseas in the form of foreign capital inflows (8). Real output per worker is

given by the aggregate production function, $y = f_h(k_h) + f_p(k_p, k_g, A)$, which includes in A the endogenous growth effects of Romer (1986) in the form of Lucas (1988) “learning by doing” and other causes of changes in total factor productivity. The inclusion of k_g in the production function captures the possible positive effects of the strategic provision infrastructure by the government.

Table 2
Summary of Important Relationships

	Variable	Specification	Equation
Savings per worker			
Household	hhs	$s_h = \dot{b}_p + \dot{b}_g = \alpha y_h - e^{\int_0^t \theta(r(s)-\rho)ds}$	(3)
Private corporate	prs	$s_p = -(\dot{b}_p + \dot{b}_f) = \beta y_p - y_h + rb_g - rb_f$	(7)
Government	pus	$s_g = -(\dot{b}_g - rb_g) = (\tau_h + \tau_p) - \dot{k}_g$	(5)
Investment per worker			
Household	hhi	$\dot{k}_h = \varphi \left[\int_t^\infty \alpha y'_{h,k_p} e^{-\rho(s-t)} ds - 1 \right]$	(15)
Private corporate	pri	$\dot{k}_p = \phi \left[\int_t^\infty (\beta y'_{p,k_p} - y'_{h,k_p}) e^{-\rho(s-t)} ds - 1 \right]$	(13)
Government	pui	$\dot{k}_g = (\tau_h + \tau_p) + (\dot{b}_g - rb_g)$	(4)
Foreign capital inflows per worker	fci	$\dot{b}_f = -\beta y_p + y_h - \dot{b}_p - rb_g + rb_f$	(8)
Production per worker	gdp	$y = f_h(k_h) + f_p(k_p, k_g, A)$	

Note: hhs : Household savings per worker; hhi : Household investment per worker;
 prs : Private corporate savings per worker; pri : Private corporate investment per worker;
 pus : Public savings per worker; pui : Public investment per worker;
 fci : Foreign capital inflow per worker; gdp : Gross domestic product per worker.

The relationships for the household and private corporate savings in (3) and (7) clearly show that savings are positive functions of same sector income and output. However the model specifies capital formation as being primarily influenced by Tobin’s marginal

valuations of capital, which are in turn functions of the respective marginal products of capital in the household and private corporate sectors. We would therefore expect close relationships between savings and output (in terms of growth) and between productivity and investment (which may demonstrate variation over time). This is consistent with the observed behaviour of sectoral savings and investment shown in Figures 1 and 2. However, the model importantly indicates a more flexible relationship between sectoral savings and investment. If production is characterised by constant returns to scale then there will be a one-to-one relationship between output and productivity, and therefore a correspondence between savings and investment. This is consistent with the Solow model, in that relatively low household and corporate savings will constrain economic growth. The relationships summarised in Table 2, will be estimated for India in the next section.

3. Estimation of the Relationships

As explained in the model derivation, the economy is divided into four sectors, namely household, private corporate, public and overseas. The household sector comprises, apart from individuals, all non-government non-corporate enterprises such as sole proprietorships and partnerships (owned and/or controlled by individuals) and non-profit institutions. The private corporate sector comprises all non-governmental financial/non-financial corporate enterprises and co-operative institutions. The public sector includes government administrations as well as departmental and non-departmental enterprises.

Annual data for the period of 1950/51 to 2000/01 are used to estimate the above relationships. The data for domestic savings and investment are taken from the National Accounts Statistics of India (2002). Data for foreign capital inflows are obtained from the Centre of Monitoring Indian Economy whilst GDP figures are available from the Reserve Bank of India. All the variables, except for GDP (which is already in constant prices), are converted into constant prices with appropriate deflators. We used the GDP at factor cost deflator for the household sector savings and investment; the GDP at market prices deflator for the public sector savings and investment; and the GDCG (unadjusted) deflator for the private corporate savings, private corporate investment and foreign capital inflows. All data are in Rupees for the 1993/94 base year. The data for the labour force is taken from the Indian Planning Commission and because it is only available for the census years 1951, 1961, 1971, 1981 and 1991, the values for other years are estimated using simple interpolations. All variables are converted to Naperian logs and divided by the labour force

to put the variables in per worker terms, consistent with the model developed in the previous section.¹⁵ The transformed variables comprise the real, logged per worker measures of household savings (*hhs*) and investment (*hhi*); per worker private savings (*prs*) and investment (*pri*); per worker public savings (*pus*) and investment (*pui*); per worker foreign capital inflows (*fci*) and per worker real GDP (*gdp*).¹⁶

Stationarity and Structural Breaks

It is well known that the ADF test for stationarity of a time series have low power and are biased towards the non-rejection of the null hypothesis of $I(1)$ if structural change is present (Perron, 1989). Early attempts to include the effects of a known *a priori* break were criticized by Christiano (1992). Since then, a number of studies developed different methodologies for endogenising the break date which reduces the bias in the unit root test. They include Banerjee, Lumsdaine and Stock (1992) Zivot and Andrews (1992), Perron and Vogelsang (1992), Perron (1997), Lumsdaine and Papell (1998) and Bai and Perron (2003).

The study uses the Innovational Outliner (IO) unit root test proposed by Perron and Vogelsang (1992) because the procedure tests the variables for unit roots in the presence of a structural break (defined as a gradual change in the mean starting with an unknown time period). Assuming at most one change, the test procedure is formulated as:

$$y_t = \gamma + \delta DU_t + \theta D(TB)_t + \lambda y_{t-1} + \sum_{i=1}^{\kappa} c_i \Delta y_{t-i} + u_t \quad (16)$$

where the time series variable being tested is y_t , DU_t is the dummy variable, TB_t is the time of the break, T_b and u_t is the error term. The null hypothesis of a unit root, $I(1)$, is conducted by testing $\lambda = 1$, which also implies $\delta = 0$, when the above equation is estimated by ordinary least squares.¹⁷

The test was conducted over the whole sample with the break search restricted to the latter period 1985-2000 because it coincides with important economic and political events. For example, Prime Minister Rajiv Gandhi introduced financial reforms in the 1986/87 budget and the years 1987 to 1989 saw high levels of policy intervention in the Indian banking sector. Agricultural production was severely affected by a major drought in 1987 and significant financial and agricultural marketing deregulation took place in 1991, after a

¹⁵ It is argued that the interpolations are not important because all variables are equally affected and the detrending is in the form of a constant factor of proportionality.

¹⁶ The lower case italics represent the variables in real, log per worker terms.

¹⁷ The unknown break time, TB is determined through minimizing the Students- t statistic for testing $\delta = 0$. The number of lags, κ is determined using the F -statistic to evaluate the significance of additional lags.

balance of payments crisis. The empirical results detailed in Table 3 show that all the variables are non-stationary in the presence of a structural break.

Table 3
Unit Root Test – Innovational Outlier (IO) model

Variable	Break Period T_b	Lag Length κ	$\hat{\lambda}$	$\hat{\delta}$	t -statistic $\lambda = 1$
<i>hhs</i>	1989	2	1.001	-0.019	0.030
<i>prs</i>	1993	3	1.009	0.037	0.163
<i>pus</i>	1989	5	1.028	-0.476	0.205
<i>hhi</i>	1990	2	1.010	0.006	0.176
<i>pri</i>	1994	4	0.890	0.074	-1.258
<i>pui</i>	1990	4	0.932	-0.023	-2.065
<i>fci</i>	1993	2	0.945	0.134	-0.982
<i>gdp</i>	1989	3	1.012	0.000	0.590

Note: Critical value for the t -statistic = -4.44.

hhs: Household savings per worker; *hhi*: Household investment per worker;
prs: Private corporate savings per worker; *pri*: Private corporate investment per worker;
pus: Public savings per worker; *pui*: Public investment per worker;
fci: Foreign capital inflow per worker; *gdp*: Gross domestic product per worker.

Long Run Cointegrating Relationships

The estimation procedure needs to take into account both the simultaneity involved in the model relationships specified in Section 2 and non-stationary variables, as described in the introduction and detected in the structural change tests above. The Johansen (1991, 1995) FIML estimation procedure is appropriate for the vector of endogenous variables, \underline{y}_t :¹⁸

$$\underline{y}_t = \underline{\gamma} + \sum_{i=1}^{\kappa} \Phi_i \underline{y}_{t-i} + \sum_{j=0}^l \Psi_j \underline{x}_{t-j} + u_t, \quad t = 1, 2, \dots, n \quad (17)$$

where vector \underline{x}_t includes the stationary, $I(0)$ variables. The VECM with: $\Pi = \sum_{i=1}^{\kappa} \Phi_i - \mathbf{I}$, is:

$$\Delta \underline{y}_t = \underline{\gamma} - \Pi \underline{y}_{t-1} + \sum_{i=1}^{\kappa-1} \Gamma_i \Delta \underline{y}_{t-i} + \sum_{j=0}^l \Psi_j \underline{x}_{t-j} + v_t \quad (18)$$

¹⁸ Vide Johansen (1991, 1995), Johansen and Julius (1992) and Pesaran and Pesaran (1997).

The long run cointegrating vector, $\underline{\beta}' y_t$, is defined to include a restricted trend, t , such that $\underline{\beta}' y_t = \{\beta_1 y_1 + \dots + \beta_n y_n + \delta t\}$.¹⁹

Whilst Table 3 shows possible structural breaks occurred in the period 1989 to 1994 it was decided to classify the variables into two groups which characterise the breaks as occurring around 1989 and 1993. A structural dummy variable: d_{89} takes the value one for the period 1989 to 2001 and zero elsewhere to include the structural change effects on the *hhs*, *pus*, *hhi*, *pui* and *gdp* variables. The other dummy variable: d_{93} is included for *prs*, *pri* and *fci*, taking values one for the years 1993 to 2001. The two dummy variables are included in the stationary vector \underline{x}_t to capture the detected structural change effects.²⁰

The optimum lag length κ of one for the VAR model (determined within the possible range of one to four lags) is selected.²¹ The first order cointegrating VAR with unrestricted intercept and restricted trend gives the estimated eigenvalues:

$$\{0.716, 0.641, 0.570, 0.518, 0.337, 0.259, 0.205, 0.062\}$$

The maximum eigenvalue and rank tests accept the null hypothesis of rank of two at the five percent level of significance. However the Schwarz Bayesian criterion (SBC) indicates a rank of one, whilst the Hann-Quinn criterion (HQC) and the Akaike Information criterion (AIC) imply ranks of four and seven respectively. Inspection of the eigenvalues shows that all of these ranks are possible because of the relative closeness of the values which the model selection criteria have difficulty discriminating between. The larger ranks are implausible because of the degrees of freedom constraint and it is felt the more reliable measure of rank would be one or two. It is well known that the Schwarz Bayesian criterion (SBC) is the preferred model selection criterion because it is consistent for large samples when the 'true' model is known.²² We therefore decided to select the parsimonious rank of one. The estimated just identified long run cointegrating vector $\hat{\underline{\beta}}' y$ is:

$$\{1.919 \text{ hhs} + 0.132 \text{ prs} - 0.017 \text{ pus} - 1.029 \text{ hhi} + 0.125 \text{ pri} - 0.405 \text{ pui} \\ + 0.101 \text{ fci} + 0.218 \text{ gdp} - 0.055 \text{ trend}\}.$$

¹⁹ A trend was included in the VAR in order to correctly specify the long run behaviour of the variables discussed in Section 1 of this paper.

²⁰ The estimated coefficients and their significance will indicate whether this approximation is justified.

²¹ The SBC criterion shows the optimum lag is of order one whilst the AIC criterion indicates the maximum four lags. This later figure is unreliable due to the limited degrees of freedom and the adjusted likelihood ratio test agrees with the SBC criterion of a lag of one at the five percent level.

The long run elasticity estimates, derived by normalising the vector for each variable, are reported in Table 4 and Figure 3. The trend was found to be significant at the one percent level for the cointegrating vector normalised on only *hhs* and *hhi*. Note that the long run trend for *hhs* is positive whilst the *hhi* trend is negative and double that for *hhs* in absolute value. This has an important interpretation which is positive for the Solow savings explanation of growth and negative for the investment based endogenous model of growth.

There are four conclusions to be drawn from Table 4 and Figure 3. The first is that per worker household investment (*hhi*) has an elastic response to per worker household savings (*hhs*). The estimated long run elasticity of 1.87 is significant at the one percent level. Whilst this is expected, it differs from the discussion of the endogenous growth model which predicts a relatively weak connection between household savings, shown in specification (3),

$$s_h = \alpha y_h - e^{\int_0^t \theta(r(s)-\rho)ds} \quad \text{and household investment, } \dot{k}_h = \varphi \left[\int_t^\infty \alpha y'_{h,k_p} e^{-\rho(s-t)} ds - 1 \right] \text{ in equation}$$

(15). The second conclusion is that per worker public investment (*pui*) has a large long run elasticity of 4.74 with respect to per worker household savings (*hhs*), which is also significant at the five percent level. Relationship (4), $\dot{k}_g = (\tau_h + \tau_p) + (\dot{b}_g - r b_g)$ details this expected strong and direct effect between public investment, \dot{k}_g and household savings, \dot{b}_g .

These two significant long run elastic relationships support the Solow view that savings determine investment in the long run, although there are two qualifications to this. The detected relationship only involves household savings, with no observed relationships from per worker private savings (*prs*) to private investment (*pri*) and per worker public savings (*pus*) to public investment (*pui*). There are also significant but inelastic responses in the opposite directions to household savings. The elasticity for per worker household investment (*hhi*) on household savings (*hhs*) is 0.54 (at the one percent level of significance) whilst per worker public investment (*pui*) has an elasticity of 0.21 on household savings (at the five percent level of significance).

The third conclusion is that there are long run inverse relationships between per worker household investment (*hhi*) and per worker public investment (*pui*). However, this evidence of long run crowding-out is significant at only the ten percent level. The elastic response of -2.54 whereby *pui* responds inversely to changes in *hhi* can be explained by an increase in the household tax rate, α_h , which increases tax receipts, τ_h and therefore *pui* via equation

²² The selection of a rank of one has the additional convenience of reducing the required number of identifying restrictions to one. So simple normalisation of an explanatory variable is sufficient to identify the vector.

(4), $\dot{k}_g = (\tau_h + \tau_p) + (\dot{b}_g - rb_g)$. This also causes *hhi* to fall because the parameter, $\alpha = 1 - \alpha_h$ will fall in relationship (15), $\dot{k}_h = \varphi \left[\int_t^\infty \alpha y'_{h,k_p} e^{-\rho(s-t)} ds - 1 \right]$. The *hhi* inelastic response of -0.39 due to a change in *pui* is more difficult to explain. If the higher household savings (*hhs*) in the form of \dot{b}_g , causing higher household investment (*hhi*), is associated with higher government debt, rb_g which dominates $(\dot{b}_g - rb_g)$, then *hhi* will fall via $\dot{k}_g = (\tau_h + \tau_p) + (\dot{b}_g - rb_g)$. This increase in public debt is the likely reason for the possible crowding-out.

The final important conclusion is the absence of significant long run relationships between the per worker savings and investment variables and per worker real GDP (*gdp*) and foreign capital inflows (*fci*). This is consistent with the data reported in Table 1 and Figures 1 and 2, which show that the long run growth in the foreign capital inflow and real GDP are very different to the aggregate measures of savings and investment in India over the period 1950/51 to 2000/01. This implies an imprecise relationship in the long run from per worker capital formation (*hhi* and *pri*) to output (*gdp*) via the production function, $y = f_h(k_h) + f_p(k_p, k_g, A)$ and from per worker output (*gdp*) to household and private per worker savings (*hhs* and *prs*) and investment (*hhi* and *pri*) through equations (3), (7) and (13) and (15).

Short Run ECM Dynamics

The empirical estimates of the short run error correction mechanism (*ecm*), given by $\alpha(\underline{\beta}' y_t) = \Pi y_t$ in (18), are summarised in Table 5. Both the *hhs* and *hhi* variables demonstrate significant (at the five percent level) stabilising behaviour to equilibrium in the short run. The error corrections are of the correct sign with slightly relatively faster adjustment to equilibrium for *hhs* than for *hhi* with elasticities of -0.48 and -0.39 respectively. Table 5 also shows that *fci*, with a positive (yet small) elasticity of 0.05 , demonstrates unstable disequilibrium behaviour at the five percent level. Per worker GDP is stable with a short run error correction mechanism elasticity of -0.01 , although it is only significant at the ten percent level and indicates very slow adjustment to long run equilibrium. The dummy variables are not significant which implies either the effects of the structural changes are common across the variables (so that they tend to net out in the

simultaneous specification) or two variables are not enough to approximate the range of detected changes shown in Table 3.

Table 6 details the estimated short run error correction elasticities which describes how the dependent variables in the VAR (18) respond to disequilibrium values of all the other variables. The diagonal terms are the same values as for column two of Table 5, which show the short run adjustment of each variable to its own deviation from long run equilibrium. Consistent with Table 5, the variables reported in Table 6 and Figure 4 which have significant error correction relationships are hhs , hhi , fci (at the five percent level of significance) and gdp (at the ten percent level).²³ Focusing on the larger elasticities, there is the dominant relationship where hhi responds to disequilibrium in hhs with positive elasticity of 0.73. This short run equilibrating adjustment where per worker household investment is determined by per worker household saving is consistent with the long run results reported in Table 4. The crowding-out relationship, where hhi responds inversely to disequilibrium in pui with an elasticity of -0.16 also supports the long run findings.

The short run estimates show links between private per worker savings and investment with per worker household investment and foreign capital inflow, at the five percent level. The small elasticity of 0.05 between pri and hhi can be explained with increasing productivity by private firms causing per worker private investment (pri) to increase via equation (13), which increases household income, y_h and hhi in equation (15). The relatively large elasticity of 0.68, whereby prs inelastically affects fci is consistent with the specifications in equations (7) and (8). An increase in household purchases of private corporate shares, \dot{b}_p , causes private corporate dis-saving, $s_p = -(\dot{b}_p + \dot{b}_f)$ which induces borrowing from overseas via equation (8), $\dot{b}_f = -\beta y_p + y_h - \dot{b}_p - rb_g + rb_f$.

Unlike the long run effects, inspection of Table 6 shows that gdp has short run inelastic effects on hhi (0.08) and hhs (-0.06) at the five percent level. The positive hhi elasticity of 0.08 indicate a small accelerator effect from gdp to hhi and is the only evidence of increases in the marginal productivity increasing the value and rate of capital formation according to equation (15), $\dot{k}_h = \varphi \left[\int_t^\infty \alpha y'_{h,k_p} e^{-\rho(s-t)} ds - 1 \right]$. The negative hhs short run elasticity of -0.06 represents the preference for households in a growing economy to increase consumption at the expense of savings. This is consistent with the Carroll and Weil (1994) hypothesis, where GDP affects savings, found in a number of studies including Mühleisen (1997), Mahambare

and Balasubramanyam (2000), Agrawal (2000), Sahoo, Nataraj and Kamaiah (2001) and Sagar (2003). Note that this short run aggregate demand interpretation contradicts the long run supply side intertemporal optimization of consumption specified in equation (3),

$$s_h = \alpha y_h - e^{\int_0^t \theta(r(s) - \rho) ds}.$$

The estimates provide some evidence of small effects in the opposite direction from *hhs* and *hhi* to *gdp*. However the elasticities are only significant at the ten percent level and are small. The negative elasticity of -0.10 for the effect of *hhs* on *gdp* can be explained by increases in household per worker savings reducing consumption demand and output. Again this short run demand explanation is consistent but very different to the long run Solow supply side model. The other effect where *hhi* determines *gdp* with a short run elasticity of 0.05 is the only evidence of increases in the rate of capital formation affecting real per worker output via the production function, $y = f_h(k_h) + f_p(k_p, k_g, A)$. This is hardly strong evidence of the endogenous growth model.

Per worker foreign capital inflow (*fci*) responds in an unstable fashion to disequilibrium in *hhs*, *prs* and *gdp* with positive elasticities 0.99 , 0.68 and 0.11 respectively. Disequilibrium in *hhi* and *pui* also affect *fci* in a stable manner with respective elasticities of -0.53 and -0.21 . It can be seen from directions of the arrows in Figure 4 that *fci* is the residual in the dynamic short run adjustment process to long run equilibrium.

In summary, *hhs* affects *hhi* in the short run adjustment process to long run equilibrium, which supports the previous finding reported in Table 4 that *hhs* drives *hhi* and *pui* in the long run. This finding is consistent with the standard Solow growth model policy prescription that per worker household savings promote household capital formation in the short and long run. However the links from per worker household, private and public investment to GDP are not evident in the long run. There are only small and marginally significant short run effects between per worker household savings and GDP, and between per worker household investment and GDP.

²³ In order to help interpretation of the more important relationships the short run elasticities with absolute values less than 0.05 are not included in Figure 4.

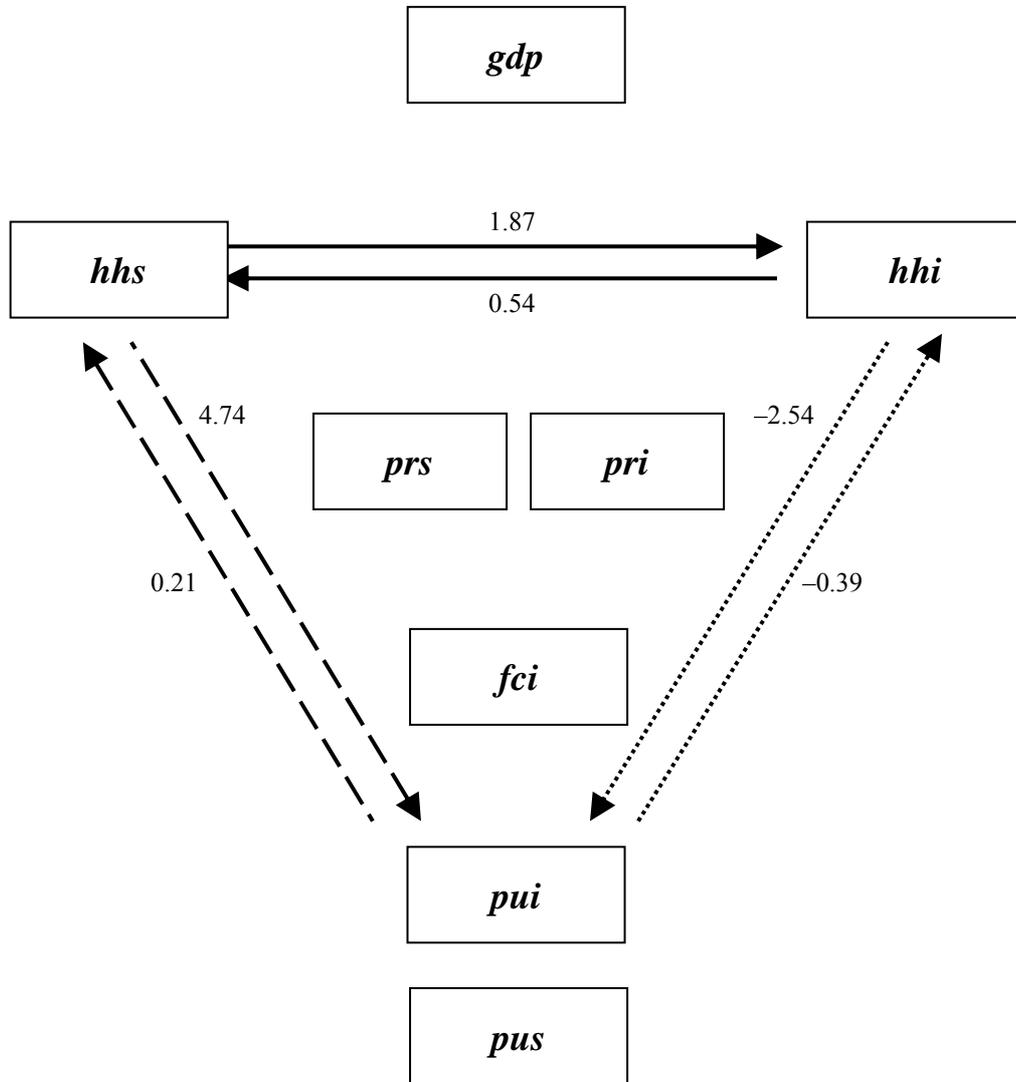
Table 4
Long Run Elasticities^{1,2}

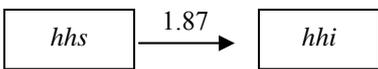
1950/51 to 2000/011: Unrestricted intercepts and restricted trends in the VAR

Dependent Variable	Explanatory Variables ^{3,4}								
	<i>hhs</i>	<i>prs</i>	<i>pus</i>	<i>hhi</i>	<i>pri</i>	<i>pui</i>	<i>fci</i>	<i>gdp</i>	<i>Trend</i>
<i>hhs</i>	–	–0.069 (0.088)	0.009 (0.012)	0.536 (0.095)***	–0.651 (0.049)	0.211 (0.098)**	–0.052 (0.037)	–0.114 (0.452)	0.028 (0.011)***
<i>prs</i>	–14.569 (18.629)	–	0.132 (0.231)	7.810 (10.444)	–0.948 (1.568)	3.072 (4.096)	–0.765 (1.197)	–1.658 (7.971)	0.415 (0.607)
<i>pus</i>	110.313 (144.214)	7.572 (13.251)	–	–59.140 (78.904)	7.177 (9.887)	–23.236 (36.341)	5.790 (10.240)	12.556 (52.765)	–3.136 (4.076)
<i>hhi</i>	1.865 (0.330)***	0.128 (0.171)	–0.017 (0.023)	–	0.121 (0.103)	–0.393 (0.214)*	0.098 (0.068)	0.212 (0.816)	–0.053 (0.018)***
<i>pri</i>	–15.371 (11.514)	–1.055 (1.745)	0.139 (0.192)	8.240 (7.019)	–	3.241 (2.457)	–0.807 (0.946)	–1.750 (7.344)	0.437 (0.382)
<i>pui</i>	4.742 (2.200)**	0.325 (0.434)	–0.043 (0.671)	–2.542 (1.381)*	0.309 (0.234)	–	0.249 (0.157)	0.540 (2.279)	–0.135 (0.107)
<i>fci</i>	–19.051 (13.330)	–1.3077 (2.047)	0.172 (0.311)	10.214 (7.073)	–1.240 (1.453)	4.018 (2.531)	–	–2.168 (8.665)	0.542 (0.464)
<i>gdp</i>	–8.786 (34.914)	–0.603 (2.900)	0.080 (0.335)	4.710 (18.098)	–0.572 (2.400)	1.853 (7.822)	–0.4612 (1.843)	–	0.250 (0.911)

- Notes: ¹ All variables (denoted in lower case italic) are per worker.
² The cointegrating vector was identified by normalising on each explanatory variable.
³ Figures in parenthesis below the estimated elasticities are standard errors.
⁴ All tests of significance are reported under the assumption of normality:
*** Significant at the 1 percent level: ** 5 percent level: * 10 percent level.

Figure 3
Long Run Elasticities ¹
1950/51-2000/01



Key:  indicates that in long run equilibrium, a 1 percent change in variable *hhs* causes variable *hhi* to change by 1.87 percent.

Note: ¹ The arrows show the significance assuming asymptotic normality:
 significant at the 1 percent level 
 significant at the 5 percent level 
 significant at the 10 percent level 

Table 5
Short Run Error Correction Estimates¹
1950/51 to 2000/01: Unrestricted intercepts and restricted trends in the VAR

Dependent Variable	Explanatory Variables ^{2,3}						
	<i>ecm₋₁</i>	<i>C</i>	<i>d₈₉</i>	<i>d₉₃</i>	<i>R</i> ²	<i>D-W</i>	<i>ψ</i> ²
<i>Δhhs</i>	-0.482 (0.216)**	1.373 (0.592)**	0.040 (0.064)	0.123 (0.081)	0.100	2.224	0.944
<i>Δprs</i>	-0.180 (0.025)	0.749 (0.985)	0.088 (0.107)	0.073 (0.135)	0.039	2.479	3.633*
<i>Δpus</i>	-0.006 (0.012)	-1.907 (3.527)	-0.155 (0.383)	-0.624 (0.485)	0.095	2.178	0.478
<i>Δhhi</i>	-0.394 (0.170)**	-1.973 (0.872)**	-0.144 (0.095)	-0.078 (0.120)	0.113	2.290	1.132
<i>Δpri</i>	-0.037 (0.076)	1.579 (3.221)	0.187 (0.350)	0.004 (0.443)	0.008	3.322	1.563
<i>Δpui</i>	0.040 (0.049)	0.579 (0.642)	0.038 (0.070)	0.057 (0.088)	0.044	2.215	0.607
<i>Δfci</i>	0.052 (0.024)**	-2.664 (1.275)	-0.002 (0.139)	-0.290 (0.175)	0.105	2.282	1.409
<i>Δgdp</i>	-0.011 (0.006)*	0.293 (0.156)*	0.010 (0.017)	0.035 (0.021)	0.090	2.289	1.201

Notes ¹ All variables (denoted in lower case italic) are per worker.

² Figures in parenthesis below the estimated elasticities are standard errors.

³ *** Significant at the 1 percent level: ** 5 percent level: * 10 percent level.

Table 6
Short Run Error Correction Elasticities of Explanatory Variables ¹
1950/51 to 2000/01: Unrestricted intercepts and restricted trends in the VAR

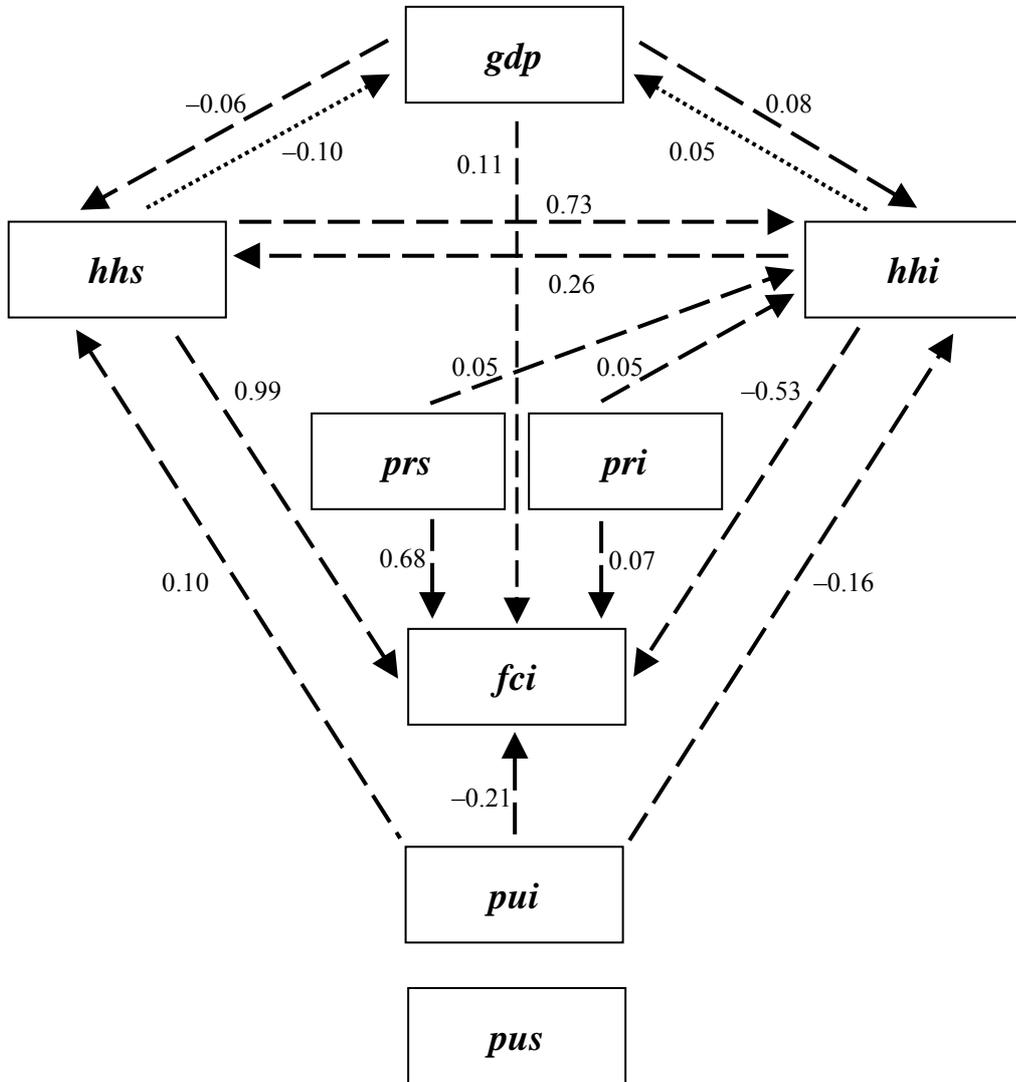
<i>ecm₋₁</i> for Dependent Variable	Explanatory Variables ^{2,3}							
	<i>hhs₋₁</i>	<i>prs₋₁</i>	<i>pus₋₁</i>	<i>hhi₋₁</i>	<i>pri₋₁</i>	<i>pui₋₁</i>	<i>fci₋₁</i>	<i>gdp₋₁</i>
<i>Δhhs</i>	-0.482 (0.216)**	-0.033 (0.015)**	0.004 (0.002)**	0.259 (0.116)**	-0.031 (0.014)**	0.102 (0.046)**	-0.025 (0.011)**	-0.055 (0.025)**
<i>Δprs</i>	-0.262 (0.359)	-0.180 (0.025)	0.002 (0.003)	0.140 (0.193)	-0.017 (0.023)	0.055 (0.076)	-0.014 (0.019)	-0.030 (0.041)
<i>Δpus</i>	0.706 (1.286)	0.048 (0.088)	-0.006 (0.012)	-0.379 (0.689)	0.046 (0.084)	-0.149 (0.271)	0.037 (0.067)	0.086 (0.147)
<i>Δhhi</i>	0.734 (0.318)**	0.050 (0.022)**	-0.007 (0.003)**	-0.394 (0.170)**	0.048 (0.021)**	-0.155 (0.067)**	0.039 (0.017)**	0.084 (0.036)**
<i>Δpri</i>	-0.566 (1.174)	-0.039 (0.081)	0.005 (0.011)	0.304 (0.630)	-0.037 (0.076)	0.119 (0.248)	-0.030 (0.062)	-0.064 (0.134)
<i>Δpui</i>	-0.191 (0.234)	-0.013 (0.016)	0.002 (0.002)	0.102 (0.125)	-0.012 (0.015)	0.040 (0.049)	-0.100 (0.012)	-0.022 (0.027)
<i>Δfci</i>	0.993 (0.465)**	0.680 (0.032)**	-0.009 (0.004)**	-0.532 (0.249)**	0.065 (0.030)**	-0.209 (0.098)**	0.052 (0.024)**	0.113 (0.053)**
<i>Δgdp</i>	-0.098 (0.057)*	-0.007 (0.004)*	0.000 (0.000)*	0.052 (0.030)*	-0.006 (0.004)*	0.021 (0.012)*	-0.005 (0.003)*	-0.011 (0.006)*

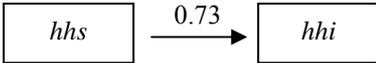
Notes: ¹ All variables (denoted in lower case italic) are per worker.

² Figures in parenthesis below the estimated elasticities are standard errors.

³ *** Significant at the 1 percent level: ** 5 percent level: * 10 percent level.

Figure 4
Short Run ECM Elasticities ¹
1950/51-2000/01



Key:  indicates that in the short run error correction, a 1 percent change in variable *hhs* causes variable *hhi* to change by 0.73 percent.

Note: ¹ The arrows show the values of the *t*-statistic:
 significant at the 5 percent level **— — —**
 significant at the 10 percent level **.....**

4. Conclusions and Policy Implications

This paper makes five contributions to the analysis of the interdependencies between savings, investment, foreign capital inflows and economic growth in India from 1950/51 to 2000/01. The first is the development of a four sector endogenous growth model with government, where households and private corporate firms are intertemporal maximisers. This provides an analytic structure which allows the identification of possible complex interdependencies between the variables. The second contribution of our work is the FIML econometric estimation of these relationships in a simultaneous VAR setting to obtain efficient elasticity estimates. The third is the use of a cointegrating estimation procedure which allows for non-stationarity of the variables in a growth context. The fourth contribution is the identification of both long run equilibrium elasticities and short run dynamic elasticities. Finally, the structural breaks in the time series are endogenously identified, consistent with the long sample of data analysed.

The FIML cointegration estimation clearly establishes the important long run elastic effects of per worker household savings on household and public investment in the long run. The elasticities are significant and show inelastic feedbacks. Public and household per worker investment tend to crowd out each other in the long run. Interestingly, no significant long run relationships were found between the private corporate sector and the other sectors in the economy. In addition to this, there is no observed long run relationship between household per worker savings and per worker foreign capital inflows and real GDP. This also applies to per worker investment not influencing foreign capital inflows and real GDP. Whilst per worker household savings affecting per worker household investment (with feedback) is consistent with the Solow model, there is the serious missing link between per worker investment and GDP. This missing link also importantly qualifies the endogenous growth explanation.

The short run adjustments to long run equilibrium show that per worker household savings, investment and real GDP exhibit stable equilibrating behaviour. Consistent with the long run findings, short run per worker household savings determine investment and there is a crowding-out relationship between per worker public and household investment.

Unlike the long run effects, the private corporate sector per worker savings and investment influence per worker foreign capital inflow and household investment. Per worker foreign capital inflow is found to demonstrate short run instability and to be residually determined by per worker household and private corporate savings and investment.

The other major differences to the long run findings are the small, yet significant, effects of per worker GDP on household per worker savings and investment. The first supports the Carroll-Weil hypothesis whilst the second represents an accelerator effect. There are also short run effects in the opposite direction, although the elasticities are small and imprecise. There is therefore very limited evidence of the popular endogenous explanation of economic growth.

The results clearly support the view that savings constrain investment, although there is very little evidence that investment is the driver of economic growth in India since independence. These findings do not support policies designed to increase household savings and investment in order to promote economic growth. Further analysis is required on the roles of disaggregated savings and investment in India.

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