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ABSTRACT

In this paper, we investigate the relationship between health and economic growth through including investment, exports, imports, and research and development (R&D), for 5 Asian countries using panel unit root, panel cointegration with structural breaks and panel long-run estimator for the period 1974-2007. We model this relationship within the production function framework, and unravel two important results. First, we find that in three variants of the growth model, variables share a long-run relationship; that is, they are cointegrated. Second, we find that in the long-run, while health, investment, exports, and R&D have contributed positively to economic growth, imports have had a statistically significant negative effect while education has had an insignificant effect. We draw important policy implications from these findings.

Keywords: Health; Economic Growth; Panel Unit Root; Panel Cointegration.

JEL classification: C23; C33; I10; I20.

1. Introduction

In a series of papers (see, *inter alia*, Barro, 1991; Barro and Lee, 1994; Barro and Sala-i-Martin, 1995; Sachs and Warner, 1995; 1997; Bloom *et al*., 2004; Mayer, 2004; Rivera and Currais, 2004) cross-sectional and panel data have been used to investigate the relationship between health and economic growth. The main finding of these studies is that health contributes to economic growth. In another group of studies (see, for instance, Basta *et al*., 1979, Spurr, 1983; Bhargava, 1997; Strauss and Thomas, 1998) attempts have been made to examine the impact of health indirectly on economic growth through its effects on productivity. The main finding of these studies is that health contributes positively to productivity. Another branch of this literature (Wheeler, 1980; Knowles and Owen, 1995, 1997; Webber, 2002; Bhargava *et al*., 2001; Chakraborty and Das, 2005; Arora, 2001) uses time series analysis and concludes that health is an important determinant of economic growth.

The literature on the role of education in economic growth is equally large and varied, ranging from cross-sectional analysis to time series analysis. This literature has been popularised by the early work of Romer (1986) and Lucas (1988), who developed the theoretical framework emphasising the role of human capital in stimulating to economic growth. Subsequently, empirical studies (see, *inter alia*, Romer, 1990; Barro, 1991; Barro, 2003; Barro and Sala-i-Martin, 1992; Mankiw *et al*., 1992; Liu and Rivkin, 1993) have supported the hypothesis that education contributes positively to growth.

Like the importance of health and education in stimulating economic growth, the role of investment in economic growth has also been found to be positive; see, *inter alia*, De-Long and Summers (1991, 1993); Podrecca and Carmeci (2001). To this end, one group of study (Schneider, 2005; Coe and Helpman, 1995; Coe *et al*., 1997; Eaton and Kortum, 1997) finds that investment, by virtue of creating technological diffusion, contributes positively to economic growth.

In addition to health, education, and investment, exports can also be viewed as an engine of growth because export expansion can contribute positively to aggregate output. Export expansion can also lead to efficient resource allocation, better capacity utilisations, and better economies of scale and technological improvement, which can stimulate economic growth (see Helpman and Krugman, 1985). Export expansion also increases foreign exchange that increases imports of intermediate goods that raises capital formation and stimulates economic growth (Balassa, 1978; Esfahani, 1991); see also Sheehey (1992), Sharma et al. (1991) Ghartey (1993), Awokuse (2003, 2006) and Dar and Amirkhalkhali (2003).

In contrast to the role of exports, imports can either stimulate or retard economic growth. In developing economies, for example, parts of imports provide factors of production for the export sector. In addition, technology transfer from developed to developing countries in the form of imports can contribute to economic growth (see Grossman and Helpman, 1991; Lawrence and Weinstein, 1999; and Mazumdar, 2002). On the other hand, if imports are heavily weighted towards consumption items rather than investment expenditures, then this can lead to persistent balance of payments problems, thus retarding growth. Finally, research and Development (R&D) is considered as an integral part of economic growth. R&D is perceived to be an important source of productivity growth; see Coe *et al*. (1995) and Coe *et al*. (1997).

The aim of this paper is to examine the long-run impact of health, education, exports, imports, R&D, and investment on economic growth for a panel of 5 South Asian countries, namely India, Indonesia, Nepal, Sri Lanka, and Thailand for the period 1974-2007. We consider these 5 Asian countries because they fall in a similar economic growth group. Our study takes the literature forward in a novel way. In studying the relationship between income, health, education, exports, imports, R&D, and investment, we take a production function approach and model the relationship within a panel unit root and panel cointegration with structural breaks framework in order to unravel the long-run relationship among the variables. The main motivation for studying the role of health in economic growth for Asian countries is that the growth of the bigger Asian countries, such as India, has been impressive in the last decade or so. Hence, the ensuing focus has been on determinants of economic growth and productivity in Asian countries in general. One limitation of the literature on the determinants of economic growth is that it has ignored the role of health in economic growth. This paper aims to fill this research gap.

Our goal is achieved in three steps. In the first step, we ascertain the integrational properties of the data series. To achieve this, we apply the Im Pesaran and Shin (IPS, 2003) panel unit root test. In the second step, we test for panel cointegration relationships accounting for structural changes in the data. We achieve this by using the test recommended by Westerlund (2006). In the third step, we set out to estimate the long-run elasticities of the impact of health, education, exports, imports, R&D and investment on per capita GDP. We achieve this by using the group mean panel dynamic OLS (DOLS) estimator suggested by Pedroni (2001).

Briefly foreshadowing the main conclusions, we find that income, health, education, exports, imports, R&D, and investment are integrated of order one and are panel cointegrated in various model specifications. The panel long-run results reveal that while health, investment, exports, and R&D have had a positive and statistically significant effect on growth, education has had a statistically insignificant effect, and imports have a statistically significant negative effect on growth.

The balance of this paper is organised as follows. In section 2, we provide a brief macroeconomic overview of the 5 South Asian countries considered in this study. In section 3, we discuss the model and the theoretical framework motivating the present study. In section 4, we present the econometric methodologies. In section 5, we discuss the empirical results. In section 6, we conclude with some policy implications.

2. A brief macroeconomic overview of the Asian countries

The aim of this section is to provide a brief overview of the key macroeconomic conditions of the 5 South Asian countries considered in this study. The importance of this is that it will better allow one to understand the relationship between income, education, health, exports, imports, R&D, and investment, and provide a platform for appropriate policy responses.

The economic growth in 2007 has been healthy for most of the Asian countries considered in this study. For instance, India's growth rate was 9.06 percent. Growth rate was also healthy for Thailand (5 percent), Sri Lanka (6.78 per-cent) and Indonesia (6.31 percent). Nepal (3.19 percent), in a comparative sense was the weakest, achieving a growth rate of less than 5 per cent. The average growth rate over the period 1999-2007 has also been fairly reasonable: 7.23 percent per annum for India, 5 per cent per annum for Thailand, and between 3.8 per cent to 5 per cent for the rest of the countries.

The inflation rate has been fairly moderate, with only Indonesia (6.4 per cent) and Sri Lanka (15.84 per cent) experiencing inflation rates of over 5 per cent in 2007. External debt as a proportion of gross national income (GNI) has been at manageable levels for Thailand (26 percent) and India (19 percent). However, the same cannot be said for Indonesia (34 per cent), Nepal (35 per cent), and Sri Lanka (44 per cent) where external debt has been well over 30 per cent of GNI in 2007. In terms of the exchange rate: an examination of the nominal exchange rates vis-à-vis the US dollar suggests that all Asian currencies have become weaker over the period 1987 to 2007. Much of this was due to the massive devaluations, as a result of the 1997 Asian financial crisis.

The performance of international trade has been mixed. While for some countries exports of goods and services as a percentage of GDP have outperformed the imports of goods and services, the opposite is true for some countries over the period 1987 to 2007. India's exports of goods and services as a percentage of GDP, for instance, increased from 5.7 per cent in 1987 to 21.2 percent in 2007, while imports of goods and services increased from 7.1 per cent to 24.1 per cent in the corresponding period. In Nepal, while exports increased from 11.8 per cent to 13 per cent from 1987 to 2007, imports increased by more over the same period – from 20.6 per cent in 1987 to 31.3 per cent in 2007. Similarly, Sri Lanka's net exports were negative over this period. Indonesia's case is the opposite: while exports increased from 23.9 per cent of

GDP in 1987 to 29.3 per cent of GDP in 2007, imports only increased from 22.4 per cent to 25.3 per cent over the corresponding period. In most years Thailand also managed to achieve positive net exports.

In terms of government finances, over the period 1987 to 2007, India achieved budget surpluses, and in 2007 it was valued at around 1.5 per cent of GDP. Thailand's experience has been mixed: while in some years it has achieved budget deficits, in other years it has achieved budget surpluses. In 2007, it achieved a budget surplus of 0.25 percent of GDP. However, Sri Lanka, Indonesia, and Nepal have experienced relatively large budget deficits. Sri Lanka's record has been the worst. Its budget deficit has been in excess of 8 per cent of GDP over the 1987 to 2007 period; in 2007 it stood at -7.75 per cent of GDP. In Nepal, in most years over the same period, budget deficits have been around or over 5 per cent; however, in 2006 and 2007 Nepal achieved fairly low deficits – valued at only 2.5 percent of GDP. Meanwhile, Indonesia's budget deficits have not been as alarming as those experienced by Sri Lanka and Nepal. Beginning with 1990, Indonesia managed to restrict its deficits to below 2 per cent of GDP.

3. Model and theoretical framework

We begin with the following aggregate production function:[1]

$$Y = AK^{\alpha}W^{\beta} \tag{1}$$

where Y is real GDP, A is total factor productivity, K is composite capital stock, which is given as $K = kXMR$, where k is investment, X is exports, M is imports and R is R&D, and W is the labour composite, which is determined by $W = EHL$, where H is the worker human capital in the form of health, E is the human capital in the form of education and L is the number of workers. We can now rewrite Equation (1) in natural log of form as

$$\log y = \theta + \alpha_1 \log k + \alpha_2 \log x + \alpha_3 \log m + \alpha_4 \log r + \beta_1 \log h + \beta_2 \log e \quad (2)$$

The production function measures physical capital by gross fixed capital formation as a percentage of GDP, exports as a percentage of GDP, imports as a percentage of GDP, R&D expenditure as a percentage of GDP; human capital is proxied by health expenditure as a percentage of GDP and education expenditure as a percentage of GDP, while income is proxied by per capita GDP. We can re-write Equation (2) for country i at time t as:

$$\log y_{it} = \theta_i + \alpha_{1i} \log k_{it} + \alpha_{2i} \log x_{it} + \alpha_{3i} \log m_{it} + \alpha_{4i} \log r_{it} + \beta_{1i} \log h_{it} + \beta_{2i} \log e_{it} \quad (3)$$

Good health can contribute to economic growth in a number of ways. First, a healthy workforce is associated with higher productivity because workers are more energetic and mentally more robust. Moreover, absenteeism at work is low since both the workers and their family members enjoy good health. Low absenteeism raises production. This argument is embedded in the theoretical models of nutrition-based efficiency wages. Leibenstein (1957), for instance, argued that those who consumed more calories relative to the poorly nourished workers are more productive, and that better nutrition is associated with increasingly higher productivity. Healthier workers with higher productivity earn higher wages (Strauss and Thomas, 1998). Higher wages in turn contribute to higher consumption and savings, which by virtue of improving the well-being and happiness of people contribute to economic growth.

Second, improvements in health raise the incentive to acquire schooling, since investments in schooling can be amortised over a longer working life (Kalemli-Ozcan *et al*., 2000). Healthier students tend to be associated with lower absenteeism and higher cognitive functioning, and thus receive a better education for a given level of schooling (Weil, 2001). It follows that better health contributes to increased schooling and knowledge accumulation, which improves the quality of a country's human capital; thus, contributing positively to economic growth.[2]

Human capital is important because it improves productivity through several ways. First, the human capital theory views schooling as an investment in skills, which contributes to improvements in productivity (see, for example, Schultz, 1960, 1961, 1971; Becker, 1975). The growth accounting literature posits that education, through increasing the human capital stock of individuals, improves their productivity and therefore contributes to economic growth. The endogenous growth literature, popularised by the work of Romer (1990), assumes that the creation of new designs/ideas is a direct function of human capital, which is reflected in the accumulation of scientific knowledge. Therefore investment in human capital, by improving research and development, generates growth in physical capital, which results in economic growth (Romer, 1990; Asterious and Agiomirgianakis, 2001). Moreover, persistent accumulation of knowledge by individuals, either with intentional efforts as explained by Lucas (1988) or with learning by doing as explained by Azariades and Drazen (1990) enhances labour and capital productivity, thus contributing to economic growth.

Second, human capital improves adaptability and allocative efficiency, in that skilled workers allocate resources more efficiently across tasks and are more able to respond to new opportunities (Heckman, 2005; Nelson and Phelps, 1966; Schultz, 1975).

Third, human capital not only improves the productivity of labour but it also produces spill over benefits, meaning that apart from benefiting the individual who receives education, it also benefits the society (Self and Grabowski, 2004).

Theoretically, investment contributes to economic growth by generating technological diffusion (see, Obwona, 2001; Borensztein *et al*., 1998). Balasubramanyam *et al*. (1998), Li and Liu (2005) and De Mello (1999), among others, explain that foreign direct investment is a composite bundle of capital stock, know-how and technology, which has the capacity of improving existing stock of knowledge through labour training, skill acquisition and diffusion, and the introduction of alternative management practices and organisation arrangement.

The causal relationship between exports and economic growth is known as Export-Led-Growth (ELG) hypothesis. This hypothesis suggests that export-led outward orienting trade policy stimulates economic growth; see Wilbur and Haque (1992), Richards (2001), Marin (1992), Yamada (1998) and Awkouse (2003). As explained earlier, exports stimulate to economic growth by contributing to aggregate output, through an efficient use of resources and capital formation through foreign exchange that increases imports of capital goods and stimulate economic growth.

On the supply side, Import-Led-Growth (ILD) hypothesis emphasise on modernisation and transfer of advanced technology through acquisition of more advanced capital which in turn affect the growth of total factor productivity, see Iscan (1998), Marwah and Klein (1996) and Marwah and Tavakoli (2004).

Technology and technological advancements are key component of economic growth (Grossman and Helpman (1994)). R&D investments are regarded as the key to secure technological potential which leads to innovation and economic growth (Trajtenberg (1990)). Investments in R&D increase the possibility of a higher standard of technology in firms, leading to the production of high quality products. This will ensure higher levels of income; see Romer (1990) and Lichtenberg (1992).

4. Econometric methodology

4.1. Panel unit root test

The IPS panel unit test is essentially a test for a unit root in series, say, y, and has the following form:

$$\Delta y_{i,t} = \alpha_i + \beta_i y_{i,t-1} + \sum_{j=1}^{k} \psi_{i,j} \Delta y_{i,t-j} + \mu_{i,t} \tag{4}$$

Here, Δ is the first difference operator, $y_{i,t}$ is a white noise disturbance term with variance σ^2. The lagged dependent variable is included to allow for serial correlation. The null hypothesis of a unit root in the panel is defined as: $\beta_i = 0$, for all i. To test the hypothesis, Im *et al*. (2003) propose a standardized t-bar statistic given by:

$$Z_{tbar} = \frac{\sqrt{N}\left\{ tbar_{NT} - \frac{1}{N}\sum_{i=1}^{N} E\left[t_{iT}(p_i,0) \middle| \beta_i = 0\right] \right\}}{\sqrt{\frac{1}{N}\sum_{i=1}^{N} Var\left[t_{iT}(p_i,0) \middle| \beta_i = 0\right]}} \overset{T,N}{\Rightarrow} N(0,1) \tag{5}$$

Where

$$tbar_{NT} = \frac{1}{N}\sum_{i=1}^{N} t_{iT}(p_i, \theta_i)$$

Here, $t_{iT}(p_i, \theta_i)$ is the individual t-statistic for testing $\beta_i = 0$ for all i.

4.2. Westerlund's panel cointegration test with multiple structural breaks

In this study, we use the panel cointegration test with multiple structural breaks proposed by Westerlund (2006) in order to test for cointegration in our panel of 5 Asian countries. It is a more general test of panel cointegartion than Pedroni's (1999) test because it allows for the possibility of multiple structural breaks both in the level and trend of a cointegrated panel regression. Since most of the Asian currencies have undergone devaluation during the period of 1987 to 2004, there may be multiple structural breaks in the macro variables of the 5 Asian economies considered in our empirical analysis. So, it is important to account for structural breaks while conducting the panel cointegration test.

The starting point for this cointegration test is an estimation of the following system of equations:

$$y_{i,t} = z_{i,t}^{'}\gamma_{i,j} + x_{i,t}^{'}\beta_i + e_{i,t} \tag{6}$$

$$e_{i,t} = r_{i,t} + u_{i,t}, \tag{7}$$

$$r_{i,t} = r_{i,t-1} + \phi_i u_{i,t}, \tag{8}$$

for $t = 1,...,T;$ $i = 1,..., N;$ $j = 1,..., M_i + 1$, where T refers to the number of observations over time, N refers to the number of individual members in the panel, and M refers to the number of structural breaks. $x_{i,t} = x_{i,t-1} + v_{i,t}^{'}$ is a K-dimensional vector of regressors and $z_{i,t}$ is a vector of deterministic components. The corresponding vectors of parameters are β_i and $\gamma_{i,j}$. The panel LM test statistic is defined as:

$$Z(M) = \sum_{i=1}^{N}\sum_{j=1}^{M_i+1}\sum_{t=T_{ij-1}+1}^{T_{ij}}(T_{ij} - T_{ij-1})^{-2}\,\hat{\omega}_{i1.2}^{-2}\,S_{it}^{2} \tag{9}$$

where $\hat{\omega}_{i1.2}^{-2} = \hat{\omega}_{i11}^{2} - \hat{\omega}_{i21}^{'} \hat{\Omega}_{i22}^{-1} \hat{\omega}_{i21}$ is the variance of u_{it}, $S_{it} = \sum_{k=T_{ij-1}+1}^{t} \hat{e}_{ik}^{*}$ where $\hat{e}_{it}^{*}$ is an efficient estimator of e_{it}, $B_i = T^{-1/2} S_{it}$ and $\hat{\Omega}_i = T^{-1} \sum_{j=-k}^{k} (1 - \frac{j}{k+1}) \sum_{t=j+1}^{T} \hat{w}_{it} \hat{w}_{it-j}^{'}$, a semiparametric kernel estimator, is the covariance matrix of B_i, where $\hat{w}_{it} = (\hat{e}_{it}, \hat{v}_{it}^{'})^{'}$.

The first step in order to construct the test statistic is to obtain $\hat{e}_{it}^{*}$ using dynamic ordinary least square estimator or fully modified OLS estimator. The next step is to construct $\hat{\Omega}_i$ and then $\hat{\omega}_{i1.2}^{-2}$.

5. Empirical results

5.1. Data

In our empirical analysis we use annual data, which is for the period 1974-2007. Data on real per capita GDP, health expenditure as a percentage of GDP, gross fixed capital formation as a percentage of GDP, exports as a percentage of GDP, imports as a percentage of GDP, R&D expenditure as a percentage of GDP, and education expenditure as a percentage of GDP are obtained from the World Development Indicator database and Easterly (2001); Easterly dataset can be downloaded from the world bank research page..

5.2. Unit root test results

In the first step of our empirical analysis, it is crucial to ascertain the integrational properties of the data series, both in a univariate and a panel sense. To investigate the unit root properties for GDP, health, education, exports, imports, R&D and investment variable for each of the 5 countries in our sample, we apply the conventional augmented Dickey-Fuller (1979, 1981) test. This test is widely known and understood, so we refrain from repeating the methodology here. We select the lag length using the Schwarz Bayesian criterion (SBC). We begin with a maximum of 5 lags and use the SBC to choose the optimal lag length. We estimate two models: one without a time trend and one with a time trend. We find that while for the log-levels of each of the seven variables for each of the five countries, we are unable to reject the unit root null hypothesis at the 5 per cent level of significance, we are able to reject the unit root null hypothesis at the conventional levels of significance for all the variables when we conduct the test on the first difference of the variables. From these findings, we conclude that GDP, health, education, exports, imports, R&D, and investment for India, Indonesia, Nepal, Sri Lanka and Thailand are integrated of order one. Full results are available from the authors upon request.

In the next step, we set out to establish the order of integration of the variables in a panel sense. As explained earlier, we have 7 panels of 5 countries, with each panel associated with each of the 7 variables (health, GDP, education, exports, imports, R&D and investment) in our study. The results based on the IPS test together with the critical values are reported in Table 1. As with the univariate test, we estimate the model including a trend and intercept. Our results are as follows. For the income variable, the calculated test statistic turns out to be 1.6 and associated probability value of 0.94. The high p-value suggests that the joint unit root null hypothesis for income cannot be rejected.

Similarly, for other variables also the test statistics and associated high p-values (all greater than 0.10) suggest that the joint unit root null hypothesis cannot be rejected at 5% level of significance.

5.3. Panel cointegration test with multiple structural breaks

In this section, we use the panel LM test statistic recommended by Westerlund (2006) to test for panel cointegration amongst GDP, health, education, exports, imports, R&D, and investment when there are unknown number of structural breaks. The results are reported in Table 2. We conduct panel cointegration test under 3 cases because only under these three cases the variables are cointegrated:

$$Model1: Income = f(investments, health, \exp orts, imports)$$

$$Model2: Income = f(investments, health, education)$$

$$Model3: Income = f(investments, health, education, R\,\&\,D)$$

As we can see from the table, for all these three cases we fail to reject the null hypothesis of cointegration as the test statistics are lower than the critical value of 2.28. In addition to the test statistics the test also provides the structural break dates for each country. For all 5 countries, we find two structural breaks between 1974 and 2007. For India the structural breaks occurred in 1980 and 1987. Indonesia and Nepal have structural changes during 1987 and 2000. In Sri Lanka, the structural breaks are 1986 and 2000, and for Thailand it is 1979 and 1986. All structural breaks time periods except for 1980 (India's first structural break) and 1979 (Thailand's first structural break) coincide with the massive devaluation of most Asian currencies from

1987 to 2004. The 1979 and 1980 breaks coincide with the second world oil price shock.

INSERT TABLE 2

5.4. Long-run results

Having found a cointegrating relationship between GDP, health, education, exports, imports, R&D and investment under 3 cases for the panel of 5 South Asian countries, in this section we estimate the long-run elasticities on the impact of health, education and investment, exports, imports, R&D on income. To achieve this, as explained earlier, we use the DOLS estimator. The results are reported in Table 3. Our results can be summarised as follows. First, we find that consistent with theory both health and investment have a statistically significant and positive impact on per capita income for the panel of 5 Asian countries. For instance, the elasticity on health ranges from 0.16-0.26, implying that a 1 per cent increase in health expenditure (measured as a percentage of GDP) leads to at most a 0.26 per cent increase in per capita income. Meanwhile, the elasticity on per capita investment ranges from 1.36 to 2.32, implying that a 1 per cent increase in investment (measured as a percentage of GDP) leads to at most a 2.32 per cent increase in per capita income. We also find exports and R&D to have a positive impact on per capita income. A 1 percent increase in exports (measured as percentage of GDP) leads to a 1.41 per cent increase in per capita income and a 1 per cent increase in R&D (measured as percentage of GDP) leads to a 0.07 per cent increase in per capita income. Imports have a negative and significant effect on per capita income: a 1 per cent increase in imports causes a 1.07 per cent decrease in per capita income. However, we find that education has a statistically insignificant effect on per capita income.

INSERT TABLE 3

This result is slightly surprising because it very clearly reflects that these Asian countries have spent relatively less on health care spending compared with expenditure on education. Still education turns out to be insignificant. Moreover, it also reflects that the performance of investment has been fairly healthy over the period 1974-2007. A close inspection of the data reflects these facts. For instance, in Sri Lanka and Thailand, health expenditure as a percentage of GDP was less than 2.5. For Sri Lanka, health expenditure was valued at 2.03 per cent and for Thailand it was valued at 1.6 per cent. Comparatively, expenditure on education as a percentage of GDP was 1.96 for Indonesia, 2.21 for Nepal, 2.72 for Sri Lanka, and 3.84 for Thailand. From these figures one can observe that expenditure on education has been much greater than expenditure on health.

Similarly, R&D expenditure as a percentage of GDP for all 5 countries varies from 0.13 to 1.70. However, the performance of gross fixed capital formation has been much healthier than education and health. For instance, for all the 5 countries, gross fixed capital formation as a percentage of GDP was valued at over 18 per cent. Exports as a share of GDP are lowest for India (9 per cent) and highest for Thailand, at 40 per cent. Similarly, imports are also lowest for India, around 11 per cent and highest for Thailand, around 40 percent.

6. Conclusion

The literature that examines the impact of health, education, and investment through controlling for other variables, such as exports/imports and R&D, on economic growth is growing and is an important one. Our aim was to contribute to this literature but from a different perspective. We examined this relationship through including three additional variables, namely exports, imports, and R&D within a panel data framework making use of recent developments in panel data econometric analysis, such as panel unit roots and panel cointegration with structural breaks. Subsequently, we were able to unravel the long-run impact of health, education, exports, imports, R&D, and investment on income for a panel of 5 Asian countries over the period 1974-2007. This has been the novel contribution of this study.

Our main findings were that: (1) per capita income, health, investment, exports, and imports were cointegrated; per capita income, health, education, and investment were cointegrated; and per capita income, health, education, R&D, and investment were cointegrated; and (2) while consistent with theory both health, investment, exports and R&D had a statistically significant and positive impact on per capita income and imports had a statistically significant negative effect on per capita income, education had a statistically insignificant impact on income for the panel of 5 countries.

There are two policy implications emerging directly from our empirical analysis. First, this study ascertains that education has not contributed to economic growth in the group of 5 Asian countries considered in this study in spite of higher education expenditures. This does not imply that education does not have the potential to contribute to growth; rather, a more micro level disaggregation is required, such as how much is spent in public vs. private education, how much is spent in primary vs. secondary education, in order to examine the role of education. The channel of education expenditure in these Asian countries should properly be examined.. Although education expenditure as a percentage of GDP is higher than health but still it is very low compared to the developed countries. For instance, while for the G7 countries expenditure on education is over 10 percent of GDP, except for Thailand, for the group of Asian countries considered in this study, education expenditure was less than 3 percent. The implication is clear: These countries must spend more on education to reap the benefits in terms of higher economic growth. This is certainly possible in the case of India and Thailand where government budget has been in surpluses. It is fair to say that this surplus can be better used to boost education. However, the same cannot be said for Nepal, Indonesia, and Sri Lanka, where budget deficits have been fairly large; in most years, valued at around or over 5 per cent of GDP (see Section 2). Moreover, these countries are likely to struggle to boost and maintain education. These countries also have high external debts, valued at over 50 per cent of GNI; hence, the possibility of borrowing more to spend on education is not recommended since it is risky, in that it can threaten the sustainability of these countries. In the light of this, the question of which sector(s) should be sacrificed in favour of education is one open to debate and very much in need of attention by policy makers.

Second, that health, R&D, exports and investment contribute positively to economic growth is welcome. However, the magnitude of the impact of health and R&D as revealed by DOLS estimator is fairly low. For instance, we find that a 1 per cent increase in health expenditure as a percentage of GDP leads to around 0.3 per cent increase in per capita income and 1 percent increase in R&D expenditure leads to 0.07 percent increase of per capita income. To this end, we notice that except for Thailand expenditure on health has been less than 3 per cent of GDP. Similarly, the share of R&D expenditure in the GDP is less than 2 percent. The Asian countries can reap the benefits of health and R&D through spending more on these vital sectors. Again, as highlighted earlier, in the face of expanding budget deficits and escalating external debts for Sri Lanka, Indonesia, and Nepal, the issue of which sectors should be sacrificed in favour of health and R&D is a moot point.

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Table 1: IPS unit root test including trend and intercept

Variables	Test statistic	Probability value
Income	1.6054	0.9458
Investment	-0.9816	0.1632
Health	1.2745	0.8988
Education	-1.5902	0.0559
Exports	1.0951	0.8633
Imports	-0.3055	0.2102
R&D	0.1732	0.9992

Notes: The null hypothesis of a panel unit root cannot be rejected in the levels of the variables. This is a pre-condition for panel cointegration test

Table 2: Westerlund (2006) panel cointegration test with structural breaks

	Model 1	Model 2	Model 3
Test statistics	1.8504	1.4880	1.4504
Break dates			
India	1980, 1987	1980, 1987	1980, 1987
Indonesia	1987, 2000	1987, 2000	1987, 2000
Nepal	1987, 2000	1987, 2000	1987, 2000
Sri Lanka	1986, 2000	1986, 2000	1986, 2000
Thailand	1979, 1986	1979, 1986	1979, 1986

Notes: The CV at the 1 per cent level is 2.28. The null hypothesis is "cointegration". We cannot reject the null hypothesis at the 1per cent level in all the three models, implying that the variables in each of the models are cointegrated.

Table 3: DOLS estimates of the long-run elasticities

Variables	Model 1	Model 2	Model 3
Investment	1.3684 *** (6.3604)	2.3217*** (8.2773)	2.0209*** (6.4294)
Health	0.2179*** (4.3777)	0.2677*** (3.4696)	0.1679* (1.8873)
Education	-	0.0165 (0.1889)	0.1084 (1.1211)
Exports	1.4178*** (11.1084)	-	-
Imports	-1.0732*** (6.9552)	-	-
R&D	-	-	0.0793** (2.1939)

Notes: *** (*) denote statistical significance at the 1 per cent and 5 per cent levels, respectively, and t-statistics are given in parenthesis.

ENDNOTES

[1] The model is similar in spirit to the work of Bloom *et al*. (2004).

[2] Lucas (1988) argues that improving the standard of living can stimulate economic growth.