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RESEARCH ARTICLE

The contribution of international trade to economic growth through human capital accumulation: Evidence from nine Asian countries

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Abstract: This study is an attempt to test the hypothesis "international trade contributes to economic growth through its effects on human capital accumulation." To assess the hypothesis empirically, we employed the extended Neo-Classical growth model that reflects some features of the endogenous growth models. We thus ended up with a model in which the change in human capital is sensitive to change in trade policies. Unlike conventional approaches, the model serves to assess and determine the impact of international trade on the accumulation of human capital. The empirical analysis estimates dynamic panel growth equations by using a data-set of nine Asian countries, over the period 1972–2012. The overall evidence substantiates the fact that in countries under consideration, international trade enhances the accumulation of human capital and contributes to economic growth positively through human capital accumulation.

Keywords: international trade, human capital, physical capital, economic growth, panel data

JEL classifications: C23, F10, O40, O47

ABOUT THE AUTHOR

I have been conducting and leading work in the design of economic research involving development and modification of theoretical models, empirical findings, analytical studies, report/policy note writing, and broad data collection. My key research area in economics is Economic Growth and International Trade in which I have done my PhD dissertation; *this paper is one of the products of my PhD dissertation.* My research experiences are rich, as I worked with various research organizations including Pakistan Institute of Development Economics (PIDE), World Bank (Islamabad), Center for Research on Economics and Social Transformation (CREST, Islamabad), and Kashmir Institute of Economics (KIE, Muzaffarabad). The structure of these projects as well as my role contributed greatly to my ability to carry out independent research projects.

PUBLIC INTEREST STATEMENT

Since economies of the world are growing interdependent, international trade is pursuing a critical element of growth promotion policy in developing countries. This paper provides rigorous analyses, which explore that how international trade increases economic growth by accumulating human capital in selected developing countries. The results of this paper demonstrate three key findings. First, the empirical results lend support to the claim that international trade enhances the accumulation of human capital and contributes to economic growth positively through human capital accumulation. Second, the results also support the liberalization of technology imports as it allows importing countries to increase the innovation rate and, hence, to accelerate economic growth. Third, our findings suggest that a significant determinant of the advantages, which developing countries can extract from international trade, is the capacity to absorb technology and the level of skill of the domestic labor force.

1. Introduction

Generally, the endogenous growth models fall into two broad groups. On one hand, there are models closer to the Neo-Classical view Romer (1986), Lucas (1988), Stokey (1991), Rebelo (1991), Barro (1991), Mankiw, Romer, and Weil (1992), Barro and Sala-i-Martin (1995) emphasize on the accumulation of human capital. On the other hand, there are models based on creative destruction idea of Schumpeter (1934), i.e. Romer (1990), Grossman and Helpman (1991a), Aghion and Howitt (1992), and Coe and Helpman (1993) that layemphasis on the endogenous development of knowledge and R&D.

Base on their growth driver, these growth frameworks have attributed different roles to international trade in the growth process. The first group of endogenous growth models tries to explain the role of international trade in terms of human capital accumulation (learning-by-doing). For instance, Romer (1986) in his growth model attributes a critical role to the process of learning-by-doing, a concept derived from Arrow (1962). Human capital is defined as a by-product of physical capital in the Romer's model. The activity of learning is said to be associated with the capital stock of the firm. An increase in the capital stock, hence, results in an increase in the firm's stock of knowledge. International trade, as the Romer model suggests, increases the total size of the market, raises the level of output, leads to an increased learning-by-doing, and hence contributes to economic growth. Similarly, Lucas's human capital accumulation-based growth model (1988) tries to explain the role of international trade in terms of human capital accumulation (learning-by-doing). His model suggests that human capital accumulation on-the-job training (learning-by-doing) is associated with the type of goods produced in an economy. The type of goods produced in an open economy is determined according to the comparative advantage. Hence, international trade helps to determine the nature and extent of the human capital accumulation through learning-by-doing.[1] Lucas (1993) explains his idea further and argues that the process of learning-by-doing exhibits diminishing returns to scale, which implies that the rate of learning in an individual production process declines overtime to zero.[2] International trade proves beneficial because it continuously creates new opportunities and activities to which the workers can shift and hence avoid diminishing returns to scale associated with the learning process.

The second group of endogenous growth models, i.e. Romer (1990), Grossman and Helpman (1991a), Aghion and Howitt (1992), Lichtenberg (1994), and Coe and Helpman (1995), tries to explain the role of international trade in the growth process in terms of innovation, technological improvement, and its transfer. In this framework, international trade affects economic growth with three different channels. First, international trade expands varieties of new products, e.g. Romer (1990) highlights that growth in knowledge rests on the introduction of greater variety of goods and international trade plays a positive role in this connection. Rivera-Batiz and Romer (1991) argued that international trade in capital goods raises the market size for new product varieties. Grossman and Helpman (1991b, 1991c) argued that trade openness proves beneficial for the introduction of new varieties because it provides access to a wider base of technical knowledge that reduces the cost of innovation. Similarly, the innovation-based growth model of Aghion and Howitt (1992) argued that international trade provides opportunities for innovation and consequently leads to technological improvements. Second, international trade provides access to foreign intermediate inputs, e.g. Romer (1990) argues that international trade enables countries to import intermediate inputs from abroad that are not invented domestically, which can help to foster productivity in manufacturing sector. Third, international trade facilitates the diffusion of international knowledge. For instance, Coe and Helpman (1995) define that "international trade in intermediate goods is the main channel of international knowledge spillovers" and support the idea that knowledge diffused through trade seemed to raise domestic productivity.

There is sizable empirical work that has investigated the contribution of international trade to economic growth through technological diffusion.[3] However, a very small segment of empirical studies is trying to investigate the role of international trade in economic growth through human capital accumulation. In this perspective, the key objective of this study is to investigate the

contribution of international trade to economic growth through its effect on human capital accumulation. In order to achieve the objective, we have developed a theoretical framework, which is mainly based on Neo-Classical growth model, while we incorporated some aspects of endogenous growth theory. We test empirically that how international trade affects economic growth through its effects on human capital accumulation by using a panel data-set of nine Asian countries over 40 years (i.e. 1972–2012).

The rest of the paper is structured as follows. Section 2 presents the theoretical framework regarding the impact of human capital that accumulates through international trade on economic growth. Section 3 discusses in detail the empirical model. In Section 4, we provide definition and construction of variables under consideration. Section 5 discusses the selection criteria of sample countries. Section 6 provides detailed econometric methodology for our empirical analysis. Section 7 presents empirical findings and inclusive interpretation. Study concludes with Section 8, which draws main conclusions emerging from the study and proposes some policy implications.

2. Theoretical framework

"Exploring the contribution of international trade to economic growth through its effects on human capital accumulation" is the main objective of this study as earlier discussed in Section 1. In order to achieve the objective, we would develop a theoretical model and this section is devoted to meet this end. Although the theoretical model, which we are going to develop, would be mainly based on Neo-Classical growth model, some aspects of endogenous growth theory would be included in it. This consequent model would enable us to assess and determine the accumulation effects of international trade on human capital and hence on economic growth.

2.1. Model

Consider that there exists an economy aggregate labor-augmenting production function,

$$Y_t = F(K_t, A_t L_t) \qquad (1)$$

where Y_t is the level of aggregate output, K_t is the stock of physical capital, L_t is the size of labor force, and A_t is the effectiveness of labor or technological progress. As one typical approach to model aggregate productivity is that of Cobb–Douglas specification, Equation 1 takes the following form.

$$Y_t = K_t^\alpha (A_t L_t)^{1-\alpha} \qquad (2)$$

The production function has constant returns to scale in aggregate, as well as in each production factor.[4] Population "$N_{(t)}$" is growing with a constant rate "n", i.e. $N_{(t)} = N_{(0)} e^{nt}$. We assume full employment in the economy and eliminated age structure in the population, which implies that labor force and employment are equal at each point in time, i.e. $L_t = L_0 e^{nt}$. Similarly, technology "A_t" is assumed to grow at constant rate "g", i.e. $A_t = A_0 e^{gt}$. The labor in efficiency units, $A_t L_t$, grows at constant rate $n + g$.

The basic production function is extended through the incorporation of human capital H_t. We have included human capital in our production function as a separate factor of production as human capital-augmented Solow model of Mankiw et al. (1992). Some studies, e.g. Nelson and Phelps (1966), followed by Benhabib and Spiegel (1994), suggest that human capital affects productivity through the adaptation and implementation of foreign technology, and by the creation of domestic technology rather than entering as an input factor. Incorporating human capital "H_t", the production function thus extended as:

$$Y_t = K_t^\alpha \cdot H_t^\beta \cdot (A_t L_t)^{1-\alpha-\beta} \qquad (3)$$

Our set-up human capital is accumulated in two different ways: one is human capital accumulation through formal education (investment in education), and another is human capital accumulation

through learning-by-doing. In this framework, human capital accumulation through formal educa-tion differs from Lucas (1988), which assumes that individuals spend time to accumulate human capital. Here, we follow Mankiw et al. (1992) that country's income may be used either for consump-tion or investment in the accumulation of human capital. Therefore, the assumptions that human capital evolves as physical capital and that it has the same depreciation rate cannot be refuted.[5] Human capital that accumulates through investment in education is denoted by "I_n" and is financed through saving "s_h"; therefore, expressed as:

$$dH/dt = I_h = S_h = s_h Y_t \qquad (4)$$

The second way of human capital accumulation is learning-by-doing. This idea reflects Arrow's (1962) model that productivity gains occur without innovations in the production process. Hence, the accumulation of knowledge occurs not because of deliberate efforts, but as a side effect of con-ventional economic activity. Romer (1986) used Arrow's (1962) approach and relaxed the assump-tion of diminishing return to physical capital by assuming that human capital is a by-product of physical capital. Accordingly, with an increase in the physical capital stock, more learning-by-doing will take place and hence more human capital will be accumulated. Lucas (1993) strengthens this idea further and argues that efficiency of learning-by-doing depends on both the nature of produc-tion (production process) and the production level of new goods. If workers engage in activities with high rates of skill acquisition and high levels of products diversification, then more learning occur and, therefore, more human capital will be built. Lucas also points out that learning-by-doing in one product is subject to diminishing returns if learning externality is limited. This idea is supported by Young (1993) who concentrates on learning and invention approaches with basic assumption of "learning in the production of any particular good using any particular process is in fact finite and bounded." According to Young (1993) "when a technical process is first invented, rapid learning takes place but after some time the productive potential of that process is diminished." Therefore, in the absence of new technical process, it is not possible to keep learning-by-doing sustained. This implies that if an economy preserves the same production line, its learning-induced activities will decline. Hence, to keep sustained learning-by-doing and thus high level of human capital accumula-tion, both level and diversification of production are imperative.[6] To incorporate this idea into our Neo-Classical growth model, we multiply "$s_h Y_t$" with an index of new goods product "q"; therefore, the evaluation of human capital is given as:

$$dH/dt = s_h Y_t (1+q) \quad 0 < q < 1 \qquad (5)$$

where "q" denotes an index of new goods production (product innovation). The value of "q" depends on production diversification and levels of production; the more a country diversifies its production coupled with high level of production, the higher will be the value of "q" and hence more human capital will be accumulated.

To normalize all variables in efficiency units of labor, we divide the variables by effective unit of labor. More precisely, defining $y_t = \frac{Y_t}{A_t L_t}$, $k_t = \frac{K_t}{A_t L_t}$, $h_t = \frac{H_t}{A_t L_t}$; hence, the effective unit income equation becomes as follows:

$$y_t = k_t^\alpha \cdot h_t^\beta \qquad (6)$$

Assuming constant rates of depreciation "σ", population growth "n", and technology "g", the evalu-ations of the capital stocks are as follows:

$$dk_t/d_t = s_k y_t - (n + g + \delta) k_t \qquad (7)$$

$$dh_t/d_t = s_h y_t \cdot (1+q)^\rho - (n + g + \sigma) h_t \qquad (8)$$

For the sake of simplicity, we omit time "*t*" and put $(n+g+\delta)=D$, then Equation 7 becomes:

$$S_k y = D \cdot k \tag{9}$$

Putting the values from Equation 6 to Equation 7,

$$k = \left[\frac{s_k(h^\beta)}{D}\right]^{1/1-\alpha} \tag{10}$$

Equation 8 will become

$$s_h y \cdot (1+q)^\rho = D \cdot h \tag{11}$$

By putting values from Equation 6,

$$h = \left[\frac{[s_h(k^\alpha) \cdot (1+q)^\rho]}{D}\right]^{1/1-\beta} \tag{12}$$

The above solutions provide two equations and two unknowns (i.e. *k* and *h*); hence, we can get the steady-state values (*k**, *h**) of these unknowns by solving this system of equations.

$$k^* = \left[\frac{s_h^\beta \cdot (1+q)^{\rho\beta} \cdot s_k^{1-\beta}}{D}\right]^{1/1-\alpha-\beta} \tag{13}$$

$$h^* = \left[\frac{s_h^{1-\alpha} \cdot (1+q)^{\rho(1-\alpha)} \cdot s_k^\alpha}{D}\right]^{1/1-\alpha-\beta} \tag{14}$$

Substituting the values of *k**, *h** into production function (Equation 6), we obtain the effective unit income equation.

$$y^* = \frac{\left[s_h^\beta \cdot (1+q)^{\rho\beta} \cdot s_k^\alpha\right]^{1/1-\alpha-\beta}}{D^{\alpha+\beta}} \tag{15}$$

By taking logarithms of both sides,

$$\ln y^* = \frac{\alpha}{1-\alpha-\beta}\ln(s_k) + \frac{\beta}{1-\alpha-\beta}\ln(s_h) + \frac{\rho\beta}{1-\alpha-\beta}\ln(1+q) - \frac{\alpha+\beta}{1-\alpha-\beta}\ln(D) \tag{16}$$

We assume that "δ" is constant across countries and human capital depreciates at the same rate as physical capital (i.e. $\delta_h = \delta_k$) as Mankiw et al. (1992). We also assume that technology is same across countries (not country specific). The technology level "*A*" is expressed as some initial stock of technology "A_0" multiplied by the exogenous growth rate "g_t" and some country specific factors "ε" (i.e. social set-up, resource endowments, institutions, climate, etc.); $A_0 \cdot e^{g_{t+\varepsilon}}$ With the incorporation of this information and by putting the value of ($D=n+g+\delta$), Equation 16 can be expressed as:

$$\ln y^* = \ln(A_0) + g_t + \varepsilon + \frac{\alpha}{1-\alpha-\beta}\ln(s_k) + \frac{\beta}{1-\alpha-\beta}\ln(s_h)$$
$$+ \frac{\rho\beta}{1-\alpha-\beta}\ln(1+q) - \frac{\alpha+\beta}{1-\alpha-\beta}\ln(n+g+\delta) \tag{17}$$

Equation 17 is our basic empirical model in which the right side identifies the variables that determine the steady-state level of per capita income. In the traditional Neo-Classical growth models at the steady state, per capita output grows with the exogenous rate of technological progress "*g*"; therefore, no further capital extension takes place. Accordingly, convergence takes place (poor

countries grow faster than their rich counterparts). However, the advocates of Neo-Classical endogenous growth theories have criticized the assumption of decreasing returns to capital, and usually do not agree with the convergence hypothesis of the traditional Neo-Classical growth model. [7] Near the steady state, the transitional growth rate can be expressed as follows:

Let y^* be the steady-state level of income per effective labor as given in Equation 16 and let y_t be the actual value at time t, then the speed of convergence is given as:

$$gy_t = d \ln y_t / dt = \lambda (\ln y^* - \ln y_t) = \lambda \ln(y^*/y_t) \tag{18}$$

where $\lambda = (n + g + \delta)(1 - \alpha - \beta)$ is the convergence coefficient, which indicates that how rapidly an economy's income per effective labor y_t approaches its steady-state value y^* in the neighborhood of the steady state.

The exponential function $\ln\left(\frac{y_t}{y^*}\right) = c \cdot e^{-\lambda t}$ is a solution to the differential function $\frac{d \ln\left(\frac{y_t}{y^*}\right)}{dt} = -\lambda \ln\left(\frac{y_t}{y^*}\right)$ for any coefficient c. Therefore, Equation 18 implies that

$$\ln y_t - \ln y^* = \ln(y_0/y^*) \cdot e^{-\lambda t} = e^{-\lambda t} \ln y^* - e^{-\lambda t} \ln y_0 \tag{19}$$

By rearranging these terms, we can get

$$\ln y_t = (1 - e^{-\lambda t}) \ln y^* + e^{-\lambda t} \ln y_0 \tag{20}$$

Subtracting $\ln y_0$ from both sides,

$$\ln(y_t) - \ln(y_0) = (1 - e^{-\lambda t}) \ln y^* - (1 - e^{-\lambda t}) \ln(y_0) \tag{21}$$

Equation 21 shows that growth rate of income per effective labor depends on the difference between income and steady-state income adjusted by the convergence rate λ. Substituting the value of $\ln y^*$ from Equation 16, we get the final equation as follows:

$$
\begin{aligned}
\ln(y_t) - \ln(y_0) \\
= \left(1 - e^{-\lambda t}\right) \frac{\alpha}{1 - \alpha - \beta} \ln(s_k) + \left(1 - e^{-\lambda t}\right) \frac{\beta}{1 - \alpha - \beta} \ln(s_h) + \left(1 - e^{-\lambda t}\right) \frac{\rho \beta}{1 - \alpha - \beta} \ln(1 + q) \\
- \left(1 - e^{-\lambda t}\right) \frac{\alpha + \beta}{1 - \alpha - \beta} \ln(n + g + \delta) - \left(1 - e^{-\lambda t}\right) \ln(y_0)
\end{aligned}
\tag{22}
$$

Equation 22 shows that the growth of per worker income depends on the determinants of the ultimate balance growth path (s_k, s_h, n, g, δ) and on the initial level of income y_0.

3. Empirical model
Based on the background of previous theoretical framework, for empirical analysis, we have estimated the following baseline model using panel data of nine Asian countries spanning between 1972 and 2012.

$$
\begin{aligned}
\ln \Delta y_{it} = \beta_0 + \beta_1 (\Delta y_{it} - 1) + \beta_1 \ln(PhyC)_{it} + \beta_2 \ln(HC)_{it} + \beta_3 \ln(INOR)_{it} \\
+ \beta_4 (IMPC)_{it} + \beta_5 \ln(OPEN)_{it} + \beta_6 \ln(GPOP)_{it} + V_{it} \quad \text{where } V_{it} = \delta_i + u_{it}
\end{aligned}
\tag{23}
$$

where $\ln \Delta y_{it}$ is the log difference of GDP per worker, the subscript i denotes countries ($i = 1, \dots, 9$), and t denotes years ($t = 1972, \dots, 2012$). $\ln(PhyC)_{it}$ denotes physical capital stock, which captures through investment as a share of GDP. $\ln(HC)_{it}$ is human capital stock, i.e. human capital accumulation through formal education, which captures through average years of schooling of the working age population. $\ln(INOR)_{it}$ is human capital accumulation through learning-by-doing, which is captured by product innovation index. $\ln(IMPC)_{it}$ is imported capital, which captures through import of

machinery and transport equipment. ln(OPEN)$_{it}$ is countries' trade openness that captures through trade-to-GDP ratio, and ln(GPOP)$_{it}$ is the rate of growth of population. Here, δ_i defines country specific effects such as heterogeneity in the initial level of technology, or differences in the efficiency level as specified by Temple (1999), and Bond, Hoeffler, and Temple (2001), and u_{it} is the idiosyncratic error term.

4. Definition and construction of variables

The data used to estimate equation 23 are five-year interval data (i.e. 1972–1976, 1977–1981, 1982–1986, ... , 2007–2012) giving a time dimension of eight periods. Instead of annual, we used five-year averaged data under the assumption that short-term business cycle effects may appear large in yearly data that distort growth estimation. The key variables of our analysis are growth of GDP per worker, physical capital stock, human capital stocks, imported capital, trade openness, and population growth. Data on growth of GDP per worker of the sample countries are taken from the Penn World Table (PWT) version 7.1. Investment as a percentage of GDP (PhyC)$_{it}$ is used as a proxy for physical capital stock. The data are taken from World Development Indicators (WDI), World Bank (2013). Regarding the data of human capital stock (HC)$_{it}$, we consider Barro and Lee (2012)[8] average years of schooling data-set and the global average Mincerian Rate of Return. Hence, the human capital stock is constructed through exponentially compounded product of the average years of schooling of working age population (i.e. 15 years and older) and with global average Mincerian Rate of Return (i.e. 9.5%). $HC_i = L \cdot e^{\pi s_i}$, where HC$_i$ is average per worker human capital stock in country i, L measures ages of working age population (i.e. 15 years and older), while $e^{\pi s_i}$ is exponentially compounded return to education, and s_i is the average number of years of schooling of working age population.

Learning-by-doing (INOR)$_{it}$ is measured with a product innovation index; the idea is that due to production of new products, or by the modification of existing products, learning takes place and hence skill of the participant labor increases. As cross-country data on new goods production are not available, we used proxy. The most reliable proxy is goods exported for the first time.[9] The export data for the sample countries have been taken from "UN Comtrade statistic." The "UN Comtrade statistics" provide export data on different types [e.g. Standard International Trade Classification (SITC), Harmonized System (HS)], with various classification, i.e. Rev_1, Rev_2, Rev_3, Rev_4, and with different digit levels. Taking into account both the nature of the study and the availability of data for a long time span (1972–2012), we have selected specification of SITC, Rev_1, and AG_3 (three digit levels) for export data.[10] We have formulated some assumptions for building product innovation. First, the good exports for the first time, second, value more than three hundred thousand dollars, and finally, exporting for three successive years. Therefore, an exporting product will be considered an innovation if it fulfills the above assumptions.

The imported capital stock (IMPC)$_{it}$ can be measured in three different ways.[11] The first way is to multiply manufacturing imports with total merchandize imports and then divide by GDP. Second way is to divide the value of imports (machinery and transport equipment) by GDP.[12] The third way is to divide the value of imported machinery and transport equipment by the value of total imports. As our countries sample is sufficiently diverse in terms of domestic market and GDP size, for example, we have large population countries with higher GDP such as India, Indonesia, and small population countries and larger GDP such as Singapore; therefore, taking into account such miscellany in GDP size, the first two measures are not relevant for importing physical capital stock. The reason is that the country that has large population and higher GDP should be a smaller share of total imports to GDP and hence has a smaller share of imported capital and vice versa for the country, which has relatively small population and lower GDP. Keeping in mind these limitations of first two measures, we have selected the third measure to calculate imported physical capital stock. As already mentioned, in this measure, we have required data on two components, i.e. imports of machinery and transport equipment, and total imports.[13]

Openness to international trade (OPEN)$_{it}$ is measured with exports plus imports to GDP,[14] which have been taken from PWT 7.1. The data of population growth (GPOP)$_{it}$ have been taken from WDI (2013). We assume constant rate of technological progress (i.e. $g = .02$) as well as depreciation rate (i.e. $\sigma = .05$) across countries which sum $(g + \sigma)$ is .07 and hence added to the growth of population "n".[15] We have used the data-set of nine Asian countries.

5. Selection criteria of sample countries

To test the hypothesis "international trade contributes to economic growth through its effects on human capital accumulation" we used data-set of nine Asian countries.[16] Four motives limit our analysis to the sample of nine Asian countries. First, these regional countries share a number of common economic features. This helps to avoid the problem of assuming a common intercept in the cross-country regression. Second, regional grouping can avoid heterogeneity of initial technology across countries, as suggested by Temple (1999) that initial technology could be similar within regions but varying between regions. Third, regional grouping offers greater scope for manipulating some of the variables, which are hard to measure at the world level, e.g. social set-up. Fourth, these countries have almost same trade policies in terms of both structure and period dimension. For instance, in 1950s and 1960s, these countries rely heavily on import substitution, whereas in 1970s, lots of consideration is paid to export-led growth. Moreover, in late 1970s and early 1980s, they have made comprehensive trade liberalization in order to make dynamic export composition and to transform structurally the productive capabilities. Owing to these trade reforms, the socio-economic developments in these countries significantly loop to international trade.

6. Econometric methodology

Considering cross-sectional specific effects, dynamic panel growth regression is the most reliable approach of estimation. Therefore, instead of usual cross-sectional growth regression, we estimate dynamic panel growth model. However, the most efficient estimation technique to estimate dynamic panel growth model is generalized method of moments (GMM) developed by Arellano and Bond (1991). There are two types of GMM estimators, i.e. first difference GMM estimator and system GMM estimator. The first difference GMM estimator developed by Arellano and Bond (1991) applies first differenced equation and an appropriate level of lagged as an instrument. On the other hand, the system GMM estimator developed by Arellano and Bover (1995) applies in addition equations in levels using first difference as an instrument. We estimate a dynamic growth model to analyze empirically the contribution of international trade to economic growth through its effects on human capital accumulation through difference GMM developed by Arellano and Bond (1991).

7. Empirical findings and interpretation

As mentioned in the introductory part, the key objective of this study is to investigate the contribution of international trade to economic growth through its effects on human capital accumulation. Hence, our empirical analysis mainly focuses on human capital accumulation through learning-by-doing ln(INOR)$_{it}$ and its interactive terms. Table 1 shows the estimated results of our extended Neo-Classical growth model for the panel of selected Asian countries. It is important to explicate that lagged dependent variable ln($\Delta y_{it} - 1$), physical capital ln(PhyC)$_{it}$, and population growth ln(GPOP)$_{it}$ are common to all of our growth regressions. For the rest of variables, we tested their significance by making different combinations of innovation rate ln(INOR)$_{it}$ with human capital and trade variables. The parameter estimates in column 2 [Model 1] of Table 1 show the results of our basic empirical model. However, from column 2 [Model 1] onwards, we do the sensitivity analysis. In column 3 [Model 2], for instance, we add interactive terms of learning-by-doing and formal education, whereas from column 5 [Model 4] to column 7 [Model 6], we add the interactive terms of learning-by-doing with trade openness and imported capital to the list of control variables. Model 1 predicts a negative relationship between the lagged per worker income and subsequent per worker GDP growth, i.e. coefficient for ln($y_{it} - 1$) is −.374, which is significantly different from zero at one percent level. The result is consistent with the Neo-Classical growth model that per capita growth rate of income tends to be inversely related to its starting level of per capita income. This suggests that there is a tendency for poor Asian countries to grow faster on average than rich

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Table 1. Panel regression for the nine Asian countries from 1972 to 2012

Variables	[Model 1]	[Model 2]	[Model 3]	[Model 4]	[Model 5]	[Model 6]
$\ln(\Delta y_{it}-1)$	−.374*** (.002)	−.179*** (.000)	−.252*** (.000)	−.187***(.000)	−.249*** (.000)	−.321*** (.000)
$\ln(\text{PhyC})_{it}$	2.763***(.001)	2.861*** (.000)	2.725*** (.000)	2.528*** (.000)	1.988** (.003)	2.373*** (.000)
$\ln(\text{HC})_{it}$	.079 (.153)			.368 (.285)	.159*** (.000)	.177 (.262)
$\ln(\text{INOR})_{it}$	.028*** (.013)				.012 (.621)	
$\ln(\text{IMPC})_{it}$					.746*** (.000)	
$\ln(\text{OPEN})_{it}$			1.442*** (.000)			
$\ln(\text{GPOP})_{it}$	−1.035*** (.014)	−1.485*** (.001)	−1.098 (.263)	−1.025** (.041)	−2.036* (.061)	−2.106*** (.000)
$\ln(\text{INOR})_{it} \times \ln(\text{HC})_{it}$		.048** (.030)	.017 (.13)			
$\ln(\text{INOR})_{it} \times \ln(\text{OPEN})_{it}$				.022** (.041)		
$\ln(\text{INOR})_{it} \times \ln(\text{IMPC})_{it}$						.019*** (.000)
Number of observations	54	54	54	54	54	54
Number of countries	9	9	9	9	9	9
Number of instruments	25	26	26	25	26	26
Sargan-test	16.21	15.44	13.21	15.46	16.73	11.28
p-value	(.28)	(.15)	(.13)	(.24)	(.35)	(.47)

Notes: The dependent variable is the average annual growth rate of real GDP per worker for each five-year interval. Columns [2–7] is the one-step difference GMM estimation. Values in parentheses are *p* value of *Z* statistics. The Sargan-test is the test of the validity of instrumental variables (test of over-identifying restrictions) in GMM estimation. In our case, the null hypotheses of Sargan-test (over identifying restrictions are valid) is not rejected, which show that instrumental variables are valid.

*Significant at 10% level.

**Significant at 5% level.

***Significant at 1% level.

Asian countries. The physical capital $\ln(\text{PhyC})_{it}$ has the strongest growth elasticity (2.763) among explanatory variables that are significantly different from zero at one percent level, suggesting that physical capital is the one strong indicator of the growth of GDP per worker in selected Asian countries.

The human capital acquired by school education $\ln(\text{HC})_{it}$ that enters in the regression is statistically insignificant but has expected positive sign (.079), suggesting that human capital acquired by school education has no significant impact on growth of GDP per worker for Asian countries. The coefficient for our second indicator of human capital learning-by-doing $\ln(\text{INOR})_{it}$ is .028, which is significantly different from zero at one percent level. This implies that in selected Asian countries, international trade plays an important role in the accumulation of human capital through learning-by-doing, which is reflected in subsequent per worker GDP growth. Thus, for the selected Asian countries, we find preliminary support for our key hypothesis that "international trade contributes to economic growth through its effects on human capital accumulation through learning by doing."

Our population growth that measures $\ln(\text{GPOP})_{it}$ adjusted by the rate of technological progress and depreciation has significant and expected negative sign (−1.035), which is comparable to the standard Neo-Classical growth model that a higher population growth rate reduces the steady-state value of capital per worker and hence reduces the steady-state value of per capita income. The result is also reposed by augmented Neo-Classical growth model of Mankiw et al. (1992) that due to high population growth, human capital spreads per worker more thinly and thereby lowers per capita income growth. The stronger and negative sensitivity (elasticity) of population growth has an interesting implication for the impact of human capital on per capita income growth.[17]

The growth regression presented in column 3 [Model 2] shows the impact of interactive term of human capital accumulation through learning-by-doing and formal education $\ln(INOR)_{it} \times \ln(HC)_{it}$ that enters the model positively and statically significant. Thus, our results indicate that human capital accumulation through formal education and innovation rate (i.e. human capital accumulation through learning-by-doing) are complementary. It has relatively stronger growth elasticity ".048", which shows that a certain level of human capital is necessary to harvest the potential gain of international trade in the accumulation of human capital through learning-by-doing and thus higher rate of economic growth. The growth regression presented in column 4 [Model 3] includes trade openness $\ln(OPEN)_{it}$, which has positive and highly significant relationship with growth of GDP per worker, whereas the interactive term $\ln(INOR)_{it} \times \ln(HC)_{it}$ is positive but not significant. This may be due to high multi-collinearity between $\ln(INOR)_{it}$ and $\ln(OPEN)_{it}$.[18] However, the interactive term of innovation rate and trade openness $\ln(INOR)_{it} \times \ln(OPEN)_{it}$ presented in column 5 [Model 4] has positive and statistically significant impact on the growth of GDP per worker. Thus, our results indicate that both human capital and trade intensification are beneficial to improve human capital through learning-by-doing and thereby enhancing growth of GDP per worker in selected Asian countries.

The growth regression presented in column 6 [Model 5] includes imported capital $\ln(IMPC)_{it}$, which shows positive and highly significant relationship with the growth of GDP per worker; however, the innovation rate $\ln(INOR)_{it}$ becomes insignificant. This illustrates that imported capital plays a crucial role in economic growth of these under-study Asian countries. One possible explanation of the result might be that, these countries have good absorption capacity to harvest the potential output of foreign technology. The findings are in relevance to Veeramani (2014) findings that knowledge embodied in a country's import basket of capital goods is positively related to the economic growth of imported country.

The last column of Table 1 displays the result of the interactive term of innovation rate and imported capital $\ln(INOR)_{it} \times \ln(IMPC)_{it}$ that enters in the model positively and statistically significant. This specification is investigated to analyze whether the contribution of international trade to economic growth through learning-by-doing also depends on a country's relative position regarding imported technology or not. Our results reveal that imported capital and innovation rate (i.e. human capital accumulation through learning-by-doing) are complementary.[19] The one possible explanation of the result is that imports of new technology enhance learning-by-doing.

The result maintains Lucas (1993) model, which argues that efficiency of learning-by-doing depends on both the nature of production (production process) and the production level of new goods. If workers engage in activities with high rates of skill acquisition and high levels of products diversification, then more learning occurs, and therefore more human capital would be built. He also pointed out that learning-by-doing in one product is subject to diminishing returns if learning externality is limited. The result is also comparable to Young (1993) idea that concentrated on learning and invention approaches with basic assumption of "learning in the production of any particular good using any particular process is in fact finite and bounded." According to Young (1993), "when a technical process is first invented, rapid learning takes place but after some time, the productive potential of that process is diminished." Therefore, in the absence of new technical process, it is not possible to keep learning-by-doing sustained. This implies that, if an economy preserves the same production line, its learning-induced activities will decline. Hence, to keep sustained learning-by-doing and thus high level of human capital accumulation, continuous introduction of new goods is imperative and imported technology plays a vital role regarding this association.

8. Conclusion and policy implications

"International trade contributes to economic growth through its effects on human capital accumulation" was the primary hypothesis that was investigated in this study. To assess the hypothesis empirically, we employed the Neo-Classical growth model while incorporating some features of endogenous growth theories. We, thus, ended up in a model, in which the changes in human capital

are sensitive to changes in the trade policies. The consequent model also mirrored the importance of absorption capacity (average years of schooling, imported capital) for the economic growth of a country. In this extended Neo-Classical growth model, growth of GDP per worker was associated with the human capital accumulation through formal education, human capital accumulation through learning-by-doing, physical capital, and population growth.

The empirical analysis estimated dynamic growth equations by using a panel data approach for a set of nine Asian countries over the period of 1972–2012. The overall evidence substantiates the fact that international trade enhances the accumulation of human capital and contributes to economic growth positively. The one noteworthy result is that interactive term of human capital accumulation through formal education (average years of schooling) and human capital accumulation through learning-by-doing (i.e. innovation rate) exhibits relatively stronger growth elasticities compared with individual term of innovation rate. This supports the idea that countries which foster trade liberalization and exports diversification policies, and have high absorption capacity (i.e. human capital), are able to benefit more from international trade in the form of human capital accumulation.

The overall impression that one can draw from these findings is that indeed international trade enhances economic growth through human capital accumulation, channel. In addition, countries that foster trade liberalization and export diversification policies, and have high absorption capacity such as human capital, are able to get more benefit from international trade in the form of human capital accumulation. These findings corroborate the evidence of endogenous growth theories, which suggest that international trade makes it possible to enhance economic growth by increasing specialization through learning-enhancing activities.

Based on the finding of the study presented in Section 7, these recommendations are put forward that can direct policies about international trade human capital accumulation and economic growth. First, as the empirical results lend support to the claim that international trade enhances the accumulation of human capital and contributes to economic growth positively through human capital accumulation. Accordingly, developing countries need to design and implement forward-looking trade liberalization policies in order to enhance and sustain economic growth. Second, the results also support the liberalization of technology imports as it allows importing countries to increase the innovation rate and, hence, to accelerate steady economic growth. This entails a trade policy that helps to sustain incentives for imported technology. Third, our findings suggest that a significant determinant of the advantages, which developing countries can extract from international trade, is the capacity to absorb technology and the level of skill of the domestic labor force. Accordingly, government policies should be designed in such a way as to maintain incentives for both human capital accumulation and technology adoption.

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Notes
1. Recently, a segment of empirical studies recognized that the nature of products and exports matters for economic growth performance Amable (2000), Lewer and Van Den Berg (2003), Crespo-Cuaresma and Worz (2005), Hummels and Klenow (2005), and Hausmann, Hwang, and Rodrik (2007).
2. The idea is supported by Young (1993) who suggested that, "when a technical process is first invented rapid learning takes place but after some time the productive potential of that process is diminished."
3. See for example, Coe and Helpman (1995), Coe, Helpman, and Hoffmaister (1997), Lichtenberg and van Pottelsberghe de la Potterie (1998), Eaton and Kortum (1999), Xu (1999), Keller (2000), Xu (2000), Mayer (2001), Xu and Chiang (2005), and Lumenga-Neso, Olarreaga, and Schiff (2005).
4. ($\alpha=1$, $1-\alpha=0$ or $1-\alpha=1$, $\alpha=0$ and also $\alpha+1-\alpha=1$, with these assumptions, the model becomes AK type (i.e. output grow proportionally with cumulative factors) which generates growth endogenously (the determinants of long-term growth are structural characteristics of the economy, such as the rate of time preferences and not exogenous factors, e.g. population growth and techno-

logical change). As the cumulative inputs have constant returns to scale, non-zero steady state growth is possible.

5. Mankiw et al. (1992) assumed that human capital is accumulated just like physical capital; therefore, it is measured in units of output instead of years of time.

6. In this case, the rate of knowledge accumulation (learning-by-doing) does not depend on the fraction of resources engaged in R&D activities as Griliches (1979) but considers the overall net investment as Arrow (1962) and Romer (1986).

7. See for instance Lucas (1988), Romer (1990), Grossman and Helpman (1991a), Aghion and Howitt (1992): these models agree on the absence of diminishing return to capital and, therefore, explain divergence between economies.

8. Data available at http://www.barrolee.com/.

9. The one serious issue of proxy (first time export) is the time gap with product innovation as discussed by Bidlingmaier (2007) that the time determination of new innovation is very difficult, "goods could be produced domestically very earlier as they were exported for the first time."

10. Data available at http://comtrade.un.org/db/.

11. See Bidlingmaier (2007).

12. See Mayer (2001), and Dulleck and Neil (2008).

13. Data are taken from the United Nation COMTRADE database system.

14. A large number of empirical studies used trade shares in GDP as a proxy of openness, for instance Dowrick (1994), Frankel and Romer (1999), Rodriguez and Rodrik (2001), Rodrik, Subramanian, and Francesco (2002), Irwin and Terviö (2002), and Yanikkaya (2003).

15. See Mankiw et al. (1992), and Hoeffler (2002) among others.

16. Indonesia, India, Korea Republic, Sri-Lanka, Malaysia, Pakistan, Philippines, Singapore, and Thailand.

17. Barro (1991) pointed that higher stock of human capital per person raises the wage rate and hence the cost of raising and caring children; therefore, higher stock of human capital motivates families to choose a lower fertility rate that results in higher rate of economic growth.

18. Innovation rate, which has captured through exports, has been covered in trade openness that is measured through exports plus imports as a percent of GDP.

19. Human capital accumulation through learning-by-doing and innovation rate are interchangeably used in this article.

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