After the 'License Raj': Economic Liberalization and Aggregate Private Investment in India

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ABSTRACT

Using three alternative models that incorporate the behavior of both credit constrained and unconstrained firms in a theoretically consistent manner, this paper presents evidence on the effects of economic liberalization of 1991 on aggregate private investment in India. Two robust conclusions emerge from the estimation of the investment function by ARDL approach. First, the response of private investment with respect to the relative cost of capital has increased at least 4.6 times after the dismantling of the 'License Raj'. Second, the evidence implies a significant improvement in the technological efficiency of the firms during the post-liberalization period. In contrast, no robust conclusion can be drawn about the severity of the credit constraint faced by the private sector following the liberalization.

Key Words: Private Investment, India, Economic Liberalization, ARDL

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Introduction

Investment and capital accumulation have traditionally been accorded a prime place in the development literature. The evidence from the vast literature on growth empirics shows investment in capital goods as one of the most robust determinants of cross-country growth (see, Levine and Renelt, 1992, Durlauf and Quah, 1999).[1] Over the last couple of decades, economic liberalization and deregulation policies have been widely adopted by developing countries that assign a central role to the private sector. The emphasis on the private sector as the engine of economic growth and development has brought the focus on the behavior of private investment in developing countries (see, for example, Fielding (1999) on South Africa and Guncavdi, Bleaney and Mckay (1998) on Turkey). After decades of lackluster performance under the all pervasive interventionist policy regime espoused after independence (the so-called 'License Raj'), India embarked on a major economic liberalization program in 1991, triggered by a severe balance of payments crisis. The objective of this paper is to assess the effects of liberalization on aggregate private investment in India. We focus on two related issues: the effects of liberalization on the responsiveness of private investment to changes in relative cost of capital (response in the choice of technique) and on the credit constraint faced by the private sector. [2]

A major focus of the liberalization policies in India has been to dismantle the complex web of controls that severely constrained the emergence and operation of the private entrepreneurs.[3] The import competition and competition from FDI unleashed by the external sector liberalization have also increased the pressure on the domestic entrepreneurs. The liberalization measures are thus expected to enable (due to deregulation and decontrol) and induce (due to increased competition) the private entrepreneurs to be more responsive to the price signals both in the output and input markets, and thus help improve efficiency in resource use. A primary objective of this paper is to assess to what extent this *á priori* expectation about improved price response is actually

[1]For a summary of the findings in the literature see table 2 in the survey by Durlauf and Quah (1999). Of the nine studies reported in the survey that include investment or investment ratio as one of the determinants of growth, only one study reports a negative but insignificant effect, while the rest of the studies report a positive effect of investment on growth which is statistically significant in seven of the cases.

[2]These questions have recently been analyzed in the context of financial liberalization in Turkey by Guncavdi, Bleaney, and Mckay (1998).

[3]The licensing regime established under Industries Development and Regulation Act (IDRA) in 1951 coupled with import restrictions controlled the private sector decisions at every stage, from entry into an industry to capacity expansion, to choice of technology, even output mix and import content. (For details, see Ahluwalia, Isher, 1985).

borne out by data, focusing on the choice of technique of the firms. While the deregulation and dismantling of License Raj are expected to improve the price responsiveness in general, and in choice of technique in particular, the effects on credit constraint are not unambiguous, on *á priori* grounds. On the one hand, liberalization might increase the availability of investment funds through higher savings mobilization, foreign capital inflows (both FDI and portfolio), and possibly a reduced demand from the public sector, a tight rein on the domestic credit creation for macroeconomic stability can reduce the availability of credit. Also, a better disciplined and cautious (prudent) financial sector may lead to a hardening of the budget constraints for individual firms (possibly the "sick enterprises") and thus reduce the net credit flow to the private sector (the so-called *excess liquidity* in the banking sector). From this perspective, liberalization might in fact make the credit constraint faced by the private sector tighter. Liberalization is also likely to spur technological upgrading, due to the competitive pressure and learning and technological externalities from FDIs, for example. Such technological change can be modelled as an autonomous shift in the aggregate investment function, i.e., as a shift in the intercept of the investment function.

Although there is a large literature on the time series estimation of aggregate private investment in developing countries, the empirical modeling has been constrained by the absence of a tractable model of investment under credit constraint. The empirical literature has used different variables to capture the effects of a binding credit constraint, including net credit to private sector both in level and as a share of GDP (for a sample of the variables used, see Rama (1993)).[4] The theoretical literature on modeling investment behavior under credit constraint has offered two alternative ways of specifying the investment function for empirical estimation. An explicit investment function can be derived, under some restrictions on functional forms, from the closed form solution of a firm's optimization problem (see Chatelain (2000) for a closed form solution). A more widely utilized empirical specification of the investment function relies on the parameterization of the Lagrange multiplier associated with the credit constraint in the Euler equation for a constrained firm's optimization problem (for a survey, see Hubbard (1998)). On *a priori* theoretical and empirical grounds, none of the specifications can be argued to dominate the others,

[4] The recent contributions using firm level data are generally based on more sound theoretical basis. See for example, Fielding (2000) and Gelos and Werner (2002).

and thus sensitivity of the parameter estimates should be tested using alternative specifications. In order to ensure robustness of parameter estimates, we estimated the three specifications of the investment function: the first one is derived from the closed form solution (termed as 'Total Cash Flow Specification') and the other two are alternative parameterizations of the Lagrange multiplier. Utilizing the results derived by Chatelain (2000), a theoretically consistent parameterization of the Lagrange multiplier associated with the binding credit constraint is formulated in terms of the first differences of the variables determining the investment of both the constrained and unconstrained firms (termed as 'Chatelain Specification'). A parsimonious parameterization of the Lagrange multiplier in terms of the ratio of total investible funds [5] to real GDP (termed as 'Cash Flow Ratio Specification') is also employed for the empirical estimation. These three specifications of aggregate investment function are used to analyze the effects of economic liberalization on aggregate private investment in India, using time series data for the period 1952-53 to 1998-99.

Apart from a binding credit constraint, the other salient issues for modelling private investment in developing countries include (possible) complementarity between private investment and public *capital* and the effects of uncertainty on private investment. We implement a model of private investment behavior that incorporates the triple issues of credit constraint, complementarity between public and private investment, and uncertainty. Thus the inference on the effects of liberalization on private investment is likely to be less susceptible to the problems of omitted variables and misspecification of the investment function.

The most interesting result from the econometric analysis based on the ARDL approach (a la Pesaran and Shin, 1999) to the estimation of the investment function is that economic liberalization has dramatically increased the price response of private investment with respect to the relative cost of capital (at least 4.6 times higher in the post-liberalization period). The elasticity of aggregate private investment with respect to the relative cost of capital is estimated to be approximately -1 in the post liberalization period. The post-liberalization period, according to estimates of this paper, has also witnessed a substantial improvement in the technical efficiency of the Indian firms. The estimates based on different specifications of the investment function,

[5] Total investible funds equals retained earnings plus change in credit deflated by the price of capital

however, lead to conflicting conclusions about the extent of the credit constraint faced by the private sector following the deregulation and liberalization.[6] These main conclusions are extremely robust surviving across different sample periods (1953-99, 1955-99, 1960-99). The evidence also indicates that uncertainty has a negative influence on aggregate private investment. The stock of public infrastructure (paved road, rail road, electricity generation capacity, and number of telephone connections) seems to have a crowding in effect, but it is not statistically significant.

The rest of the paper is structured as follows. The first section presents a discussion of the theoretical and empirical issues in modelling of aggregate private investment function. The next section, arranged in a number of subsections, is devoted to the analysis of the empirical results. The paper ends with a summary of the empirical findings and their policy implications for India.

Section 1: Modelling Aggregate Private Investment: Theoretical and Empirical Issues

The standard neoclassical model of investment behavior is based on the optimal input choice decision of a profit maximizing firm facing no credit constraint.[7] However, at any given time, in any given economy, a certain proportion of firms will be credit constrained in the sense that the credit available falls short of the amount required for acquiring the optimal capital stock. The credit constraint may be due to government imposed restrictions (like directed credit that discriminates against certain sectors), or problems of moral hazard and adverse selection in the credit markets arising from asymmetric information (Stiglitz and Weiss, 1981). In a theoretically consistent specification of the aggregate investment, we need to account for the existence of these two types of firms, credit constrained and unconstrained.

An unconstrained firm maximizes profit given the input and output prices, and the production function. Let $Q = F(K, L; G)$ be the production function where Q is output produced, K and L are capital and labor inputs respectively, and G stands for the stock of public infrastructure (henceforth called public capital stock). It is assumed that the production function is concave

[6] The results are somewhat different from those found by Guncavdi et. al. (1998) for Turkey, where they do not find any evidence of a change in price response, but find a significant reduction in credit constraint.

[7] In strict theoretical sense, the objective is to maximize the present value of the firm. However, the present value maximization is equivalent to profit maximization at each point in time when the appropriate cost of capital is used (see, Sargent, 1987, P.80).

in the private inputs. The complementarity between public and private capital implies that $F_{KG}(.) > 0$ and $F_{KGG}(.) < 0$, i.e., the marginal product of private capital is a positive but declining function of the stock of public capital available in the economy.[8] Denoting the user cost of capital and wage rate by r and w respectively, the implicit form of optimal capital stock function can be written as:[9]

$$K^* = \Psi\left(\frac{r}{w}, Q, G\right) \tag{1}$$

In steady state the optimal investment is given by $I^* = \delta K^*$ where δ is the depreciation rate. So the optimal investment function can be written as:[10]

$$I^*_{uc} = \delta\Psi\left(\frac{r}{w}, Q, G\right) \tag{2}$$

where the subscript uc to I^* denotes unconstrained firms.

For the firms facing a binding credit constraint the standard price and output variables are not likely to be important in the investment function. Theoretical literature has identified two alternative ways of modeling investment decision under credit constraint for empirical estimation. First, the investment function of a firm facing binding credit constraint can be derived, given some restrictions on functional forms, from the closed form solution of the firm's optimization problem (Chatelain, 2000). Alternatively, the investment function of a constrained firm can be specified by parameterizing the Lagrange multiplier associated with the binding credit constraint. Indeed, parameterization of the Lagrange multiplier has been utilized widely for the estimation of the investment function using firm level panel data (Schiantarelli, 1996 for a survey). However, as noted before, both of the approaches are subject to some caveats. To guard against the sensitivity of parameter estimates and to ensure the robustness of our results regarding the impact

[8] The use of public capital as an argument in the production function to study the complementarity between private and public investment was pioneered by Aschauer (1989).

[9] Although it is standard to assume a log-linear functional form, there is no clear justification for it. For a log-linear functional form to be valid, both the production and the demand functions need to be of Cobb-Douglas form. Also note that we are using a relative price variable instead of separate price variables r and w. This is done for two reasons. First, it reduces the number of parameters to be estimated and also minimizes the problem of potential collinearity problem among the price variables. Second, the relative cost of capital seems to be the appropriate variable given our focus on the effects of liberalization on the choice of technique, i.e., the optimal capital-labor ratio.

[10] A similar approach is followed by Guncavdi et. al. (1998).

of liberalization on private investment, we estimate three different specifications of the investment function.

According to the closed form solution of a constrained firm's optimization problem derived in Chatelain (2000), the investment of a credit constrained firm is a function of the change in credit from the banking sector and a measure of internal funds available to the firm, where both the variables are deflated by the price of capital.[11] The investment function for the credit constrained firm can be written as:[12]

$$I^*_{c,t} = \frac{(1-\tau)\left(P_t F\left(K,L,G\right) - w_t L_t - r_{t-1}B_{t-1}\right)}{P^k_t} + \frac{B_t - B_{t-1}}{P^k_t} \equiv H_t \tag{3}$$

where τ is the tax rate, B is credit to the private sector, P^k the price of capital goods, the subscripts $t, (t-1)$ denote time periods and subscript c in $I^*_{c,t}$ stands for constrained firms. Observe that the first term on the right hand side of the above equation is essentially the retained profit of the firm expressed in units of capital goods. As is clear from equation (3), the right hand side can be collapsed into a single measure of the availability of investment funds from both internal and external sources expressed in units of capital goods which we denote as H_t. Although this gives us a theoretically consistent specification for the investment behavior of the credit constrained firms, its empirical application often becomes difficult because of the 'near identity' problem. The problem of "near identity" arises because the actual investment undertaken by even an unconstrained firm may be, as a matter of accounting identity, equal to the sum of internal and external funds.[13] This implies that when an aggregate measure of investible funds is used in the private investment function, the estimating equation may behave almost like an accounting identity, as the availability of investment funds *alone* accounts for a large share of the variations in private investment. This may render the other variables of interest like income (aggregate demand) and relative cost of capital statistically insignificant.

[11] Observe that even when the change in credit or measures of internal funds have been used in the literature, they are NOT deflated by the price of capital.

[12] This is essentially equation (17) in Chatelain (op cit) where both sides of the equation have been multiplied by $K_{i,t-1}$. This specification is derived by using first order Taylor series expansion and under the assumption of negligible adjustment costs.

[13] The accounting identity relating aggregate private investment and total investible funds of the private sector is, however, not exact due to the fact that some of the credit usually goes to finance working capital, hence it is called "Near Identity".

For the estimation of the parameters of the investment function, different researchers have used different indicators of a firm's financial status to parameterize the Lagrange multiplier associated with the credit constraint. There is a large empirical literature using panel data where the firms are split into separate groups based on some indicator of the likelihood of a firm being credit constrained, for example, cash flow or internal net worth (for a survey, see Hubbard (1998)). In the literature on time series estimation of private investment functions, especially in the context of developing countries, the net credit to the private sector advanced by the banking sector has widely been used as an indicator of the degree of credit constraint. In the absence of clear theoretical and empirical guidance, some researchers have used the level of credit as an indicator of degree of credit constraint, while others have used the ratio of credit to GDP, or change in credit (see Rama (1993)). Chatelain (2000) shows that a theoretically consistent parameterization of the Lagrange multiplier associated with the binding credit constraint can be formulated in terms of the first differences of the variables determining the level of investment of both the constrained and unconstrained firms. This means that an array of variables including change in retained earnings, second difference of credit to the private sector, change in income, changes in input prices are needed to parameterize the Lagrange multiplier. However, the inclusion of such a large number of variables in the regression often leads to the problems of severe multicollinearity and over-parameterization of the investment function.[14] In order to tackle the multicollinearity problem, we estimated the first principal component (M_t) of the variables suggested by Chatelain (2000) approach to the parameterization of the Lagrange multiplier.[15] The investment function for the credit constrained firm, according to this 'Chatelain' formulation can be specified as:

$$I^*_{c,t} = \Psi(M_t); \quad \frac{\partial \Psi}{\partial M_t} > 0 \tag{4}$$

Note that the investment by a constrained firm is a positive function of the index of finance

[14] In fact, in case of India, the model can not be estimated because of the singularity of data matrix due to near-perfect collinearity when using the parameterization suggested in Chatelain (2000).

[15] The list of variables used for the estimation of principal components include change in retained earnings, second difference of credit to the private sector, inverse of change in income, changes in input prices, inverse of changes in stock of public capital, changes in black market exchange premia (an indicator of uncertainty). Note that we used the inverse of change in income and of change in infrastructure. The reason is that these two variables affect the excess demand for credit positively while the other three variables affect it negatively.

constraint, M_t. The intuition is that the excess demand for credit is a negative function of M_t, because each individual component of M_t relates negatively to the excess demand, *ceteris paribus*. For example, consider the inverse of change in GDP. A positive change in GDP, *ceteris paribus*, implies a stronger investment demand, and thus a higher excess demand for credit. So the inverse of change in GDP relates negatively to the excess demand in the credit market. Since the virtual[16] (or 'equilibrium') cost of capital consistent with the observed aggregate demand for credit is a positive function of the excess demand, and the investment demand is a negative function of the virtual cost of capital, we get a positive relationship between constrained investment and M_t.

A second parameterization of the Lagrange multiplier which is both intuitive and parsimonious can be formulated in terms of the ratio of total investible funds (retained earnings plus change in credit, both deflated by the price of capital) to real GDP ($Z_t \equiv \frac{H_t}{Q_t}$). The rationale for this 'Cash Flow Ratio' parameterization is that the excess demand for credit by the private sector is, *ceteris paribus*, a negative function of the total available investible funds (H_t) and a positive function of aggregate demand, proxied by GDP (Q_t) and thus is a negative function of Z_t. By exactly the same logic as in the case of M_t, this specification implies a positive relationship between investment by the constrained firms and 'Cash Flow Ratio' Z_t.

$$I^*_{c,t} = \Gamma(Z_t); \quad \frac{\partial \Gamma}{\partial Z_t} > 0 \tag{5}$$

The advantage of this 'Cash Flow Ratio' specification is that it avoids both the near identity and multicollinearity problems and also relates more closely to the available estimates from time series studies which used net private credit as an indicator of credit constraint.

Denoting Ω_t as a vector of variables determining the investment by constrained firms and assuming linear specifications for the investment functions of both the constrained and uncon-

[16] In the sense of Neary and Roberts (1980).

strained firms, the aggregate investment function can be specified as follows:

$$\begin{aligned} I_t^* &= \lambda I_{uc,t}^* + (1-\lambda) I_{c,t}^* \\ &= \lambda \left\{ \tilde{\beta}_0 + \tilde{\beta}_1 Q_t + \tilde{\beta}_2 \left(\frac{r_t}{w_t} \right) + \tilde{\beta}_3 G_t \right\} + (1-\lambda) \left\{ \tilde{\varphi} \Omega_t \right\} \\ &= \zeta_0 + \beta_1 Q_t + \beta_2 \left(\frac{r_t}{w_t} \right) + \beta_3 G_t + \varphi \Omega_t \qquad (6) \end{aligned}$$

where

$$\zeta_0 \equiv \lambda \tilde{\beta}_0 \qquad (7)$$

and λ and $(1-\lambda)$ are the proportions of unconstrained and constrained firms in the economy respectively. The variable determining investment by credit constrained firms, Ω_t,is assumed to have three different specifications $(H_t, \Psi(M_t), \text{or } \Gamma(Z_t))$. The vector $\tilde{\beta}$ and $\tilde{\varphi}$ in equation (6) denote the (deep) parameters of the aggregate investment function.[17] Note that the treatment of ζ_0, β and φ as parameters constant across the sample period depends on the validity of the implicit assumption that the proportions of constrained and unconstrained firms remain relatively stable over the entire sample period. However, the hypothesis that liberalization might have resulted in a significant relaxation (or tightening) of credit constraint faced by the private entrepreneurs implies that the value of $(1-\lambda)$ will be significantly smaller (or higher) in post liberalization period. Such compositional changes are allowed for in the empirical implementation of the model by using appropriate slope and intercept dummies. Also, observe that, strictly interpreted, the model derived in equation (6) allows for changes in price response (with respect to the relative cost of capital $\frac{r}{w}$) only through a change in the proportion of unconstrained firms in the economy. However, such an interpretation will be too restrictive, especially in the context of India where the main impetus to an improved price response is likely to come from the freedom of investment decisions (in the choice of both input proportions and technology) after the demise of License Raj. This can be modelled as access to an expanded technology set, to be captured by a

[17]In the above formulation, the credit constraint is assumed to be binding for a subset of firms in the economy even in the long run. We believe, this is consistent with the experience of developed countries like USA characterized by complete freedom of private entrepreneurial activity and a well developed financial and capital market; there is overwhelming evidence of a subset of firms being credit rationed due to moral hazard and adverse selection (See Hubbard (1998)).

change in the production parameters $\tilde{\beta}$, after economic liberalization. [18] As noted earlier, the technological upgrading can also take the form of a shift in the intercept of investment function ζ_0. However, given the formulation in equation (6), it is, in general, not possible to disentangle the effects of changes in proportions of constrained and unconstrained firms from the effects of a pure technological shift.

Equation (6) gives us the basic specification for aggregate private investment. However, we need to augment the specification to incorporate the implications of uncertainty for private investment behavior. The theoretical analysis of the effects of uncertainty on investment, however, does not yield any unambiguous prediction. On the one hand, the option value of waiting for arrival of new information before committing to irreversible investment implies that the actual investment will be less than the level predicted by simple neoclassical model (Dixit and Pindyck, 1994). However, as pointed out by Abel and Eeberley (1996), there are both a call option (limited liability to expand capital stock) and a put option (limited liability to contract capital stock) involved in the irreversible investment decision, and *á priori*, the net effect is ambiguous. Since there is no unambiguous theoretical prediction regarding the investment uncertainty relationship, it is ultimately an empirical issue. In the context of developing countries, much recent effort has gone into understanding the effects of uncertainty on private investment (for example, Rodrik (1991), Aizenman and Marion (1993), Bleaney and Greenaway (2001)). We use black market exchange rate premium as a proxy for uncertainty regarding returns to domestic investment. In the presence of uncertainty about the future stream of income generated by an irreversible investment in the real sector of the domestic economy, foreign exchange holding (which is essentially perfectly reversible) can become an attractive portfolio choice. Thus the demand for foreign exchange in the black market (and hence the black market premium) responds positively to uncertainty about domestic economy (see Van Wijnbergen, 1985 and Rodrik, 1991). Also, observe that black market premium is a portmanteau statistic for uncertainty about domestic investment covering uncertainties emanating from price and exchange rate fluctuations, from lack of government policy credibility and also from insecurity regarding the claim to property rights due to predation by government or private Mafia.

[18] The constraints on capacity expansion, input and output mix and technology import were tantamount to assuming that only a subset of the production set was effectively available to the Indian private entrepreneurs.

We use the logarithm of the first principal component of four types of infrastructure (length of paved road, length of rail track, electricity generation capacity, and number of telephone connections) as an index of stock of public infrastructure.[19] Assuming homogeneous specifications for the functions $\Psi(M_t) = \sigma M_t$ and $\Gamma(Z_t) = \rho Z_t$, the final specification of the aggregate investment function for three alternative models can be written as follows:

$$\begin{aligned}
(1)I_t^* &= \zeta_0 + D + \beta_1 Q_t + \beta_2\left(\frac{r_t}{w_t}\right) + \check{\beta}_2\left(D * \frac{r_t}{w_t}\right) + \beta_3 G_t + \varphi H_t \\
&\quad + \check{\varphi}\left(D * H_t\right) + \theta_1 J_t + \upsilon_t \qquad \text{(Total Cash Flow Specification)} \qquad (8) \\
(2)I_t^* &= \zeta_0 + D + \beta_1 Q_t + \beta_2\left(\frac{r_t}{w_t}\right) + \check{\beta}_2\left(D * \frac{r_t}{w_t}\right) + \beta_3 G_t + \theta M_t \\
&\quad + \check{\theta}\left(D * M_t\right) + \theta_1 J_t + \upsilon_t \qquad \text{(Chatelain Specification)} \qquad (9) \\
(3)I_t^* &= \zeta_0 + D + \beta_1 Q_t + \beta_2\left(\frac{r_t}{w_t}\right) + \check{\beta}_2\left(D * \frac{r_t}{w_t}\right) + \beta_3 G_t + \delta Z_t \\
&\quad + \check{\delta}\left(D * Z_t\right) + \theta_1 J_t + \upsilon_t \qquad \text{(Cash Flow Ratio Specification)} \qquad (10)
\end{aligned}$$

where J_t is black market exchange rate premium and D is the dummy for liberalization taking one for the years 1991-1992 to 1998-1999 and zero otherwise, $\theta = \varphi\sigma$, $\delta = \varphi\rho$ and υ_t is the error term. In terms of equations (8), (9) and (10), a higher price response after liberalization implies that $\check{\beta}_2 < 0$ and a relaxed credit constraint implies that $\check{\varphi}, \check{\theta}, \check{\delta} < 0$. Thus equations (8), (9) and (10) form the basis of our empirical analysis.

Section 2: Empirical Analysis

In the empirical analysis we employ ARDL approach due to Pesaran and Shin (1999) for estimation of the long run investment function. An important advantage of ARDL approach to the estimation of a cointegrating vector is that it corrects for endogeneity of the explanatory variables. In the aggregate investment model developed above, the finance constraint variable Z_t and H_t may be (at least partly) endogeneous given the fact that, for the unconstrained firms, the observed amount of investment funds will be determined by their demand function.[20] The other nice feature of the ARDL approach is that it obviates the need for determining the order

[19] Logarithm of index of stock public infrastructure capital is taken to allow for possible non-linearity (decreasing returns) in the relationship between private investment and public capital, as posited in the theoretical model.

[20] Of course, if most of the firms are credit constrained, then the potential endogeneity is negligible.

of integration of the individual data series, and thus can avoid the uncertainties involved in the unit root pretesting (see Maddala and Kim, 1998, for a discussion on the problems associated with unit root pretesting). Also, there is evidence that the ARDL estimator has desirable small sample properties (see, for example, Caporale and Pittis (1999) and Pesaran and Shin (1999)).

Since the ARDL approach to the estimation of a long run relationship (cointegrating vector) and related bounds tests for the existence of a cointegrating relationship do not require any unit root pre-testing, we start with a brief discussion of the bounds tests (Pesaran, Shin and Smith (2001)). The evidence clearly shows that there is no problem of autocorrelation in any of the possible alternative specifications of the deterministic part, and we perform the bounds tests for all different specifications except for the unrestricted trend case. Since a quadratic trend seems implausible in the data, we exclude the case of an unrestricted trend as argued by Pesaran et. al. (2000). The results on the bounds 'F' tests for the existence of a cointegrating relationship are reported in appendix table A1. The results clearly show the existence of a long run relationship among the variables of the investment model.[21] The null hypothesis of no long run relationship (no cointegration) is rejected at 1 percent significance level across all the different specifications of the deterministic part, with the exception of two cases where the null is rejected at 5 percent level (they are: (i) the unrestricted intercept with no trend for Cash Flow Ratio model, and (ii) the unrestricted intercept with restricted trend for Total Cash Flow model, both at lag order 3).

Estimation of the Long Run Investment Function

Table (1) presents the results of the estimation of equations (8), (9) and (10) using ARDL method for the sample period (1953-99). To save space, we present the results from the ARDL specifications chosen by the Schwartz Bayesian information criterion only.[22] The residuals from the ARDL models selected by the SBC are well behaved. In particular, the results of F test for autocorrelation show that the null of no autocorrelation can not be rejected at 10 percent for all the different specifications.

[21] We do not test for the exact number of long run relations, as the ARDL approach (or other single equation methods like FMOLS estimator of Phillips and Hansen and the DOLS estimator of Stock and Watson) gives efficient estimate of a cointegrating vector even when there are multiple long run relations if there are no cross equation restrictions (Caporale and Pittis (1999). See also Phillips (1991)).

[22] One important advantage of using SBC rather than AIC is that it usually picks up a lower lag order which conserves degrees of freedom.

The first striking thing to notice is that different specifications of the investment functions provide conflicting evidence regarding the extent of credit constraint, especially for the post-liberalization period. In all three specifications of the investment function, the credit constraint variable has consistently positive coefficient indicating the existence of a binding credit constraint. However, according to the specifications based on the parameterization of the Lagrange multiplier ['Cash Flow Ratio Specification' (column 2 in table 1) and 'Chatelain Specification' (column 3)], credit constraint has not been statistically important during the pre-liberalization period (P-value of 0.78 and 0.23 respectively) . The specification based on the closed form solution ('Total Cash Flow Specification' in column 4), in contrast, suggests a statistically significant credit constraint during the pre-liberalization period (P-value$= 0.02$). Similar conflicting evidence emerges from these three specifications regarding the effect of liberalization on credit constraint faced by the firms. The slope dummy for credit constraint is statistically significant in all three specifications with P values of 0.001 (Cash Flow Ratio), 0.002 (Chatelain), and 0.00 (Total Cash Flow). However, the sign of the coefficient of the slope dummy for credit constraint is positive according to the Chatelain specification and negative according to the Cash Flow Ratio and Total Cash Flow specifications. The latter two specifications defined on the basis of cash flow indeed suggest a complete relaxation of credit constraint during the post liberalization period.[23] In contrast, the Chatelain specification represented by the first principal component of the first differences of the relevant variables indicates a significant tightening of the credit constraint during the post liberalization period. Thus the evidence does not allow us to reach any unambiguous conclusion regarding the effect of liberalization on credit constraint in the case of India. As already noted in the preceding section, all three specifications of the investment function estimated in table 1 are theoretically consistent, yet they produce conflicting evidence. This highlights the need for more detailed empirical investigation as well as the pitfalls in relying on the results from any single specification. A clear lesson is that one needs to be careful about ensuring the robustness of results regarding the effect of a credit constraint by using different theoretically consistent specifications.

[PLEASE INSERT TABLE (1) HERE]

[23] As evident from Table 1 column 2 and 4, the magnitude of the coefficient of slope dummy is larger than or equal to that of the coefficient of credit constraint variable itself.

The evidence in favor of a desirable effect of liberalization on price response, in contrast, is very strong. The slope dummy for the relative cost of capital is statistically highly significant with a P value of 0.00 across all three specifications of the investment function. The coefficient of the slope dummy is also numerically large in magnitude [-1.41 (Cash Flow Ratio), -0.85 (Chatelain), -1.60 (Total Cash Flow)]. In contrast, the relative cost of capital itself ($\frac{r}{w}$) has a much weaker effect: the coefficient is numerically small (-0.31 (Cash Flow Ratio), -0.14 (Chatelain), -0.15 (Total Cash Flow)) with P-values equal to 0.001 (Cash Flow Ratio), 0.11 (Chatelain) and 0.08 (Total Cash Flow) respectively. The evidence thus suggest the existence of a very weak price response in the choice of technique before the economic liberalization in 1991-1992. This is not at all surprising given the pervasiveness of controls on the private investment in India under the 'License Raj'. The estimates imply a dramatic increase in the price response after liberalization. For example, the estimates for the Cash Flow Ratio specification imply that the strength of the response of aggregate private investment with respect to the relative cost of capital has increased approximately by five times after the dismantling of the control system over private sector. The estimates for the other specifications are even larger [six times (Chatelain) and eleven times (Total Cash Flow)]. This is a remarkable testimony in favor of the agility of the private entrepreneurs in face of changing relative cost of capital. Also, observe that this price response can not be attributed completely to an increase in the proportion of unconstrained firms in the economy; the price response has increased by six times even in the specification (Chatelain) which indicates an increase in the proportion of constrained firms during the post liberalization period. This implies that the firms have responded vigorously to the new-found freedom of business decision making not only through substitutions between capital and labor, but also by upgrading the technology.

The results reported in table 1 also provide strong evidence in favor of a significant technological shift in the private sector production function after the liberalization of 1991-92. The intercept dummy has a positive coefficient and is statistically highly significant with a P-value of 0.00 across all three specifications of the investment function. As noted in equation (7), a significant upward shift in the intercept dummy can result from a pure technological shift in the production function or from an increase in the number of unconstrained firms or from a combination of both. None of the specifications estimated in table 1 allow us to isolate the extent of shift in intercept term due to the technological upgrading from that due to a change in the number of unconstrained firms, but they help to determine the direction of these shifts. We notice in table 1 that the estimates from the Chatelain specification imply an increase in the number of constrained firms during the post liberalization period. Even in this specification, the intercept dummy has a positive coefficient though its magnitude is smaller compared with the estimates from other two specifications. Note also that the intercept dummy is also statistically highly significant [t-value= 4.58]. Thus one can safely argue that the evidence clearly indicates a positive shift in the private sector production function in the post liberalization period. This finding is consistent with the available evidence from micro studies using firm level data which reported significant improvement in technological efficiency of the firms during the post liberalization period (see, for example, Forbes, 2001).

As to the other determinants of aggregate private investment, all three specifications tell a consistent story. The level of GDP has a numerically large and statistically significant positive effect on private investment suggesting a strong accelerator mechanism at work. Uncertainty as captured by black market exchange rate premium has a negative effect across all three specifications. The coefficient of the index of public infrastructure capital has a consistent positive sign across all specifications indicating possible complementarity with private investment. However, the coefficient is not statistically significant even at 10 percent.

As a further test of the robustness of our results, we estimated all three specifications of the investment function for three different sample periods (1953-99 reported in table 1, 1955-99 and 1960-99). The estimates for 1955-99 are similar to that for 1953-99 and are omitted for brevity. The estimates for 1960-99 are reported in table 2. It is interesting and reassuring to note that our central result regarding the dramatic increase in the price response remains nearly unchanged. In the specifications based on the parameterization of the Lagrange multiplier (Cash Flow Ratio and Chatelain), the estimates for the coefficients of the relative cost of capital ($\frac{r}{w}$) and its slope dummy are approximately same as those reported in table 1 for the sample period 1953-99. The estimates for 1960-99 imply an increase in price response during the post liberalization period ranging from 4.6 to 6 times. However, the estimates for the Total Cash Flow specification imply a much larger increase in price response (14 times) compared with that implied by the estimates for

1953-99 sample (11 times). Similar to the results for the1953-99 sample, the estimates of different specifications of the investment function for 1960-99 provide conflicting evidence regarding the effect of liberalization on credit constraint. The evidence from the 1960-99 sample on the effects of liberalization on the technological upgrading is consistent with that from 1953-99 sample. The estimates of the coefficient of the intercept dummy across different specifications imply a significant upward shift in the intercept term indicating improved technological efficiency during the post liberalization period. Thus our main results regarding the impact of liberalization remain equally valid for the 1960-99 sample. A comparison of the estimates in table 1 and 2 shows that the estimates of the coefficient vector for 1953-99 and 1960-99 differ substantially only in the case of Total Cash Flow specification. For instance, the coefficient of GDP becomes much smaller (0.07 for 1960-99 sample compared with 0.11 for 1953-99 sample) and statistically insignificant (t-value = 1.58 compared with $t = 3.24$ for 1953-99). The insignificance of GDP is not surprising as the Total Cash Flow specification is subject to the 'near identity' problem mentioned earlier.

[PLEASE INSERT TABLE 2 HERE]

An important concern, especially from the policy perspective, is the potential instability of the estimated coefficients of the private investment function. However, the results, especially regarding the effects of liberalization on price response and technical efficiency, are remarkably consistent across different sample periods, and thus provide us with strong indications that the estimated parameters are not fragile. As additional checks, we implemented four different sets of stability tests: CUSUM, CUSUMSQ, Rolling Regression, and Recursive Estimation. We present the detailed results from only CUSUM and CUSUMSQ tests. The Figure 1 presents the CUSUM and CUSUMSQ tests estimated for the sample period 1953-1999 for all three specifications. The results show that there is no instability problem with any of the specifications. The results of the CUSUM and CUSUMSQ tests for the other sample periods are similar and thus omitted. [24] The results on the stability of each individual coefficients from the Recursive Estimation and Rolling Regression corroborate the evidence from the CUSUM and CUSUMSQ tests reported here and

[24] There is some indication of instability for the Total Cash Flow Specification from the CUSUMSQ test for the 1960-1999 sample

are not reported for the sake of brevity. [25]

[PLEASE INSERT FIGURE 1 HERE]

Elasticity Estimates

To get a feel of the relative effects of different factors influencing aggregate private investment in India, table (3) presents estimates of elasticities calculated at mean. The estimates clearly show that the elasticity of aggregate private investment with respect to the relative cost of capital ($\frac{r}{w}$) is very high in the post-liberalization period. Even if one focuses on the most conservative estimate (Chatelain specification), a 1 percent increase in the relative cost of capital decreases investment by approximately 0.91 percent. This evidence cautions us about the potentially strong negative effects of a significant increase in the lending interest rate charged by the banking sector. Since the user cost of capital incorporates the effects of the price of capital along with the interest rate, this also implies that a rise in the price of capital, for example, due to a large depreciation of rupee, can have significant adverse effect on aggregate investment in India.[26]

The negative effect of uncertainty as represented by black market exchange rate premium is, however, not large in magnitude; a one percent increase in the black market exchange premium lowers private investment only by 0.07 percent, even if one uses the highest estimate. This muted effect of uncertainty is not totally unexpected, as the effect is not unambiguous on *á priori* grounds also.[27] We take a cautious approach to the estimates of elasticities with respect to other policy relevant variables presented in table 3 either because, contrary to the widely held prior expectation, the variable in question has statistically insignificant impact (e.g. public infrastructure) or the sign of the coefficient changes across specifications (e.g. credit constraint). Thus it would be premature to draw any firm conclusions about the extent of their effects on private investment in India without further research.

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[25] The results of Rolling Regressions and Recursive Estimation for each individual coefficient in all three models are available from the authors.

[26] An increase in the price of capital will have especially depressing effect on the current investment if the price of capital is expected to come down subsequently. This is so because in this case the expectation of a capital loss reinforces the disincentive created by the higher current price of capital.

[27] The black market exchange premium also captures, at least in part, the effects of international trade distortions on domestic private investment. The evidence thus shows that there is a negative, albeit small, effect of trade distortions on aggregate private investment in India.

[PLEASE INSERT TABLE 3 HERE]

Conclusions

Using three alternative models of aggregate private investment that incorporate the behavior of both credit constrained and unconstrained firms in a theoretically consistent manner, this paper presents evidence on the effects of the economic liberalization of 1991-92 on the aggregate private investment in India. The empirical results, using ARDL approach to the estimation of a cointegrating vector, show that the response of private investment with respect to relative cost of capital has improved dramatically following the liberalization. While the response to a change in relative cost of capital was very weak in pre-liberalization period, it has increased by at least 4.6 times after liberalization, the most conservative elasticity estimate being -0.91 for the post-liberalization period. This implies that an increase in the lending interest rate or price of capital is likely to have significant adverse impact on private investment and thus on economic growth. The evidence also indicates a significant improvement in technological efficiency of the firms during post-liberalization period. These evidence attest to the remarkable agility of the Indian firms in taking advantage of the opportunities presented by the dismantling of the License Raj after 1991-92.

The negative effect of uncertainty as measured by the black market exchange rate premium, however, seems to be numerically small, although statistically significant. While the estimates imply a complementary relationship between the stock of public infrastructure capital and private investment in India, the relationship is rather tenuous and statistically insignificant. Estimates from different theoretically consistent specifications of the investment function provide conflicting evidence on the severity of credit constraint during pre- and post- liberalization periods. Thus no robust conclusion can be drawn about the impact of liberalization on the extent of credit constraint faced by the firms. Our empirical analysis thus shows that the conclusion about the extent of credit constraint may be sensitive to the specification of the investment model and highlights the pitfalls in relying on any given specification. The results bring into focus the need for robustness checks using alternative theoretically consistent specifications of private investment under credit constraint.

Appendix:

Bounds Tests

[PLEASE INSERT TABLE A1 HERE]

Data Sources and Variable Definitions

The data used in this paper were taken from Economic Survey (Government of India), International Financial Statistics (IMF), Statistical Yearbook (UN), Key Indicators of Developing Asian and Pacific Countries (ADB), Chandhok (1990), Canning (1998), Mallick and Kuma (1995), CIA Database, Statistical Yearbook for Asia and the Pacific (UN), and Singh, V.B. (1963).

I = Aggregate private investment in local currency (Rupee) deflated by the price of capital (gross domestic capital formation deflator).

Q = Gross Domestic Product (GDP) in Rupee deflated by GDP deflator.

r/w = Ratio of real user cost of capital and real wage in the manufacturing sector. The nominal user cost of capital and nominal wage are deflated by GDP deflator. The nominal user cost of capital at time t is defined as:

Price of capital(t) [lending rate (t) + 0.04 {1+lending rate(t)} -expected Capital Gain (t)]. With the assumption of perfect foresight, expected capital gain (t) is calculated as [Price of capital (t+1)-Price of capital (t)]/Price of capital (t)]. The main results of the paper are robust to alternative assumptions of expectations formation including static expectations and a fixed parameter AR model based estimate of expected capital gains. Also, the results are not sensitive with respect to the alternative assumption regarding depreciation rate.

G = log of Public capital stock represented by the first principal component of KW of electricity generating capacity, Rail route length in KM, Number of telephones, and Paved road length in KM.

H(t)=(Retained earnings (t) +Change in credit (t)) / Price of Capital (t).

Z= H (t) / Q (t).

M=first principal component of of first differences in total investible fund (retained earning plus change in credit both deflated by price of capital), inverse of change in real GDP, change in relative cost of capital, inverse of change in public infrastructure and change in black market exchange premia.

J = Black market exchange rate premium.

D = Dummy variable. D is 1 for the post liberalization period (1992-1999) and zero otherwise.

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Table 1: Estimated Long Run Coefficients using the ARDL Approach
ARDL Model selected by Schwartz Baysian Information Criterion
Sample : 1953-99

	Parameterization of Lagrange Multiplier for credit constraint		Closed form Solution for credit constraint
Regressor	Cash Flow Ratio[a]	Chatelain Specification[b]	Total Cash Flow[c]
GDP	0.196 (13.27) [0.000]	0.157 (9.56) [0.00]	0.110 (3.24) [0.003]
Relative Cost of Capital	-0.308 (-3.56) [0.001]	-0.136 (-1.66) [0.11]	-0.149 (-1.79) [0.083]
Slope Dummy for Relative Cost of Capital	-1.412 (-4.56) [0.000]	-0.845 (-3.90) [0.00]	-1.60 (-6.17) [0.00]
Credit Constraint	0.004 (0.35) [0.78]	0.001 (1.23) [0.23]	0.069 (2.40) [0.022]
Slope Dummy for credit Constraint	-0.350 (-3.57) [0.001]	0.012 (3.28) [0.002]	-0.096 (-4.17) [0.00]
Public Infrastructure Capital	0.661 (1.54) [0.13]	0.58 (1.27) [0.21]	0.469 (1.20) [0.24]
Black market Exchange Premium	-0.130 (-2.76) [0.009]	-0.078 (-1.68) [0.10]	-0.11 (-2.49) [0.02]
Intercept Dummy	584033 (4.14) [0.00]	143241 (4.58) [0.00]	322627 (6.34) [0.00]

Note: t-ratios are reported in first parentheses under the coefficient and p-values are in square bracket.
a: Cash flow ratio is equal to the ratio of total investible fund (retained earnings plus change in credit, both deflated by the price of capital) to real GDP.
b: Chatelain specification:1st Principal component of first differences in total investible fund (retained earning plus change in credit both deflated by price of capital), inverse of change in real GDP, change in relative cost of capital, inverse of change in public infrastructure and change in black market exchange premia.
c: Cash flow is equal to total investible fund ((retained earnings plus change in credit, both deflated by the price of capital).

Table 2: Estimated Long Run Coefficients using the ARDL Approach
ARDL Model selected by Schwartz Baysian Information Criterion
Sample : 1960-99

	Parameterization of Lagrange Multiplier for credit constraint		Closed form Solution for credit constraint
Regressor	Cash Flow Ratio[a]	Chatelain Specification[b]	Total Cash Flow[c]
GDP	0.196 (11.52) [0.000]	0.156 (8.40) [0.00]	0.071 (1.58) [0.125]
Relative Cost of Capital	-0.313 (-2.95) [0.006]	-0.142 (-1.50) [0.14]	-0.107 (-1.20) [0.24]
Slope Dummy for Relative Cost of Capital	-1.418 (-4.18) [0.000]	-0.843 (-3.56) [0.001]	-1.62 (-6.15) [0.00]
Credit Constraint	0.003 (0.23) [0.78]	0.014 (1.27) [0.22]	0.120 (2.79) [0.01]
Slope Dummy for credit Constraint	-0.350 (-3.29) [0.005]	0.117 (3.00) [0.005]	-0.11 (-4.42) [0.00]
Public Infrastructure Capital	0.72 (0.74) [0.47]	0.852 (0.81) [0.43]	-0.45 (-0.53) [0.60]
Black market Exchange Premium	-0.135 (-2.36) [0.025]	-0.079 (-1.42) [0.17]	-0.127 (-2.50) [0.019]
Intercept Dummy	588015 (3.81) [0.001]	143006 (4.18) [0.00]	336054 (6.41) [0.00]

Note: t-ratios are reported in first parentheses under the coefficient and p-values are in square bracket.
a: Cash flow ratio is equal to the ratio of total investible fund (retained earnings plus change in credit, both deflated by the price of capital) to real GDP.
b: Chatelain specification:1st Principal component of first differences in total investible fund (retained earning plus change in credit both deflated by price of capital), inverse of change in real GDP, change in relative cost of capital, inverse of change in public infrastructure and change in black market exchange premia.
c: Cash flow is equal to total investible fund (retained earnings plus change in credit, both deflated by the price of capital).

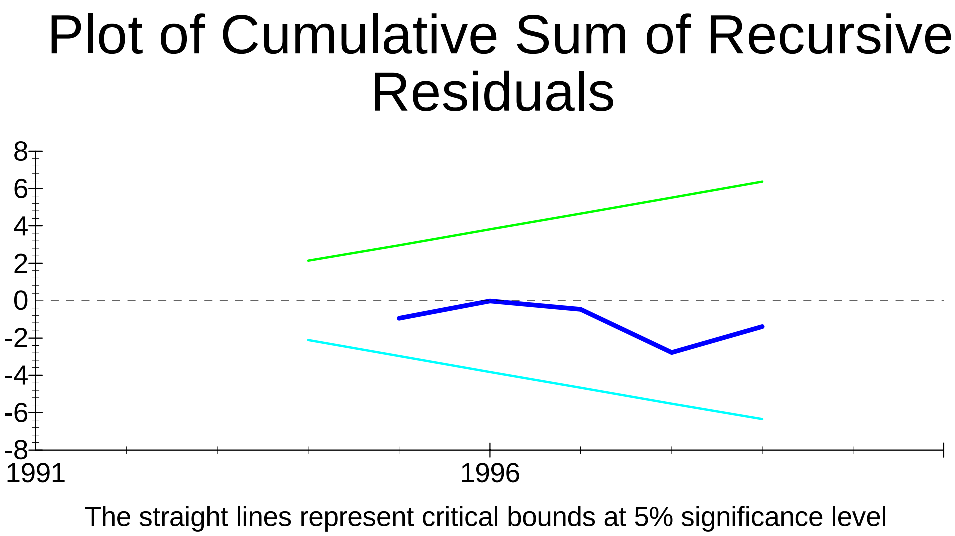
Table 3

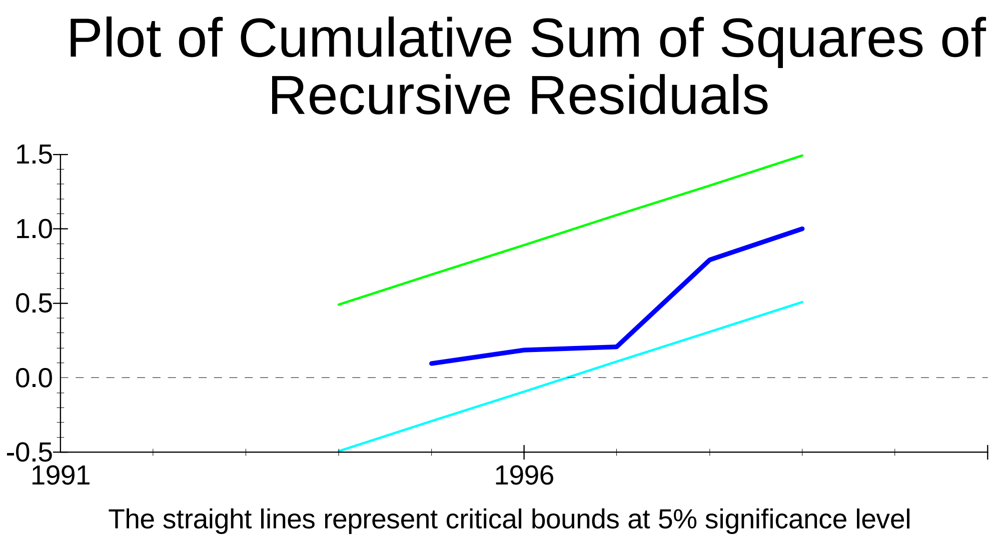
ELASTICITY ESTIMATES

	Parameterization of Lagrange Multiplier for credit constraint				Closed form Solution for credit constraint	
	Cash Flow Ratio[a]		Chatelain Specification[b]		Total Cash Flow[c]	
	1953-99	1960-99	1953-99	1960-99	1953-99	1960-99
GDP	1.35	1.32	1.08	1.05	0.76	0.48
Relative Cost of Capital (Pre-reform)	**-0.28**	**-0.29**	**-0.13**	**-0.13**	**-0.14**	**-0.10**
Relative Cost of Capital (Post-reform)	**-1.58**	**-1.60**	**-0.91**	**-0.91**	**-1.61**	**-1.60**
Credit Constraint (Pre-reform)	0.07	0.05	0.003	0.001	0.52	0.89
Credit Constraint (Post-reform)	-6.07	-5.34	0.03	0.001	-0.21	0.05
Public Infrastructure Capital	0.10	0.10	0.09	0.12	0.07	-0.06
Black Market Exchange Premium	-0.07	-0.07	-0.04	-0.04	-0.06	-0.06

Note: a: Cash flow ratio is equal to the ratio of total investible fund (retained earnings plus change in credit, both deflated by the price of capital) to real GDP.
b: Chatelain specification:1st Principal component of first differences in total investible fund (retained earning plus change in credit both deflated by price of capital), inverse of change in real GDP, change in relative cost of capital, inverse of change in public infrastructure and change in black market exchange premia.
c: Cash flow is equal to total investible fund (retained earnings plus change in credit, both deflated by the price of capital).

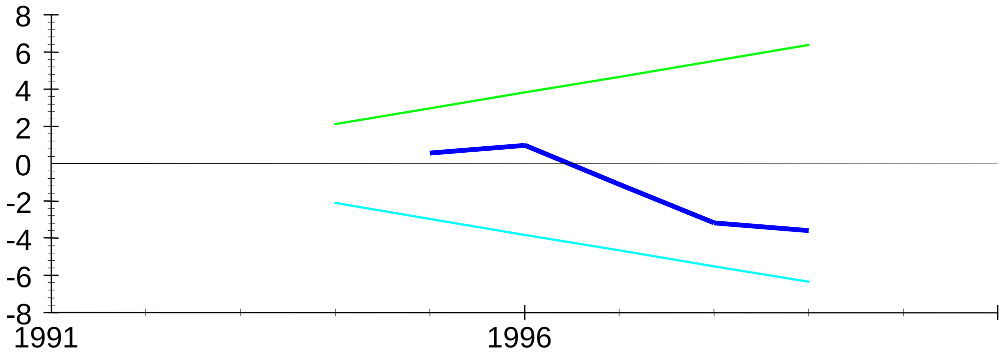
Figure 1: Cumulative Sum Tests
1953-99
A. Cash flow Ratio Specification





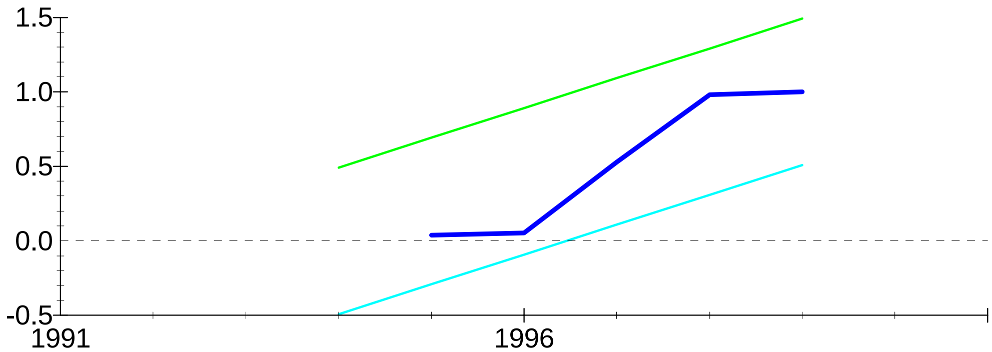
B. Chatelain Specification

Plot of Cumulative Sum of Recursive Residuals



The straight lines represent critical bounds at 5% significance

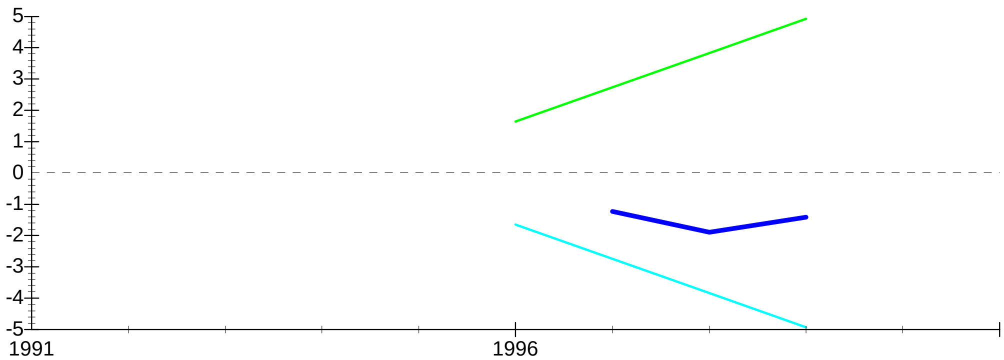
Plot of Cumulative Sum of Squares of Recursive Residuals



The straight lines represent critical bounds at 5% significance level

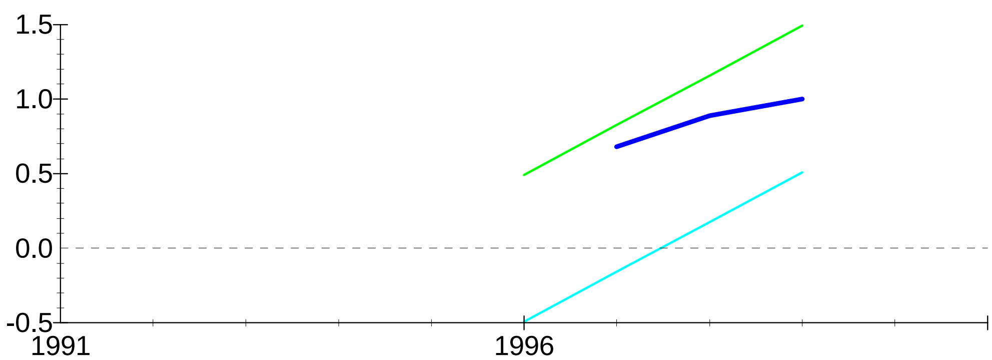
C. Total Cash Flow Specification

Plot of Cumulative Sum of Recursive Residuals



The straight lines represent critical bounds at 5% significance level

Plot of Cumulative Sum of Squares of Recursive Residuals



The straight lines represent critical bounds at 5% significance level

Table A.1: BOUNDS TESTS FOR COINTEGRATION

F-Statistics for Testing the Existence of an Investment Equation:1953-99

Cash Flow Ratio

		Deterministic Part		
Lags	No Intercept No Trend	Restricted Intercept	Unrestricted Intercept	Restricted Trend
1	13.4434	14.7076	12.8887	13.7098
2	5.1843	4.5001	5.1011	4.4642
3	5.0844	4.3337	4.9696	5.3639

Chatelian Specification

		Deterministic Part		
Lags	No Intercept No Trend	Restricted Intercept	Unrestricted Intercept	Restricted Trend
1	9.9046	8.5229	9.5586	8.2412
2	4.9841	4.8677	5.4300	4.3805
3	4.7756	4.3082	4.9125	4.6531

Total Cash Flow

		Deterministic Part		
Lags	No Intercept No Trend	Restricted Intercept	Unrestricted Intercept	Restricted Trend
1	14.2136	14.5459	16.0735	15.2135
2	7.5150	7.7717	8.6218	7.9363
3	6.8829	6.0985	6.7607	6.3062

F-Statistics for Testing the Existence of an Investment Equation :1960-99

Cash Flow Ratio

		Deterministic Part		
Lags	No Intercept No Trend	Restricted Intercept	Unrestricted Intercept	Restricted Trend
1	10.4919	11.9967	13.7030	11.6793
2	4.4346	4.6987	4.7387	4.3497
3	4.4396	4.9856	4.2539*	4.2436

Chatelian Specification

		Deterministic Part		
Lags	No Intercept No Trend	Restricted Intercept	Unrestricted Intercept	Restricted Trend
1	11.1851	9.7205	10.8003	9.4351
2	6.1677	5.8254	6.4556	6.0629
3	6.3508	4.0792	4.4019	8.3496

Total Cash Flow

		Deterministic Part		
Lags	No Intercept No Trend	Restricted Intercept	Unrestricted Intercept	Restricted Trend
1	11.4903	12.2919	13.6179	12.1475
2	5.8337	6.8397	5.3842	5.4762
3	4.8670	4.3789	4.6964	4.0200*

Note: The F statistics fall outside the upper bounds at 1 percent significance, except for the starred ones which are significant at 5 percent. The critical bounds from Pesaran et. al. (2001) at 1 percent are 2.54-3.91 (no intercept, no trend), 2.73-3.90 (restricted intercept), 2.96-4.26 (unrestricted intercept), 3.07-4.23 (restricted trend).