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Nexus Between Human Capital, Technology and Economic Growth: The Role of Stages of Economic Development in Asian Countries

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ABSTRACT

This paper explores the effect of human capital and technology on economic growth in Asian countries while considering economic development. The paper expands the Solow Growth model by further incorporating the import of machinery and equipment reflecting total factor productivity. Panel data for 30 Asian countries has been used over 1995-2015. Due to the endogeneity problem in human capital and other variables, the System Generalized Method of Moment (GMM) is used to address this problem. Empirical results reveal that human capital and technology have increased economic growth in the total sample of Asian countries. Furthermore, the sample has been disaggregated into high-income (HI) and low-income (LI) Asian countries. Our findings determine that human capital and technology are reflecting a positive and statistically significant role in enhancing economic growth in both samples of countries. However, the magnitude of the impact is high in HI Asian countries relative to LI Asian countries, respectively. When the import of machinery and equipment are replaced with patents, a positive and insignificant results are obtained for LI countries because these countries have lacked legal systems, but a positive and statistically significant relationship is observed for HI Asian countries.

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INTRODUCTION

Economic growth (EG) has been a challenging task ever since the beginning of the economic system. Rapid economic growth and macroeconomic reliability are the core goals of every economy. High economic growth leads to industrialisation and improvement in people's living standards. An increase in physical capital stock, technological advancement, and an increase in the labour force are the main drivers of economic growth. After World War II, it has been recognised that physical capital accumulation is the most critical determinant of economic growth and development (Bauer, 1948). Later on, many development economists such as Lewis and Rostow debated that developing countries suffer in a poverty trap; therefore, they could not accumulate physical capital without significant savings. However, physical capital accumulation does not cause long-run sustainable economic growth due to diminishing scale property returns. Improvement in technology or continuous technological breakthrough can lead to long-run sustainable growth.

Moreover, human capital development is another instrumental factor for economic growth (Romer, 1986; Uzawa, 1962). Because production needs the interaction of different capabilities affected by human capital(HC), we believe that HC plays a vital role when interacted with technology and other productive factor. EG directly depends on human capital because persons with more education are likely to produce more output. Their creative attitude leads to the conception of new and improved products and refining the efficiency of factors of production (Sachs & Warner, 1995). Human capital improves technology innovation from neighbouring countries through tempting ideas and importing machinery and equipment (Benhabib & Spiegel, 1994; Pegkas & Tsamadias, 2014; Zhu & Li, 2016).

However, many countries have perceived the different impacts of HC on EG. For instance, the interesting point is that South Korea and Taiwan brought small changes in education, but it drastically increased their growth (Easterly, 2001). Cross countries regression reveals no relationship between education attainment and output per capita growth (Pritchett, 2001). HC could not contribute to EG due to insufficient jobs and low returns to the educated worker.

Therefore, physical and human capital may be part of the story of rising economic growth, but certain other factors contribute to the growth process. Much technological progress embodied with HC has been substantiated as the primary driver of EG in the theoretical and empirical literature (R. J. Barro & Lee, 1998; Romer, 1990). However, a low level of expenditures on education in developing countries is the primary cause of disability to innovation and productivity. Deficits in HC have proven to be the factors of low standard productivity. Technological changes worldwide are forcing every economy to ponder the role of technology in economic development. It is believed that the technology innovation is the leading driver of economic growth in the long run. New invention in technology is the immediate need of developing countries as many of them are standing at the edge of development, demanding progressive policy to innovate technology.

In Asian countries, East Asian nations such as Taiwan, South Korea, Singapore, and Hong Kong are comparatively newly industrialised countries (NICs) and have higher per capita income than South Asian countries.In a study, Young (1995) emphasises that increased investment in infrastructure, education, health, high labour force participation, and sectoral shift from agriculture to manufacturing are the major factors that caused the high growth of NICs. Developing Asia's sustainable growth rate depends on innovation, human capital, and infrastructure to enhance productivity and economic growth (Asian Development Outlook, 2017).

This study intends to investigate the influence of HC and technological progress on the economic development and growth of Asian countries while controlling the level of stages of economic development. A limited strand of literature has examined the impact of HC and technological innovation on the economic development and growth of Asian countries. Still, these studies are either region-specific, country-specific, or time series. There is hardly any study that captures the effects of both human capital and technological progress on the growth of all Asian nations. It is to this reason he present study analyses the influence of human capital and technological improvement on the growth of all Asian countries by categorising them as developed and developing countries as per the World Bank definition. In developed countries, high-income and upper-middle-income (UMI) Asian countries are included, while low- and lower-middle-income (LMI) Asian countries are included in developing countries. Countries are segregated into HI and LI countries to encounter the role of stages of development. Stages of development have a definite impact on economic growth. The Augmented Solow model is used, and technological progress is captured with imports of machinery and equipment. Human capital is measured in percentage of primary, secondary, total years of schooling, and population life expectancy. System-GMM is used as a remedy for the problem of endogeneity.

LITERATURE REVIEW

Economic growth in the classical framework

The classical theory of EG is the contribution of Smith, Ricardo, and Malthus. Economic growth is the outcome of physical capital accumulation and technological progress. Land Labor and Capital were recognised as factors of production with increasing returns to scale. According to Smith (1776), when the size of the market increases, internal and external economies of scale are achieved, and the cost of production will eventually lower.

The production function of Coats and Ricardo (1973) is similar to that of Smith (1776), with the distinguishing of diminishing marginal productivity, which means productivity. Malthus (1826) differed from both and found that savings are always equal to investment. He captured EG through three factors. First, improvements in domestic transport and communication can enhance the small size of markets through international trade. Second, unemployment can be reduced by the increase in technological progress. Technological progress generates employment in the industrial sector. Where technology fails, there is a fall in income and a rise in unemployment. Third, technological progress has a significant investment in the industrial sector, where the impact of diminishing return on land can be neutralised.

The neoclassical framework of economic growth

Solow (1956) model is regarded as the model of exogenous growth. This model found that economic growth can only be achieved exogenously with technological progress. But how it can be achieved has not been explained by this model. Arrow (1962) criticised the assumption of diminishing returns in the production process. He used the idea of learning by doing and defined knowledge as a capital good. With learning by doing, physical capital is utilised efficiently, and an increase in knowledge enhances productivity instead of decreasing returns to scale. Uzawa (1962) argued that technological knowledge is a crucial determinant of economic growth and formulated a model. Advancement in technological knowledge can be achieved by utilising scarce resources in a positive direction. The economy consists of labour (L) and physical capital (K) in this framework. These factors of production are used together to yield output. Output can be consumed or used again to gather further capital stock. Nelson and Phelps (1966) explained economic growth based on differences in human capital. They argued that the ability of a country to innovate and compete with developed countries depends on the capability to adopt technology and do internal innovations. This model assumes that the growth of TFP depends on the employment of new findings/innovations. The production of goods and growth of a country depends upon human capital development.

Endogenous growth theories considered economic growth as a product of endogenous sources. Investment in human capital, innovation, and knowledge primarily contribute to economic development. Endogenous growth theory can be disaggregated into two generations. The theory of first-generation argued that human capital is a vital determinant of long-run economic growth as specified by Romer (1986) and Lucas (1988). Theory of second-generation considered technological progress as the main factor of economic growth of a country in the long run. (Grossman & Helpman, 1994; Romer, 1990).

Economic growth and human capital

In the 1980s, a group of endogenous theorists substituted the exogenous growth variable (mysterious technical progress) with a model with a determinant of growth evident in the model. Growth in this model was attained because of unlimited investment in human capital, which had spillover effects on the economy and reduced the decreasing return to physical capital accumulation. (Arrow, 1962; Uzawa, 1962). The economy has three sectors, including R&D, Intermediate, and final goods sectors. Human capital is a rival good among R&D and the final goods sector. If more human capital is engaged in R&D, then the economy can sustain long-run growth. Romer (1986)and Mankiw et al. (1992) incorporated human capital as a distinct factor of production. They used the OLS method on data of 121 countries from 1960 to 1985 and used the human capital as an explanatory variable. Taking the people enrolled in the secondary schools between the ages of 12 to 17 years, they used the secondary school variable as a proxy for human capital.

The impact of human capital on the economic growth of India and Pakistan was investigated by Abbas and Nasir (2001). He used the dataset of 25 years from 1970 to 1994 and applied the OLS estimation technique. He considered physical capital, labour, and human capital stock as independent variables. Enrollment of the population at different stages of education was taken as proxies for human capital. In both countries, secondary school enrollment proxy for human capital proved statistically significant with expected positive results. Ranis et al. (2000) investigated the links between human capital development and economic growth for developing countries ranging from 35 to76 and tested the results with cross-country regressions. They interpreted the results with two chains: 1) economic growth to human development and 2) human development to economic growth. Regressions of cross-country data showed a significant connection in both orders. They found that government spending on health and education, especially for females, contributed much in the first chain (economic growth to human development). On the other hand, the investment rate and income distribution played a substantial role in the second chain (human development to economic growth). They suggested that where choice is available, the development of humans should be given importance for sustainable growth in the long run.

Mayer (2001) investigated the effect of machinery imports and domestic R&D for developed and developing countries to measure technology transfer in developing countries. He assembled a dataset on machinery imports and employed a growth-accounting framework to examine the influence of machinery imports and human capital on economic growth. The results showed a positive impact of human capital and machinery imports on growth variances in the transition period. Teixeira and Fortuna (2004) estimated the long-run relationship among total factor productivity (TFP), human capital, internal invention, and absorption capabilities of Portugal from 1960 to 2001. Co integration test results displayed the importance of human capital relatively more significant than innovation capabilities to explain productivity. Constant relationship among productivity, human capital, and interior innovation capabilities indicated the importance of human capital for Portugal's economy. Mgadmi and Rachdi (2014) conducted an empirical finding in Tunisia from 1974 to 2012. They concluded that the non-linear relationship between human capital (HC) and growth and HC significantly influenced economic growth. They used the Smooth Transition Autoregressive model (ESTAT, LSTAR) to underline this non-linear relationship. They argued that Human capital proved to be the most crucial driver for economic growth in Tunisia.

Queirós and Teixeira (2014) investigated that the economic growth of OECD countries depends on the development of human capital (HC), and technological progress relies on human capital development. Using the panel data estimations technique for OECD countries from 1960 to 2011, they established that prolific specialty dynamics play a vital role in economic growth. Collaboration between human capital and physical change in knowledge intense industries has a more significant impact on growth. In developed countries, the relationship between HC and structural change is optimistic in the long run. Whereas in less developed countries, the effect of human capital appeared unfavorable in a shorter time. Sunde and Vischer (2011) argued that the weak experimental outcome of human capital (HC) on economic growth is partially the result of an unsuitable description for the diverse networks through which HC shakes growth. According to growth literature, HC can interrupt growth in two ways: it may speed up growth by supplementing the current production factors and enabling the dissemination and implementation of new technology. Initial stages and changes in HC both have optimistic growth properties; on the other hand, in isolation, every channel appears insignificant. They found that HC is underrated in empirical stipulations. Therefore, the meager effects of HC on growth are constructed on explanations and quantitative issues. Bodman and Le (2013) examined the networks through which Foreign Direct Investment (FDI) improves the productivity of developing countries. For 15 industrialised countries, using data from 1983 to 2003, they investigated that FDI is an actual medium of technology transfer across countries. They also analysed that FDI channelised more resources to promote educational activities and supplement economic growth indirectly by enhancing the host country's absorptive capacity. Geographical distances proved to be the barriers to technology transfer and the economic growth of developing countries.

Health and economic growth

Akram et al. (2008) focused on the contribution of health poles to the economic growth of Pakistan for the period 1972-2006 using Granger causality, co-integration, and error correction techniques for analysis. They found that health expenditures have no casual relation with per capita GDP. Still, the Granger causality test showed that mortality rate, life expectancy, and population per bed cause economic per capita growth of Pakistan. As per co-integration results, health has a vital determinant of economic growth in the long run. Error correction results revealed the meager impact of health indicators in the short-run analysis.

An increase in enrollment in schools leads to a reduction in fertility rate accompanied by an increase in life expectancy has a positive influence on economic growth (Zhang & Zhang, 2005). Acemoglu and Johnson (2007) have challenged the causal relationship between health and economic growth by instrumenting health on the worldwide epidemiological transition after 1940. Contrary to the mainstream economic findings, they found a negative relationship between health improvement and economic growth. However, this relationship turned positively when initial health was included in regression (Acemoglu & Johnson, 2007; Bloom et al., 2014). Moreover, few studies have demonstrated that an increase in life expectancy has no adverse effects on economic growth subject to initial health (Hansen, 2014; Hansen & Lønstrup, 2015).

Moreover, a negative causal relationship was observed between cardiovascular disease and economic growth in high-income countries, the Organization of Economic Co-operation and Development (OECD) countries and European countries (Hansen & Strulik, 2017; Hyclak et al., 2016; Suhrcke & Urban, 2010). No study is yet conducted to study the impact of health on economic growth in Asian countries. In the light of the literature cited above, there is a need to examine the impact of human health capital in Asian countries to see how increased health facilities has affected economic growth and development.

Technological progress and economic growth

The promotion of competition, productivity, and job opportunities considered innovation as essential drivers of economic growth (Romer, 1986). Globalisation has forced countries to increase their invention and technological competencies to increase productivity. Technological advancement can be achieved internally through investment in R&D or externally through the import of technology. Economic growth is driven by technological advancement, and domestic capabilities of technology can be attained via invention or replication, and imitation of technology leads to conditional convergence (Connolly, 1998).

Mayer (2001) utilised a growth accounting framework to study the impact of importing machinery with domestic research and development (R&D) outflows. Machinery imports and human capital stock strongly influence productivity and economic growth. This implies that human capital has a facilitating role in absorbing foreign technology and independent capacity has a limited role as a production factor. Teixeira and Fortuna (2004) investigated Portuguese long-run economic growth by using co-integration techniques and suggested that by building specific capacities like human capital and local R&D, countries can apply knowledge of developed countries to enhance productivity and achieve long-run economic growth. They found that human capital contributes more to TFP than local R&D, and imports of machinery and equipment through trade have a more substantial impact on long-run economic growth.

Tiwari and Mutascu (2011) investigated the impact of Foreign Direct Investment (FDI) on the growth of Asian countries using the data from 1986 to 2008. In the economic process of Asian countries, non linearity associated with exports and FDI was also taken into consideration. Results proved that FDI and exports enhance the economic growth process. They also found that labour and capital play an essential role in the growth of Asian countries. In addition, they suggested that export-led growth is better than that of FDI-led growth for developing countries. Moreno and Surinach (2014) evaluated the influence of innovation adoption on productivity growth by using descriptive statistics and regression analysis. It is believed that a significant relationship exists between innovation adoption and productivity. Innovative activities carried out in 25 European countries and Turkey and Norway were considered in 1998-2004. The analysis is made with the help of statistical information provided by the Community Innovation Survey (CIS). They found that the adoption of innovations leads to productivity growth in the long run.

It is evident from the above-mentioned previous studies that a lot of work has been done on the role of human capital and technology that explains the development and economic growth of all developing and developed economies.

A literature review showed that many proxies had been used for human capital and technology. This study uses total years of schooling and primary and secondary school enrollment as proxies for human capital. Technological progress for all Asian countries is captured through imports of machinery, whereas the application for domestic and international patent rights is also used to capture the technological progress. Earlier studies were either region-specific or country-specific. The role of human capital and technological progress is investigated for all Asian countries for which data was available. There is hardly any study that captures the effect of both human capital and technological progress on the growth of all Asian countries.

Furthermore, all Asian countries are bifurcated as high income and low income as per the World Bank definition. High and upper-middle-income countries are included in high-income countries, while low and lower-middle-income countries are included in low-income countries. Countries are segregated into high and low-income countries to encounter the role of stages of development. Stages of development show light on the determinants of growth for all countries.

METHODOLOGY

To examine the effect of human capital and technological progress on long-run economic growth using the neoclassical growth theory of Solow (1956). We will develop a framework based on work of Mankiw et al. (1992) and Mankiw et al. (1992) incorporated human capital as a distinct factor in the production function following the neoclassical model.

$$Y_t = K_t^{\alpha} H_t^{\beta} (A_t L_t)^{1-\alpha-\beta} \tag{1}$$

Where Y_t shows output, K_t is physical capital, H_t is human capital, A_t is technology, L_t is workers or labour force. Moreover, $\alpha,\ \beta\ and\ 1-\alpha-\beta$ show the elasticity of output to the factor inputs.

To what extent does human capital and technological progress affect the economic growth of Asian countries, we extend the Augmented Solow growth model of Mankiw et al. (1992) by incorporating technological progress for Asian countries through total factor productivity. Physical capital (K), human capital (H), and labor (L) are used to produce output. The Cobb-Douglas production function is specified as:

$$Y = AK^{\alpha} H^{\beta} L^{1-\alpha-\beta} \tag{2}$$

The effective output in per capita form can be expressed as;

$$y = k^{\alpha} h^{\beta} \tag{3}$$

Where $y = \frac{Y}{AL}$ is an output per unit of the practical worker, $k = \frac{K}{AL}$ is the physical capital per unit of effective worker and $h = \frac{H}{AL}$ is the human capital per capita. By following Mankiw et al. (1992), the Steady-state value of k and h is determined using the following equation of motion for the rate of change of k and h and having the same depreciation rate for private capital and human capital.

$$\dot{k} = s_k k^{\alpha} h^{\beta} - (n + \delta + g)\, k \tag{4}$$

$$\dot{h} = s_h k^{\alpha} h^{\beta} - (n + \delta + g)\, h \tag{5}$$

Where s_k is the fraction of savings allocated for the development of physical capital and s_h is the fraction of savings allocated for human capital development. In steady-state, $\dot{k} = \dot{h} = 0$.Equation (4) and Equation (5) are simultaneously solved to find the steady-state values of k and h

$$k^* = \left[\frac{s_k^{\alpha} s_h^{1-\alpha}}{n + \delta + g}\right]^{1/1-\alpha-\beta}$$

$$h^* = \left[\frac{s_k^{\beta} s_h^{1-\beta}}{n + \delta + g}\right]^{1/1-\alpha-\beta}$$

By substituting k^* and h^* into Equation (3) , we get the following expression

$$y^* = \left[\frac{s_k^{\alpha} s_h^{1-\alpha}}{n + \delta + g}\right]^{\alpha/1-\alpha-\beta} \left[\frac{s_k^{\beta} s_h^{1-\beta}}{n + \delta + g}\right]^{\beta/1-\alpha-\beta} \tag{6}$$

We know that $y = \frac{Y}{AL}$ but we need here output per capita therefore, we multiply the right-hand side of Equation (6) with A, hence

$$\frac{Y}{L}^* = A\left[\frac{s_k^{\alpha} s_h^{1-\alpha}}{n + \delta + g}\right]^{\alpha/1-\alpha-\beta} \left[\frac{s_k^{\beta} s_h^{1-\beta}}{n + \delta + g}\right]^{\beta/1-\alpha-\beta} \tag{7}$$

We assume that total factor productivity depends on the constant rate of technological progress 'g' and import of machinery and equipment. Therefore, total factor productivity is specified as

$$A = A(0)\, e^{g+\theta lnimports} \qquad Where \;\; \theta > 0$$

Where θ determining the outcome of the import of machinery and equipment. However, technological progress depends not only on a constant rate of technological improvement but also on the import of machinery in the case of Asian countries. Now substitute A in Equation (7)

$$y = A(0)\, e^{g+\theta lnimports} s_k^{\frac{\alpha}{1-\alpha-\beta}}\, s_h^{\frac{\beta}{1-\alpha-\beta}} \left[\frac{1}{n+\sigma+g}\right]^{\frac{\alpha+\beta}{1-\alpha-\beta}} \tag{8}$$

The above equation explicitly demonstrates that y is an increasing function of g + imports, s and a decreasing function of σ and g. Taking the natural log of the above Equation (8)

$$lny = ln\left[A(0)e^{g+\theta imports} s_k^{\frac{\alpha}{1-\alpha-\beta}} s_h^{\frac{\beta}{1-\alpha-\beta}} \left[\frac{1}{n+\sigma+g}\right]^{\frac{\alpha+\beta}{1-\alpha-\beta}}\right] \tag{9}$$

$$lny = lnA(0) + g + \theta lnimports + \frac{\alpha}{1-\alpha-\beta} ln\ sk + \frac{\beta}{1-\alpha-\beta} ln\ sh - \frac{\alpha+\beta}{1-\alpha-\beta} + ln(n+\sigma+g)$$

There are three basic assumptions of the model: 1) human and physical capital depreciated at the same and constant rate, 2) Constant return to scale for both types of capital, and 3) technology raises ate the constant rate g plus imports of machinery and equipment. Our model is different from Mankiw et al. (1992). We consider the augmented Solow model along with technology is captured with a constant growth rate of technology g plus imports of machinery and equipment. Equation (9) indicates that steady-state output per capita depends on the constant growth rate of technology, imports of machinery and equipment, physical and human capital. Therefore, we can summarise the variant of the above model as

i) Human capital directly impacts economic growth as an added factor in the production and growth process.

ii) The import of machinery and equipment, a technology proxy, also impacts economic growth indirectly through total factor productivity (TFP).

From Equation (8), an empirical econometric model is set out to measure the impact of technology and human capital on economic growth. However, $lnA(0) = \alpha_0 + U_{it}$, α_0 is the intercept of the equation and U_{it} is the term that captures the country-specific effect. Therefore, equation (8) is modified as

$$lny_{it} = \alpha_0 + \alpha lnimports_{it} + \beta ln\ H_{it} + \gamma X_{it} + U_{it} \tag{10}$$

Where lny is the natural logarithm of GDP per capita of country i for time t, import is the natural logarithm of import of machinery and equipment, lnH is the natural logarithm of human capital, X is a vector of controlled variables and U is error term which is identically and independently distributed. The vector of controlled variables consists of democracy, trade openness, and physical capital. We disaggregate human capital into educated human capital and heal human capital. We measure educated human capital with average years of secondary school enrolment of the working-age population. Health human capital is measured with life expectancy.

Sampling and data collection

A sample of 30 Asian countries is used to study the impact of technology, transfer, and human capital on economic growth. The choice of countries is based on the availability of data. The total sample of 30 countries is further separated into two sub-samples based on low and high-income groups by following the definition of the World Bank. We have 17 high-income Asian countries in the first sub-sample, while 13 Asian countries have a low income in the second subsample.

Data of GDP per capita, life expectancy, trade openness, and gross fixed capital formation as an indicator of physical capital are collected from the World Development Indicators (WDI). Data of import of machinery as an indicator of technology diffusion is retrieved from the UN. Comtrade and data of educated human capital are obtained from Barro-Lee Educational Attainment Data (2018) Database. Data on democracy are retrieved from the Polity IV database compiled by Marshall et al. (2014).

To examine the effect of physical capital, human capital, and technological advancement on the growth of Asian countries, this study used the System GMM technique. We can estimate our model using Least Square Dummy Variable (LSDV) method if the mean of the error term is zero, the variance of the stochastic term is constant, co-variance between the explanatory and random variable is zero, and no serial correlation problem. In practice, at least one of the four problems exists in the model. The most important is the presence of endogeneity i.e. E (U_{it} , X_{it}) $\neq$ 0 and E (X_{it}, U_{it} ,) $\neq$ 0. Therefore, the LSDV method produces biased and inconsistent estimators along with the problem of endogeneity and heteroscedasticity. Although the endogeneity problem can be eliminated through 2SLS, heteroscedasticity can never be dealt with 2SLS. In such conditions, GMM is the most appropriate technique. GMM was developed by Arellano and Bond (1991); they related the performance of difference GMM, Ordinary Least Square (OLS), and Within Group (WG) estimator and found that Difference GMM produced the minor bias and variance. Another inadequacy of difference GMM is that the level variables with their lags are used as instruments considered weak for the first differences equation, leading to biased and inconsistent coefficients (Blundell & Bond, 1998). To handle this problem, it is suggested to use system GMM to combine the level equation and first difference equation (Arellano & Bond, 1991; Blundell & Bond, 1998). It is claimed that System GMM (SGMM) is superior to difference GMM because this permits for correction of measurement error in the other variables.

Therefore, we employ SGMM to estimate the effect of physical capital, human capital, and technological advancement on the long-run growth of Asian countries. Following growth literature, we use system GMM to tackle endogeneity problem and dynamic growth equation can be written as

$$lny_{it} = \alpha_0 + \theta lny_{it-1} + \alpha lnimports_{it} + \beta ln\ H_{it} + \gamma X_{it} + U_{it} \tag{11}$$

This study uses the lagged value of dependent and explanatory variables as instruments. The validity of the instrument is essential for unbiased and consistent results. Therefore, two specification tests are used. Overall instrument validity is tested through the Sargan test of over-identifying restriction. To check serial correlation in error terms, Arellano and Bond (1991) tested AR1 and AR2.

RESULTS AND DISCUSSION

We have estimated the effect of human capital and technological progress on the economic growth of Asian countries. Proxies for human capital include primary school enrollment, secondary school enrollment, total years of schooling, and life expectancy. On the other hand, technological progress is measured by importing machinery and equipment. The total sample includes 30 countries, while the sample for lower-income and higher-income countries includes 13 and 17 countries. We also estimated the same model by using patents instead of imports of machinery as a proxy for technology. But the data for patents are not available for Cambodia, Kuwait, and United Arab Emirates. Therefore, we only analyse this relation to 27 countries and present the results in the appendix.

Full Sample

The results show that the impact of human health capital captured through life expectancy on GDP growth is positive and statistically significant. The estimated coefficient ranges from 0.013 to 0.032 in different specifications. This implies a strong association of life expectancy with economic growth. These findings match with research conducted by previous authors (R. Barro, 1996; R. J. Barro

& i Martin, 1990) as they considered life expectancy a measure of human health capital. The positive influence of life expectancy on economic growth can be accepted in many ways. For example, a population having a higher life expectancy can work for many years; a longer life expectancy is a symbol to work better that increases productivity. We also estimate the impact of human capital using total average years of schooling as an indicator for this variable. The results show a positive and statistically significant association between average years of schooling and the logarithm of GDP per capita economic growth. The estimated coefficient ranges from 0.0001 to 0.082 in different specifications. Results are similar to the findings of R. J. Barro and Lee (1998). A rise in total years of schooling is the sign of higher labour productivity and the ability of the workforce to absorb advanced technology from developed countries.

We further estimated the impact of human capital using average years of primary schooling on economic growth. The results show a positive but insignificant relationship between primary schooling and economic growth. The effect of human capital on economic growth is further tested through average years of secondary schooling. Results indicated a positive and statistically significant influence of secondary school human capital on economic growth. Overall results show that human capital has a productive and meaningful connection with the economic growth of Asian countries. Countries with high enrollment at primary and secondary levels have made rapid growth in per capita GDP because higher enrollment leads to improved productivity. These results are consistent with Abbas and Nasir (2001). Similarly, Bils and Klenow (2000) found that countries with high secondary school enrollment achieve higher per capita growth.

In our baseline model, the variable of interest of this study is technological progress captured with the import of machinery and equipment. It appears in the model significantly positive and statistically significant, with a co-efficient value ranging from 0.022 to 0.033. Results show the influential impact of import of machinery and equipment, a positive and statistically significant association between the import of machinery and equipment, and economic growth. Importing machinery and equipment can contribute to economic growth through many channels. With the import of machinery and equipment, learning comes at the workplace and causes capital accumulation (Romer, 1987). Secondly, Grossman and Helpman (1994) argue that the real engine for long-run economic growth is technology transfer. The findings of this study are exact and consistent with Mayer (2001)'s claim a positive and significant relationship between imports of machinery and equipment and economic growth.

All control variables such as democracy, trade openness, and gross fixed capital formation show increasing association with growth. When patents are used

Table 1.
The Economic Growth of Asian Countries and the Role of Human Capital & Technological Progress (Full Sample) Dependent variable (logarithm of GDP per capita)

Variables	Fixed effect		SGMM	
	1	2	3	4
GDP per capita (-1)			0.827*** (0.000)	0.850*** (0.000)
Life expectancy	0.115*** (0.000)	0.120*** (0.000)	0.013** (0.030)	0.032** (0.030)
Average years of schooling(total)	0.180*** (0.000)	—	0.082*** (0.000)	—
Average years of schooling(primary)	—	0.023 (0.776)	—	0.017 (0.592)
Average years of schooling(secondary)	—	0.311*** (0.000)	—	0.112*** (0.000)
Imports of machinery	0.255*** (0.000)	0.248*** (0.000)	0.033*** (0.000)	0.022** (0.042)
Democracy	0.002 (0.821)	0.0061 (0.851)	0.004 (0.415)	0.008* (0.088)
Trade	-0.006*** (0.000)	-0.006*** (0.000)	0.002*** (0.000)	0.001*** (0.001)
Physical capital	0.022*** (0.000)	0.022*** (0.000)	0.007*** (0.000)	0.006*** (0.000)
Constant	-7.276*** (0.000)	-7.128*** (0.000)	-1.315*** (0.000)	-1.009*** (0.002)
Chi square/F-value	316.69	267.68	13197.41	14214.66
Sargan test			1.00	1.00
AR (2)			0.10	0.10
No. of countries	30	30	30	30

*, ** and *** represent significance level at 10%, 5% and 1% respectively.

in place of imports of machinery, results are again positive and significant for the entire sample. Patents cause more innovations which increase growth by introducing such types of technologies which can save both cost of production and time (Hu & Png, 2013).

Estimation of Sub samples

By splitting data into two sub samples, i.e. low, income and lower-middle-income Asian countries and upper-middle-income and higher-income Asian countries, we estimate the effects of human capital and technology on economic growth.

Table 2.
The Role of Human Capital & Technological Progress (low and lower middle income countries): Dependent variable (log of GDP per capita)

Variables	Fixed effect		System-GMM	
	1	2	3	4
GDP per capita (-1)			0.817*** (0.000)	0.833*** (0.000)
Life expectancy	0.048*** (0.000)	0.057*** (0.000)	0.0295*** (0.000)	0.031*** (0.000)
Average years of schooling(total)	0.217*** (0.000)	—	0.040*** (0.002)	—
Average years of schooling(primary)	—	-0.168 (0.139)	—	0.087 (0.714)
Average years of schooling(secondary)	—	0.566*** (0.000)	—	0.009** (0.012)
Technology transfer	0.392*** (0.000)	0.379*** (0.000)	0.028* (0.050)	0.011* (0.060)
Democracy	0.004 (0.699)	0.0066 (0.587)	0.013 (0.119)	0.013 (0.124)
Trade	-0.009*** (0.000)	-.0097*** (0.000)	0.010* (0.096)	0.010* (0.090)
Gross fixed capital formation	0.025*** (0.000)	0.021*** (0.000)	0.009*** (0.000)	0.009*** (0.000)
Constant	-6.107*** (0.000)	-5.808*** (0.000)	-1.814*** (0.000)	-1.825*** (0.000)
Chi square/F-value	176.31	156.14	9663.86	9442.55
Sargan test			1.00	1.00
AR (2)			0.36	0.33
No. of countries	13	13	13	13

*, ** and *** represent significance level at 10%, 5% and 1% respectively.

The results are reported in Table 2 and Table 3 . The results are almost identical: technology and human capital positively and statistically impact economic growth in high-income and low-income Asian countries. The interesting point is that the magnitude of the life expectancy coefficient of high-income countries is higher than that of low-income countries. Average years of primary schooling have insignificant positive results, while the average year of secondary schooling has significant positive results. These results are consistent with R. J. Barro (2001).

The possible reason for this insignificant result is that primary education alone cannot increase the skills of labourers. It is also suggested in the IIASA policy (IIASA, 2008) that primary education can contribute to economic growth if

Table 3.
Human Capital & Technological Advancement (High income and upper-middle-income countries): Dependent variable (log of GDP per capita)

Variables	Fixed effect		System-GMM	
	1	2	3	4
GDP per capita (-1)			0.952*** (0.000)	0.949*** (0.000)
Life expectancy	0.166*** (0.000)	0.168*** (0.000)	0.0138** (0.038)	0.001** (0.031)
Average years of schooling(total)	0.144*** (0.000)	—	0.069*** (0.000)	—
Average years of schooling(primary)	—	0.172 (0.144)	—	0.010 (0.758)
Average years of schooling(secondary)	—	0.110 (0.271)	—	0.126*** (0.000)
Technology transfer	0.185*** (0.000)	0.1878*8 (0.000)	0.019** (0.037)	0.019** (0.023)
Democracy	-0.007 (0.636)	-0.007 (0.616)	0.0016** (0.006)	0.0048** (0.032)
Trade	-0.005*** (0.000)	-0.005*** (0.000)	0.020*** (0.001)	0.020*** (0.001)
Gross fixed capital formation	0.024*** (0.000)	0.024*** (0.000)	0.102** (0.012)	0.101** (0.032)
Constant	-8.864*** (0.000)	-9.002*** (0.000)	0.633 (0.116)	-0.035** (0.012)
Chi square/F-value	180.58	151.58	6529.33	2196.31
Sargan test			1.00	1.00
AR (2)			0.10	0.10
No. of countries	17	17	17	17

*, ** and *** represent significance level at 10%, 5% and 1% respectively.

it is complemented with at least junior secondary education. However, human capital contributes more to the growth process of high-income Asian countries than low-income Asian countries. When patents replace imports of machinery and equipment, we get insignificant results for lower-income Asian countries while significant results for higher-income countries. The insignificant relation of patents in lower-income countries is that these countries lack legal, political, and economic structures. Patent protection cannot perform well in these countries. According to Imam (2005), developing countries can't benefit from patent protection without a proper legal and economic setup. Trade openness is statistically significant at 1%. It has a minor effect on growth for lower-income countries, while its effect on growth is relatively high and significant in the case of high-income countries (Fenira, 2015). As a result of trade liberalisation policies, developing countries have to decrease the tariffs on exports which causes a decrease in export earnings of the developing countries. Export earnings are the primary financial source for these countries, and the decrease in export earnings reduces the overall revenues of developing countries which affects the growth badly. Democracy, a measure of democratic institutions, has increased economic growth in high-income Asian countries, whereas it is statistically insignificant in low-income Asian economies. This result indicates that democratic institutions are more potent in high-income Asian countries than low-income Asian countries.

CONCLUSION AND POLICY RECOMMENDATIONS

The present study endeavoured to explore the effect of human capital and technological progress on the economic development and growth of Asian countries. The Augmented Solow model is used, and technological progress is captured with imports of machinery and equipment. Human capital is measured as average years of primary, secondary, total years of schooling, and life expectancy of the population.

Results for the entire sample show that primary, secondary, and total years of schooling must be prioritised to achieve economic growth. Technological development plays a vital role in achieving long-run economic growth by importing machinery from developed countries. The positive effect of life expectancy on economic growth also emphasised expanding expenditures on the health of the labour force. The democratic attitude of countries has a significant role in economic growth. In all estimated models, primary years of schooling give positive but insignificant results.

In contrast, secondary years of schooling give positive and significant results showing that secondary years of schooling are more important for economic growth. When patents replace imports of machinery, results are positive but insignificant for lower-income countries of Asia while significant for high and upper-middle-income countries. This indicates that technological progress is meager in low-income countries and has minor effects on economic growth.

This study suggests the following recommendations; developing countries should improve technology to increase productivity and achieve sustainable economic growth. To absorb new technology garnered through imports, human capital should increase by increasing education expenditures and increasing enrollment at each level of education with a particular focus on quality education. The absorption capacity depends on the development of healthy human capital. Developing countries should increase their spending on health infrastructure to provide better health facilities.

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APPENDIX A

Table A. 1.

List of Countries

Serial No.	Name of country	code	Region	Category
1	Bahrain	BHR	Middle east	High and Upper middle income
2	Cyprus	CYP	Central Asia	High and Upper middle income
3	Israel	ISR	Middle east	High and Upper middle income
4	Japan	JPN	East Asia	High and Upper middle income
5	Korea, Rep	KOR	East Asia	High and Upper middle income
6	Saudi Arabia	SAU	Middle east	High and Upper middle income
7	United Arab Emirates	ARE	Middle east	High and Upper middle income
8	China	CHN	East Asia	High and Upper middle income
9	Georgia	GEO	Central Asia	High and Upper middle income
10	Iran, Islamic Rep.	IRN	Middle east	High and Upper middle income
11	Jordan	JOR	Middle east	High and Upper middle income
12	Kazakhstan	KAZ	Central Asia	High and Upper middle income
13	Malaysia	MYS	East Asia	High and Upper middle income
14	Maldives	MDV	South Asia	High and Upper middle income
15	Russian Federation	RUS	Central Asia	High and Upper middle income
16	Thailand	THA	East Asia	High and Upper middle income
17	Turkey	TUR	Central Asia	High and Upper middle income
18	Armenia	ARM	Central Asia	Low and Lower middle income
19	Bangladesh	BGD	South Asia	Low and Lower middle income
20	Cambodia	KHM	East Asia	Low and Lower middle income
21	India	IND	South Asia	Low and Lower middle income
22	Indonesia	IDN	East Asia	Low and Lower middle income
23	Kyrgyz Republic	KGZ	Central Asia	Low and Lower middle income
24	Mongolia	MNG	East Asia	Low and Lower middle income
25	Pakistan	PAK	South Asia	Low and Lower middle income

Continued on next page

Table A. 1 continued

26	Philippines	PHL	East Asia	Low and Lower middle income
27	Sri Lanka	LKA	South Asia	Low and Lower middle income
28	Syrian Arab Republic	SYR	Middle East	Low and Lower middle income
29	Yemen, Rep.	YEM	Middle East	Low and Lower middle income
30	Nepal	NPL	South Asia	Low and Lower middle income

Table A. 2.

Descriptive Statistics

Variables	Observations	Mean	Standard dev.	Min.	Max.
Foreign direct investment	600	3.53	9.63	-43.46	198.31
Population growth	600	1.79	1.80	-3.32	15.05
Av. Year schooling(total)	600	7.95	2.46	2.34	12.32
Av. Year schooling(primary)	600	4.30	1.11	1.59	6.38
Av. Year schooling(secondary)	600	3.19	1.45	0.52	6.87
Life expectancy	600	71.16	5.63	55.12	83.59
Technology	600	22.94	2.14	17.40	27.17
Ln(GDP per capita)	600	8.12	1.47	5.33	10.91
Democracy	600	4.26	3.31	1	10
Ln(Patents)	540	6.39	2.61	0	12.79

Table A. 3.

Full sample: Patents, human capital and growth

Variables	System GMM	
	1	**2**
Log(GDP Per Capita (-1))	0.9221*** (0.000)	0.912*** (0.000)
Life Expectancy	0.005 (0.202)	0.009* (0.070)
Av. Year of Schooling(Total)	0.045*** (0.000)	—
Av. Year of Schooling(Primary)	—	0.003 (0.888)
Av. Year of Schooling(Secondary)	—	0.052*** (0.000)
logPatents	0.007** (0.011)	0.010** (0.031)
Democracy	0.002 (0.406)	0.004 (0.257)
Trade	0.006** (0.048)	0.006* (0.093)
Gross Fixed Capital Formation	0.005*** (0.000)	0.007*** (0.000)
Constant	-0.332 (0.155)	-0.385 (0.117)
Chi Square	18541.12	17978.91
Sargan Test	1.00	1.00

Continued on next page

Table A. 3 continued

AR (2)	0.10	0.12
Observations	513	513
No. of Countries	27	27

*, ** and *** represent significance level at 10%, 5% and 1% respectively.

Table A. 4.
High income Asian countries: Patents, human capital and growth

Variables	System GMM	
	1	**2**
GDP Per Capita (-1)	0.970*** (0.000)	0.973** (0.030)
Life Expectancy	0.010** (0.040)	0.011* (0.057)
Av. Year of Schooling(Total)	0.039*** (0.000)	—
Av. Year of Schooling(Primary)	—	0.027 (0.407)
Av. Year of Schooling(Secondary)	—	0.055*** (0.000)
Ln(Patents)	0.015** (0.012)	0.121** (0.031)
Democracy	0.004 (0.333)	0.001 (0.675)
Trade	0.001*** (0.000)	0.001*** (0.000)
Gross Fixed Capital Formation	0.001 (0.560)	0.001 (0.331)
Constant	0.488* (0.073)	0.552* (0.052)
Chi Square	9074.58	9248.85
Sargan Test	1.00	1.00
AR (2)	0.10	0.15
Observations	285	285
No. of Countries	15	15

*, ** and *** represent significance level at 10%, 5% and 1% respectively.

Table A. 5.
Low income: Patents, human capital and growth

Variables	System GMM	
	1	**2**
GDP Per Capita (-1)	0.885*** (0.000)	0.886*** (0.000)
Life Expectancy	0.019*** (0.000)	0.020*** (0.000)
Av. Year of Schooling(Total)	0.026*** (0.000)	—
Av. Year of Schooling(Primary)	—	0.022 (0.259)
Av. Year of Schooling(Secondary)	—	0.016** (0.037)
Ln(Patents)	0.004 (0.510)	0.008 (0.231)

Continued on next page

Table A. 5 continued

Democracy	0.013** (0.002)	0.012** (0.005)
Trade	0.001** (0.015)	0.005 (0.327)
Gross Fixed Capital Formation	0.008*** (0.000)	0.008*** (0.000)
Constant	-0.884*** (0.000)	-0.961*** (0.000)
Chi Square	9310.67	9458.60
Sargan Test	1.00	1.00
AR (2)	0.13	0.27
Observations	228	228
No. of Countries	12	12

*, ** and *** represent significance level at 10%, 5% and 1% respectively.