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CONTRIBUTION OF ADVANCED TECHNOLOGY AND FOREIGN CAPITAL TO GROWTH OF DIFFERENT STAGE OF DEVELOPMENT COUNTRIES

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ABSTRACT

This study determines influence of advanced technology and foreign capital on economic growth apart from contribution of the other major domestic inputs. The countries were classified into four groups; i.e., lower and lower middle income countries, upper middle income countries, non-OECD high income countries, and OECD countries. Five major factors as sources of growth in this study are domestic factors; i.e., domestic capital, labour, and human capital and supporting factors; i.e., foreign capital, and advanced technology. The long run cointegrating relation of the five major factors and its output was estimated for each group of countries. By using panel dynamic production function, most factors in the model were found significantly determining growth in all income groups. Human resources, in form of labour and human capital, were the most contributors to growth. Although all factors were found significantly contributing to growth in the OECD, at least one of the factors has not played significant role in the other three lower stages of development countries. Noticeably, both advanced technology and foreign capital were found significantly contributing to growth in all countries except for the high income Non-OECD where the advanced technology being insignificant source of growth. All five engines of growth must be put attention to play role in development of economy so that the development can be sustainable such as found all being significant factors in the case of the OECD.

Keywords: Domestic capital, Foreign capital, Human capital, Advanced technology, Country specific, Sources of growth, Cointegrating relation, Panel dynamic model.

JEL Classification: O33, O40, O50.

Contribution/ Originality

This study has used panel dynamic model that can help demonstrate the role of country specific factor and the crucial factors determining growth in the various level of development countries. Furthermore the study incorporated into the model human capital, foreign capital and role of technology of which data are often unavailable and inconsistent across countries and over periods of time.

1. INTRODUCTION

The well-known classical economic growth theory identified sources of growth into two major factors: input growth and residual growth. The input growth consists of capital growth and labour growth. The residual growth, or Total Factor Productivity growth, is the growth of output caused by factor other than the inputs' growth so is named as the residual and is determined exogenously outside the system of the model.

The new endogenous growth approach has believed in roles of human capital and accumulation of knowledge process such as research and development and technological progress or advanced technology including externality and scale economies. The econometric method states clearly that the omission of relevant variables in the regression equation can cause biased estimate. In addition, possible endogenous explanatory variables included in the model can also cause the endogenous biasedness and inconsistency of the estimation.

This study constructed the model of sources of growth by incorporating major factors contributing to growth and estimating the model using panel data. Owing to problem of non-stationarity of time series data of variables in the model, the dynamic model in line with the error correction model is therefore constructed and estimated. Moreover, unobservable specific cross country effect possibly due to differences in institutions, socioeconomic factors, culture, and production was also incorporated into the study.

Next section will review the related literatures. It is expected to provide background on some related studies on sources of growth. The third section described the model construction and the data being used in the estimation. Estimation of domestic capital stock and foreign capital stock are described. The proxies of human capital, advanced technology as well as incorporated country specific factor being used in the study are presented in this section. Section four discussed the estimation result and its detailed analysis in comparison across the groups of the countries. Section five presented the conclusion.

2. LITERATURE REVIEW

The traditional Solow's growth model put role of capital accumulation and population growth as two important conventional inputs that contribute to output growth apart from the exogenously given residual growth being explained by technical progress (Solow, 1956; 1957). The Solow's growth model however requires the equilibrium condition of input elasticity equals input share and hence constant returns to scale is a necessary condition.

To add few more important factor inputs into the sources of growth, Nelson and Phelps (1966) explain the role of human capital and also showed that Solow residual depends on the gap of the level of knowledge. They put emphasis on the role of education as human capital factor that can invent and adopt new advanced technology earlier or faster so can speed up diffusion of technology. The adoption and implementation of technology is being invented gradually at a rate exogenously given. Therefore increase in educational attainment of labour can raise technological path in the long run.

Mankiw *et al.* (1992) examined roles of physical and human capital stocks on the determinants of economic growth as factors included in the Cobb-Douglas production function. They augmented human capital as the other capital input apart from the physical capital in the Solow's growth model. They argued that the omission of human capital input in the model can lead to biased estimate and can explain why the roles of population growth and physical capital inputs were found too large. Data set of selected 98 countries from Summers and Heston, the Penn World Table, was used in the estimation. The study could indicate why some countries were rich and some countries were poor and showed existence of conditional convergence using the traditional two input growth model. Moreover the study found existence of non-constant returns to scale production function and supported for the augmented human capital input into the Solow's production function. It is interesting to note that the Adjusted R^2 or the goodness of fit of the estimated augmented production function of the OECD countries was found obviously the highest value than those of the other 98 non-oil countries and 75 intermediate income level countries.

Human capital is also considered an important factor in the growth in Benhabib and Spiegel (1994). When the model in which human capital associated with the growth of Total Factor Productivity was constructed and estimated, the result showed that the human capital was confirmed to be a significant factor determining growth. According to this paper, the human capital can affect growth through two mechanisms: affecting the speed of technology adoption and influencing domestically produced technology and innovation. The first mechanism was postulated in line with Romer (1990a) that the human capital can directly influence productivity by way of increasing capacity of the nation to innovate new appropriate technology. The second mechanism was the one in which adapted from the model of Nelson and Phelps (1966) to allow human capital to catch up the speed of technological innovation and diffusion. The relationship between human capital and economic development was also tested by using long run cointegrating relation. Enrolment rates in primary, secondary and tertiary education were found to be correlated with the per capita GDP while the causality was tested and found that education causes GDP for primary school and secondary school. However, for the tertiary education, it was found the reversal relation.

Human capital was considered to be an important factor of growth. The author constructed the human capital that based on Mincerian wage equation in the previous study for Thailand (Kraipornsak, 2009). Data of individual samples from the Labour Force Survey of the National Statistical Office in year 1993 and 2006 was used in the estimation of the sectoral wage equations. The human capital index was then augmented into the production function for the analysis of growth in Thailand. The finding of the study indicated the existence of the positively long run contribution of human capital and the Total Factor Productivity to growth in agriculture while the physical capital input positively contribute to all sectors. The long run growth of industry can be traded off with those of agriculture and services when allowing all sectors to interact in the growth of the economy wide. Advanced technology has been placed a crucial role in sources of growth. Lucas (1988) and Romer (1990b) have modeled the growth of advanced technology, or technological progress, to depend directly on the educational level of labour, saying as human capital input, and the endogenous nature of technological progress and growth. The allocation of human capital is determined by incentives in the market that allocates between production and invention that enhances the growth of technology. Therefore the role of human capital is facilitating adoption of technology from other advance countries and creation of appropriate technology locally.

Research and development can be considered as an investment flow that cumulates stock of the capital investment and finally affects output as a consequence. The stock of research and development capital was therefore accounted for another source of growth that is not easily measurable (Griliches, 1980). He found a substantial decline in the effectiveness or the rate of research and development capital on productivity growth during the period of the productivity slowdown in the US during 1969 – 1977. Research and development is a process of knowledge creation that cumulates stock of knowledge to achieve advancement in technology. Advanced technology as a consequence of research and development investment can then be accounted for a source of growth. It was believed that foreign direct investment can affect positively or negatively to any economy. The positive effect of foreign direct investment has been obtained by various possible ways such as enhancing capital formation, promoting exports, learning by doing and technological transfer and spillover effects. The negative effect of foreign direct investment has been mainly based on the Marxist and the dependency theories over the exploitation of and gaining control over the host countries. In addition, there are various effects of the foreign direct investment such as employment, growth, balance of payment, transfer of technology, and income inequality. In overall, whether or not the foreign direct investment affects the economy positively or negatively depends very much on how it affects the national welfare in the long run.

There have been many studies on the effects of foreign direct investment using panel data. Recently various empirical studies on growth used panel data on the estimation of the model. The advantage of using panel data is on its correcting for country specific differences in various factors including institutions, culture, and socio-economic factors. Moreover, the frequent problem of autocorrelation in the time series and the problem of heteroscedasticity in the cross sectional data estimation can also be minimized or avoided (Hsiao, 1986). Although, to ovoid biasedness of omitted variables in the model so country specific factor is included and fixed effect estimation is adopted in the panel data analysis; it relies on homogeneity assumption of the different panel country groups for a common slope. In dynamic panel data with a large time dimension, Pesaran and Smith (1995) showed that ignorance of heterogeneity of groups of countries can create autocorrelation of disturbances and inconsistent estimates of parameters. Average effects with changing slopes across individual groups in dynamic panel model can be used to give consistent estimation of mean group procedure.

De Mello (1999) studied impact of foreign direct investment on capital accumulation, Total Factor Productivity growth and output growth and compared the results of estimation from time series and panel data. It was found that foreign direct investment can be growth enhancing depending on its degree of complementarity and substitution with domestic investment. If foreign direct investment can positively affect growth, complementarity between foreign direct investment and domestic investment is required at least in the short run. Foreign direct investment can also create spillovers in the production of the economy significantly so it can lead to growth of output. By using panel data set of Summers and Heston, The Penn World Table, and divided countries into two income level groups; i.e., OECD and non-OECD countries, the impact of foreign direct investment should be smaller in the OECD countries group. The impact of foreign direct investment should be smaller for the more advance countries or net exporters of foreign direct investment. There is however evidences that many foreign direct investments occurred across advanced economies where they are higher level of technology countries (Lucas, 1990).

The study of De Mello found mixed (positive and negative) results of foreign direct investment impact on output growth in time series analysis in both short run and long run. Foreign direct investment showed positively affect output growth suggesting the dominant complementary effect between foreign direct investment and domestic investment in the fixed effect panel data estimation after introduction of the country specific factor into the model. Under the dynamic model of foreign direct investment, foreign capital is complementary to the domestic capital when it involves transfer of new technology and new process and management style. Borensztein *et al.* (1998) also found that in sixty nine developing countries during 1970 – 1989 they needed foreign direct investment to be as domestic absorptive capacity to enhance growth. The study revealed marginally significant impact of foreign direct investment on growth. The foreign direct investment is considered to be complementary to the domestic investment in the developing countries. The magnitude of this positive effect of foreign direct investment on the economic growth however depended on stock of human capital available in the host country.

3. MODEL AND ESTIMATION

The aggregate production function in this study consists of five major factors; i.e., domestic capital input (KD), foreign capital input (KF), labour (L), human capital (HC), and advanced technology (τ). By using panel data estimation, there is an important advantage over the time series estimation in that the time series estimation of the standard two factor input production function leads to possible simultaneity or endogeneity bias. The bias is caused by the relationship between the regressors in the model and the error term since the model omits some other important variables such as human capital and advance knowledge especially country specific difference. The high estimates of capital elasticity coefficient well above the capital share in output found in many studies can also be the evidence of this endogeneity bias (Young, 1995). The panel data estimation can help correct for the endogeneity bias caused by the omission of unobservable cross-country effects or country specific differences in institutions, socioeconomic factors, culture, and production (Hsiao, 1986).

Recall the aggregate production function, assuming that the production function exhibits Cobb-Douglas functional form and the technological progress is in exponential form, the aggregate production equation is therefore written as in Equation (1) below.

$$Y_{it} = A_{0i}e^{(\gamma\tau_{it}+\varepsilon_{it})}KD_{it}^{\beta1}KF_{it}^{\beta2}L_{it}^{\beta3}HC_{it}^{\beta4} \quad (1)$$

Where, ε_{it} is the White Noise residual term of the regression of Equation (1). Y_{it} is the output of the economy.

Taking natural logarithmic form into Equation (1), it becomes log-linear equation as in Equation (2) below.

$$lnY_{it} = \alpha + \gamma\tau_{it} + \beta_1 lnKD_{it} + \beta_2 lnKF_{it} + \beta_3 lnL_{it} + \beta_4 lnHC_{it} + \varepsilon_{it} \qquad (2)$$

Panel data of 108 countries during 1992 – 2011 was collected and used in the estimation of the model basically depending on availability of completeness of data on all variables in the model. List of the countries included in the study is shown in the Appendix. Since data of some variables used in the model estimation are not available and those available data are not consistently defined among these countries, the study generated series to be the proxies of those variables to be used in the model estimation. Details of each variable used in the study can be described as follows.

Y is Gross Domestic Product (GDP) measured in purchasing power parity in billion US dollars from IMF-World Economic Outlook.

τ, or *HTECX* named in this study, is to represent the advanced technology or the stage of knowledge in each country over time. The study used the proportion of hi-tech exports on the total exports to be the proxy of the advanced technology in the model.

KD is domestic capital stock which was estimated in the study as in Equation (3) by using the conventional Perpetual Inventory Method (PIM) (Christensen and Jorgenson, 1969). Total investment was divided into domestic investment and foreign investment. Capital stock was then calculated by using the PIM equation below. Both domestic capital stock and foreign capital stock were measured in million US dollar.

$$K_t = I_t + (1 - \delta)K_{t-1} \qquad (3)$$

Where, K_t is capital stock, I_t is investment, and δ is depreciation rate.

KF is foreign capital stock which was calculated in the same manner as in the domestic physical capital stock (KD) described below whereas foreign direct investment was used in place of domestic investment in the calculation. This paper estimated the capital stock as suggested by Berlemann and Wesselhöft (2012). Their study provides comprehensive estimations of aggregate capital stocks for 103 countries in 2010 using the Perpetual Inventory Method in hoping for suggestion of constructing internationally comparable datasets of capital stock. It is one of few studies on the estimation of capital stock worldwide while it is easily extended for more countries and for more recent years. Most available studies estimated the capital stock for the US such as Nadiri and Prucha (1996) for the US manufacturing sector, Griliches (1980) for the US 3-digit manufacturing industry, and Kamps (2006) for the estimated capital stock for 22 OECD countries using investment data from the OECD Database. Kamps (2006) assumed 4.25 percent of the depreciation rate for nonresidential assets and 1.5 percent for residential assets and 2.5 percent for government assets. The study of Berlemann and Wesselhöft applied various approaches of the estimation of capital stock including the unified approach. The initial capital stock (K_{t0}) was estimated by the following Equation (4).

$$K_{t0} = \frac{I_{t1}}{g_I + \delta} \qquad (4)$$

Where, g_I is the long term growth rate of investment that is obtained by the estimation of the equation of semi log function as in Equation (5) below. Here b_j is the long term growth rate of investment. The initial period of the investment (I_0) can also be obtained by this estimated equation.

$$lnI_{jt} = a_j + b_j t + \varepsilon_t \quad (5)$$

The estimation results of the depreciation rate obtained by the study of Berlemann and Wesselhöft were 3.7 percent, 0.03 percent and -1.02 percent for private non-residential fixed assets, private residential fixed assets, and government fixed assets, respectively. Therefore, the average rate of 1.6 percent of these three assets was assumed to be the depreciation rate in the estimation in this study.

L is Employed labour in thousand persons from UNCTAD.

The UNDP Human Development Index combines various dimensions of human indicators covering health, education and living standard. A minimum and a maximum for each dimension (or goalpost) is set and each country stands in relation to these goalposts is then expressed in values between 0 and 1 (The United Nations Development Programme). It is noted that instead of using education enrolment rate to be the proxy of human capital as many studies did, this study constructed the human capital index by using the international human development index of the United Nations to make adjustment for the human capital index. In details, Human capital (HC, or HDIAVG named in this study) was constructed by taking the human development index of the United Nations to adjust into the number of labour to have this index reflecting its quality of human of each country. Human development index or HDI (ranged between 0, the lowest, and 1, the highest) that having been constructed and ranked by the United Nations was used as the parameter to adjust the number of employed labour to be the proxy of human capital index (HDIAVG) in the model. While higher HDI implies better human development status relatively, many more people also means higher human capital stock. Nevertheless, the HDI was available only for the year 1990, 2000 and in each year from 2005 on. To deal with the unavailable annual data of the HDI during 1991 - 2004, the human capital index (HDIAVG) was therefore calculated by using the HDI in 1990 and 2000 for the construction of HDIAVG during 1991 – 1999 and 2000 – 2004, respectively.

The study classified the countries into four income groups mainly based on the World Bank classifications by Gross National Income per capita as of 1st July 2013; i.e., lower and lower middle income countries, upper middle income countries, non-OECD high income countries, and OECD countries. Heterogeneous character across groups of countries such as natural resources, political system, geography, weather, and religion can be considered as specific factor of countries significantly determining different growth. In order to avoid the problem of autocorrelation of disturbances and to gain consistent estimate, responding to Pesaran and Smith findings as mentioned earlier, this study separately estimates the model into four income groups of countries. The study denotes this country specific factor by variable's name of C1, C2, C3, and C4 being for the lower and lower middle income countries, the upper middle income countries, the non-OECD high income countries, and the OECD countries, respectively (Table A1 in Appendix).

4. RESULTS AND DISCUSSION

In general, there are advantages of using panel data in the estimation over cross sectional units or time series data. The case of a particular country in which too short period of time series data available can create the problem of too small degree of freedom causing large variances of estimated parameters and loss of power of hypothesis tests. The panel data model can be used to avoid this small degree of freedom if under assumption of homogeneous parameter across countries. In case of too small number of cross section or countries, the panel data can be used by assuming country specific effect or fixed effect model. Most of all, comparing with cases of cross sectional data, the panel data model can help avoid the possible problem of misspecification of dynamic model biases in the estimation in case that the static model ignores the possible dynamic adjustment of the model over time. Specifically, by inclusion of lagged dependent variable in the dynamic model, it can control the problem of ignorance some possible omitted variables.

As almost being the case, non-stationary process is found in time series. To test for the unit root in panel data, assuming the autoregressive process of degree 1 as written in Equation (6) below.

$$\Delta y_{it} = \rho y_{it-1} + z_{it}^{/}\gamma + \varepsilon_{it} \qquad (6)$$

Where $i = 1, 2, ..., N; t = 2, 3, 4, ..., T$; ε_{it} is a stationary process; $z_{it}^{/}$ is the deterministic component and can be 0, 1, fixed effects (ε_i) and time trend (t).

The null hypothesis of unit root ($\rho_i = 1$) for all i is set against the alternative hypothesis of stationary ($\rho_i < 1$). The standard unit root tests include Levin *et al.* (2002), Im *et al.* (2003) and Fisher-type proposed by Maddala and Wu (1999) and Choi (2001).

Levin, Lin and Chu allowed heterogeneity of individual deterministic effects and heterogeneous autocorrelation structure of the residuals and assuming homogeneous parameters in the autoregressive process or generally so called common unit root process across cross sectional units. It is sometimes referred to common unit root process null hypothesis. The structure of the analysis can be written as in Equation (7) below. This panel unit root tests is more relevant for the moderate size of the panel data.

$$\Delta y_{it} = \rho y_{it-1} + \alpha_{0i} + \alpha_{1i} t + \varepsilon_{it} \qquad (7)$$

Where ε_{it} is an invertible ARMA stationary process and is assumed to be independently distributed across individuals. The equation for this test is estimated by pooled OLS regression.

Im, Pesaran and Shin test introduces a more flexible and simple procedure of the unit root test and allows for simultaneous stationary and non-stationary series of parameter (ρ_i) that can be different between individuals. The test also allows for autocorrelation and heterogeneity of the dynamic error variances across groups. It is sometimes referred to individual unit root process null hypothesis. This test calculates for each cross sectional unit when the residual term can be autocorrelated and dimensions of time and cross section are sufficiently large. The equation for this test is estimated by balance panel data procedure. In case of autocorrelation of the residuals the test uses Augmented Dickey Fuller t test for individual series. The rejection of the null hypothesis does not necessary means that the unit root is rejected for all cross sectional units.

Maddala and Wu and Choi offered an alternative test following the non-parametric Fisher's Type test. This test is based on a combination of the probability values of the test statistics for a unit root in each unit of cross section. While Im, Pesaran and Shin test and Fisher's test combine information on individual unit root tests, this test also relax the assumption of the Levin, Lin and Chu of the same parameter (ρ_i) under alternative hypothesis. In addition, the Fisher test is based on general assumption compared to both Im, Pesaran and Shin test and Levin, Lin and Chu test. The Fisher's test has some advantages especially that it does not require the balance panel data and is possible to use different lag lengths in the Augmented Dickey Fuller regression.

Although the data used in this study is a moderate size sample that is more relevant for the Levin, Lin and Chu test, the other two tests were also considered and see whether there is any test rejects the null hypothesis of the unit root. The results of the unit root tests of each variable in the study showed that all variables are non-stationary process (Table A2 and Figure A1 in Appendix). All series appear to be random walk processes. This suggests that there is a short-run disequilibrium and the long-run equilibrium of the model equation. The cointegrating relation is therefore estimated based on the approach of dynamic model. The study began by estimating the static panel data model as in Equation (2) preliminarily using panel Least Square for all countries in the panel data. The estimation result clearly showed that although all the estimated coefficients of the equation were statistically significant but some of them were found to be the questionable sign (negative sign); i.e., those of labour (ln(L)) and advanced technology (ln(HTECX)) (Equation (8) below). In addition, the residuals of the regression line appeared to have autocorrelation problem (Figures A2 and A3 in Appendix). This indicates possible omission of some relevant variables (i.e., country specific factor) in the model.

$$\begin{aligned} \ln y_{it} &= -6.3400 + 0.3545 \ln KD_{it} + 0.1176 \ln KF_{it} - 0.7632 \ln L_{it} + 1.2644 \ln HDIAVG_{it} \\ (t) \quad & (-77.4074) \quad (41.1868) \qquad (18.5365) \qquad (-13.7644) \qquad (20.5124) \\ & - 0.0677 \ln HTECX_{it} \\ & (-12.4874) \\ \text{Adj } R^2 &= 0.9567, SumSquare\text{Re}sid = 224.0738, \\ F &= 8328.4880\,[p = 0.0000], \text{ DW Stat} = 0.1317 \end{aligned} \tag{8}$$

The fixed effect panel data model was next estimated. The advantage of fixed effect inclusion into the model is to help eliminate any unobservable factor assuming constant over time while varying across countries. This implies the existence of country specific effect in the model. The fixed effect model is written as Equation (9) below. Here, the fixed effect is denoted by δ_i.

$$\ln y_{it} = \alpha + \beta_1 \ln KD_{it} + \beta_2 \ln KF_{it} + \beta_3 \ln L_{it} + \beta_4 \ln HDIAVG_{it} + \tau \ln HTECX_{it} + \delta_i + \varepsilon_{it} \quad (9)$$

The study estimated the model by introducing panel fixed effect to take account of the country specific factor. The result is shown in Equation (10) below and country fixed effect in Table A3 in Appendix. The sign of labour and advanced technology coefficients were still negative but now they became insignificant. The residual plot and its correlogramme were examined and found that the residual still had some autoregressive moving average problem (Figures A4 and A5 in Appendix), though it was little better than that of Equation (8) (as showed earlier in Figures A2 and A3 in Appendix).

$$\begin{aligned} \ln y_{it} &= -5.9236 + 0.1585 \ln KD_{it} + 0.1530 \ln KF_{it} - 0.1166 \ln L_{it} + 0.8740 \ln HDIAVG_{it} \\ (t) \quad & (-21.7745) \quad (14.7331) \quad (27.1164) \quad (-1.4595) \quad (13.9940) \\ & - 0.0059 \ln HTECX_{it} \qquad (10) \\ & (-1.7898) \\ & AdjR^2 = 0.9952, Sum\ Squared\ \mathrm{Re}sid = 23.2555, F = 3515.2760\,[p = 0.0000] \\ & DW\ Stat = 0.3460 \end{aligned}$$

The random effect was estimated based on Generalized Least Square. The result was shown in Equation (11) below. Whether the fixed effects specification of cross sectional units is appropriate or not, the test for random effect can be carried out. The essential assumption in the random effects model is that the random effects must be uncorrelated with the explanatory variables. The study performed the Hausman Test for random effect that is Chi-Square distribution. It was 113.9754, which was significant, so the statistic rejected null hypothesis of independence between the residual and the explanatory variables. The fixed effect is therefore preferable. However, the estimation result similarly gave the unsatisfied residual property owing to the existence of autocorrelation. (Figures A6 – A7 in Appendix).

$$\begin{aligned} \ln y_{it} &= -5.2378 + 0.1957 \ln KD_{it} + 0.1417 \ln KF_{it} - 0.3951 \ln L_{it} + 1.0219 \ln HDIAVG_{it} \\ (t) \quad & (-31.4973) \quad (19.5442) \quad (26.2443) \quad (-6.8679) \quad (18.9696) \\ & - 0.0073 \ln HTECX_{it} \qquad (11) \\ & (-2.2493) \\ & \text{Weighted Statistic}: AdjR^2 = 0.8982, Sum\ Squared\ \mathrm{Re}sid = 26.1159 \\ & F = 3328.8430[p = 0.0000], DW\ Stat = 0.3418 \end{aligned}$$

The study conducted the unit root test as mentioned earlier. Since the variables used in the model estimation were non-stationary processes; therefore, the estimate of static model as written in Equation (2) was mis-specified dynamic biased. The unit root test of all variables could not reject the null hypothesis of non-stationarity. The second difference series were also tested to see whether they are non-stationary. The results of second difference series test for unit root showed to be stationary processes therefore it indicates that all variables are integrated of order one. By being non-stationary process of the time series variables, the appropriate equation must be constructed by using dynamic model. The error correction mechanism type of model can be used to specify short run disequilibrium and long run cointegrating relation between variables in the model described as follows.

The general linear dynamic panel model specification can be written as in Equation (12) below. The first differenced equation of the general linear dynamic model can help eliminate the individual effect that is showed in the Equation (13).

$$Y_{it} = \delta_i + \sum_{k=1}^{P} \rho_k Y_{it-k} + X_{it}^{/}\beta + \varepsilon_{it} \quad (12)$$

$$\Delta Y_{it} = \delta_i + \sum_{k=1}^{P} \rho_k \Delta Y_{it-k} + \Delta X_{it}^{/}\beta + \Delta\varepsilon_{it} \quad (13)$$

The panel dynamic structure for the n+1 dimensional time series vector $(Y_{it}, X_{it}^{/})$ and if cointegration exists, it can be written as in Equation (14) below. The cointegrating relation between Y and X above is assumed to be homogeneous across cross sectional units and the specification allows for cross section specific deterministic effects.

$$Y_{it} = X_{it}^{/}\beta + Z_{1it}^{/}\gamma_i + \mu_{it} \quad (14)$$

Where $Z_{it} = \left(Z_{1it}^{/}, Z_{2it}^{/}\right)^{/}$ are deterministic trend regressors.

$$X_{it} = \Gamma_{21i}^{/} Z_{1it} + \Gamma_{22i}^{/} Z_{2it} + \varepsilon_{2it} \quad (15)$$

And $\Delta\varepsilon_{2it} = \mu_{2it}$ (16)

There are two basic estimation methods for a single cointegrating relation in general; i.e., Fully Modified Ordinary Least Square (FMOLS) and Dynamic Ordinary Least Square (DOLS). The study adopted DOLS method in the cointegrating relation and assumed homogeneity in the equation[1]. Given cointegration is found, the panel DOLS estimator pools the data along within dimension of the panel. Kao and Chiang (2000) argued that under cointegration, DOLS is promising in small samples and performs well so that it is consistent with the sample used in this study. However Pedroni (2001) proposed the group mean FMOLS estimator to allow endogeneity and autocorrelation problems to obtain consistent and asymptotically unbiased estimates.

When a panel contains large numbers of time series and cross sectional unit, the model can be practically estimated by either separately cross sectional regressions or mean group estimator, assuming the slope coefficients and error variances are identical. In case of pooled mean group estimation, the long run coefficients must be constrained to be identical and the short run coefficients and error variances can be different across groups. Pesaran *et al.* (1997) empirically estimated various cases including the case where it followed unit root processes and derived the asymptotic distribution of the estimators with varying length of time period. In case of short time period panel data, all estimators (group specific, mean group, pooled mean group, and fixed effect) were subject to downward biased on the coefficient of lagged dependent variables.

The panel DOLS augments the panel cointegrating regression with the cross section specific lags and leads of the difference of explanatory variable to eliminate th9 asymptotic endogeneity

[1] The study also complemented the DOLS estimation of the long run cointegrating relation by the group mean FMOLS as showed in the Appendix A2.

and autocorrelation. The method estimates an augmented cointegrating equation as in Equation (17) below by OLS. The equation indicates that the short run dynamic coefficients (δ_i) are cross section specific.

$$\bar{Y}_{it} = \bar{X}_{it}^{/} \beta + \sum_{k=-q_i}^{r_i} \Delta \bar{X}_{it-k}^{/} \delta_i - \bar{v}_{1it} \qquad (17)$$

Let $\Delta \bar{X}_{it-k}^{/}$ interact with cross section dummy variables to be formed as regressors ($\bar{Z}_{it}$) and let $\bar{W}_{it}^{/} = \left(\bar{X}_{it}^{/}, \bar{Z}_{it}^{/} \right)^{/}$, the pooled DOLS estimator can be written as Equation (18).

Moreover, Kao and Chiang showed that asymptotic distribution of the estimation is the same as for the pooled FMOLS.

$$\begin{bmatrix} \hat{\beta} \\ \hat{\gamma} \end{bmatrix} = \left(\sum_{i=1}^{N} \sum_{t=1}^{T} \bar{W}_{it} \bar{W}_{it}^{/} \right)^{-1} \left(\sum_{i=1}^{N} \sum_{t=1}^{T} \bar{W}_{it} \bar{Y}_{it}^{/} \right) \qquad (18)$$

To test for cointegration, panel Pedroni's cointegration test was performed for each of the four groups of countries as showed in Table 1 below. The test performed by lag length selection based on SIC with lags from 0 to 2 and using Newey-West automatic bandwidth selection and Bartlett kernel. The test can reject the null hypothesis of no unit root or, in the other word, variables are cointegrated, especially the tests of those ADF statistics in which it allows the use of different lag lengths in the regression equation.

To estimate for the cointegrating relation, the panel Dynamic Least Square (DOLS) estimation method is used. It however does not allow the importance of country specific difference or cross country heterogeneity. The study therefore took into account the country specific difference by separately estimating the model for each of the four income groups of countries.

Table-1. Panel Cointegration Test

	C1	**C2**	**C3**	**C4(OECD)**
H_a: common AR coefficients. (within-dimension)				
	Statistic [prob]	Statistic [prob]	Statistic [prob]	Statistic [prob]
Panel v-Stat.	-2.0875[0.9816]	-0.8909[0.8135]	-0.9876[0.8383]	-1.2748[0.8988]
Panel ρ-Stat.	4.7562[1.0000]	4.1675[1.0000]	3.1131[0.9991]	5.0749[1.0000]
Panel PP-Stat.	-1.4979[0.0671]	0.5120[0.6957]	0.5520[0.7095]	2.9231[0.9983]
Panel ADF-Stat.	-4.5282[0.0000]	-1.8914[0.0293]	-1.3986[0.0810]	-1.1466[0.1258]
H_a: individual AR coefficients. (between-dimension)				
	Statistic [prob]	Statistic [prob]	Statistic [prob]	Statistic [prob]
Group ρ-Stat.	7.4753[1.0000]	6.1271[1.0000]	5.0538[1.0000]	7.5770[1.0000]
Group PP-Stat.	-2.9575[0.0016]	-1.4707[0.0707]	1.0192[0.8459]	1.4578[0.9276]
Group ADF-Stat.	-4.8723[0.0000]	-4.6051[0.0000]	-2.0986[0.0179]	-3.0529[0.0011]

The long run cointegrating relations for four groups of countries; i.e., one, the lower and lower middle income countries; two, the upper middle income countries; three, the non-OECD high income countries; and four, the OECD countries were estimated and showed in Equations (19) – (22). The unit root tests of the residuals was also done and found that the tests reject the null hypothesis (Table 2 – 5).

$$\ln Y_{it} = 0.3355\ln KD_{it} + 0.1379\ln KF_{it} + 0.4793\ln L_{it} + 0.2180\ln HDIAVG_{it}$$
$$(t) \quad (9.9791) \quad (8.0343) \quad (2.4615) \quad (1.6332)$$
$$+ 0.0333\ln HTECX_{it} \qquad (19)$$
$$(3.8081)$$
$$\text{AdjR}^2 = 0.999929, \textit{Sum Squared Resid} = 0.2744, \textit{Long Run Variance} = 0.0006$$

Table-2. Test for unit root of the residuals of Equation (19): country group 1

Panel unit root test				
Series: **RESCOINTC1**				
Exogenous variables: Individual effects				
Automatic selection of maximum lags				
Automatic lag length selection based on SIC: 0 to 2				
Newey-West automatic bandwidth selection and Bartlett kernel				
Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-16.7370	0.0000	25	337
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-13.1846	0.0000	25	337
ADF - Fisher Chi-square	245.102	0.0000	25	337
PP - Fisher Chi-square	295.989	0.0000	25	348

** Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution. All other tests assume asymptotic normality.

$$\ln Y_{it} = -0.2738\ln KD_{it} + 0.1421\ln KF_{it} + 0.8621\ln L_{it} + 0.7203\ln HDIAVG_{it}$$
$$(t) \quad (-1.6942) \quad (7.0027) \quad (3.6742) \quad (7.0234)$$
$$+ 0.1668\ln HTECX_{it} \qquad (20)$$
$$(8.5265)$$
$$\text{AdjR}^2 = 0.999992, \textit{Sum Squared Resid} = 0.0186, \textit{Long Run Variance} = 2.61E-05$$

Table-3. Test for unit root of the residuals of Equation (20): country group 2

Panel unit root test				
Series: **RESCOINTC2**				
Exogenous variables: Individual effects				
Automatic selection of maximum lags				
Automatic lag length selection based on SIC: 0 to 3				
Newey-West automatic bandwidth selection and Bartlett kernel				
Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
				Continue

Levin, Lin & Chu t*	-22.2529	0.0000	17	260
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-19.0890	0.0000	17	260
ADF - Fisher Chi-square	477.386	0.0000	17	260
PP - Fisher Chi-square	1672.56	0.0000	17	271

** Probabilities for Fisher tests are computed using an asymptotic Chi
-square distribution. All other tests assume asymptotic normality.

$$\ln Y_{it} = 0.1681 \ln KD_{it} + 0.0970 \ln KF_{it} - 0.1459 \ln L_{it} + 1.2750 \ln HDIAVG_{it} - 0.0101 \ln HTECX_{it} \quad (21)$$

(t) (4.4961) (3.5644) (-0.4001) (3.9122) (-0.4825)

$$\text{AdjR}^2 = 0.999859, \textit{Sum Squared Resid} = 0.3466, \textit{Long Run Variance} = 0.0017$$

Table-4. Test for unit root of the residuals of Equation (21): country group 3

Panel unit root test				
Series: **RESCOINTC3**				
Date: 12/06/13 Time: 07:58				
Sample: 1992 2011				
Exogenous variables: Individual effects				
Automatic selection of maximum lags				
Automatic lag length selection based on SIC: 0 to 1				
Newey-West automatic bandwidth selection and Bartlett kernel				
Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-9.90936	0.0000	13	180
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-7.90001	0.0000	13	180
ADF - Fisher Chi-square	106.865	0.0000	13	180
PP - Fisher Chi-square	137.927	0.0000	13	185

** Probabilities for Fisher tests are computed using an asymptotic Chi
-square distribution. All other tests assume asymptotic normality.

$$\ln Y_{it} = 0.1565 \ln KD_{it} + 0.1370 \ln KF_{it} + 0.6670 \ln L_{it} + 0.5693 \ln HDIAVG_{it} + 0.0315 \ln HTECX_{it} \quad (22)$$

(t) (7.1101) (14.0390) (4.2649) (4.5748) (2.0494)

$$\text{AdjR}^2 = 0.999962, \textit{Sum Squared Resid} = 0.3109, \textit{Long Run Variance} = 0.0007$$

The equation estimation is the part of the long run equilibrium in addition to the short run disequilibrium dynamic part following the error correction mechanism approach. Furthermore, the Pedroni cointegrating relation estimation extends the grouped estimator concept to DOLS estimation by averaging over the individual cross section estimates. Therefore the goodness of fit (R^2) of this theoretical long run relation can be noticeably recorded very high as it left only very small regression error component in the calculation of R^2. The study further imposed the constant returns to scale restriction into the production function equation. The Wald test for constant returns to scale restriction was rejected in all the production function estimations (Table 6) and so it confirmed the non-constant returns to scale production function (increasing returns as found in Equations (19) – (22)).

Table-5. Test for unit root of the residuals of Equation (22): country group 4

Panel unit root test				
Series: **RESCOINTOECD**				
Date: 12/06/13 Time: 08:00				
Sample: 1992 2011				
Exogenous variables: Individual effects				
Automatic selection of maximum lags				
Automatic lag length selection based on SIC: 0 to 3				
Newey-West automatic bandwidth selection and Bartlett kernel				
Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-12.5736	0.0000	30	480
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-11.4361	0.0000	30	480
ADF - Fisher Chi-square	239.690	0.0000	30	480
PP - Fisher Chi-square	269.016	0.0000	30	489

** Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution. All other tests assume asymptotic normality.

Table-6. The Wald test for constant returns to scale production function

Wald Test	F-Statistic [Prob]
Lower and lower middle income countries	82.3702 [0.0000]
Upper middle income countries	25.4295 [0.0000]
Non-OECD high income countries	6.7012 [0.0098]
OECD countries	77.6517 [0.0000]

The study further examined sizes of the estimated coefficients in details in order to compare the differences of the impacts among factors of growth. However, the sizes of coefficients of regressors in any regression equation are not directly comparable due to their differences in their units and their variances. The standardization adjusts the different units and different standard errors of the variables just like the Z-score statistic so that these standardized coefficients unit-less scores can be comparable across variables as written in Equation (23) below.

$$\beta_j^s = \beta_j \frac{SE_j}{SE_y} \quad (23)$$

Where β_j^s = standardized coefficient of the jth explanatory variable

β_j = coefficient of the jth explanatory variable

SE_j = standard error of the jth explanatory variable

SE_y = standard error of y variable

Table 7 below shows the sizes of the standardized coefficients of variables in each group of country. Since the production function was a log-linear equation, the coefficient of variable means its elasticity of output or its factor share in the equilibrium condition. The result in Table 7 thus clearly indicated that either labour or human capital or both forms of human factor are the factors contributing most to the output growth in the four income level groups of countries. Note also that labour was found to be the least (and insignificant) contributor to growth for the non-OECD high income countries, where most of them are oil exporting and small population countries. The domestic capital was found to be the least (and insignificant) contributor to growth for the upper middle income countries (group 2) where many of them are new emerging or rapidly growing countries. This insignificant negative impact of domestic capital on growth can imply that there was substitution or displacement of stronger effect of foreign capital and its weaker effect of domestic capital on growth in such countries. Although all factors were found significantly contributing to growth in the OECD, at least one of the factors has not played significant role in the other three lower stages of development countries. Both advanced technology and foreign capital significantly contribute to growth in all countries except the high income Non-OECD where the advanced technology being insignificant source of growth.

Table-7. The standardized coefficients of the production function

Coefficient of	C1	C2	C3	C4
L	0.0490	0.0872	-0.0352	0.0377
HDIAVG	0.0153	0.0319	0.2750	0.0256
KD	0.0059	-0.0191	0.0042	0.0012
KF	0.0012	0.0012	0.0017	0.0005
HTECX	0.0002	0.0014	-0.0001	0.0002

Source: Author’s calculation

The finding of significant long run contribution of human capital to economic growth in most income countries, except in the lower and lower middle income countries, is consistently found as in many previous studies. In addition, the advanced technology was found to be a crucial factor to growth except for the high income non-OECD. These two findings confirm the essential role of human capital and advanced technology in promoting sustainable economic growth especially in the upper middle income countries and the advanced high income OECD. Likewise, foreign capital was found to play significant contribution to growth in all countries from the rich to the poor. This confirms the conventional hypothesis of the role of capital accumulation in economic growth particularly that of foreign capital. A policy implication on these findings indicates importance of advanced technology and foreign capital which are crucial supporting factors apart from investment in human capital to sustain economic growth in the long run. Most of all, all the mentioned five engines of growth must be placed attention to play role in development of economy so that the development can become of great success such as found all being significant factors in the case of the OECD. Certainly, the country specific factor cannot simply be changed though it is also found important.

5. CONCLUSION

Apart from the conventional role of capital accumulation and population growth in economic growth; human capital, foreign capital, and advanced technology are also the other important sources of supporting growth. This study empirically examines the contribution of advanced technology and foreign capital as being supporting factors to growth in different countries’ stage of development.

Panel data of 108 countries during 1992 – 2011 was collected and used in the estimation of the aggregate production function. For the disaggregate model, the study classified the countries into four groups; i.e., lower and lower middle income countries, upper middle income countries, non-OECD high income countries, and OECD countries based on the World Bank income classifications by GNI per capita. The study generated indices as proxies for some variables used in the model estimation. Since data for physical capital in many countries in the study is incomplete, Perpetual Inventory Method (PIM) was used to estimate the countries' domestic and foreign physical capital stocks. Human capital was estimated and used as the proxy by taking the Human Development Index of the United Nations to make adjustment to number of workers for each country. The ratio of hi-tech export to the total export of goods was used to be the proxy of advanced level of technology.

Since all variables in the model are found to be non-stationary processes and be integrated of order one, the dynamic model is appropriate and the cointegrating relation of the production function was estimated. By using panel dynamic least square method, the long run cointegrating relations of the production function were estimated for the four groups of countries separately. This separated equation estimation can also help avoid the biased problem due to the possible omission of country specific factor as the separately estimated equations can be considered as each individual or independent function. This study showed that the pooled mean group panel dynamic model estimation for each group of countries provided better result than the panel fixed effect model. As a part of the superiority of the panel dynamic model estimated separately by each income group to be accounted for each country specific factor, the pooled mean group dynamic model allows short run dynamic to differ across countries while the aggregate panel fixed effect model does not have this dynamic effect.All the estimated production functions were found exhibiting non-constant returns to scale and were consistent with most findings of the new endogenous growth theory. Interestingly, all coefficients of factors were found significant for the OECD's long run production function. At least one of those factors of growth was found insignificant for the other three lower income groups. The advanced technology and foreign capital can be the supporting factors and thus the OECD growth is better sustainable than the other countries. The finding indicates importance of advanced technology and foreign capital which are crucial factors apart from investment in human capital to sustain economic growth in the long run. All the five engines of growth were found being significant factors in the case of the successful OECD therefore a policy must be placed attention to these five factors to fully play their roles on growth.

Besides, these estimation results are in line with the endogenous growth approach. The human capital and the advancement of knowledge, or named in this study the advanced technology, are the two important endogenous factors of growth and must be included in explanation of the conventional Total Factor Productivity growth, previously considered as the exogenously given residual growth. As the result, the residual growth is found insignificant or it is approaching zero mean in this study.

REFERENCES

Benhabib, J. and M.M. Spiegel, 1994. The role of human capital in economic development: Evidence from aggregate cross country data. Journal of Monetary Economics, 34(2): 143-173.

Berlemann, M. and J.E. Wesselhöft, 2012. Estimating aggregate capital stocks using the perpetual inventory method: New empirical evidence for 103 countries. Diskussionspapierreihe Working Paper Series No. 125. Hamburg, Germany: Helmut Schmidt University, Department of Economics.

Borensztein, E., J.D. Gregorio and J.W. Lee, 1998. How does foreign direct investment affect growth?. NBER Working Paper No. 5057, Cambridge.

Choi, I., 2001. Unit root tests for panel data. Journal of International Money and Finance, 20(2): 249-272.

Christensen, L.R. and D.W. Jorgenson, 1969. The measurement of U.S. real capital input, 1929-67. Review of Income and Wealth, 15(4): 293 - 320.

De Mello, J.L.R., 1999. Foreign direct investment-led growth: Evidence from time series and panel data. Oxford Economic Papers, 51(1): 133-151.

Griliches, Z., 1980. R&D and the productivity slowdown. NBER Working Paper Series No. 434. Cambridge.

Hsiao, C., 1986. Analysis of panel data. Cambridge: Cambridge University Press.

Im, K.S., M.H. Pesaran and Y. Shin, 2003. Testing for unit roots in heterogeneous panels. Journal of Econometrics, 115(1): 53-74.

Kamps, C., 2006. New estimates of government net capital stocks for 22 OECD countries 1960 – 2001. IMF Staff Paper, 53(1): 120 – 150.

Kao, C. and M.H. Chiang, 2000. On the estimation and inference of a cointegrated regression in panel data. In Baltagi, B.H. et al. eds. Nonstationary panels, panel cointegration and dynamic panels, 15. Amsterdam: Elsevier. pp: 179-222.

Kraipornsak, P., 2009. Roles of human capital and total factor productivity growth as sources of growth: Empirical investigation in Thailand. International Business & Economics Research Journal, 8(12): 37-52. Available from http://journals.cluteonline.com/index.php/IBER/article/view/3196/3244.

Levin, A., C.F. Lin and C.S.J. Chu, 2002. Unit root tests in panel data: Asymptotic and finite sample properties. Journal of Econometrics, 108(1): 1-24.

Lucas, R., 1988. On the mechanics of economic development. Journal of Monetary Economics, 22(1): 3-42.

Lucas, R., 1990. Why doesn't capital flow from rich to poor countries? American Economic Review, 80(2): 92 – 96.

Maddala, G. and S. Wu, 1999. A comparative study of unit root tests and a new simple test. Oxford Bulletin of Economics and Statistics, 61(S1): 631-652.

Mankiw, M.G., D. Romer and D.N. Weil, 1992. A contribution to the empiric of economic growth. Quarterly Journal of Economics, 107(2): 407 – 437.

Nadiri, M.I. and L.R. Prucha, 1996. Estimation of the depreciation rate of physical and R&D capital in the U.S. total manufacturing sector. Economic Inquiry, 34(1): 43 – 56.

Nelson, R. and E. Phelps, 1966. Investment in humans, technological diffusion, and economic growth. American Economic Review, 56(1/2): 69-75.

Pedroni, P., 2001. Purchasing power parity tests in cointegrated panels. Review of Economics and Statistics, 83(4): 727-731.

Pesaran, M.H., Y. Shin and R.P. Smith, 1997. Pooled estimation of long-run relationships in dynamic heterogenous panels. DAE working papers amalgamated Series No. 9721, University of Cambridge.

Pesaran, M.H. and R. Smith, 1995. Estimating long-run relationships from dynamic heterogeneous panels. Journal of Econometrics, 68(1): 79-113.

Romer, P., 1990a. Endogenous technological change. Journal of Political Economy, 98(5): S71-S102.

Romer, P., 1990b. Human capital and growth: Theory and evidence. Carnegie Rochester Conference Series on Public Policy, 32(1): 251-286.

Solow, R., 1956. A contribution to the theory of economic growth. Quarterly Journal of Economics, 70(1): 65 – 94.

Solow, R., 1957. Technical change and the aggregate production function. Review of Economics and Statistics, 39(3): 312 – 320.

The United Nations Development Programme. Human development report, various issues. Available from: http://hdr.undp.org/en/statistics/hdi.

Young, A., 1995. The tyranny of numbers: Confronting the statistical realities of the East Asian growth experience. Quarterly Journal of Economics, 110(3): 640 – 680.

APPENDIX

As of 1 July 2013, the World Bank income classifications by GNI per capita are as follows:

- Low income: $1,035 or less
- Lower middle income: $1,036 to $4,085
- Upper middle income: $4,086 to $12,615
- High income: $12,616 or more

Appendix-1.

Table-A1. List of the countries included in the study

1	Albania	ALB	C2	37	Honduras	HON	C1	73	Panama	PAN	C2
2	Algeria	ALG	C2	38	Hong Kong	HOK	C3	74	Paraguay	PAR	C1
3	Argentina	ARG	C2	39	Hungary	HUN	C2	75	Peru	PER	C2
4	Amenia	AME	C1	40	Iceland	ICE	C4	76	Philippines	PHI	C1
5	Australia	AUS	C4	41	India	IND	C1	77	Poland	POL	C4
6	Austria	AUT	C4	42	Indonesia	INN	C1	78	Portugal	POR	C4
7	Azerbaijan	AZE	C2	43	Iran	IRA	C2	79	Qatar	QAT	C3
8	Bahrain	BAH	C3	44	Ireland	IRE	C4	80	Romania	ROM	C2
9	Bangladesh	BAN	C1	45	Israel	ISR	C4	81	Russian Federation	RUS	C3
10	Belarus	BEL	C2	46	Italy	ITA	C4	82	Saudi Arabia	SAU	C3
11	Belgium	BEG	C4	47	Jamaica	JAM	C2	83	Singapore	SIN	C3
12	Bolivia	BOL	C1	48	Japan	JAP	C4	84	Slovakia	SLK	C4
13	Botswana	BOT	C2	49	Jordan	JOR	C2	85	Slovenia	SLN	C4
14	Brazil	BRA	C2	50	Kazakhstan	Kaz	C2	86	South Africa	SAF	C2
15	Brunei	BRU	C3	51	Kenya	KEN	C1	87	Spain	SPA	C4
16	Bulgaria	BUL	C2	52	Korea	KOR	C4	88	Sri Lanka	SLA	C1
17	Cambodia	CAM	C1	53	Kuwait	KUW	C3	89	Sudan	SUD	C1
18	Canada	CAN	C4	54	Kyrgyzstan	KYR	C1	90	Sweden	SWE	C4
19	Chile	CHI	C4	55	Latvia	LAT	C3	91	Switzerland	SWI	C4
20	China	CHN	C2	56	Lebanon	LEB	C2	92	Syrian Arab Rep	SYR	C1
21	Colombia	COL	C2	57	Lithuania	LIT	C3	93	Tajkistan	TAJ	C1
22	Costa Rica	COS	C2	58	Malawia	MAL	C1	94	Tanzania	TAN	C1
23	Croatia	CRO	C3	59	Malaysia	MAY	C2	95	Thailand	THA	C2
24	Cyprus	CYP	C3	60	Maulitus	MAU	C2	96	Trinidad and Tabago	TRI	C3
25	Czech Rep	CZE	C4	61	Mexico	MEX	C2	97	Tunisia	TUN	C2
26	Denmark	DEN	C4	62	Moldova	MOL	C1	98	Turkey	TUR	C2
27	Ecuador	ECU	C2	63	Mongolia	MON	C1	99	Uganda	UGA	C1
28	Egypt	EGY	C1	64	Morocco	MOR	C1	100	UK	UK	C4
29	El Savador	ELS	C1	65	Nepal	NEP	C1	101	Ukraine	UKR	C1
30	Estonia	EST	C4	66	Netherlands	NET	C4	102	United Arab Emirate	UAE	C3
31	Finland	FIN	C4	67	New Zealand	NEW	C4	103	Uruguay	URU	C3
32	France	FRA	C4	68	Nicaragua	NIC	C1	104	USA	USA	C4
33	Georgia	GEO	C1	69	Nigeria	NIR	C1	105	Venezuela	VEN	C2
34	Gernamy	GER	C4	70	Norway	NOR	C4	106	Vietnam	VIE	C1
35	Greece	GRE	C4	71	Oman	OMA	C3	107	Yemen	YEM	C1
36	Guatemala	GUA	C1	72	Pakistan	PAK	C1	108	Zambia	ZAM	C1

Table-A2. Test for panel unit root

Panel unit root test				
Series: **lnY**				
Sample: 1992 2011				
Exogenous variables: Individual effects				
Automatic selection of maximum lags				
Automatic lag length selection based on SIC: 0 to 4				
Newey-West automatic bandwidth selection and Bartlett kernel				
Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-1.34632	0.0891	109	1969
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	10.5067	1.0000	109	1969
ADF - Fisher Chi-square	124.740	1.0000	109	1969
PP - Fisher Chi-square	81.7986	1.0000	109	2060

** Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution. All other tests assume asymptotic normality.

Panel unit root test				
Series: **lnKD**				
Exogenous variables: Individual effects				
Automatic selection of maximum lags				
Automatic lag length selection based on SIC: 0 to 4				
Newey-West automatic bandwidth selection and Bartlett kernel				
Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	6.61186	1.0000	108	1838
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	20.8896	1.0000	108	1838
ADF - Fisher Chi-square	35.7602	1.0000	108	1838
PP - Fisher Chi-square	38.1107	1.0000	108	2025

** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.

Panel unit root test				
Series**: lnKF**				
Exogenous variables: Individual effects				
Automatic selection of maximum lags				
Automatic lag length selection based on SIC: 0 to 4				
Newey-West automatic bandwidth selection and Bartlett kernel				
Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	2.26494	0.9882	108	1875
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	15.4172	1.0000	108	1875
ADF - Fisher Chi-square	137.395	1.0000	108	1875
PP - Fisher Chi-square	31.0000	1.0000	108	2025

** Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution. All other tests assume asymptotic normality.

Panel unit root test				
Series: **lnL**				
Exogenous variables: None				
Automatic selection of maximum lags				
Automatic lag length selection based on SIC: 0 to 4				
Newey-West automatic bandwidth selection and Bartlett kernel				
Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	27.1507	1.0000	109	1985
Null: Unit root (assumes individual unit root process)				
ADF - Fisher Chi-square	56.1011	1.0000	109	1985
PP - Fisher Chi-square	82.4210	1.0000	109	2069

** Probabilities for Fisher tests are computed using an asymptotic Chi
-square distribution. All other tests assume asymptotic normality.

Panel unit root test: Summary				
Series: **lnHDIAVG**				
Exogenous variables: Individual effects				
Automatic selection of maximum lags				
Automatic lag length selection based on SIC: 0 to 3				
Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-0.49219	0.3113	109	2055
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	12.1373	1.0000	109	2055
ADF - Fisher Chi-square	81.3718	1.0000	109	2055
PP - Fisher Chi-square	129.203	1.0000	109	2069

** Probabilities for Fisher tests are computed using an asymptotic Chi
-square distribution. All other tests assume asymptotic normality.

Panel unit root test				
Series: **lnHTECX**				
Exogenous variables: Individual effects, individual linear trends				
Automatic selection of maximum lags				
Automatic lag length selection based on SIC: 0 to 3				
Newey-West automatic bandwidth selection and Bartlett kernel				
Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-6.58995	0.0000	107	1715
Breitung t-stat	4.74294	1.0000	107	1608
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-1.52661	0.0634	107	1715
ADF - Fisher Chi-square	261.311	0.0150	107	1715
PP - Fisher Chi-square	273.833	0.0036	107	1759
** Probabilities for Fisher tests are computed using an asymptotic Chi				
-square distribution. All other tests assume asymptotic normality.				

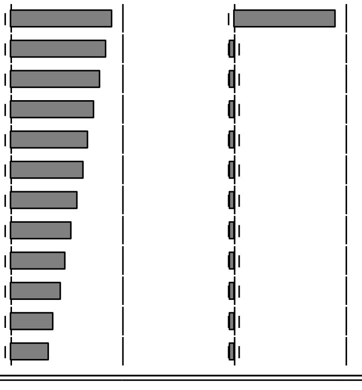
Table-A3. Country fixed effect

Country	Effect	Country	Effect	Country	Effect	Country	Effect
ALB	-0.051723	EGY	-0.118681	LAT	0.219227	SAU	0.864067
ALG	0.189144	ELS	0.138111	LEB	0.269898	SIN	0.383350
ARG	-0.234324	EST	0.226432	LIT	0.315831	SLK	0.288783
AME	-0.336875	FIN	0.446690	MAL	-1.098180	SLN	0.430264
AUS	0.171635	FRA	0.253092	MAY	-0.122445	SAF	0.213056
AUT	0.509618	GEO	-0.666923	MAU	0.275740	SPA	0.251122
AZE	-0.411226	GER	0.113099	MEX	0.029313	SLA	-0.545041
BAH	0.558381	GRE	0.419888	MOL	-0.860204	SUD	-0.279379
BAN	-0.979745	GUA	-0.120938	MON	-0.282612	SWE	0.291848
BEL	0.079830	HON	-0.185630	MOR	-0.396387	SWI	0.190712
BEG	0.223984	HOK	-0.106272	NEP	-0.719319	SYR	0.169853
BOL	-0.430102	HUN	0.239419	NET	0.197941	TAJ	-0.934786
BOT	0.146613	ICE	0.673376	NEW	0.040867	TAN	-0.988154
BRA	-0.215584	IND	-0.469333	NIC	-0.169729	THA	-0.646395
BRU	0.998680	INN	-0.732903	NIR	-0.652862	TRI	0.086940
BUL	0.247494	IRA	0.650182	NOR	0.609617	TUN	-0.167959
CAM	-0.910534	IRE	0.342754	OMA	0.751708	TUR	0.317470
CAN	0.249379	ISR	0.475244	PAK	-0.305521	UGA	-0.683005
CHI	-0.101160	ITA	0.430061	PAN	-0.213310	UK	0.202770
CHN	-1.022496	JAM	-0.152117	PAR	-0.308637	UKR	-0.433052
COL	0.005928	JAP	-0.066856	PER	-0.200575	UAE	0.992904
COS	-0.013239	JOR	-0.203652	PHI	-0.742052	URU	-0.029914
CRO	0.631168	KAZ	-0.195778	POL	0.239432	USA	0.212959
CYP	0.344226	KEN	-0.654190	POR	0.118393	VEN	0.142447
CZE	0.258095	KOR	0.234784	QAT	1.486632	VIE	-1.069250
DEN	0.275603	KUW	1.725792	ROM	0.149837	YEM	-0.036514
ECU	-0.071428	KYR	-0.752796	RUS	0.083042	ZAM	-1.124330

Figure-A1. Correlogramme of Series

Series lnY

Sample: 1992 2011
Included observations: 2169



Autocorrelation	Partial Correlation		AC	PAC	Q-Sta...	Pro...
		1	0.946	0.946	1945.1	0.000
		2	0.892	-0.033	3674.3	0.000
		3	0.837	-0.032	5198.7	0.000
		4	0.782	-0.035	6529.3	0.000
		5	0.727	-0.031	7679.0	0.000
		6	0.672	-0.026	8662.8	0.000
		7	0.618	-0.026	9495.5	0.000
		8	0.565	-0.027	10191.	0.000
		9	0.513	-0.027	10764.	0.000
		10	0.461	-0.028	11227.	0.000
		11	0.410	-0.031	11593.	0.000
		12	0.359	-0.029	11874.	0.000

Series lnKD

Sample: 1992 2011
Included observations: 2133

Autocorrelation	Partial Correlation		AC	PAC	Q-Sta...	Pro...
		1	0.942	0.942	1893.8	0.000
		2	0.886	-0.007	3570.7	0.000
		3	0.830	-0.034	5041.8	0.000
		4	0.774	-0.021	6324.4	0.000
		5	0.720	-0.023	7433.9	0.000
		6	0.666	-0.026	8384.8	0.000
		7	0.613	-0.026	9190.8	0.000
		8	0.561	-0.027	9865.3	0.000
		9	0.509	-0.030	10421.	0.000
		10	0.457	-0.031	10870.	0.000
		11	0.406	-0.031	11224.	0.000
		12	0.356	-0.031	11496.	0.000

Series lnKF

Sample: 1992 2011
Included observations: 2133

Autocorrelation	Partial Correlation		AC	PAC	Q-Sta...	Pro...
		1	0.932	0.932	1854.3	0.000
		2	0.862	-0.048	3441.2	0.000
		3	0.791	-0.042	4779.3	0.000
		4	0.721	-0.036	5891.0	0.000
		5	0.652	-0.028	6802.0	0.000
		6	0.586	-0.024	7538.0	0.000
		7	0.523	-0.018	8124.9	0.000
		8	0.464	-0.015	8586.3	0.000
		9	0.408	-0.019	8942.3	0.000
		10	0.354	-0.020	9210.8	0.000
		11	0.303	-0.020	9407.4	0.000
		12	0.255	-0.017	9546.6	0.000

Series lnL

Sample: 1992 2011
Included observations: 2178

Autocorrelation	Partial Correlation		AC	PAC	Q-Sta...	Prob
		1	0.950	0.950	1967.2	0.000
		2	0.899	-0.027	3732.3	0.000
		3	0.849	-0.027	5305.7	0.000
		4	0.798	-0.028	6698.1	0.000
		5	0.748	-0.030	7919.9	0.000
		6	0.697	-0.031	8981.7	0.000
		7	0.646	-0.031	9894.4	0.000
		8	0.595	-0.031	10669.	0.000
		9	0.544	-0.031	11317.	0.000
		10	0.493	-0.032	11850.	0.000
		11	0.443	-0.033	12280.	0.000
		12	0.392	-0.034	12617.	0.000

Series lnHDIAVG

Sample: 1992 2011
Included observations: 2178

Autocorrelation	Partial Correlation		AC	PAC	Q-Sta...	Pro...
		1	0.949	0.949	1963.8	0.000
		2	0.898	-0.028	3721.9	0.000
		3	0.846	-0.028	5285.5	0.000
		4	0.795	-0.029	6665.5	0.000
		5	0.743	-0.030	7873.0	0.000
		6	0.692	-0.032	8918.6	0.000
		7	0.640	-0.031	9813.9	0.000
		8	0.588	-0.028	10571.	0.000
		9	0.537	-0.029	11203.	0.000
		10	0.486	-0.032	11721.	0.000
		11	0.435	-0.034	12136.	0.000
		12	0.384	-0.034	12460.	0.000

Series lnHTECX

Sample: 1992 2011
Included observations: 1897

Autocorrelation	Partial Correlation		AC	PAC	Q-Sta...	Pro...
		1	0.798	0.798	1211.3	0.000
		2	0.666	0.079	2054.7	0.000
		3	0.604	0.141	2747.7	0.000
		4	0.557	0.067	3337.8	0.000
		5	0.500	0.003	3814.6	0.000
		6	0.456	0.028	4210.5	0.000
		7	0.422	0.023	4549.9	0.000
		8	0.368	-0.051	4807.6	0.000
		9	0.325	0.002	5009.4	0.000
		10	0.272	-0.059	5151.0	0.000
		11	0.226	-0.025	5248.6	0.000
		12	0.184	-0.027	5313.1	0.000

Figure-A2. Residual Plot of Equation (8)

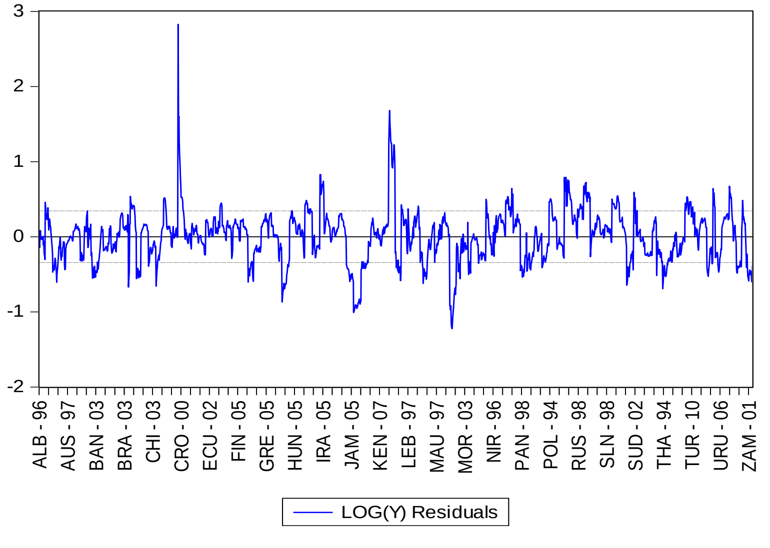


Figure-A3. Residual Correlogramme of Equation (8)

Sample: 1992 2011
Included observations: 1886

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.876	0.876	1450.0	0.000
		2	0.790	0.097	2630.1	0.000
		3	0.713	0.012	3591.5	0.000
		4	0.649	0.027	4389.1	0.000
		5	0.589	-0.005	5045.1	0.000
		6	0.534	-0.001	5584.9	0.000
		7	0.486	0.007	6031.7	0.000
		8	0.436	-0.025	6391.8	0.000
		9	0.386	-0.026	6675.1	0.000
		10	0.335	-0.037	6888.7	0.000
		11	0.287	-0.024	7045.4	0.000
		12	0.241	-0.025	7155.9	0.000

Figure-A4. Residual Plot of Equation (10)

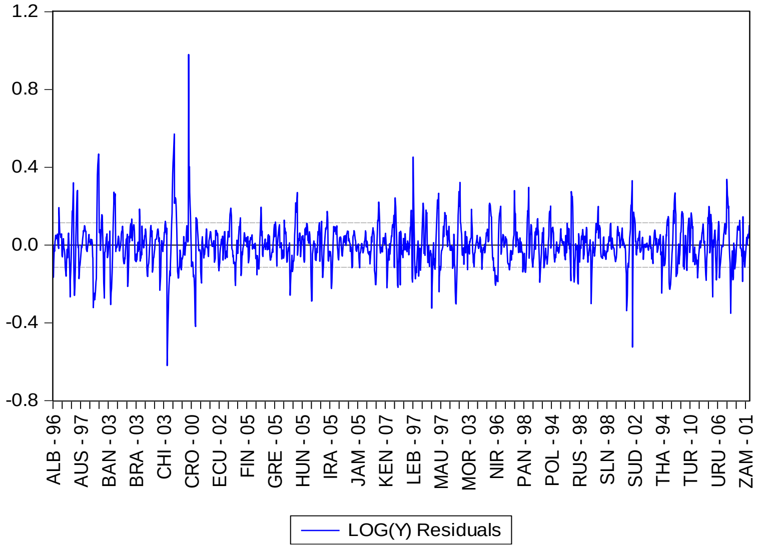


Figure-A5. Residual Correlogramme of Equation (10)

Sample: 1992 2011
Included observations: 1886

Autocorrelation	Partial Correlation		AC	PAC	Q-Sta...	Prob
		1	0.757	0.757	1082.1	0.000
		2	0.534	-0.090	1621.5	0.000
		3	0.327	-0.107	1823.8	0.000
		4	0.153	-0.076	1868.0	0.000
		5	0.010	-0.075	1868.2	0.000
		6	-0.096	-0.056	1885.7	0.000
		7	-0.152	-0.010	1929.5	0.000
		8	-0.177	-0.025	1988.9	0.000
		9	-0.189	-0.047	2056.9	0.000
		10	-0.198	-0.059	2131.3	0.000
		11	-0.207	-0.065	2212.8	0.000
		12	-0.207	-0.042	2294.4	0.000

Figure-A6. Residual Plot of the Equation (11)

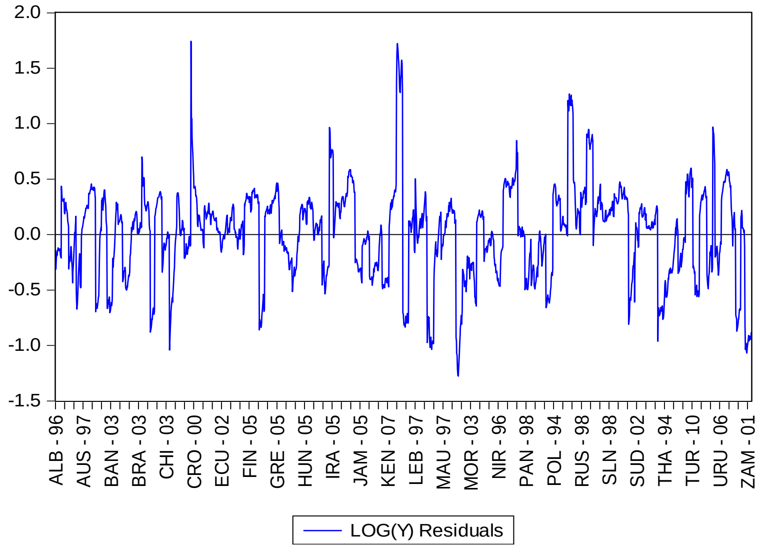


Figure-A7. Residual Correlogramme of the residuals from Equation (11)

Sample: 1992 2011
Included observations: 1886

Autocorrelation	Partial Correlation		AC	PAC	Q-Sta...	Pro...
		1	0.891	0.891	1498.6	0.000
		2	0.818	0.118	2762.7	0.000
		3	0.756	0.042	3843.9	0.000
		4	0.696	-0.004	4761.2	0.000
		5	0.637	-0.021	5529.8	0.000
		6	0.585	0.003	6177.7	0.000
		7	0.529	-0.038	6708.3	0.000
		8	0.474	-0.031	7134.5	0.000
		9	0.419	-0.036	7467.7	0.000
		10	0.361	-0.053	7715.3	0.000
		11	0.309	-0.016	7897.1	0.000
		12	0.260	-0.020	8025.9	0.000

Appendix-2. Estimated Cointegration Relation using Fully Modified Least Square

Country Group 1

$$\ln Y_{it} = 0.3261 \ln KD_{it} + 0.1617 \ln KF_{it} - 0.0581 \ln L_{it} + 0.4344 \ln HDIAVG_{it}$$

(t) (37.1261) (41.5862) (-0.9637) (10.8889)

$$+ 0.0019 \ln HTECX_{it}$$

(1.2016)

$$\text{AdjR}^2 = 0.9975, \textit{Sum Squared Resid} = 3.3840, \textit{Long Run Variance} = 0.0008$$

Country Group 2

$$\ln Y_{it} = 0.4124 \ln KD_{it} + 0.0550 \ln KF_{it} - 0.6866 \ln L_{it} + 1.2309 \ln HDIAVG_{it}$$

(t) (7.6387) (2.3211) (-2.1245) (5.1961)

$$- 0.0253 \ln HTECX_{it}$$

(-1.3920)

$$\text{AdjR}^2 = 0.9963, \textit{Sum Squared} \text{ Re} \textit{sid} = 7.8496, \textit{Long Run Variance} = 0.0357$$

Country Group 3

$$\ln Y_{it} = 0.0954 \ln KD_{it} + 0.1633 \ln KF_{it} + 0.0300 \ln L_{it} + 0.8235 \ln HDIAVG_{it}$$

(t) (1.60247) (3.7242) (0.0634) (1.8391)

$$- 0.0254 \ln HTECX_{it}$$

(-1.3466)

$$\text{AdjR}^2 = 0.9871, \textit{Sum Squared} \text{ Re} \textit{sid} = 3.4262, \textit{Long Run Variance} = 0.0381$$

Country Group 4

$$\ln Y_{it} = 0.1938 \ln KD_{it} + 0.1102 \ln KF_{it} + 0.1371 \ln L_{it} + 0.9551 \ln HDIAVG_{it}$$

(t) (7.1881) (9.5251) (0.7263) (6.6287)

$$+ 0.0270 \ln HTECX_{it}$$

(1.7035)

$$\text{AdjR}^2 = 0.9995, \textit{Sum Squared} \text{ Re} \textit{sid} = 1.6918, \textit{Long Run Variance} = 0.0064$$