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A Multivariate Analysis of Savings, Investment and Growth in India

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ABSTRACT

This paper considers per worker household, private corporate and public sector savings and investment, foreign capital inflows and economic growth for India in a multivariate setting for the period 1950-2001. The analysis, uses FIML to estimate the long run cointegrating equilibriums and short run Granger causing dynamics for the non-stationary time series data, which includes endogenously detected structural breaks in 1989 and 1993, consistent with the recent period of financial reforms in India.

The estimates do not support the commonly accepted Solow and endogenous models of economic growth. The popular view that increases in savings are a necessary condition for economic growth is supported with the detected strong direct links from per worker household and private corporate savings to output in the long run and sectoral per worker savings to investment links in both the short and long run. This implies the need to encourage savings, which is being realised with the estimated significantly higher growth rates in household and private corporate per worker savings during deregulation in the late 1980s and early 1990s.

However, the link from investment to output is missing. Despite extensive analysis, per worker private corporate and household sector investment are not found to affect output in the short run or long run as required by the Solow and endogenous growth models. Indeed household investment, being the largest sector for gross domestic capital formation, does not appear to have any influence on other variables. Per worker public investment is found to adversely affect output per worker in the short and long run, contradicting Barro's hypothesis of the benefits of the public provision of capital.

These findings, plus the estimated reductions in the rates of growth in sectoral per worker investment during the 1990s, are worrying. The lack of empirical validation of commonly accepted growth theories is problematic for policy formulation and further research on the role of investment in the post-reform Indian economy is required.

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I. Introduction

There is a large literature on the role of savings and investment in promoting economic growth. The early Domar-Harrod models specified investment as the key to promoting economic growth, although this was challenged by the neoclassical Solow (1970) model in the 1950s. The Solow model argues that savings importantly contribute to economic growth and policies therefore need to be directed to increasing domestic savings. However, the new growth theories since the mid 1980s, typified by Romer (1986, 1990), Lucas (1988) and Barro (1990), reconfirm the view that the accumulation of physical and human capital are the drivers of long run economic growth.

The roles of savings, investment and foreign inflows in promoting economic growth have received considerable attention in India since independence. However, there have been relatively few studies on Indian savings and investment behaviour for the period starting with the economic crises of the late 1980s and subsequent financial reforms initiated in the early 1990s. The work of Krishnamurty, Krishnaswamy and Sharma (1987) was the first for this period, followed by Laumas (1990), Pandit (1991), Ketkar and Ketkar (1992), Mühleisen (1997), Agrawal (2000), Mahambare and Balasubramanyam (2000), Sahoo, Nataraj and Kamaiah (2001), Athukorala and Sen (2002), Sandilands and Chandra (2003), Saggar (2003), Verma and Wilson (2004) and Seshaiah and Sriyval (2005). Surprisingly, these studies provide little empirical evidence which supports the crucial role that savings and investment play in promoting economic growth. The studies commonly test for Granger causality between Indian savings and growth, or between Indian investment and growth. The findings tend to support the Carroll-Weil hypothesis (Carroll and Weil, 1994) that savings do not cause growth, but economic growth causes savings.

Sahoo, Nataraj and Kamaiah (2001) use annual data for the period 1950/51 to 1998/99 to examine the link between savings and growth in India. They find one-way causality from gross domestic product to gross domestic savings in real terms, both in the long run and short run. Mahambare and Balasubramanyam (2000) conclude 'the Granger causality test suggests that causality runs from growth to savings' for India. Agrawal (2000) examines the savings rate and the growth rate of real GNP using VAR specifications. His analysis finds causality from growth to the savings rate, not only for India but also for Sri Lanka. Mühleisen (1997) conducts Granger causality tests by running bivariate VARs on the growth in real GDP and the levels of total, public and private savings rates. Whilst these tests indicate there is significant causality from growth to savings, they consistently reject causality from savings to growth for all forms of savings. Mühleisen also states that this outcome is robust with respect to variations in the VAR lags, the choice of growth variable and other forms of savings.

Saggar (2003) extends Mühleisen's (1997) period to 2000/01 in order to analyse the consequences of India's financial reforms in the 1990s. He estimates bivariate VARs between the log of real GDP and total, public, private and foreign savings rates. The results support Mühleisen's conclusions in that causality runs from output to savings and not in the opposite direction.[1]

In terms of investment, Sandilands and Chandra (2003) conclude that 'Indian capital accumulation is the result rather than the cause of growth'. However Saggar (2003) shows that total and private investment rates Granger cause real GDP growth. Despite this, he finds no evidence of causality from public investment to real GDP and from the growth in real GDP to the different measures of investment. Saggar (2003, p. 116) wisely concludes:

> *We find it is not easy to decipher causality between saving and growth and investment and growth, given the low power of the unit root tests and limitations of VAR and cointegrating methodologies in the face of relatively small sample sizes. The Carroll-Weil hypothesis is upheld, perhaps more as a statistical quirk and it is best to interpret these results with caution …. While this paper has provided new evidence …further theoretical and empirical work is necessary…"*

This paper therefore attempts to further explore the interdependencies between sectoral savings and investment, foreign capital inflows and real GDP for the Indian economy, over the period 1950 to 2001. We include four innovations:

1. Despite the above studies, only Saggar (2003) examines all sectors including the household sector (although his econometric estimation aggregates household and private corporate savings). There is a need to include the household sector into the analysis because household savings have increased from 65 per cent to over 85 per cent of India's gross domestic savings during the decades from 1950 to 2001. Whilst household investment is relatively less important, it contributes a stable and sizeable 40 to 45 per cent of total gross domestic investment over the same period

[1] Saggar found in the case of the VAR in levels, that the causality from output to public savings is significant at the five per cent level, whereas Mühleisen found the causality from GDP to savings significant at the one per cent level for all savings rates. Saggar found no evidence of causality between the foreign savings rate and the real GDP growth rate, in either direction.

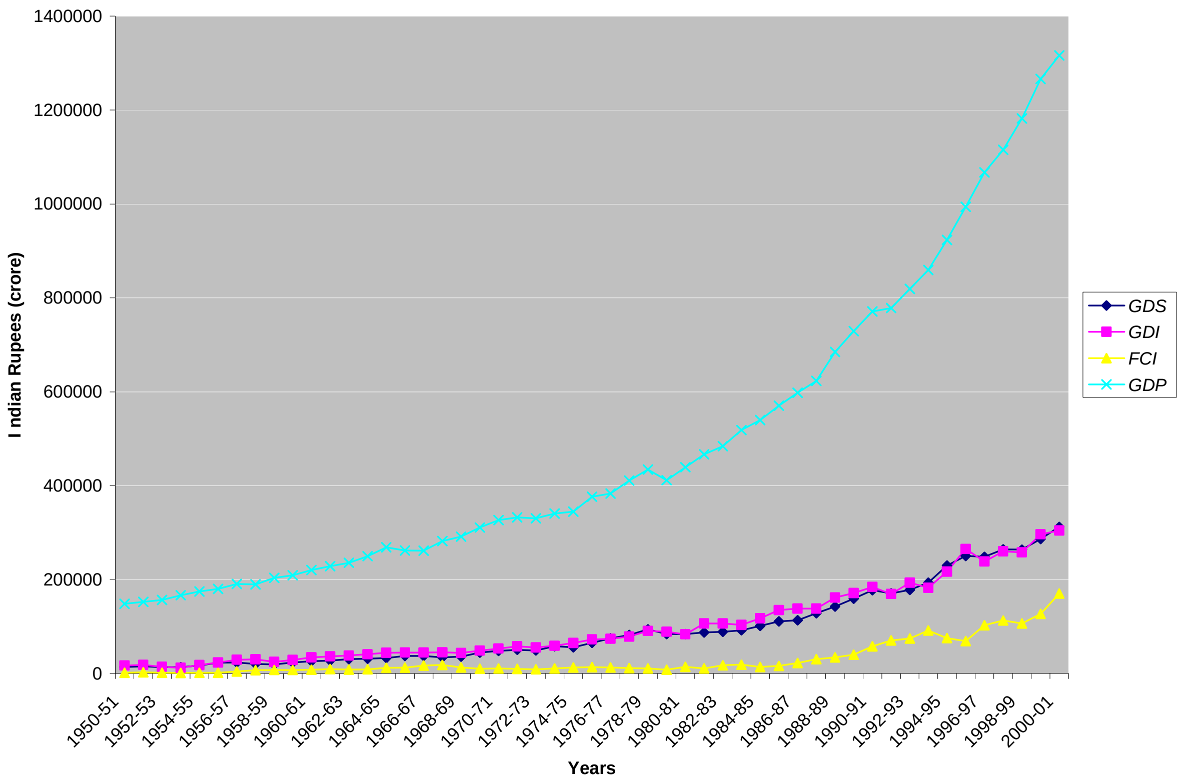
2. The sample, although having relatively few observations, covers five decades. This long span in time introduces the problems of non-stationarity, low power of the traditional unit root tests (with relatively few observations) and bias in these tests caused by the presence of structural change (which is to be expected over the extended period). This study will include the result of Perron and Vogelsang's (1992) unit root test, which endogenously determines the time of the break point.
3. Saggar perceptively points out there is a "need for further investigation … in a multivariate setting" (2003, p. 111). Given the complex interdependencies among the variables, FIML estimation is appropriate in order to obtain efficient parameter estimates. The Granger causality tests will therefore be conducted in a multivariate setting with respect to household, private and public savings and investment, foreign capital inflows and GDP.
4. Given the trending nature of the time series, it is essential to incorporate cointegration estimation techniques to determine long run equilibrium relationships. It is also important that the multivariate Granger causality analysis is conducted with correctly specified VARs, which include short run disequilibrium behaviour via the error correction mechanisms.

We expect that these complications, plus the observed significant divergence of GDP from the other variables as shown in Figure 1, will make it difficult to find robust and statistically significant relationships between real output and savings and real output and investment. Indeed the growth rate in real GDP has consistently exceeded five per cent throughout the 1980s and 1990s.[2] Seshaiah and Sriyval (2005) demonstrate that savings and investment are closely related. Verma and Wilson (2004) estimate that per worker household savings have an elastic 1.87 effect on household per worker investment in the long run. The reverse long run elasticity from household sector per worker investment to savings is 0.54 and both estimates are significant at the one per cent level. However Verma and Wilson (2004) show there is only weak and imprecise evidence of the links between these variables and real per worker output in the short run. We will therefore focus on the difficult task of identifying and quantifying links between sectoral savings and GDP and sectoral investment and GDP in the long run and the short run. The paper will consider the links between the household, private corporate and public sectors.

2 The exception was during the adjustment and world recession year of 1991-92.

Figure 1

Savings, Investment, Foreign Capital Inflows and Real GDP
R's crore at constant prices



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

Note: Constant 1993/94 prices.

GDS: Gross domestic savings; GDI: Gross domestic capital formation;
FCI: Foreign capital inflows; GDP: Gross domestic product.

The household sector comprises individuals, non-profit institutions and non-government non-corporate enterprises.[3] The private corporate sector comprises co-operative institutions and non-governmental corporate enterprises.[4] The public sector includes government administrations as well as departmental and non-departmental enterprises.

All data used in this study are annual observations for the period from 1950/51 to 2000/01. The nominal savings and investment data for the household, private corporate and public sectors have been taken from the National Accounts Statistics of India (2002). The Centre of Monitoring Indian Economy (2002) is the source for foreign capital inflows at

[3] Examples include sole proprietorships and partnerships owned or controlled by individuals.

current prices. These variables are converted into constant prices with appropriate deflators.[5] The data for the labour force is obtained from the Indian Planning Commission.[6] All variables are converted to Naperian logs and divided by the labour force to put the variables in per worker terms, consistent with the standard representation of growth models, as detailed in Verma and Wilson (2004). The resulting variables comprise the log of real per worker measures of household savings (*HHS*) and investment (*HHI*); per worker private corporate savings (*PRS*) and investment (*PRI*); per worker public savings (*PUS*) and investment (*PUI*); per worker real GDP (*GDP*) and per worker foreign capital inflows (*FCI*).[7]

Given that the ADF test for stationarity of a time series is biased towards the non-rejection of the null hypothesis of $I(1)$ if structural change is present this paper employs Perron and Vogelsang's (1992) Innovational Outliner (IO) unit root test.[8] The empirical results reported in Verma and Wilson (2004) indicate that all the variables are non-stationary in the presence of two structural breaks around 1989 and 1993 which coincide with the period of financial reforms. Our estimation therefore includes two structural dummy variables; d_{89} (taking the value one for the years 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 also included for *PRS*, *PRI* and *FCI* (taking value of one for the later period 1993 to 2001).

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4 These include financial and non-financial corporate enterprises.

5 Real GDP figures were obtained from the Reserve Bank of India. We used the GDP at factor cost deflator for household sector savings and investment; the GDCG (unadjusted) deflator for private sector savings and investment and foreign capital inflows; and the GDP at market prices deflator for the public sector savings and investment. All data are in Rupees for the 1993/94 base year.

6 The labour force data are only available for the census years 1951, 1961, 1971, 1981, and 1991. The values of the labour force for other years were estimated using simple interpolations between the census figures. Because all variables are equally divided by the same labour force figures for each year, they only differ by a common constant of proportionality.

7 The italics represent the variables in real, log per worker terms.

8 There are numerous variations on detecting structural change detailed in Perron (1989), Banerjee, Lumsdaine and Stock (1992) Zivot and Andrews (1992), Perron and Vogelsang (1992), Perron (1997), Lumsdaine and

II. Long Run Relationships

The long run cointegrating vectors are derived from the VAR, without trend, for the eight endogenous $I(1)$ variables, $\underline{y}_t$:[9]

$$\underline{y}_t = \underline{\gamma} + \sum_{i=1}^{\kappa} \Phi_i \underline{y}_{t-i} + \Psi \underline{x}_t + u_t \ , \qquad t = 1, 2, ..., n$$

where vector $\underline{x}_t$ comprises the $I(0)$ dummy variables. The vector error correction (VECM) is:

$$\Delta \underline{y}_t = \underline{\gamma} - \Pi \underline{y}_{t-1} + \sum_{i=1}^{\kappa-1} \Gamma_i \Delta \underline{y}_{t-i} + \Psi \underline{x}_t + v_t$$

where: $\Pi = \sum_{i=1}^{\kappa} \Phi_i - \mathbf{I}$ and $\mathbf{I}$ is the identity matrix. The φ cointegrating vectors are given by $\underline{\beta}' \underline{y}_t$ where $\Pi = \underline{\alpha \beta}'$ has rank φ. The estimation of cointegrating vectors by the Johansen (1991, 1995), Johansen and Julius (1992) and Pesaran and Pesaran (1997) FIML method should provide efficient estimates of the long run elasticities in $\underline{\beta}$.

The optimum lag of the VAR was tested and although the Schwarz Bayesian criterion (SBC) indicated a lag of one it was decided to over-parameterise the system with $\kappa = 2$ so that we can conduct Granger causality tests in the next section using the VECM.[10] The likelihood ratio (LR) tests based on the maximal eigenvalue and trace of $\Pi = \underline{\alpha \beta}'$ indicate a rank of three, $\varphi = 3$, at the five per cent level of significance.[11] The eigenvalues are:

$$\{0.790, \quad 0.738, \quad 0.567, \quad 0.412, \quad 0.347, \quad 0.233, \quad 0.093, \quad 0.024\}.$$

The Schwarz Bayesian (SBC), Hanna–Quinn (HQC) and Akaike Information (AIC) model selection criteria indicate ranks of two, five and six, respectively. Whilst there is a gap

Papell (1997), Lee and Strazicich (2003) and Bai and Perron (2003). There have been numerous applications including Strazicich, Lee and Day (2004) and Pahlavani, Valadkhani and Wilson (2005).

9 The trend is not included in the cointegration analysis, consistent with its exclusion in the tests for stationarity under structural change for time series defined in per worker terms.

10 Any evidence of Granger causality in the next section will justify this choice.

11 The null hypothesis of a rank of three is not rejected according to the maximal eigenvalue statistic with value 26.02, which is less than the 95 per cent critical value of 33.64. Similarly, the value of the trace statistic at 65.84 is also less than the 95 per cent critical value of 70.49.

between the second and third eigenvalues, it is preferred to include the third value into the long-run analysis, consistent with the maximal eigenvalue and trace tests.[12]

The three cointegrating vectors are just identified by normalising initially on GDP per worker (*GDP*), household savings per worker (*HHS*) and private corporate investment per worker (*PRI*). Two further restrictions are required to identify each vector and this is done by setting the less significant variables, according to the analysis of Verma and Wilson (2004), to zero.[13] Consistent with the previous discussion and analysis, the VAR is estimated without trend and with unrestricted intercepts (γ) to derive the long run elasticities. The elasticity estimates for the cointegrating vectors, CV_{1a}, CV_2 and CV_3 are given in Table 1.

Table 1

Estimated Long Run Cointegrating Vector Elasticities
Unrestricted intercept and no trends

$$GDP = \underset{(0.12)^{***}}{0.646}\ HHS - \underset{(0.11)}{0.089} HHI + \underset{(0.06)^{***}}{0.151} PRS + \underset{(0.05)^{**}}{0.101} PRI - \underset{(0.06)^{***}}{0.255} PUI \qquad CV_{1a}$$

$$PRS = \underset{(2.56)^{**}}{6.626} GDP - \underset{(1.44)^{***}}{4.278} HHS + \underset{(0.60)}{0.589} HHI - \underset{(0.55)}{0.672} PRI + \underset{(0.69)^{***}}{1.690} PUI \qquad CV_{1b}$$

$$HHS = \underset{(0.33)^{***}}{1.364}\ GDP + \underset{(0.13)^{***}}{0.364} HHI + \underset{(0.16)}{0.040} PRS + \underset{(0.02)^{***}}{0.055} PUS - \underset{(0.06)^{*}}{0.069} FCI \qquad CV_2$$

$$PRI = \underset{(2.33)^{***}}{7.171}\ GDP - \underset{(1.15)^{***}}{3.945} HHS - \underset{(0.63)^{*}}{1.045} PRS + \underset{(0.42)^{***}}{1.781} PUI + \underset{(0.18)}{0.142} FCI \qquad CV_3$$

Notes: Figures in parenthesis are standard errors. The tests of significance assume asymptotic normality.
*** represents significant at the 1per cent level; ** significant at the 5 per cent level;
* significant at the 10 per cent level.

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 estimates are striking, and show for the first cointegrating vector (CV_{1a}) that GDP per worker (*GDP*) is determined by *HHS* and *PRS* with respective long run elasticities 0.65 and 0.15, which are significant at the one per cent level.[14] These estimates support the Solow growth model whereby domestic private sector savings promote (or constrain) long run

[12] If the foreign capital inflow variable is excluded the rank falls to two.

[13] No over-identifying restrictions were imposed.

[14] Whilst the figures in parenthesis in Table 1 are standard errors, the levels of significance reported in the text assume asymptotic normality.

economic growth. These effects are in the opposite direction to the Carroll-Weil hypothesis and, to the best of the authors knowledge, they have not been reported elsewhere.

Importantly, *PRI* and *PUI* also affect *GDP* with elasticities of 0.10 and −0.26 which are significant at the five and one per cent levels, respectively. The first estimate supports the endogenous growth view that private sector investment per worker drives long run economic growth. However the negative effect of per worker public investment is unmistakable and refutes Barro's claim that the provision of infrastructure capital by the government will promote long run economic growth.

The second cointegrating vector (CV_2) shows that GDP per worker (*GDP*) has an elastic effect of 1.36 on *HHS* which is significant at the one per cent level. This supports the Carroll-Weil hypothesis reported in other studies, including Sahoo, Nataraj and Kamaiah (2001). The variables *HHI* and *PUS* also affect *HHS* with respective elasticities of 0.36 and 0.06 at the one per cent level of significance.

The third vector (CV_3) was eventually normalised on *PRI* after trying alternative specifications.[15] There are highly elastic effects of *GDP* and *HHS* on *PRI* with respective values of 7.17 and −3.95, which are significant at the one per cent level. The other significant relationship (at the one per cent level) is that *PUI* affects *PRI* positively with an elasticity of 1.78. This is consistent with Athukorala and Sen (2002) regression analysis which found that public investment is an important determinant of private investment. It is unclear why *HHS* has an elastic and negative relationship with *PRI* with a one per cent significant long run elasticity of −3.95.[16] The two vectors show that per worker foreign capital inflows do not appear to be important in the growth process. The sole identified long run effect on *HHS* in the second vector is small and only significant at the ten per cent level.

An alternative specification of the first cointegrating vector was considered by normalising on private corporate per worker savings (*PRS*) instead of *GDP*. The estimates, shown as CV_{1b} in Table 1, clearly extend the Carroll-Weil hypothesis to *PRS* with an elastic response of 6.23 at the five per cent level of significance. The magnitude of the response reflects the size of the elasticity of *GDP* on *PRI* in CV_3 of 7.17. The only other significant variable (at the one per cent level) is *PUI* affecting *PRS* elastically with a coefficient of 1.69 in CV_{1b}. Again this is similar to the coefficient 1.78 of *PUI* on *PRI* in CV_3. It appears that

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15 We also tried normalising CV_3 on *HHI*, *PUI*, *PUS* and *FCI*. However all coefficients were not significant for each estimated equation, even at the ten per cent level (assuming normality).

16 We similarly note that *PRS* has a negative relationship with *PRI*, although it is only significant at the ten per cent level.

CV_{1b} and CV_3 are spanning much the same space and therefore provide little additional information. On the other hand, CV_{1a} adds interesting information, consistent with it being more orthogonal to CV_2 and CV_3, which reflects the additional rank of three. However, the estimate of the error correction for *PRI* using CV_{1a} is unusually large and it was decided to conduct the Granger causality analysis using CV_{1b}, CV_2 and CV_3.[17] Having decided this, only the estimates of the three error correction mechanisms differ, with all other parameter estimates invariant to the choice of CV_{1a} or CV_{1b}.

III. Short Run Granger Causality

The tests of Granger causality are conducted on the VECM of the VAR, which reduces to the simple specification, with lag, $\kappa = 2$:

$$\Delta \underline{y}_t = \underline{\gamma} - \Pi \underline{y}_{t-1} + \Gamma \Delta \underline{y}_{t-1} + \Psi \underline{x}_t + v_t$$

It is readily apparent that we can apply Granger causality tests to the elements of Γ, which relates the one period lag for all eight endogenous variables, to the dependent variable for each equation in the VAR. The eight short run error correction mechanisms are given by the vector $\underline{\alpha}$, where $\underline{\alpha}\left(\underline{\beta}' \underline{y}_{t-1}\right) = \Pi \underline{y}_{t-1}$ and $\underline{\beta}' \underline{y}_{t-1}$ are the three long run cointegrating vectors. The effects of structural change, modelled by the dummy variables, are included in Ψ. As mentioned before, the estimates of the elements of Γ and Ψ are invariant to the choice of the cointegrating vectors, provided they are just identified and consistent with the determined rank of Π.

The Student's-*t* statistic will be used to test the significance of the coefficients in Γ (for each one period lagged endogenous variable) and for the coefficients of the dummy variables in Ψ.[18] Because many Granger causality studies do not include the error correction mechanism and the effects of structural change, the coefficients estimates in Γ and their tests of significance, will be subject to misspecification bias. In addition to this, most studies use single equation estimation and lose efficiency in estimation of the standard errors of the

[17] The estimated error correction coefficient for *HHI* with CV_{1a} is a very large 36.563, which is also significant at the one per cent level.

[18] Because there is only one lag, the *F* test is equivalent to the Student's-*t* test.

coefficients, due to ignoring the simultaneity across the eight endogenous variables. Finally, the inclusion of the eight one period lagged variables in each equation is a much stricter test of Granger causality of each right hand side variable on the dependent variable. That is, a significant relationship for any one right hand side variable will exist in addition to the explanation of the other right hand side variables (including the lagged dependent variable).

Table 2 presents the estimates of the coefficients for each vector error correction mechanism (*ecm*) in $\underline{\alpha}$, the unrestricted intercept in γ and the dummy variables (d_{89} and d_{93}) in Ψ. The coefficient of determination, R^2, the Durbin Watson statistic, *D-W*, and $F_{\rho=0}$ test for serial correlation are also reported in Table 2. The $F_{\rho=0}$ tests (with 1 and 34 degrees of freedom) show that there is no serial correlation for each equation. Heteroskedasticity is detected for the *PUS*, *FCI* and *PRS* equations according to the *F* test.[19] These three equations are re-estimated with Newey-West adjustments to obtain consistent standard errors, which are reported in Table 2.[20]

There are no significant error correction mechanisms for the *HHS*, *PUS*, *HHI*, *FCI*, and *GDP* equations.[21] The error correction mechanisms for *PRI*, with values −5.518 (ecm_{1b}) and 4.805 (ecm_3), are of the correct sign and significant at the one per cent level. These large elastic magnitudes indicate considerable overshooting behaviour for per worker private corporate investment in the short run equilibrating process. In contrast, the ecm_2 error correction for *PRS*, which is also significant at the one percent level, is elastic but has much smaller value of −1.172 (with correct sign). The one per cent significant error correction values for *PUI* of −1.091 (ecm_1) and 0.879 (ecm_3), imply minor overshooting for the first case and instability for the second case (because the second value is of the wrong sign).[22]

The major findings reported in Table 2 are that the dummy variables, d_{89} and d_{93} are significant for the *HHS, PRS, PUS*, *PRI* and *PUI* variables. They show that the short run change in *HHS* (ΔHHS) increases by 0.12 in 1989 and a further 0.27 in 1993 at the five and one percent levels of significance, respectively. Given that the average annual increase in *HHS* over the full sample of 1950 to 2001 is 5.0 per cent, this implies the growth rate

[19] The *F* statistic (with 1 and 47 degrees of freedom) tests the significance of the regression of the square of the residuals on the square of the predicted dependent variable. The *F* statistic is 124.10 for the *PUS* equation (significant at the 1 per cent level), 4.52 for the *FCI* equation (significant at the 5 per cent level) and 3.22 for the *PRS* equation (significant at the 10 per cent level).

[20] The Newey-West adjustment was made with Parzen weights and a truncation lag of 15.

[21] Since the rank of Π is three, there are three error correction mechanisms for each equation.

[22] Many of these values are large indicating instability in the short-run equilibrating processes. This is the subject of further research.

increases to 5.6 per cent per annum in 1989 and then to 7.2 per cent per annum from 1993. The average annual growth rate for *PRS* of 4.8 per cent for the full sample also increases at the one per cent level of significance to 5.7 per cent in 1989 and 6.5 per cent per annum in 1993. These increases in household and private corporate per worker savings contrast with the estimated decreases in per worker private corporate investment and public savings and investment during the period of financial reforms and deregulation. There is a reduction of 0.61 in ΔPRI in the period 1989 to 2001 at the one per cent level. The lower average annual increase since 1950 of 3.7 per cent for *PRI* therefore falls to only 1.5 per cent per annum in 1989 at the one percent level of significance. Similarly, the average annual growth rates for *PUI* and *PUS* fall from their respective average annual growth rates of 4.4 per cent and 2.2 per cent for the full period to 3.5 per cent and 1.5 per cent per annum respectively, in 1989 at the five per cent level of significance.[23]

Table 3 includes the estimates of Γ to be used in the Granger causality tests. The results indicate many important short run relationships. *HHS* and *PRS* Granger cause *HHI* and *PRI*, with short run elasticises of 1.07 and 1.15 respectively, which are both significant at the one per cent level. However there was no significant feedback causation from household and private corporate investment to savings. Similar to the household and private corporate savings, *PUS* Granger causes *PUI*, although the elasticity is small and negative, –0.06 at the five per cent level of significance. This inverse relationship reflects the government's budget constraint whereby an increase in *PUS* will reduce the budget deficit by decreasing *PUI*.

There are interdependencies between the household and the private corporate sectors with *HHI* Granger causing *PRI* with elasticity of 1.47 at the one per cent level of significance. The feedback effect is weaker with the *PRI* elasticity on *HHI* smaller at 0.12 and only significant at the ten per cent level.

Importantly, *PUI* crowds-out *HHI* with an elasticity of –0.60 and crowds-in *PRI* with an elastic response of 1.24 at the five per cent level of significance. The analysis also shows that *PUI* negatively Granger causes GDP per worker (*GDP*) with a five per cent elasticity of –0.14. This reinforces the long run finding of an inverse relationship, although the elasticity is only around half the long run value of –0.26.

GDP negatively Granger causes *HHS* with a five per cent significant elasticity of –1.08. This inverse short run relationship presumably reflects increasing consumption demand

[23] The average annual per cent growth for *PUS* is calculated from 1950 to 1997 only, because public savings become negative in the period 1998 to 2001.

(consistent with higher incomes) is at the expense of household per worker savings. It is worth noting that *GDP* has a very elastic short run accelerator affect in that it Granger causes *PRI* and *PUI* with elasticities of 3.22 and 1.54, although they are only significant at ten and five per cent levels respectively. This short run effect on *PRI* is less than half the long run elasticity of 7.17.

Similar to the long run analysis, *FCI* has no short run story to tell except that it negatively Granger causes *PRS* with an elasticity of −0.32 at the one per cent level. This indicates higher levels of foreign capital inflows per worker are associated with lower per worker private corporate savings.

The long run negative effect between *HHS* and *PRI* also holds in the short run with *HHS* Granger causing *PRI* with a one per cent significant elasticity of −2.25. This apparently robust result requires further consideration. The other links from *HHS* to *GDP* and *PRS* to *GDP*, which were identified in the long run, do not hold in the short run Granger causality analysis.

Table 2

Short Run Error Corrections, Dummy Variables and Summary Statistics
Unrestricted intercepts and no trends

Dependent variable	**Explanatory variable**								
	ecm_{1b}	ecm_2	ecm_3	γ	d_{89}	d_{93}	R^2	*D-W*	$F_{\rho=0}$
ΔHHS	0.359	0.236	–0.117	**–9.310*** **	**0.124** **	**0.274*** **	0.583	2.256	2.116
ΔPRS	0.248	**–1.172*** **	–0.040	1.488	**0.179*** **	**0.141*** **	0.743	1.514	2.389
ΔPUS	1.872	–4.066	–1.520	20.810	**–0.308** **	–0.228	0.351	2.066	0.299
ΔHHI	0.356	–0.222	–0.171	–4.096	–0.031	**0.301***	0.368	2.146	1.017
ΔPRI	**–5.518*** **	0.484	**4.805*** **	7.560	**–0.609*** **	**–0.549***	0.809	1.729	0.825
ΔPUI	**–1.091*** **	0.519*	**0.879*** **	1.252	**–0.195** **	**–0.193***	0.415	1.856	0.491
ΔFCI	0.273	–0.789	–0.314	7.767	0.060	–0.149	0.298	1.919	0.018
ΔGDP	0.058	–0.083	–0.033	–0.099	0.003	0.035	0.293	1.848	0.794

Notes: ecm_i represents the error correction mechanism for the cointegrating vector, CV_i with i = 1b, 2 and 3.
d_{89} is a dummy variable taking a value of one for 1989 to 2001 and zero elsewhere; d_{93} takes value one for the period 1993 to 2001.
All tests of significance of the coefficients are reported using the Student's-*t* test.
*** represents significant at the 1 per cent level; ** significant at the 5 per cent level; * significant at the 10 per cent level.
$F_{\rho=0}$ tests the equation for serial correlation: $\rho = 0$ where $v_t = \mu + \rho v_{t-1} + \varepsilon_t$. The equations for ΔPRS, ΔPUS and ΔFCI are corrected for heteroskedasticity using a Newey-West adjusted consistent variance-covariance matrix with Parzen weights and a truncation lag of 15.
HHS: Household savings per worker; *HHI*: Household investment per worker; *FCI*: Foreign capital inflow per worker;
PRS: Private corporate savings per worker; *PRI*: Private corporate investment per worker; *GDP*: Gross domestic product per worker.
PUS: Public savings per worker; *PUI*: Public investment per worker;

Table 3

Short Run Granger Causality Elasticities
Unrestricted intercepts and no trends

Granger caused variable	Granger causing variable							
	ΔHHS_{-1}	ΔPRS_{-1}	ΔPUS_{-1}	ΔHHI_{-1}	ΔPRI_{-1}	ΔPUI_{-1}	ΔFCI_{-1}	ΔGDP_{-1}
ΔHHS	**0.419***	0.125	–0.019	–0.141	**0.123*****	**–0.359****	0.079	**–1.079****
ΔPRS	0.398	–0.192	**0.061*****	–0.043	0.031	–0.216*	**–0.322*****	0.785
ΔPUS	0.729	1.078	–0.031	–1.550	–0.210	–0.191	**–0.410***	6.169
ΔHHI	**1.069*****	0.141	0.010	**–0.644*****	**0.119***	**–0.599****	0.117	–0.355
ΔPRI	**–2.246*****	**1.149*****	–0.047	**1.474*****	0.071	**1.243****	–0.113	**3.217***
ΔPUI	**–0.524***	–0.030	**–0.059****	**0.312***	0.020	0.142	–0.058	**1.542****
ΔFCI	–0.106	**0.244***	0.001	0.154	–0.033	**0.497***	–0.088	–1.223
ΔGDP	–0.016	0.017	0.002	–0.003	0.014	**–0.144*****	–0.022	–0.060

Notes: The Student's-*t* tests of significance are conducted on the lagged variables.
*** represents significant at the 1 per cent level; ** significant at the 5 per cent level; * significant at the 10 per cent level.
The equations for ΔPUS, ΔFCI and ΔPRS are corrected for heteroskedasticity using a Newey-West adjusted consistent variance-covariance matrix with Parzen weights and a truncation lag of 15..
HHS: Household savings per worker; *HHI*: Household investment per worker; *FCI*: Foreign capital inflow per worker;
PRS: Private corporate savings per worker; *PRI*: Private corporate investment per worker; *GDP*: Gross domestic product per worker.
PUS: Public savings per worker; *PUI*: Public investment per worker;

IV. Summary and Conclusions

This paper considers the interdependencies between per worker household, private corporate and public sector savings and investment, foreign capital inflows and GDP in a multivariate setting. The analysis is applied to all eight non-stationary variables over the period 1950 to 2001 when two endogenously determined structural breaks have occurred in 1989 and 1993. The long run cointegrating relationships and short run adjustments are estimated in a multivariate setting using Johansen FIML estimation procedure. This derives long run and short run elasticity estimates and correctly specified tests of Granger causality provide six major findings.

First, the Carroll-Weil hypothesis is supported for household savings per worker at the one per cent level of significance in both the long run cointegrating equilibrium and short run Granger causality tests. Per worker GDP affects household savings per worker with a long run elastic relationship of 1.36, whilst the negative short run elasticity of −1.08 reflects the effects of household consumption on savings. More importantly though, this study also finds long run feedbacks from per worker household and private corporate savings to GDP per worker. The long run household elasticity of 0.65, while around half of the value in the opposite direction at 1.36, is still sizeable and very significant at the one per cent level. Whilst the long run per worker private corporate savings affect GDP is lower at 0.15, is also significant at the one per cent level. To the best of the authors knowledge, these important feedbacks whereby savings affect GDP in the long run, have not previously been detected in other studies. This maybe because we include the household sector into the analysis, explicitly distinguish between long and short run relationships, and include endogenously detected structural breaks.

The second major finding identifies that savings directly affect investment within each sector in the short run, at the one per cent level of significance. For example, the elastic response of per worker household investment to savings is 1.07, whilst per worker private corporate investment responds elastically to private corporate savings with a estimated value of 1.15. Per worker public savings also affect investment in the short run, but negatively, with a relatively small elasticity of −0.06, at the five per cent level. It was also found that per worker household savings affect private corporate investment in the short and long run at the one per cent significance level, with elasticities of −2.25 and −3.95 respectively. Whilst these strong effects require further consideration, it is unmistakable that sectoral savings significantly drive own sector investment in the short run, but not the long run.

Thirdly, per worker GDP has very large effects on per worker private corporate investment with a long run elasticity of 7.17 and short run elasticity of 3.32, at the one and ten per cent levels of significance, respectively. These relatively large responses by investment indicate a strong accelerator effect of per worker GDP on private sector investment. It is interesting to find there is a feedback from per worker private corporate investment to GDP in the long run (only), with a relatively small, five per cent significant elasticity of 0.10.

The fourth major finding is that per worker public investment is found to adversely and significantly affect GDP per worker in the both the long run and short run. The long run elasticity of −0.26**,** significant at the one per cent level, almost halves to −0.14 in the short run. Per worker public investment is found to crowd-out household investment with a five per cent significant elasticity of −0.60. Fortunately, per worker public investment does crowd-in private corporate investment with an elastic response of 1.24 (at the five per cent level) in the short run and 1.78 (at the one per cent level) in the long run.

Fifthly, foreign capital inflow per worker is not found to be important in the growth process. The only identified link is the expected inverse short run relationship with per worker private corporate savings. The short run elasticity of −0.32 is significant at the one per cent level.[24] An increase (decrease) in domestic savings requires less (more) reliance on savings from the rest of the world.

Finally the dummy variable analysis shows significant increases in the annual growth in per worker household and private corporate savings. The average annual growth in per worker household savings increases from 5.0 per cent to 7.2 per cent in the 1990s whilst the average annual growth in per worker private corporate savings increases from 4.8 per cent to 6.5 per cent in the same period. Conversely, the average annual growth rate in private corporate per worker investment falls dramatically from 3.7 to 1.5 per cent per annum in the 1990s. The fall in the annual growth in public per worker investment from an average of 4.4 per cent to 3.5 per cent for the same period is relatively less than for private corporate per worker investment. The average growth in per worker public savings also declines from an average of 2.2 per cent to 1.5 per cent per annum in the 1990s.

In conclusion, whilst there is support for the Carroll-Weil hypothesis, the key findings identify per worker household and private corporate savings affecting GDP in the long run. Sectoral savings also directly determine same sector investment in the short run. These

[24] Per worker foreign capital inflows affect household savings (with long run elasticity of –0.07) and per worker public savings (with short run elasticity of –0.41), which are both significant at the ten percent level.

findings may be considered to support the Solow growth model whereby domestic private sector savings promote long run economic growth. However, the link from investment to output is missing in this explanation. Whilst there is a strong Keynesian accelerator feedback from per worker GDP to private corporate investment (mostly in the long run), per worker private corporate investment has relatively weak effects on GDP in the long run. This is the missing link in the Solow model explanation and it certainly does not support the endogenous growth view that private sector investment is the key driver of long run economic growth. Indeed the very strong direct feedback effects between per worker savings and real GDP could have an aggregate demand interpretation. In addition to this, there are negative long and short run effects of per worker public investment on GDP, which counters Barro's argument that the public provision of infrastructure promotes long run economic growth. Per worker public investment also crowds-out household investment in the short run, but crowds-in per worker private corporate investment in both the short run and long run. During the period of financial reforms in the late 1980s and the early 1990s, the growth rates in per worker household and private corporate sector savings significantly increased, whilst the growth rates in per worker private corporate investment and public savings and investment fell. Surprisingly, per worker household investment does not appear to be important and is only found to affect private corporate investment in the short run.

The analysis of Indian sectoral savings and investment, in a non-stationary multivariate setting with endogenously determined structural breaks does not support the commonly accepted models of economic growth. Accordingly, the policy prescriptions to promote economic growth are not straightforward. The popular view that increases in savings are a necessary condition for economic growth is supported with the detected strong direct savings to output and savings to investment links. This implies the need to encourage savings, which is being realised with higher growth rates during the recent period of financial deregulation in India. However, the offsetting reduction in the rates of growth in investment during the 1990s, the lack of any identified strong links from private sector investment to output and the apparent negative influence of public investment, means that the growth propagation mechanism is unclear. The problematic role of investment is also coupled with the observed lack of influence of household investment. It is possible that this may be due to the overwhelmingly strong effects detected for household savings and further analysis of this relative imbalance between savings and investment is required.

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