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Abstract

This study uses the extreme bounds analysis of Leamer (1983) to identify some robust determinants of the long-run growth rate in seven South-Asian countries. The relationships between the two are estimated using panel data. We also consider some methodological issues concerning the specification. It is argued that the frequently used specification of the growth equation by the cross-country studies is inappropriate for estimating the long-run or steady state growth effects of variables such as the investment ratio. We use an alternative specification. Since the steady state growth rate in theoretical growth models depends on total factor productivity (TFP), we estimate the long-run growth effects of variables by analysing the determinants of TFP. This approach is suggested by a few influential economists and has been used by Senhadji (2000).

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Keywords: South-Asian countries, Extreme bounds analysis, Long-run growth rate, Total factor productivity.

1. Introduction

Empirical growth equations select a few explanatory variables from a large list of potential growth affecting variables. However, this selection often is *ad hoc* and the results are likely to be sensitive to the selected variables. A solution to this problem is to use first the extreme bounds analysis (*EBA*) of Leamer (1983) to identify a few robust determinants of the growth rate and then estimate the growth equation with these robust variables. Levine and Renelt (1992) and Sala-I-Martin (1997a and 1997b) have shown how to identify such robust variables with *EBA.* We follow their procedures to identify the key determinants of the long-run growth rate for South-Asia. Our sample consists of data from seven South-Asian countries for the period 1970 to 2008. These are Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka and are selected for two reasons. Firstly, compared to panel data studies on the East-Asian countries, South-Asia has received relatively less attention and this paper partly fills this gap. Secondly, our approach and methodology differ from the existing procedures in the empirical growth literature. We shall argue that the specification and methodology in the existing cross-country studies are inappropriate for estimating permanent growth effects of explanatory variables. Therefore, it is appropriate to determine the robustness of the selected variables and then estimate the growth equations with the robust determinants. We illustrate the use of our approach and methodology for estimating the long-run and permanent growth effects of the determinants. We mean that the long-run and permanent growth effects are the same as the steady state growth rate (SSGR) of the theoretical growth models. These terms will be used synonymously in this paper.

The structure of this paper is as follows. Section 2 presents and discusses some key economic features of the South-Asian countries. Section 3 examines the methodological issues on the specification and estimation of cross-country growth equations. Section 4 consists of four subsections. Firstly, *EBA* is used to evaluate the robustness of explanatory variables. Secondly, estimates of the growth effects of selected determinants are presented in this section. Thirdly, the policy implications of our estimates are also discussed. Section 5 concludes. We use data from 1970 to 2008 in the empirical results.

2. Country Characteristics

South-Asia comprises a heterogeneous group of countries faced with a number of obstacles such as conflict, corruption and high fiscal deficits. An early phase of growth was initiated from 1950-1970 by planned industrialization based on a strategy of import substitution and widespread protection, which led to inefficiency and stagnation. A growth revival took place in 1980s and 1990s following a shift towards an export-led industrialization strategy. A series of economic reforms were undertaken under the auspices of the IMF and the World Bank in Sri Lanka in the 1970s, Bangladesh and Pakistan in the 1980s, India, Nepal and Bhutan in the in 1990s. Liberalisation involved trade and industrial sector reforms and financial sector deregulation. A number of direct export incentive schemes were introduced and foreign direct investment was encouraged through the establishment of export processing zones. There has also been a significant increase in migrant remittances with remittances being a main source of external financing into these economies following economic reform. In the years following liberalisation, the growth rates of these countries have accelerated, in particular, that of India.

Gross capital formation in these countries as a percentage of GDP has increased, and population growth has fallen over the 1990-99 to 200-08 period (see Table 1). Although inflation rates in South-Asia are relatively high, they remain below the developing country average (Devarajan and Nabi, 2006). There has in addition, been an increase in the female enrolment ratio leading to a narrowing of the differential between male and female enrolment ratios in the educational institutions over the 1970-2008 period. Given the progress made by this region in the recent past, we attempt to identify the variables that are robust in the growth performance of South-Asia.

Table 1: Some Country Characteristics

	GDP Per Capita Constant $US 2000	GDP per Capita Growth Annual %	Population Growth Rate %	Budget Deficit % of GDP	Gross Capital Formation % of GDP	Inflation %
Bangladesh						
1990-1999	284.2	2.7	2	-	19.1	5.5
2000-2008	390.2	4.1	1.7	0.82	23.7	6.0
Bhutan						
1990-1999	600.4	5.3	1	0.49	41.7	9.9
2000-2008	944.1	6.2	1.6	2.47	52.3	4.3
India						
1990-1999	367.7	3.8	2	2.81	23.7	9.5
2000-2008	565.4	5.8	1.3	3.07	31.3	4.8
Maldives						
1990-1999	1,959.6	-	2.5	6.13	31.8	-
2000-2008	2,784.1	5.0	1.2	7.01	32.5	7.3
Nepal						
1990-1999	198.4	2.0	2.0	-	22.6	9.6
2000-2008	236.0	1.7	2.0	1.16	25.2	5.4
Pakistan						
1990-1999	505.0	1.3	2.5	5.55	18.9	9.6
2000-2008	585.4	2.4	2.0	3.39	19.0	7.2
Sri Lanka						
1990-1999	693.0	4.4	1.0	6.35	24.8	11.2
2000-2008	990.7	4.1	0.88	7.36	25.1	11.6

Source: Calculated from World Development Indicators

3. Specification and Estimation

3.1 Introduction

In cross-country studies, the dependent variable usually is a five or ten-year average growth rate of per capita income. It is regressed on the initial level of per capita income, some selected variables with growth effects and control variables. The general form of the specifications in pure cross-section and panel data studies are as follows.

$$\Delta \ln y_{it} = \alpha + (1-\lambda)\ln y_{i0} + \beta X_{it} + \pi Z_{it} + \varepsilon_{it} \tag{1}$$

$$\Delta \ln y_{it} = \alpha + (1-\lambda)\ln y_{it-1} + \beta X_{it} + \pi Z_{it} + \varepsilon_{it} \tag{2}$$

where $\Delta \ln y =$ the average or annual growth rate of per capita income, $\ln y_{i0} =$ initial per capita income, $\ln y_{t-1} =$ one panel lagged level of per capita income, $X =$ set of explanatory variables of interest, $Z =$ control variables, and $\varepsilon =$ error term with the classical properties. The i and t subscripts are, respectively, for the cross-section and time series dimensions. For ease of exposition we assume that X and Z vectors consist of only one variable each.

Equation (1) is used in the pure cross-country empirical work, where the time series dimension is one. The dependent variable in (1) is the average growth rate over the whole sample period and X and Z are averages over the entire sample period. The well-known extension to the Solow model by Mankiw, Romer and Weil (1992, MRW) is based on this methodology and specification. Equation (2) is used in many panel data studies and this approach is now popular with the availability of software for estimation with panel data methods. The dependent variable is generally the average growth rate over a five-year period and the explanatory variables are average values over the five-year period. The lagged dependent variable $\ln y_{it-1}$ is the level of per capita income of the previous panel. The pioneering works of Islam (1995) and Barro (1996) are the earliest to use panel data methods to estimate growth equations.

3.2 Limitations

Some limitations in the existing empirical growth literature, based on equations (1) and (2), should be noted. Firstly, a drawback is that aggregation reduces variation in the variables along the time series dimension and may give implausible results. According to Zorn (2007, p. 9) "… it is almost always the case that disaggregated data can tell us things that aggregates cannot." For this reason there is support for panel data studies rather than pure cross-section studies. Secondly, a common criticism of cross country studies is their basic assumption that one size fits all. Thirdly, almost all cross country studies use *ad hoc* specifications, such as in (1) and (2), to estimate the growth effects of a few selected variables. Cross country studies explicitly claim that their objective is to estimate the long-run or the permanent growth effects of X, given that Z is the control variable. As stated before, it is reasonable to interpret this long-run or permanent growth rate as the steady state growth rate (*SSGR*) of theoretical growth models. If this is the main objective, a five-year or ten-year average growth rate is not a good proxy for the unobservable *SSGR*. Conceptually *SSGR* is similar to the natural rate of unemployment (*NRU*) and both are to be derived from the estimates of appropriate dynamic models by imposing the equilibrium or the steady state conditions. Proxying the *SSGR* with the annual or some average growth rate is similar to proxying the *NRU* with the current period or some average unemployment rate. Consequently, the growth effects of X will be overestimated in (1) and (2) because average growth rates will also be affected by transitory growth rates. These transitory growth rates may persist for some time because it takes decades for the economy to converge even by 50% towards its steady state level of income.[1] Although justification is offered for these specifications, there is confusion as to whether these are valid for estimating the actual growth rate or the effects of X on the *SSGR*. Fourthly, many empirical studies state that their specifications are based on some endogenous growth model. However, they are based on the extensions to the Solow (1956) exogenous growth model by MRW (1992), Islam (1995) and Barro (1996). In these three works the steady state solution for the *level* of per capita income (y^*) for the Solow model is derived first and next the partial adjustment equation is used to explain the actual rate of growth.[2]

$$\Delta \ln y_t = \lambda(y^* - y_t) \qquad (3)$$

[1] The justification for using an average growth rate to proxy the SSGR in the cross country studies is that this measure smooths business cycle fluctuations. If this argument is valid, then there is no need to estimate an expectations augmented Phillips curve to derive NRU because some average rate of unemployment that smooths the business cycle effects would also be a valid estimate of NRU.

For estimates on the speed of convergence, see Barro (1996), Sato (1963) and Rao (2006). However, the speed of convergence also depends on the method of estimation. In general, estimates with GMM seem to imply that convergence is faster than estimates with standard panel data methods.

[2] This is similar to $Dy = f(y,\ y^*)$ of equation (1) in Barro (1996).

With MRW's human capital augmented production function, y^* in the Solow model depends on the investment ratios of physical capital (s_K) and human capital (s_H). Therefore, it can be assumed that $y^* = \Phi(s_K, s_H)$. Equation (3) is estimated by MRW using cross-sectional data for the period 1960-1985 and a sample of 98 countries of both developed and developing countries. The change made by MRW is to replace the continuous time specification in (3) with the discrete time specification as follows.

$$(\ln y_t - \ln y_0) = -\lambda \ln y_0 + \Phi(s_{Kt},\ s_{Ht}) \tag{4}$$

where y_0 is income per worker in the initial year 1960. Therefore, the dependent variable is the proportionate change of per worker income over 1960-1985; see Table V in MRW (1992). This equation was used by MRW mainly to estimate the speed of convergence of incomes in developed and developing countries and not to estimate permanent growth effects of any variables such as s_K and s_H because these ratios have only permanent level effects and no permanent growth effects on output. Therefore, it is difficult to accept that permanent growth effects of variables can be estimated with the specification in (4) or its variants in several cross country studies including Islam (1995) and Barro (1996). Furthermore, following Barro, later cross country studies have added a number of additional variables, such as trade openness, financial development and institutional reform, to the Φ function as potential determinants of the steady state level of income. Justification for these additional variables is generally based on some form of endegenous growth model. Since the dependent variable is the rate of growth of output, estimates of (4) or similar equations are interpreted as growth equations and the coefficients of the explanatory variables as their permanent growth effects. However, it is difficult to accept these arguments because the main objective of MRW in estimating (4) was to test the convergence hypothesis.[3] The transient growth effects in (4) vanish when the economy reaches its steady state growth path. Therefore, this equation is not appropriate for estimating the permanent growth effects of X.

There are a few additional problems. Specifications derived from endogenous growth models are difficult to estimate because it is necessary to estimate a system of non-linear

[3] The convergence hypothesis is widely tested because its acceptance is seen to validate indirectly, the neoclassical growth models of Solow (1956), Swan (1956), Cass (1965) and Koopmans (1965) against the endogenous growth models of Romer (1986). Islam (1995) states this more explicitly.

dynamic equations with appropriate econometric techniques; see Greiner et. al., (2005) and Greiner and Semmler (2002). However, there is also no clear-cut evidence that endogenous growth models can explain observed facts better than simpler exogenous growth models based on Solow (1956); see Jones (1995) and Parente (2001). Rogers (2003) also observed that the older neoclassical growth theory continues to provide inspiration to cross-country studies. Barro (1996, p. 4) noted, “It is surely an irony that one of the lasting contributions of endogenous growth theory is that it stimulated empirical work that demonstrated the explanatory power of the neoclassical growth model.”

Different empirical studies select different explanatory variables from a large number of potential explanatory variables. Durlauf, Johnson, and Temple (2005) have found that the number of such potential growth improving variables used in various empirical works is as many as 145. There is no endogenous growth model in which the specification to estimate the permanent growth effects uses more than one or two growth enhancing and control variables. Additional explanatory variables are often included on a heuristic rather than a theoretical basis if they are supposed to have some potential externalities.

Cross-country studies also used different methods of estimation. Pure cross-section studies use *OLS* and panel studies use the standard fixed and random effects panel methods. More recently, generalised method of moments (GMM) and the system GMM (SGMM) methods are also used. GMM and SGMM are used to eliminate country specific fixed effects and to minimise biases due to endogeneity by instrumenting the explanatory variables. There are hardly any cross-country studies that use time series based panel methods. We postpone any evaluation of the relative merits of these alternative estimation methods due to space constraints.

3.3 Alternative approaches

In light of the above criticisms, two alternative approaches are worth consideration. Following Barro, many empirical works have treated equation (4) as if it were a growth equation to estimate the permanent growth effects of variables. Since we have argued that (4) is not suitable for this purpose, the question of what factors determine permanent growth effects and how these growth effects should be estimated remains unexplained. There are a few alternative methods to analyse the determinants of the permanent growth rate and they depend on the selected theoretical growth model. The simpler methods are based on extensions to the growth model of Solow (1956). The more complex ones use endogenous growth models and the interest reader may refer to Greiner et. al., (2004). In this paper we shall consider two approaches based on the Solow model.

In Solow (1956) the *SSGR* equals the rate of growth of technical progress (TFP). A well-known weakness of this model is that it does not explain what factors determine TFP and the endogenous growth models of the 1980s are developed to fill this gap. Two types of factors that determine TFP can be distinguished viz., growth factors that need no additional resources and those that need additional resources. The first is the manna from heaven type, of which the classic example is Arrow's (1962) learning by doing (LBD). A typical example of the second type is expenditure on research and development (R&D). While the Solow model can easily be extended to include the manna from heaven type determinants of TFP, a two-sector endogenous growth framework is appropriate for estimating the permanent growth effects of variables like R&D. However, empirical works, including Barro (1996), based on equation (4), have arbitrarily added both categories of variables as determinants of the growth rate.

Edwards (1998), Bernanke and Gurkaynak (2001) and Dollar and Kraay (2004) have suggested that the permanent growth effects of variables should be estimated by estimating their effects on TFP. Senhadji (2000) has followed this approach and selected the MRW human capital augmented Solow (1956) model. He has estimated TFP by conducting a growth accounting exercise based on Solow (1957) for 88 countries for the period 1960 to 1994. The estimated TFPs are used to compute relative TFPs with respect to the USA and this ratio is regressed on some potential explanatory variables. Subsequently Rao and Hassan (2010a and 2010b) have also followed this approach to estimate the determinants of the long-run growth rate in Bangladesh. They have used the growth accounting approach of Senhadji in Rao and Hassan (2010a). In Rao and Hassan (2010b) a simpler one-step method is used, which is explained below.

3.4. TFP Determinants: An Alternative Method

We shall use the standard model of Solow. For simplicity, we shall ignore human capital and the cross-section dimension. With this simplification, the Cobb-Douglas production function with constant returns and Harrod neutral technical progress is as follows.

$$Y_t = K_t^{\alpha} \left(A_t L_t \right)^{1-\alpha} \tag{5}$$

where A is the stock of knowledge, Y is income , K is capital and L is employment. The solution for the steady state level of per worker income is:

$$y^{*} = \left(\frac{s}{d+g+n} \right)^{\frac{\alpha}{1-\alpha}} A \tag{6}$$

where $y = (Y / L)$. The steady state growth rate (*SSGR*), when the parameters in brackets remain constant, is:

$$\Delta \ln y^{*} = \Delta \ln A = g \tag{7}$$

In the Solow model although the stock of knowledge (A) is assumed to be exogenous, in the empirical work it is commonly assumed that A grows at a constant rate of g, i.e.,

$$A_t = A_0 e^{gt} \tag{8}$$

where A_0 is the stock of knowledge in the initial period. It is reasonable to extend the model by making the stock of knowledge depend, besides time, on other variables, Z_i, which are found to be growth affecting by some endogenous models.[4] To extend the Solow model we assume that g in (8) is a function of the Z variables, so that:

$$A_t = A_0 e^{(g_0 + \sum g_j Z_{jt})t} \quad j = 1.....m \tag{9}$$

The advantage of this extension is that it is relatively easy to estimate the permanent growth effects of Z_j with the panel or country specific time series data. In (9) *TFP* is:

$g = g_0 + \sum g_j Z_j$ where g_0 captures the effects of the neglected but trended variables. Thus, the long-run growth rate depends on the levels of the Z_j variables, as in the endogenous growth models. The coefficients $g_j (j = 0...m)$ should be significant if the Z_j variables have externalities.

[4] This type of extension to the Solow (1956) growth model has been used in several studies by Rao and his coauthors. A few recent studies are Rao (2010), Rao, Gounder and Loeing (2010), Rao, Tamazian and Singh (2010) and Rao and Vadlamannati (2010) etc.

While in country specific studies it is not possible to include more than a handful of variables in Z_j due to limited sample sizes, in cross country studies it is possible to do this because of more observations. In their *EBA* Levine and Renelt (1992) find that the only robust explanatory variable in growth regressions is the investment ratio. In contrast, using a less stringent version of *EBA*, Sala-I-Martin (1997a ad 1997b) found that out of about 62 explanatory variables that have been used by various empirical studies, 25 variables have robust effects on growth of which three are MUST variables.[5] However, both studies have some limitations because they have used the standard specification of the growth equation based on (4) and pure cross-section OLS method of estimation. The limitations of the specification of the growth equation are noted by Sala-I-Martin. He has noted that "The problem faced by empirical growth economists is that growth theories are not explicit enough about what variables belong in the 'true' regression."

In light of the above discussion and for pragmatic reasons, it seems necessary to follow a few methodological guidelines in growth empirics. If several works based on alternative methodologies, data sets, estimation methods and different explanatory variables indicate, for example, that while the investment rate and trade openness have positive and significant growth effects and the ratio of government expenditure and inflation have negative growth effects, our confidence in their growth effects will increase. In further research on the growth effects of a new variable, for example, health or schooling, these four variables should be included as the MUST variables. Many empirical studies follow more or less such a methodology in estimating not only growth equations but also other relationships. However, the findings by known experts and published papers in prestigious professional journals generally receive more weight in the justification for the choice of specifications and explanatory variables. We shall follow this practice for the choice of explanatory variables. If the main objective is to estimate the permanent growth effects of these explanatory variables, alternative specifications and procedures, which are discussed in the previous sections, are more appropriate than the present specifications based on equation (4).

[5] Out of these 25 variables, three MUST variables are included in all regressions. These are initial income, life expectancy and years of primary schooling. Levine and Renelt have also used them as their MUST variables. For the list of the 22 significant variables see Table-1 in Sala-I-Martin (1997b).

4. Empirical Results

4.1 Introduction

In this section, we first use our alternative specification and approach for estimating the permanent growth effects of thirteen variables. These are similar to those used by Levine and Renelt (1992) and Senhadji (2000). Instead of selecting some to estimate their growth effects, we apply *EBA* to check how many are robust in their effects with the methods used by Levine and Renelt (1992) and Sala-I-Martin (1997a and 1997b). A comparison between our findings with the results in these previous works would be useful to see their differences. Since in the *EBA* several combinations of three explanatory variables are used to evaluate their robustness, it is necessary to estimate our specification (5) with all the variables that are expected to be robust. The specification of our extended production function based on (5) and (9), with cross-section and time series subscripts, is as follows. However, it is convenient to assume Hicks neutral technical progress instead of Harrod neutral technical progress and it makes no difference for the results. Equation (5) with these changes is as follows.

$$y_{it} = A_{i,0} e^{(g_{i,0} + \sum g_{jit} Z_{jitt})T} k_{it}^{\alpha} + \varepsilon_{it} \tag{10}$$

$$\begin{aligned} \therefore \ln y_{it} = \ln A_{i,0} + (g_{i0} + g_{1it} Z_{1it} + \ldots + g_{13it} Z_{13it})T \\ + \alpha \ln k_{it} + \varepsilon_{it} \end{aligned} \tag{11}$$

Where $y = (Y / L)$, $k = (K / L)$, $Z_{1it} \ldots Z_{13it}$ are variables with growth effects, $T =$ time, $A_0 =$ initial stock of production knowledge, which may depend on not only education but also other factors such as resource endowments etc., (see MRW, 1992), $i =$ cross-section subscript which is seven in this paper and $t =$ time series subscript which is 39. We assume that the error term ε is $N(0, \delta^2)$, but its structure differs in the fixed effects estimates.

4.2 Extreme Bounds Analysis

Leamer's (1983) *EBA* is adequately explained by Levine and Renelt and Sala-I-Martin. Therefore, we shall be brief here. Essentially, in *EBA* all possible combinations of three explanatory variables are selected and estimates are made with the random effects method. In these estimates, one or two variables, usually included in many regressions, are retained as MUST variables in all estimates. In this paper we treat time and capital per worker (k) as the MUST variables. Leamer, Levine and Renelt treat a variable as robust if its coefficient does not change sign in the estimates with all combinations of the three explanatory variables. With this criterion, they find that only the investment rate is a robust explanatory variable in growth equations. However, Sala-I-Martin is critical of this criterion because it is too stringent and a variable becomes fragile even if it changes sign only once. Therefore, he uses the cumulative distribution functions (CDF) of the estimated coefficients to determine the robustness of the variable. He selects the 95% probability level as the critical value. Therefore, a variable becomes fragile only if its coefficient changes sign in more than 5% of estimates. Table 3 gives *EBA* results for our 13 variables, with their average estimated values and the Levine and Renelt and Sala-I-Martin critical values. These estimates are based on 286 combinations of three variables at a time of the 13 selected variables. Altogether 3,718 equations are estimated.

According to Levine and Renelt, a variable is robust if the critical value is 1 and fragile if it is zero. In Sala-I-Martin, a variable is robust if the critical value is equal to or more than 95% and fragile otherwise. The thirteen variables selected are, with the expected signs for their coefficients are: the ratio of investment to GDP (*IRAT*, +), ratio of foreign direct investment to GDP (*FDIRAT*, +), ratio of exports to GDP (*EXRAT*, +), ratio of M2 to GDP (*M2RAT*,+), inflation rate ($\Delta \ln P, -$), ratio of government consumption expenditure to GDP ($GRAT, -$), a measure of corruption (*CORR*, -), a measure of institutional development (*POL*, +), primary enrolment ratio (*PEDU*, +), secondary enrolment ratio (*SEDU*, +), ratio of workers' remittances to GDP (*REMRAT* , +), ratio of budget deficit to GDP (*BDRAT*, -) and ratio of military expenditure to GDP (*MILRAT*, + or -). Some average values of the variables are given in Table 2.

Although in the Solow model variables such as *IRAT* and *FDIRAT* etc., have only permanent level effects, these variables may have permanent growth effects if they have some externalities. Levine and Renelt and Sala-I-Martin's *EBA* showed that *IRAT* is a robust variable in growth equations, in spite of our reservations on the specification of the growth equation. Therefore, it is of interest to see if *IRAT* has robust growth effects with our alternative specification. *EXRAT* is used as a proxy for trade openness. When we used the ratio of exports plus imports to GDP (*TRAT*), which is a frequently used proxy for trade openness, its coefficient was negative and fragile. This may be due to the dominance of the negative growth effects of imports. *M2RAT* is a proxy for financial development and many studies have found that it has positive growth effects. $GRAT$, $\Delta \ln P$ and *BDRAT* are proxies for government's economic policies. *CORR* and *POL* measure institutional quality. Remittance by migrant workers (*REMRAT)*, which are a rising proportion of GDP in the South-Asian countries, may have a small indirect effect on the growth rate; see Rao and Hassan (2010 a,b). Education at the primary and secondary levels (*PEDU* and *SEDU*) capture the growth effects of human capital. It is hard to say whether *MILRAT* has a positive or negative growth effect. It will have a negative growth effect if resources are diverted from productive sectors to the defence sector. However, its contribution to growth will be positive if it increases infrastructure investment, adoption of new technologies and improves political stability. Details of the definitions and sources of data are in the appendix.

Table 2: Descriptive Statistics

Variable	Observations	Mean	Standard Deviation	Minimum	Maximum
Per capita income(constant 2000 US$)	237	530.42	554.90	138	3418
Investment to GDP (IRAT)	234	0.23	0.10	0.05	0.59
Rate of Inflation, consumer prices annual % (Δ lnP)	209	8.51	5.09	-0.8	29
Enrolment ratio primary gross (PEDU)	102	0.92	0.29	0.08	1.48
Enrolment ratio secondary gross (SEDU)	184	0.35	0.18	0.08	0.88
M2 to GDP (M2RAT)	242	0.34	0.13	0.08	0.73
Government final consumption expenditure to GDP (GRAT)	227	0.11	0.05	0.03	0.28
Military expenditure to GDP (MILRAT)	105	0.03	0.02	0.01	0.07
Budget Deficit to GDP (BDRAT)	105	-3.98	3.42	-13.67	6.98
Exports to GDP (EXRAT)	252	0.26	0.27	0.03	1.66
Exports + Imports to GDP (TRAT)					
FDI to GDP (FDIRAT)	211	0.007	0.009	-0.002	0.07
Remittances to GDP (REMRAT)	187	0.04	0.04	0.002	0.23
Polity 4 Index (-10 to +10) POL	229	0.67	7.29	-10	9
Corruption Index (CORR) (-2.5 to +2.5)	69	-0.34	0.58	-1.42	0.93

The *EBA* results in Table 3 show that both criteria give similar results. According to the more stringent criterion of Levine and Renelt only *CORR*, *REMRAT* and *BDRAT* are fragile, while according to Sala-I-Martin's criterion *REMRAT* is robust just at the margin but

CORR and *BDRAT* are fragile. Our results based on these two criteria are much closer than the wide gap in the results Levine and Renelt and Sala-I-Martin with the conventional specification. The signs of the coefficients on inflation, government expenditure and remittances are contrary to prior expectation and it is hard to accept that the coefficient of military expenditure could be positive. These unexpected results are not uncommon. In Sala-I-Martin (1997) the coefficients of some variables such as civil liberties, public investment share, political assassinations and trade openness etc., have the wrong signs.

Table 3: Extreme Bounds Analysis with Data from 1970 to 2008

	Variable	LR CV	Average Estimate	t-Ratio	S-I-M CV
1	*IRATT*	1	0.0580	15.85	1
2	*FDIRATT*	1	0.2857	6.01	1
3	*EXRATT*	1	0.0639	17.88	1
4	*M2RATT*	1	0.0309	16.86	1
5	$\Delta \ln PT$	1	0.0417	3.38	1
6	$GRATT$	1	0.1887	17.41	1
7	*CORRT*	0	-0.1332	-1.02	0.843
8	*POLT*	1	0.0515	4.59	1
9	*PEDU*	1	0.0146	15.25	1
10	*SEDUT*	1	0.0322	17.18	1
11	*REMRATT*	0	-0.0233	-1.74	0.958
12	*BDRAT*	0	-0.0087	-0.72	0.763
13	*MILRAT*	1	0.2389	4.43	1

Notes: All determinants are multiplied by time. Thus IRATT= $IRAT \times T$ etc. LR CV is Levine and Renelt (1992) critical value. If it is equal to one, the variable is robust and when it is zero, the variable is fragile. S-I-M CV is Sala-I-Martin's (1997) critical value. When it is ≥ 0.95 the variable is robust. CDF is the cumulative distribution of the estimates of the coefficients.

4.3 Empirical Results on the Determinants

Empirical estimates of equation (11) are reported in Table 4 with the 13 determinants with alternative panel methods of fixed effects (*FE*), random effects (*RE*) and system GMM (*SGMM*) yielded poor results. The log of per worker capital ($\ln k$), *EXRAT*, *GRAT* and the intercept are significant at the 5% level. *RE* estimates, with the Swamy and Arora (1972) option, which has better finite sample properties, give slightly improved results. With this estimate $\ln k$, *FDIRAT*, *EXRAT*, *GRAT* , *POL, SEDU* and *MILRAT* are statistically significant. However, *POL, SEDU* and *MILRAT* have the wrong sign. It is surprising that *IRAT*, which found to be the only robust determinant of growth by Levine and Renelt, is not significant in all these three estimates. The Breusch and Pagan test with the null for the *RE* model over *FE* model is insignificant. The computed test statistics is $\chi^2(1) = 1.14$ with a p-value of 0.286. Therefore, *RE* estimates seem to be preferable to *FE* estimates. These preliminary results are not reported to conserve space.

Next, we estimated (11) without the three fragile variables *CORR*, *REMRAT* and *BDRAT* but the results are similar. The coefficient of inflation remained still positive and that of investment ratio is insignificant. We deleted these two variables and the *FE* and *RE* estimate with the Swamy and Arora option are reported in columns (1) and (2) of Table 4. The Breusch-Pagan test statistic ($\chi^2(1) = 1.16$ with p-value of 0.282) cannot reject the null of *RE*. To minimise the endogenous variable bias and the likely persistence in the variables, we reestimate this equation with *SGMM* after limiting the number of instrumental variables; see Roodman (2009) for this requirement. Two *SGMM* estimates without intercept (but with trend) and with intercept (but without trend) are made to see if trend is significant. These two *SGMM* estimates are reported in columns (3) and (4) of Table 4.

It can be seen from the results in Table 4 that the coefficient of trend is insignificant in the three equations with trend. The coefficient of capital, share of profits, is low at 0.17 in the *FE* estimate but near its stylised value of one third in the *RE* estimate in column (2). However, in the two *SGMM* estimates it is around 0.25 and this is a plausible value for the developing countries. The higher estimate in column (2) may be due to the endogeniety of capital stock. For a similar reason the coefficient of *IRAT* is insignificant in the *RE* estimate but significant in the two *SGMM* estimates.

Table 4: Empirical results Determinants of Long-Run Growth Rate with Data from 1970 to 2008							
	(1) FE	(2) RE	(3) SGMM	(4) SGMM	(5) SGMM	(6) SGMM	(7) SGMM
Time	-0.013 (-0.27)	-0.0012 (-0.23)	-0.0023 (-0.68)	---	-0.015 (-4.93)**	-0.016 (-5.98)***	-0.168 (-5.99)***
Lnk	0.257 (5.22)***	0.3107 (14.15)***	0.2526 (5.21)***	0.2505 (5.1)***	0.205 (4.58)**	0.208 (4.80)***	0.254 (5.77)***
IRATT	0.0247 (3.64)***	0.0064 (-0.54)	0.0221 (4.54)***	0.0232 (4.91)***	0.007 (1.64)	0.008 (1.80)*	0.006 (1.31)
FDIRATT	-0.0253 (-1.08)	0.0748 (1.75)*	-0.0108 (-0.60)	-0.0121 (-0.67)	0.023 (1.43)	0.020 (1.46)	-0.001 (-0.08)
M2RATT	0.0039 (-1.22)	-0.0042 (-0.70)	0.0031 (-1.39)	0.0027 (-1.24)	0.013 (4.70)***	0.013 (5.34)***	0.010 (3.69)***
E XRATT	0.0243 (3.08)***	0.0711 (7.21)**	0.0174 (2.63)***	0.0179 (2.69)***	0.017 (2.47)**	0.016 (2.48)**	0.018 (3.08)***
GRATT	0.0502 (3.40)***	0.1113 (4.55)**	0.045 (4.30)***	0.045 (4.21)***	0.021 (2.02)**	0.023 (2.49)**	----
PEDUT	$0.15E^{-2}$ (-0.38)	$-0.10E^{-3}$ (-0.02)	$0.24E^{-2}$ (-0.85)	$0.80E^{-3}$ (-0.50)	---	---	
SEDUT	-0.004 (-0.92)	-0.023 (-3.32)***	-0.003 (-1.14)	-0.004 (-1.42)	---	---	
FPEDUT	---	---	---	---	0.007 (2.73)***	0.007 (2.98)***	0.010 (3.87)***
FSEDUT	---	---	---	---	-0.017 (-5.5)***	-0.017 (-5.61)***	-0.011 (-3.22)***
MPEDUT	---	---	---	---	$-0.8E^{-3}$ (-0.35)	----	
MSEDUT	---	---	---	---	0.027 (6.77)***	0.027 (7.26)***	0.020 (4.80)***
POLT	$0.10E^{-3}$ -1.46	$-0.88E^{-2}$ (-2.28)**	$0.11E^{-3}$ (1.67)*	$0.10E^{-3}$ (1.87)*	$0.10E^{-3}$ (0.18)	---	
MILRATT	0.0475 -1.59	0.1116 (2.28)**	0.066 (2.89)***	0.065 (2.81)***	0.045 (1.93)*	0.042 (2.06)**	
(G+M)RATT							-0.054 (-2.44)***
(G+M)RATT^2							0.011 (3.89)***
Intercept	5.2377 (21.58)***	4.2165 (23.69)***	---	4.6766 (13.44)***	-0.021 (16.5)***	5.14 (16.85)***	4.94 (16.32)***
Notes: In the *SGMM* estimates AR(1) and AR(2) test statistics could not reject the null of no serial correlation.							

At this stage it can be said that *SGMM* estimates are preferable to *RE* estimates because this estimate minimises biases due to endogeniety and persistence in the variables. Of the two *SGMM* estimates, the one in column (4), without trend, is preferable because its pseudo $\overline{R}^2$, at 0.881 is marginally higher than the estimate in column (3) of 0.804.[6] In subsequent estimates we shall use variants of this specification and estimation.

Estimates of the preferred equation in column (4) are not entirely satisfactory. The coefficients of *FDIRAT* and *SEDU* are negative and insignificant. The coefficient of *PEDU*, although has a positive sign, is insignificant. The positive and significant coefficient for *MILRAT* is difficult to justify. Since the coefficients of trend, primary and secondary enrolment ratios are insignificant, we have tested in a different way for the significance of trend by replacing the two enrolment ratios with the components of the enrolment ratios viz., female and male enrolment ratios in primary schooling (*FPEDUT* and *MPEDUT*) and female and male enrolment ratios in secondary schooling (*FSEDUT* and *MSEDUT*). These estimates are reported in column (5). Of the four enrolment ratios only the male enrolment ratio in primary schooling is insignificant in column (5). The coefficient of female enrolment ratio in secondary schools is negative and the coefficient of political institutions became insignificant. In column (6) estimates of this equation, without the two insignificant variables *MPEDU* and *POL*, are reported. It can be seen that there are no significant changes in the estimates of the parameters in the last two columns.

We shall use the estimates in column (6) for a few conclusions. All the coefficients, except *FDIRAT*, are significant at the five or ten percent levels. The coefficient of *FDIRAT* has the expected positive sign and significant at about 14.5 percent level. This and the equation in column (5) imply that TFP is negative at about 1.5 percent per year. This high negative value may be due to stringent bureaucratic systems and closed economy policies in South-Asian countries.[7] India opened up its economy and implemented market reforms only in the 1990s. In general, the permanent growth effects of many variables are found to be much less than in the previous studies with conventional specifications of the growth equation. For example, the coefficient of *IRAT*, which is highly significant in Levine and

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[6] These are generated by obtaining the predicted values of the dependent variable of the two *SGMM* estimates.

[7] In two country specific studies, Rao and Vadlamannati (2010) for India and Rao and Hassan (2010) for Bangladesh have found that the trend rate of *TFP* is negative in both countries.

Renelt and Sala-I-Martin with coefficients of about 0.17 (slow growers) to 0.14 respectively, has a much lower coefficient of 0.008 in our estimate. Our estimate implies that the permanent growth effect of the investment ratio is about 0.01 percentage points at most and not as high as in Levine and Renelt. As pointed out before, the conventional specification of the growth equation overestimates the permanent growth effects because it also captures the transitory growth effects. Male secondary school enrolments (*MSEDU*) has a much larger growth effect of about 0.03. The growth effects of progress of financial sector (*FDIRAT*) and exports (*EXRAT*) are also higher than *IRAT*. Only female primary school enrolments (*FPEDU*) has a similar growth effect to *IRAT*.

Some less plausible estimates are the relatively large and positive growth effects of government expenditure ($GRAT$) and military expenditure (*MILRAT*).[8] When $GRAT$ is replaced with the ratio of budget deficit (*BDRAT*), its coefficient is insignificant but remains positive. Allowing for nonlinear effects and interaction terms with inflation does not make the coefficients of $GRAT$ and *MILRAT* negative or insignificant. Both these ratios are somewhat correlated with a correlation coefficient of 0.71. Therefore, we added these two ratios and allow for a combined nonlinear effect with the square of this combined term. Estimates with these changes are in column (7) of Table 4. It can be seen that the coefficient of the combined term is negative and significant. The nonlinear effect of this combined term implies that its effects are negative until it reaches an implausible value of 260 percent whereas the sample average is only 12.5 percent. However, the coefficient on *IRAT* becomes insignificant and the profit share increases slightly. There are no other significant changes in the estimates of other coefficients. Therefore, the effects of *GRAT* and *MILRAT* need further analysis but this is beyond the scope of the present paper.

4.4 Policy Implications

[8] It is likely that since the government expenditure includes some development expenditures like education, salaries of public servants and subsidies to farmers etc., it may have some positive growth effects. Similarly military expenditure may have some growth affecting components like encouraging investment in the capital goods sectors (vehicles, manufacture of arms, aircraft and ship building and repairs) and infrastructure etc. However, the estimated size of the coefficients are of some concerns. It is likely that these two ratios may be capturing the positive effects of some growth inducing variables and this needs further scrutiny and analysis in future studies.

One of the important objectives of analysing the determinants of long-run permanent growth is to understand the policy options which may increase the long-run growth rate. The average per worker income growth rate of the South-Asian countries is around 2.33 percent, which is about the same as the growth rate of per capita income. If this permanent growth rate needs to be increased by one percent, i.e., to make the current rate of 2.33 into 3.33 percent, what are the policy options? Although this target can be achieved with some alternative combinations of policy options, our subjective preference is as follows. This target can be achieved by emphasising the male and female school enrolment ratios. It is possible by increasing by 20% the current ratios of *IRAT*, *EXRAT*, *M2RAT*, and by increasing *FPEDU* and *MSEDU* by 55%. If all these ratios are increased by 20%, the permanent growth rate will increase only by half percent. In our view both policy options are not difficult to implement.

5. Conclusions

Using the EBA we have identified some robust determinants of the long-run growth rate in seven South-Asian countries. We found that these robust determinants, with the exception of FDI, are all statistically significant at the 5% or 10% level. The evidence suggests that the growth effects of investment are relatively smaller compared to other determinants like education. This may be due to investments taking place in the traditional and less innovative sectors. More growth enhancing determinants are female primary enrolment and male secondary enrolment ratios. Similarly, our results suggest that countries with a larger and more active financial sector grow faster. Government expenditure has a positive effect on economic growth. This is possibly due to the fact that the government is the main provider of education, health and other services in the South-Asian countries. Similarly military expenditure has a positive impact on growth possibly due to investment taking place in infrastructure and capital goods.

We have also argued that it is important to distinguish between the transient growth effects from the permanent and long-run growth effects of the determinants of growth. Currently used specifications in the cross-country studies are likely to overestimate the growth effects of the determinants by failing to make this distinction. We hope that our specification and methodology would encourage other investigators to avoid overestimating these permanent growth effects of the determinants.

Data Appendix

Variable	Source
Per capita income(constant 2000 US$)	World Development Indicators 2010
Investment to GDP (IRAT)	World Development Indicators 2010
Rate of Inflation, consumer prices annual % (Δ lnP)	World Development Indicators 2010
Enrolment ratio primary (PEDU)	World Development Indicators 2010
Enrolment ratio secondary (SEDU)	World Development Indicators 2010
M2 to GDP (M2RAT)	World Development Indicators 2010
Government final consumption expenditure to GDP (GRAT)	World Development Indicators 2010
Military expenditure to GDP (MILRAT)	World Development Indicators 2010
Budget Deficit to GDP (BDRAT)	World Development Indicators 2010
Exports to GDP (EXRAT)	World Development Indicators 2010
FDI to GDP (FDIRAT)	World Development Indicators 2010
Remittances to GDP (REMRAT)	World Development Indicators 2010
Polity 4 Index -10 to +10 (POL)	Marshall and Jaggers (2010): http://www.systemicpeace.org/polity/polity06.htm#nam
Corruption Index -2.5 to +2.5 (CORR)	Kaufmann, Kraay and Mastruzzi (2009): Governance Matters VIII: Governance Indicators for 1996-2008. World Bank Policy Research Working Paper 4978.
Note: World Development Indicators (WDI). http://databank.worldbank.org/ddp/home.do?Step=2&id=4&DisplayAggregation=N&SdmxSupported=Y&CNO=2&SET_BRANDING=YES	

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