Nexus of Financial Development, Innovation for Green Growth in ASEAN Countries

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Abstract: Albeit economic growth of global economies is increasing, nexus of green economic growth, innovation, and financial development needs to be thoroughly understood to make prudent economic policies for sustainability. The research question intends to identify the green growth promoting policies and impact of innovation and financial systems on sustainable economic growth. Rationale for the research is to provide pragmatic evidences to build up economic systems that lead green growth under the emission control and abatement. Empirical approach is used to (i) estimate augmented-Green-Solow model for ASEAN countries (ii) EKC is also estimated with Generalized Method of Moments (GMM) estimation to reveal the impact of financial development, innovation, and trade openness using World Bank data from 1980 to 2014. The empirical results indicate, across estimation methods and specifications, a strong correlation of the innovation, financial development and CO_2 emissions per capita for green growth. Further, increase of innovation and financial structure leads the economies to be sustainable with increase of abatement cost with technological adaptation, and human capital. The implications of the study are to deliberate on the determinants of green growth to promote sustainable development in the economies. Finally, the paper guides policymakers to reform financial and innovation systems to achieve advancement in green technologies adapting sustainable economic policies for green growth.

Keywords: Finance, Innovation, Green Solow Growth, Generalized Methods of Moments estimation.

JEL: O11, O32, O38, O44, O47

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1. Introduction

Economic growth is driven by the innovation, as one of the major determinants for many economies, while its potential is an important source of comparative advantage for ASEAN region. Theoretical substructures for the link between innovation, finance and growth are studied in many seminal studies in the literature. Schumpeter (1912) emphasizes the role of finance in stimulating economic growth and technological innovation because entrepreneur as innovator is capable of making drastic changes to the economy in a process of creative destruction. Further it suggests that the roles of the banks in the process of financing innovative activities allocating resources to entrepreneurs with the most promising new opportunities, such as new products, production methods, and new markets that have the highest success rate (King and Levine, 1993; Morales, 2003 and Acemoglu et al., 2006). The idea of innovation, finance and economic growth are highly interrelated among many developed and developing countries. To facilitate the economic growth in terms of green growth perspective, this study analyzes the EKC model for the ASEAN and Japan, China and Korea to thoroughly evaluate the nexus of innovation, financial development and emissions. In sustainable development, policy analysis has been devoted to explain these relationships with economic growth. Nevertheless, the literature shows a gap in ASEAN countries to provide empirical evidences to foster the green economic growth.

Literature provides different avenues of the relationships and also augmented-Solow growth model but little on augmented-green-Solow model, especially for green growth analysis. Many Asian governments remain severely involved in the provision of financial development and in innovation process fostering economic growth. But underline facts inhibit the EKC with lack of studies for the factors governing the sustainable development policies for the region. According to the EKC hypotheses, the relationship between environmental quality and economic development: various indicators of environmental degradation tend to get worse as modern economic growth occurs until average income reaches a certain point over the course of development. Finding a set of appropriate green growth promoting policies is a complicated mission since different countries face different constraints in terms of institutional, structural, and socio-economic factors. After the augmented-green-Solow growth model estimation, EKC hypotheses are tested for the group of countries to identify the factors governing the CO_2 emission per capita for sustainability perspectives.

In terms of methodology, serious econometric issues are raised for parameter estimation to obtain the robust results with the use of panel data in the designed augmented-green-Solow growth model. The endogeneity issue center around the likely non-random nature of the distribution of the residuals obtained from time series estimation. Therefore, it needs a number of specifications to test and estimate the accurate coefficients while detecting and correcting these problems. This paper, first, construct the green-Solow growth model based on the Solow growth hypothesis and then augmented it for the human capital obtaining robust estimations. Lastly, EKC hypothesis was tested to build empirical evidences for green growth policies for ASEAN region with determinants of optimal emissions and its impact on economic growth.

Building on the above discussion, in a similar passion, the objective of this paper is to examine the extent to which financial development and innovation explain the green growth for ASEAN countries. It examines the role of financial development and innovation in promoting a country's innovation-related activity for mitigating level of emissions. To support the growth literature, this paper builds a model as green Solow growth model including countries of ASEAN and Japan, Korea and China. Since patent counts have been extensively used in economic analyses as the best available proxy for innovation, this model also includes the two proxies for innovation including R&D expenditure and number of patent applicants. Findings of the study will support the group of countries to take macroeconomics policy alternatives to enhance green growth.

The outline of the remainder of this paper is as follows. Section 2 provides an explanation of literature review. Section 3 presents the Data and Empirical Methodology, in particular, the estimation model, methodology process, and section 4 gives the estimation of results and discussion. Section 5 and 6 present conclusion and policy recommendations respectively.

2. Literature Review

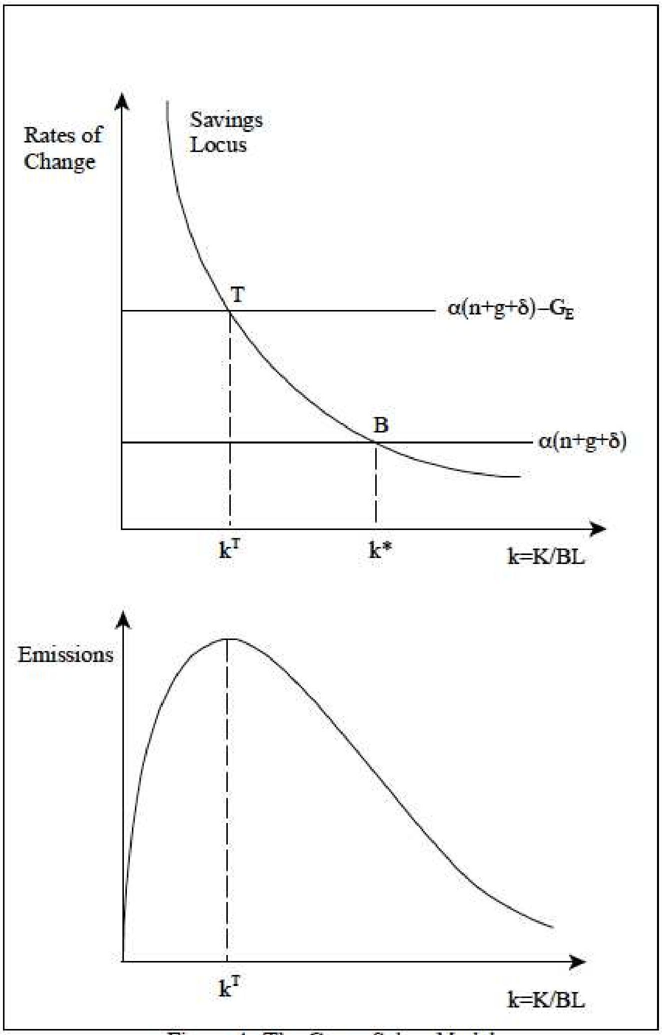

Figure 4: The Green Solow Model

Source: Brock and Taylor (2004)

The concept of green growth emerges with the sustainable development goals of the developed and developing economies. Until recent years, the literature provides endogenous and exogenous growth models to study the economic growth pattern. With the concerns of more environmental friendly economic growth, green growth has been given higher values in studying the facts of economic growth. Solow growth model is one of the seminal studies to assess the economic growth theories with extension to human capital as augmented-Solow growth model. However, there are little concerns of augmented version of green-Solow model to investigate the green growth in developing economies.

In seminal studies, literature provides evidences for the links between green growth, innovation and financial development. Cabral and Mata (2003) shows that the unavailability of financing sources averts firms from achieving their optimal size and hence reduces their involvement in innovation activities. In the presence of properly developed banking system is critical in providing financing to spur growth and to enhance innovations. Rajan and Zingales (1998) argue that well-developed financial sector liberates firms from the need of sourcing funds internally focusing on industries that are more dependent on external finance growth. In the literature, bank-based view emphasizes the importance of banks in facilitating capital allocation and enforcing corporate governance (Diamond, 1984; Ramakrisnan and Thakor, 1984) for financial sector development. Instead, banking institutions are preferred channel of financing firms need additional capital for funding business expansion and for extending innovative activities. Aghion et al. (2005), and Aghion and Howitt (2009) show an innovation-based growth model that financial development plays vital role in creating and sustaining innovation based economies.

In literature, innovation and growth has been studied in numerous ways. Based on the growth theories, economic growth is driven by a growth in production inputs such as labour and capital by a higher efficiency in allocation or improving productivity. Improvements in productivity are in turn fundamentally underpinned by innovation. The innovation of introducing new products or process help to improve the efficiency with which various factors of production are combined and thus raise total factor productivity known as the unexplained residual in the neoclassical growth theory. Empirical studies of the impact of innovation on economic growth have focused on testing the effect of a proxy of innovation on the total factor productivity (TFP) growth. In these studies, innovation is represented by inputs in the innovation process (R&D expenditure) and by measures of creation of knowledge (patenting of new technologies). Further, the ratio of R&D investment to GDP (Scherer, 1982; Griliches and Lichtenberg, 1984; Aghion and Howitt, 1998; Zachariadis, 2004) provides strong positive evidence for the US economy. A similar relationship has been documented for a number of other advanced economies (Lichtenberg, 1992; Patel and Soete, 1988). It's well known that the innovation has the highest impact on economic growth at the point when many firms adopt a new technology that technological advances are matched with labour and capital in the economy. The importance of international spillovers of ideas and innovation in particular from industrialized to developing countries has been studied and channeled through trade (Coe and Helpman, 1995; Eaton and Kortum, 1997), a combination of trade and foreign direct investment (Lichtenberg and Van Pottelsbergh de la Potterie, 1998), and licensing of foreign patents (Nadiri, 1993). Focusing on patent output or R&D spending in emerging market and developing economies has not been studied the link between innovation and economic performance properly. Indeed, studies of innovation and growth focus largely on advanced economies.

Number of studies has been devoted arguments for the finance and economic growth relationships. The arguments on the finance-growth nexus have studied in many literatures. Graff (2003) reports that financial activity has generally supported economic growth. Tran (2008) found that financial development has a positive impact on economic growth in Vietnam. Jalil and Ma (2008) employ bound testing (ARDL) approach to cointegration with deposit liability ratio (DLR) and credit to private sector (CPS) as proxies for financial development and report that both DLR and CPS have significant impact on economic growth. King and Levine (1993a and 1993b) and Levine (2002) have also reported a positive relationship between financial development and economic growth. However, some studies have found a negative relationship between finance and growth (Adusei, 2012; Loayza and Rancie`re, 2006; Demirguc-Kunt and Degatriache, 1998, 2000; Gourinchas et al. 2001, Kaminsky and Reinhart, 1999).

Finance-growth link has studied in number of literature shows the effect as the stock market on economic growth. Further, some studies found a positive impact of stock market on economic growth, because stock market encourages the liquidity of capital and transmits capital to companies (Saci, et. al., 2009; Bencivenga, et. al., 1995; Greenwood and Smith, 1997; Holmstrom and Tirole, 1993). Conversely, an inverse relationship between stock market and economic growth has shown, submitting that stock market promotes asymmetric information on companies and contributes to the reduction in savings (Devereux and Smith, 1994; Mayer, 1988; Morch, et. al., 1990a, 1990b; Shleifer and Summers, 1988; Stiglitz, 1985). Moreover, the relationship among financial market development, stock market development and economic growth (Saci, et. al. 2009) have concluded that the banking sector variables, credit to the private sector and liquid liabilities shows mixed effects on growth.

3. Data and Empirical Methodology

This approach first follows previous empirical studies to build the green-Solow Growth model and to augment it with the human capital with several econometric specifications. Second, starting from a basic EKC model with macroeconomic data that cover different time periods, different explanatory variables with robust estimation of GMM estimation method is employed to control for endogeneity, omitted variable bias, simultaneity, and measurement error.

3.1 Data

The dataset includes ASEAN countries and Japan, China, and South Korea over the period 1980-2014. Based on the availability of data for the region, annual data on tax revenues, tax rates, government expenditure, real GDP per capita, inflation, total population growth, old dependency ratio, young dependency ratio, foreign direct investment, unemployment rate, debt, trade openness, workforce and education expenditure, population density are generated from various years of the World Development Indicators of the World Bank and PWT 9; all nominal values are converted to constant 2015 U.S. dollars using the CPI. Further, financial data are obtained from the Penn (PWT 9) database. All nominal variables are expressed in real terms. Table 6 shows the variable description and Table 8 (see Annex) represents the countries of the study. The key variables are constructed as below.

CO_2 emission per capita (CO_2): CO_2 emissions per capita is calculated. If the estimated coefficient is negative and significant, it is concluded that countries with low CO_2 per capita emissions catch up countries with high CO_2 per capita emissions. In other words, convergence occurs when countries with high initial level of per capita CO_2 emissions have lower emission growth rate than countries with low initial level of per capita CO_2 emissions.

Population growth rate ($\boldsymbol{n+g+\delta}$): According to Brock and Taylor (2004), an investment rate leads to high physical capital stock at regular state and increases CO_2 per capita emissions during transitional dynamics. Many authors have analyzed the importance of population on environment. They conclude that population growth is responsible for the increase in energy consumption (annual emissions growth). The population growth rate was obtained from PWT 9 and adjusted with the depreciation rate and technical progress.

Capital stock and investment (s): Country level data concerning inflation, capital, and labor output was obtained from the Penn World Tables version 9 (PWT9). Capital stock (K) is calculated from the investment variable using a standard perpetual inventory approach with geometric deprecation. The investment data series and average growth of investment must be calculated from the Penn World Tables. Investment data are provided as a component of real GDP per capita, using price levels in the US with 2011 as the base year.

Ratio of abatement cost to GDP per capita ($\boldsymbol{\theta}$): Proxy for abatement cost was defined as the damage of the CO_2 emission calibrated as total savings minus adjusted savings for carbon dioxide damage (current US$). The CO_2 damage is estimated to be $20 per ton of carbon (the unit damage in 1995 U.S. dollars) times the number of tons of carbon emitted. [World Bank staff estimates based on Samuel Fankhauser's "Valuing Climate Change: The Economics of the Greenhouse" (1995)]. Then the ratio of abatement costs to GDP per capita was obtained as θ.

Human capital (hc): Proxy for the human capital accumulation by the percentage of labour force was obtained from the Human capital index, based on years of schooling and returns to education were obtained from the PWT 9. Further it focuses on human capital investment measuring in the form of education and keeping aside investment in health and training.

Technical progress (tp): Technical progress is defined as all technology and production processes contributing to the reduction of environmental damages. It is modeled from the estimation of economy's CO_2 intensity, by the structure of economy and technical progress to reduce it. Structural factors are the level of economy activities (income per capita), openness to international trade and the energy intensity. This method consists to estimate CO_2 intensity on structural factors and the coefficient associated with time trend variable is technical progress. Table 7 (In the annex) shows the estimation results of the Hausman-Taylor approach and the Solow residuals are obtained to construct the technical progress.

3.2 Estimation of Green Solow Model

The basic Solow model (Solow, 1956) assumes a neoclassical production at time t:

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

Where y_t is output, K_t is physical capital, L_t is labour and A_t is technology. $A_t L_t$ is referred to as effective labour, taking into account labour L_t and technology A_t. The neo-classical production function has three important assumptions (Barro and Sala-i-Martin, 2004; Romer, 2006). First it has constant returns to scale in its capital and labour input:

$$F(aK_t, aA_tL_t) = a * F(K_t, A_tL_t) \; for \; all \; a \geq 0 \ldots\ldots (2)$$

Under the above assumption, setting $a = \frac{1}{A_tL_t}$ yields the intensive form of the production function,

$$\frac{Y_t}{A_tL_t} = F(\frac{K_t}{A_tL_t}, 1) = \frac{1}{A_tL_t} F(K_t, A_tL_t) \ldots\ldots (3)$$

Define,

$$y_t \equiv \frac{Y_t}{A_tL_t}, k_t \equiv \frac{K_t}{A_tL_t} \, and \, F(k_t) \equiv F(k_t, 1) \ldots\ldots (4)$$

Where $y_t \equiv \frac{Y_t}{A_tL_t}$ referred to as output per effective worker and $k_t \equiv \frac{K_t}{A_tL_t}$ refers to capital per effective worker.

The equation then becomes,

$$y_t = f(k_t) \ldots\ldots (5)$$

The second assumption for the production function is the rule of diminishing returns in capital and labour. This assumption implies that, holding labour and the level of technology constant, the marginal product of capital is positive but it reduces if capital increases. In similar pattern, under the assumption of diminishing returns to labour, the marginal product of labour is positive but it decreases if labour increases, holding capital and the level of technology constant.

$$\frac{\partial F(K_t, A_tL_t)}{\partial K_t} > 0 \; and \; \frac{\partial^2 F(K_t, A_tL_t)}{\partial K_t^2} < 0 \ldots\ldots (6)$$

$$\frac{\partial F(K_t, A_tL_t)}{\partial L_t} > 0 \; and \; \frac{\partial^2 F(K_t, A_tL_t)}{\partial L_t^2} < 0 \ldots\ldots (7)$$

The third assumption is that the production function satisfies the Inada (1963) conditions as follows.

$$\lim_{K_t \to 0} \frac{\partial F(K_t, A_tL_t)}{\partial K_t} = \infty \; and \; \lim_{K_t \to \infty} \frac{\partial F(K_t, A_tL_t)}{\partial K_t} = 0 \ldots\ldots (8)$$

$$\lim_{K_t \to 0} \frac{\partial F(K_t, A_tL_t)}{\partial L_t} = \infty \; and \; \lim_{K_t \to \infty} \frac{\partial F(K_t, A_tL_t)}{\partial L_t} = 0 \ldots\ldots (9)$$

The assumptions imply that the marginal product of capital (or labour) is very large if capital (or labour) is very small, and the marginal product becomes very small if capital (or labour) is very large.

Beyond the above basic Solow growth model, incorporation of Environmental Kuznets Curve (EKC) using an augmented version of the Solow model is developed for this estimation. The EKC is a relationship between environmental degradation and per capita income. At low levels of economic activity, the environment is worsening, where as economic activity increases, environmental degradation peaks and then begins to fall.

In literature, Brock and Taylor (BT, 2004) make three seminal contributions: (i) Provide a theoretical explanation for the EKC and other features of abatement and emission intensity. (ii) Use a simple variant of the Solow model where the key drivers are diminishing returns in capital and technological progress for abatement. (iii) Derive an estimating equation for pollution convergence. Previous explanations for the EKC have included: threshold effects for abatement; policy changes driven by income; move to a service economy; increasing returns in abatement. Further, BT argues that these explanations are inconsistent with the certain features of emissions and abatement data.

The Green Solow model augments the conventional Solow model to include pollution and abatement activities.

The standard production function is;

$Y = F(K, BL)$……………………………………………………………………..*(10)*

Where BL is labor-augmenting technological progress that grows at a constant exponential rate gB. The population grows at rate n and the K capital stock grows according to;

$K = sY - \delta K$………………………………………………………………………*(11)*

Emission of pollution is given by;

$$\begin{aligned} E &= \Omega F - \Omega A(F, F^A) \\ &= \Omega F[1 - A(1, F^A/F)] \\ &= \Omega F \alpha(\theta) \end{aligned}$$

Where, E is emitted pollution, Ω is pollution from output, A is abatement with CRS production function, $A(F, F^A)$ and technological growth at exogenous rate gA, F is total economic activity, $F^A$is total abatement activity; $\theta = F^A/F$ is the fraction of economic activity dedicated to abatement; $\alpha(\theta) = 1 - A(1, \theta)$ with $\alpha(0) = 1, \alpha'(\theta) < 0 \; and \; \alpha''(\theta) > 0$.

Output available for consumption or investment is then modified as;

$Y = F - F^A = (1 - \theta)F$………………………………………………………..…*(12)*

The model written in intensive form is,

$y = f(k)[1 - \theta]$ ……………………………………………………………………………..(13)

$k = sy - (\delta + n + gB)^k$……………………………………………………………………..(14)

$e = f(k)\Omega\alpha(\theta)$ where $k = \frac{K}{BL}, y = \frac{Y}{BL}$ and $e = E/BL$

Sustainable Growth

The growth rate of emissions along the balanced growth path is;

$gE = gB + n - gA$ ……………………………………………………………………………(15)

The sustainable growth can be defined as;

$gB > 0$ (i.e. technological progress in goods production – GDP per capita growth)

$gA > gB + n$ (i.e. technological progress in abatement must outpace output growth – improving environment). This condition implies $gE < 0$.

The Green Solow model traces out an EKC. To see this, consider the following law of motion for emissions;

$\frac{\dot{E}}{E} = gE + \alpha\frac{\dot{k}}{k}$………………………………………………………………………………(16)

and the law of motion of capital,

$\frac{\dot{k}}{k} = sk^{\alpha-1}(1 - \theta) - (\delta + n + gB)$ ……………………………………………….....(17)

Assuming sustainable growth $gE < 0$ and using the two equations above equations, the top panel in the equation is the standard geographical representation of the Solow model in growth rates. The lower panel shows the corresponding emission levels. The following summarizes the two propositions.

Proposition #1.

- *If growth is sustainable $gE < 0$ and $k(0) < k(T)$, then emissions grow initially and then fall continuously.*
- *If growth is sustainable $gE < 0$ and $k(0) > k(T)$, then emissions fall continuously.*
- *If growth is unsustainable $gE > 0$, then emissions grow but at a decreasing rate.*

The first case in Proposition #1 produces the EKC.

Proposition #2.

- *Identical economies with different initial values produce different per capita income and emission profiles over time. The peak level of emissions and the associated level of per capita income are not unique.*

This explains the mixed evidence for the EKC in cross-country data. It will be important to control for initial conditions and unobserved heterogeneity.

Estimating the equation

The estimating equation is derived differentiating a per capita version with respect to time.

$$\frac{\dot{e}^c}{e} = -gA + \frac{\dot{y}^c}{y} \qquad (18)$$

A discrete-time version of above (9) equation is

$$\frac{\ln(e^c_{i,t}/e^c_{i,t-N})}{N} = -gA + \frac{\ln(y^c_{i,t}/y^c_{i,t-N})}{N} \qquad (19)$$

Substituting out income per capita, the estimating equation becomes;

$$\frac{\ln(e^c_{i,t}/e^c_{i,t-N})}{N} = \beta_{0,i} + \beta_1 \ln\left(e^c_{i,t-N}\right) + \mu_{i,t} \qquad (20)$$

To consistently estimate (11), we require $\beta_{0,i}$ and $\ln\left(e^c_{i,t-N}\right)$ are independent of $\mu_{i,t}$. This is unlikely because steady states are different across countries (conditional convergence) and because initial technology and pollution $\Omega^c_{i,t-N}$ and $B^c_{i,t-N}$ may be correlated with $e^c_{i,t-N}$. To address this issue, BT solve for steady states from the Green Solow model and substitute into above (11) to produce;

$$\frac{\ln(e^c_{i,t}/e^c_{i,t-N})}{N} = \beta_0 + \beta_1 \ln\left(e^c_{i,t-N}\right) + \beta_2 \ln(s_i) + \beta_3 \ln(1-\theta_i) + \beta_4 \ln(n_i + g + \delta) + \mu_{i,t} \qquad (21)$$

Further, the above estimation (21) is augmented incorporating the human capital for the Solow model estimation. Hence, in order to estimate the above augmented sustainable growth model, GMM dynamic panel data estimation is applied. A number of reasons can be explained as a rationale for the use of GMM in the model. First, the incorrect treatment of country specific effects representing differences in technology or preferences (Islam, 1995; Caselli et al., 1996; Temple, 1999a). Second, due to the presence of lagged dependent variable, most explanatory variables might be endogenous to economic growth, and the presence of simultaneous or reversed causality can generate a bias in the estimation. Accordingly, the standard panel models such as pooled OLS regression model, fixed-effect panel model and random effect panel model are not appropriate due to the presence of country-specific effects and lagged dependent variable or potential endogeneity of explanatory variables. To handle these issues Arellano and Bond (1991) suggest a Generalized method of moments (GMM) estimator. Arellano and Bond (1991) suggest instrumental variables known as the first-difference GMM estimator to be used to resolve the resulting correlation between lagged dependent variable and disturbance terms after first differencing. In this method, the differenced lagged dependent variables and other endogenous variables can be instrumented with their lags in levels, lagged two or more periods while the exogenous variables can serve as their own instruments. This method can be either one-step GMM estimator or two-step GMM estimator. The one-step GMM estimator assumes independent or terms and homoscedastic error variances across countries and times, whereas, the second-step GMM estimator uses residuals of the first-step estimation to construct a consistent variance – covariance matrix when the assumptions of independence and homoscedasticity do not hold.

The main problem in first-difference GMM estimator is that potential information in the level relationship and in the relations between the levels and the first differences is neglected. To solve this problem Arellano and Bover (1995) suggest estimating the level and first-difference regressions as a system known as system-GMM estimator. This method combines, in a system, level regression, instrumented by lagged first-differenced variables with first-differenced regression by using lagged level variables as instruments. In light of these econometric issues the one-step and two-step, as well as difference and system GMM are used in the analysis. Still, results from the two-step first-difference GMM are also reported for comparison. The consistency of GMM estimator depends on two specification tests, Sargan over-identifying restrictions and a serial correlation test in disturbances (Arellano and Bond, 1991). To test overall validity of the instruments, Sargan over-identifying restrictions in the estimation process are used.

3.3 EKC Estimation

In addition to the above growth analysis, EKC (Kuznets, 1955) for the region is estimated to evaluate the factors that govern the sustainable development. The relationship between measures of pollution, per capita income and other possible control variables is traditionally estimated in the literature by means of the following equation (Khanna and Plassmann, 2004; Stern, 2004; Ang, 2007; Orubu and Omotor, 2011):

$$\ln CO_{2_{it}} = \beta_0 + \beta_1 Y_{it} + \beta_2 Y_{it}^2 + \beta_3 Z_{it} + \varepsilon_{it} \quad (22)$$

Where i and t refer to the i-th country and the year respectively. The dependent variable is the environmental degradation, in here; CO_2 emissions per capita and Y_{it} is represented by per capita GDP. Z_{it} indicates other variables with potentially explanatory power including financial development factors and innovative indicators in the economies. The literature shows a variety of strong evidences of an EKC relationship. However, the evidences for an EKC relationship in cross-country empirical work are mixed (List and Gallet, 1999; Harbaugh et al., 2002; Barbier, 1997).

4. Results and Discussion

Before presenting the relationships between the variables, the following table (1) provides the summary statistics of the explanatory variables in the study. Then, the EKC is estimated using difference-GMM and system-GMM estimators in the proceeding results of the analysis.

4.1 Estimation of Green Solow Growth Model (GSGM)

Given the availability of the data, proposed empirical equation for calibration of GSGM is estimated and the results are shown in the table (2 and 3).

Table 1: Summary statistics of variables in estimation of green Solow model

Variable	Mean	Standard Deviation	Min	Max	Observations
CO_2	4.25	7.69	0.004	67.412	692
rGDPpc	11784.54	17970.98	264.037	95142.15	673
K	2102015	6147187	3182.862	6.94e+07	673
s	13272.85	29272.66	-6138.29	201286.2	466
h	2.03	0.61	1.155	3.593	673
(n+g+d)	1.93	1.04	-3.343	6.396	715
ei	0.17	0.06	0.022	0.431	505
ti	90.97	89.67	0.174	439.656	584
1-theta	0.99	0.00	0.993	0.999	582

Note: the dependent variable is lngCo2 = average growth rate of log Co2 emissions per capita; Co2 = Co2 emissions per capita; rGDPpc = real GDP per capita; K=capital stock; s=investment to GDP ratio; h= human capital; (n+g+d) = average population growth adjusted by the depreciation rate and rate of technical progress (tp); ei=energy intensity; ti = trade intensity and theta=ratio of abatement cost to GDP per capita. The data for the 13 countries are prepared from 1960 to 2014, balanced panel data.

Table 2: GMM Estimation Results of Green Solow Growth Model (One-step dynamic panel data procedure)

Dependent Variable: $\frac{\ln(e^c_{i,t}/e^c_{i,t-N})}{N}$	Difference GMM			System GMM		
	(1)	(2)	(3)	(4)	(5)	(6)
$\ln(e^c_{i,t-N})$	0.26***	0.25***	0.26***	0.13	0.14	0.13
	(4.53)	(4.54)	(4.56)	(1.01)	(1.08)	(1.09)
$\ln(s_{it})$	0.00	0.01	0.00	0.00	0.00	0.00
	(0.87)	(0.83)	(0.53)	(.98)	(0.52)	(0.46)
$\ln(1-\theta_{it})$	16.33	34.04	35.77**	-9.21***	-8.14**	-8.12**
	(2.10)	(2.09)	(2.19)	(-3.36)	(-2.67)	(-2.69)
$\ln(n_{it}+g+\delta)$	0.03**	0.02**	0.02	0.01	0.00	-0.00
	(1.32)	(1.36)	(1.22)	(0.72)	(0.19)	(-0.24)
$\ln(h_{it})$		-0.05	-0.07		-0.08***	-0.08***
		(-0.34)	(-0.43)		(-3.98)	(-4.04)
$\Delta\ln(h_{it})$			0.88***			0.12
			(1.10)			(0.14)
tp_{it}	0.64**	-0.25***	-0.25***	-0.02	-0.02	-0.02
	(-4.07)	(-4.08)	(-4.18)	(-1.08)	(-0.94)	(-0.88)
N	344	344	344	364	364	364
Wald chi^2	48.74	48.93	50.02	-	-	-
p-value	0.00	0.00	0.00			
F statistic	-	-	-	2.42	5.60	4.82
p-value				0.09	0.00	0.00
Sargan Test:	389.72	390.25	389.40	396.57	393.94	394.10
p-value	0.02	0.02	0.02	0.07	0.07	0.02
Hansen Test:	-	-	-	7.97	3.81	2.84
p-value				1.00	1.00	1.00
AR (1)	-6.59***	-6.60***	-6.56***	-1.67*	-1.66*	-1.66*

AR (2)	-0.62	-0.59	-0.70	-0.68	-0.68	-0.68

Cluster robust standard errors in parenthesis. a * denotes statistical significance at the 10 percent level and a ** denotes statistical significance at the 5 percent level and a *** denotes statistical significance at the 1 percent level. Sargan test for over-identification restrictions. Augmented green-Solow growth model with human capital (h) in equations (2,3,5,6).

Table (2) shows the results of estimated green-Solow growth model with one-step difference and system GMM procedure to obtain robust estimations. Equation (1), (4) show the green-Solow model, equation (2), (5) represent the augmentation with human capital, and equation (3), (6) show the augmentation with differenced-human capital.

Based on the difference GMM estimation (1), CO_2 emission per capita, growth of labour force (adjusted by the rate of technological progress and the rate of depreciation) and technical progress is positively significant. When the GSGM is augmented with the human capital in (2), same results can be observed. However, when it further augmented with the differenced-human capital, CO_2 emissions per capita, (1- ratio of abatement cost to GDP), first differenced human capital are positively significant and technical progress is negatively significant. In conventional level, the results suggests that the prediction of average growth rate of CO_2 emissions has shown a positive relationship with the CO_2 emission per capita, growth of labour force, and technical progress of the region. But, system GMM results revealed that only abatement cost ratio and human capital are negatively significant with the predication of average growth rate of CO_2 emissions. This implies that, in robust estimation level, these two factors are exceedingly influenced on the green growth of the economies. Increase of these factors severely reduces the growth rate of CO_2 emission.

Table 3: GMM Estimation Results of Green Solow Growth Model (Two-step dynamic panel data procedure)

Dependent Variable: $\frac{\ln(e^c_{i,t}/e^c_{i,t-N})}{N}$	**Difference GMM**			**System GMM**		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
$\ln(e^c_{i,t-N})$	0.52**	0.49	0.74*	0.28	0.99*	0.87
	(1.23)	(1.16)	(1.74)	(-0.74)	(2.07)	(1.75)
$\ln(s_{it})$	0.05	0.05	0.01	-0.01	0.09	0.07
	(0.88)	(0.96)	(0.12)	(-0.08)	(1.04)	(0.82)
$\ln(1-\theta_{it})$	-139.49	-189.23**	78.93	-1.08	-640.55*	-405.23**
	(1.56)	(1.28)	(0.50)	(-0.01)	(0.99)	(0.49)
$\ln(n_{it}+g+\delta)$	0.24	0.20	0.10	0.24	0.26	0.29
	(0.92)	(0.73)	(0.36)	(0.98)	(1.10)	(1.20)
$\ln(h_{it})$		-4.98	-2.33		0.68	-0.17
		(-0.48)	(-0.22)		(0.30)	(-0.07)
$\Delta \ln(h_{it})$			-104.57**			-60.80**
			(-2.29)			(-0.93)
tp_{it}	-0.26	-0.24	-0.36**	-0.11	-0.18*	-0.51
	(-0.57)	(-0.53)	(-0.77)	(-0.26)	(-0.41)	(-0.91)
N	344	344	344	364	364	364
Wald chi^2	9.28	9.58	15.94	-	-	-
p-value	0.23	0.29	0.06			
F-statistic	-	-	-	0.47	0.89	0.89

p-value				0.82	0.54	0.56
Sargan Test:	389.72	390.25	389.40	396.57	393.94	394.01
p-value	0.02	0.02	0.02	0.07	0.08	0.07
Hansen Test:	8.52	390.25	2.98	7.97	3.81	2.84
p-value	1.00	0.02	1.02	1.00	1.00	1.00
AR (1)	-1.41	-0.99	-0.84	-1.57	-0.68	-1.03
AR (2)	-0.64	0.55	1.35	-0.52	-1.87*	-0.56

Cluster robust standard errors in parenthesis. a * denotes statistical significance at the 10 percent level and a ** denotes statistical significance at the 5 percent level and a *** denotes statistical significance at the 1 percent level. Sargan test for over-identification restrictions. Augmented green Solow growth model with human capital (h) in equations (2,3,5,6).

For more precise results, two step difference and system GMM estimations are conducted. These results depicted that although the previous results are not significant at 5% or 1% level, some of the determinants are significant at 10% level. In equation (1), CO_2 emission per capita is the only significant variable at 5% level. Equation (2) shows only abatement cost ratio has negatively significant impact at 5% level. In addition to the above results, augmented equation (3) shows CO_2 emissions per capita is positively whereas human capital and technical progress are negatively significant at 5% levels. Comparing with the system GMM estimations in equation (4,5,6), the results show that the abatement costs and human capital have significant impact on the growth of CO_2 emissions.

In summary, the coefficient on initial CO_2 emissions per capita is significantly different from zero, and less than one, in all regressions in this section, robustly confirming the conditional-convergence predictions. Investment ratio has not significant in any estimation and at any level. Therefore, for these economies, investment has not contributed for the green growth especially towards growth rate of CO_2 emissions. Form all the estimations, it can be suggested that abatement cost and human capital have significant impacts on the growth of CO_2 emissions per capita. Thereby the study suggests that the consideration of the average savings adjusted to the CO_2 emission per capita as abatement cost has significant negative impact implying that the increase of abatement cost per GDP per capita can significantly reduce the growth of CO_2 emissions.

4.2 Impact of Finance, Innovation on Green Growth

Beyond the green growth of this region, it is vital to understand which factors are influenced on the CO_2 emissions in the ASEAN economies. Therefore, EKC has been performed to evaluate the factors governing the sustainable growth to analyze the policies.

Table 4: Summary statistics of the variables

Variable	Mean	Standard Deviation	Min	Max	Observations
CO_2	4.58	5.59	0.04	35.65	442
GDP	8805.29	12770.79	97.15	56007.29	421
Education	1.56e+07	3.19e+07	30513	1.47e+08	411
GCF	28.02	8.17	6.17	47.68	389

GDS	30.91	13.35	-4.77	67.56	389
High-tech	27.71	19.40	0.00	74.99	261
FDI	1.08e+10	3.55e+10	-4.55e+09	2.91e+11	421
Finance	86.37	74.84	4.45	357.31	409
EnImport	-49.84	236.97	-1466.02	100	395
EnCons	2123.10	2229.26	246.10	9695.71	395
Patent	66886.59	140788.4	3	928177	312
R&D	1.53	1.24	0.01	4.29	126
PopGro	1.61	0.92	-1.47	5.32	468
PopDen	579.06	1498.03	14.09	7806.77	468
Openness	101.06	90.29	0.17	439.66	420

Note: Data was obtained for a period of 1980-2014 from WDI of World Bank and PWT 9.

Given the availability of the data, proposed empirical equation for the EKC is estimated and the results are shown in the table (5).

Table 5: System GMM Estimation Results of Environmental Kuznets Curve

Dependent Variable:	**Difference GMM**		**System GMM**	
ln (CO_2)	**(1 step)**	**(2 step)**	**(1 step)**	**(2 step)**
GDP	-0.000	-0.002	0.076***	0.002
	(0.01)	(0.00)	(5.33)	(1.33)
GDP^2	-0.368**	0.018	-0.161***	-0.000
	(0.08)	(0.15)	(0.02)	(0.01)
Lag (GDP)	-0.005	0.000*	0.001	0.002**
	(-0.98)	(0.00)	(0.00)	(-1.27)
EnCons	0.000***	-0.000	0.030***	0.004***
	(0.00)	(0.01)	(0.00)	(3.68)
FDI	0.007***	-0.019	0.001***	0.001
	(2.93)	(-1.46)	(0.00)	(-0.92)
Patent	0.001	0.000	-0.235***	-0.000**
	(1.51)	(0.00)	(0.00)	(-2.21)
R&D	-0.123**		-0.058**	
	(-2.02)		(0.88)	
Openness	-0.004*	-0.003	-0.001	-0.030*
	(-1.73)	(-1.23)	(0.00)	(-1.83)
Finance	-0.001**	-0.027*	0.003***	0.012***
	(-1.99)	(-1.65)	(0.00)	(2.73)
Technical progress	1.001**		-0.015	
	(2.13)		(0.00)	
Human Capital	0.562**		-0.064	
	(1.62)		(0.45)	
EnImport	-0.001*	0.013	0.001**	0.044**
	(-0.74)	(1.28)	(1.62)	(0.02)
HighTech	0.005**		-0.005***	
	(1.92)		(0.00)	
Log (PopDen)	0.888		-0.121***	
	(0.85)		(0.01)	
Log (PopGro)	0.058***		0.064**	-5.181**
	(2.72)		(0.00)	(2.28)
N	78	78	107	274

Sargan Test:	107.84	107.84	232.02	2369.48
p-value	(0.000)	(0.000)	(0.000)	(0.000)
Hansen test	-	0.00	-	0.00
p-value		(1.000)		(1.000)
Wald Chi2	106.24	62.9	1658.26	90.80
P-value	(0.000)	(0.000)	(0.000)	(0.000)
AR (1)	-2.31**		-1.66**	1.96**
AR (2)	-2.34**	-0.78***	-1.71*	

Cluster robust standard errors in parenthesis. a * denotes statistical significance at the 10 percent level and a ** denotes statistical significance at the 5 percent level and a *** denotes statistical significance at the 1 percent level. Both time and year fixed effects are used. Instrumental variables: gds, gcf, and lag variables of the explanatory variables. Failure to reject the null of Sargan test would imply that the instruments are valid and the model is correctly specified. To test the serial correlation in disturbances, one should reject the null of the absence of first-order serial correlation (AR1) and not the absence of second-order serial correlation (AR2), respectively.

EKC model has evaluated to understand thoroughly the factors governing the sustainable growth of the ASEAN economies and to find the nexus between financial development and innovation for the CO_2 emissions per capita. Both one-step and two-step and difference and system GMM estimations are presented in the above Table (5). In comparison to two GMM estimations, system GMM increased efficiency of the estimation. First, the system GMM uses more instruments than the difference GMM. Second, in a panel with fixed effects including the equation in levels requires the first-differenced instruments used for the variables in levels should not be correlated with the unobserved country effects.

Particularly, Difference GMM estimation (1) exposes that GDP^2, energy consumption, FDI, R&D, finance, technical progress, human capital, High-tech export, and population growth are significant in the prediction of CO_2 emissions. In particular, R&D and finance are negatively significant in the estimation, implies that increase of R&D expenditure and financial development sector decreases the emission in the ASEAN economies. However, the equation (2) revealed none of the variables are significant at least 5% level.

System GMM estimation (3) discloses that GDP, GDP^2, energy consumption, FDI, R&D, finance, technical progress, human capital, patent, energy import, high-tech export, urbanization rate, and population growth are significant predictors. Patent and R&D expenditure are negatively significant indicating that the increase of number of patent applicants and R&D expenditure decreases the CO_2 emissions. This can be supported with the previous studies that technological innovation can reduce the emissions considerably. However, financial development indicator is positively significant. Equation (4) revealed that lag GDP, energy consumption, number of patent applicants, finance, energy importation, and population growth is determinants of sustainable growth. Number of patent applicants is negatively significant supporting the previous results.

5. Conclusion

The empirical analysis of augmented-green-Solow growth model was developed to estimate the green growth in ASEAN economies providing pragmatic evidences for sustainable development policy. Further, EKC model is estimated to identify the factors determining the CO_2 emissions and then sustainable economic growth with identifying the relationships between CO_2 emission, and innovation and financial development employing the recently developed econometric methods, GMM estimation.

The advantage of the GMM estimation is that it counts for the many econometric issues like endogeneity. The results of GMM approach, difference-GMM and system-GMM, revealed a strong correlation in Green growth estimation. It is found that many macroeconomic variables in the GSGM have significant effect on the rate of CO_2 emission of robust coefficients with signs. The coefficient on initial CO_2 emissions per capita is significantly different from zero, and less than one confirming the conditional-convergence predictions. Investment ratio has not significant. Thus, for these economies, investment has not contributed for the green growth, whereas abatement cost and human capital have significant impacts on the growth of CO_2 emissions per capita. Thereby the study suggests that the consideration of increasing abatement cost per GDP per capita can significantly reduce the growth of CO_2 emissions in these countries with high human capital.

Overall summary of EKC exposes that energy consumption, R&D, finance, FDI, High-tech export, patent applicants, population growth, energy importation are significant predictors of CO_2 emissions per capita. In particular, number of patent applicants and R&D expenditure are negatively significant; imply that increase of technological innovation leads to reduce the CO_2 emissions, thereby move towards the green growth. Financial sector development is positive and significant indicating that the expansion of domestic credit provided by financial sector can increase the CO_2 emissions per capita in ASEAN economies.

Therefore, combining both results of the green growth model and EKC determinants, one of the significant evidences of this study is that green growth can be promoted with the increase of financial sector with the motivation of abatement for the emissions, while stimulating the financial sector towards innovative approaches though firms to produce goods and services that are sustainable with green technologies. Human capital also played a significant role in the green growth while other determinants can be considered for policymaking in these economies. Therefore, the research evidences suggest the policymakers to design the appropriate green economic policies with the use of pragmatic findings for these countries.

6. Policy Recommendations

The findings from the study can be inferred to provide recommendations to the sustainable growth policies for policymakers in selected economies. The implications of the study are cautious on the determinants of the sustainable economic growth to reform the innovative and financial systems. Provided that, the determinants, especially patents and R&D expenditure have negative impacts on the emissions in the EKC for ASEAN. Therefore, it implies that increase of innovative green technologies for mitigation of damages to the savings under abatement cost with human capital, and improved financial system decrease the environmental damages while leading towards green growth. Therefore, it is evidence that policies need to focus on improving firms' innovative capacities with financial development, technology adoption to improve innovation, and green growth promoting policies. Sustainable development policies can be certainly incorporated activities, which is lack and insufficient to mitigate the environmental damages with adjustment of costs associated with the abatement.

7. References

Acemoglu, D., Aghion, P. and F. Zilibotti (2006). Distance to Frontier, Selection, and Economic Growth. Journal of European Economic Association, 4, 37–74.

Adusei, M. (2012). Financial Development and Economic Growth: Is Schumpeter Right? British Journal of Economics, Management & Trade, 2(3), 265-278.

Aghion, P. and P. Howitt (1998). Endogenous Growth Theory, MIT Press Books.

Aghion, P., Howitt, P. and D. Mayer-Foulkes (2005). The Effect of Financial Development on Convergence: Theory and Evidence. Quarterly Journal of Economics, 120 (1), 173–222. DOI:10.18267/J.Pep.478172 PRAGUE ECONOMIC PAPERS, 2, 2014

Aghion, P., and P. Howitt (2009). The Economics of Growth. Cambridge, Massachusetts: MIT Press, 2009.

Ang, J. B., (2007). CO_2 Emissions, Energy Consumption, and Output in France. Energy Policy, 5, 4772-4778.

Arellano, M., and S. R. Bond (1991). Some Tests of Specification for Panel Data: Monte Carlo Evidence and An Application to Employment Equations. Review of Economic Studies, 58(2), 277–297.

Arellano, M. and O. Bover (1995). Another Look at the Instrumental Variable Estimation of Error- Components Models. Journal of Econometrics, 68(1), 29–51.

Barbier, E. B. (1997). Introduction to the Environmental Kuznets Curve Special Issue. Environment and Development Economics, 2, 369–381.

Barro, R., and Sala-I-Martin, X., Economic Growth, 2nd Edition, Cambridge, Mass MIT Press, 2004.

Bencivenga, V. R., Smith, B. D. and R. M. Starr (1995), Transactions Costs, Technological Choice, and Endogenous Growth, Journal of Economic Theory, 67, 153–177.

Brock, W.A., and M. S. Taylor (2004). The Green Solow Model. NBER Working Paper Series, No: 10557.

Cabral, L., and J. Mata (2003). On the Evolution of the Firm Size Distribution: Facts and Theory. American Economic Review, 93(4), 1075–1090.

Caselli, F., Esquivel, G. And F. Lefort (1996). Reopening the Convergence Debate: A New Look at Cross-Country Growth Empirics, Journal of Economic Growth, 1, 363–389.

Coe, D., and E. Helpman (1995). International R&D Spillovers, European Economic Review, 39, 859-887.

Demirguc-Kunt, A., and E. Degatriache (1998). The Determinants of Banking Crises in Developing and Developed Countries, International Monetary Fund Staff Papers, 45, 81–109.

Demirguc-Kunt, A., and G. Detregiache (2000). Banking Sector Fragility: A Multivariate Logit Approach, World Bank Economic Review, 14, 287–307.

Devereux, M. B., and G. W. Smith (1994). International Risk Sharing and Economic Growth, International Economic Review, 35, 535–550.

Diamond, D. W. (1984). Financial Intermediation and Delegated Monitoring. Review of Economic Studies, 51 (3), 393–414.

Eaton, J., and S. Kortum (1997). Technology and Bilateral Trade, NBER Working Paper 6253.

Gourinchas, P., Landerretche, O. and R. Valde´S, (2001). Lending Booms: Latin America and the World Economia 1, 47–100.

Graff, M. (2003). Financial Development and Economic Growth in Corporatist and Liberal Market Economies, Emerging Markets and Trade, 39(2), 47-69.

Greenwood, J., and B. Smith. (1997). Financial Markets in Development and the Development of Financial Market, Journal of Economic Dynamic and Control, 21(1), 145-181.

Griliches, Z., and F. Lichtenberg (1984). Inter-Industry Technology Flows and Productivity Growth: A Re-Examination, Review of Economics and Statistics, 66, 324-29.

Harbaugh, W., Levinson, A. M., and D. M. Wilson (2002). Reexamining the Empirical Evidence For an Environmental Kuznets Curve. Review of Economics and Statistics, 84, 541–551.

Holmstrom, B., and J. Tirole (1993). Market Liquidity and Performance Monitoring. Journal of Political Economy, 101 (4), 678–709.

Islam, N. (1995). Growth Empirics, A Panel Data Approach. Quarterly Journal of Economics, 110(4), 1127–1170.

Jalil, A., and Y. Ma (2008). Financial Development and Economic: Time Series Evidence From Pakistan and China, Journal of Economic Cooperation, 29(2), 29-68.

Kaminsky, G., and C. Reinhart, (1999). The Twin Crises: The Causes of Banking and Balance of Payments Problems, American Economic Review, 89, 473–500.

Khanna, N., and F. Plassmann (2004). The Demand for Environmental Quality and the Environmental Kuznets Curve Hypothesis, Ecological Economics, 51 (3-4), 225-236.

King R. G., and R. Levine (1993). Finance, Entrepreneurship, and Growth: Theory and Evidence, Journal of Monetary Economics, 32, 513–542.

King, R., and R. Levine (1993a). Finance and Growth: Schumpeter Might Be Right, Quarterly Journal of Economics, 153, 717–738.

King, R., and R. Levine (1993b). Finance, Entrepreneurship, and Growth: Theory And Evidence, Journal of Monetary Economics, 32, 513–542.

Kuznets, S. (1955). Economic Growth and Income Inequality. American Economic Review, 45, 1-28.

Levine, R. (2002). Bank-Based or Market-Based Financial Systems: Which Is Better?, Journal of Financial Intermediation, 11 (4), 398–428.

Lichtenberg, F. (1992). R&D Investment and International Productivity Differences, NBER Working Paper 4161.

Lichtenberg, F. and B. Van Pottelsberghe De La Potterie (1998). International R&D Spillovers: A Comment, European Economic Review, 42, 1483-1491.

List, J. A., and C. A. Gallet (1999). The Environmental Kuznets Curve: Does One Size Fit All? Ecological Economics, 31, 409-423.

Loayza, N.V., and R. Rancie're (2006). Financial Development, Financial Fragility, And Growth, Journal of Money, Credit and Banking, 38(4), 1051-1076.

Mayer, C. (1988). New Issues in Corporate Finance, European Economic Review, 32, 1167– 1188.

Morales, M. F. (2003). Financial Intermediation in a Model of Growth Through Creative Destruction. Macroeconomic Dynamics, 7, 363–393.

Morck, R., Shleifer, A. and R. W. Vishny (1990a). The Stock Market and Investment: Is the Market a Sideshow? Brookings Papers on Economic Activity, 21, 157–216.

Morck, R., Shleifer, A. and R. W. Vishny (1990b). Do Managerial Objectives Drive Bad Acquisitions? Journal of Finance, 45, 31–48.

Nadiri, M. (1993). Innovations and Technological Spillovers, NBER Working Paper

4423.
Orubu, O.C., and D. G. Omotor (2011). Environmental Quality and Economic Growth: Searching for Environmental Kuznets Curves for Air and Water Pollutants in Africa. Energy Policy, 39, 4178-4188.
Patel, P., and L. Soete (1988). L'évaluation Des Effets Économiques De La Technologie, STI Review, 4, 133-183.
Rajan, R., and L. Zingales (1998). Financial Dependence and Growth, American Economic Review, 88, 559-586.
Ramakrishnan, R., and A. Thakor (1984). Information Reliability and Theory of Financial Intermediation. Review of Economic Studies, 51 (3), 415–432.
Romer, D. (2006). Advanced Macroeconomics, Mcgraw-Hill Irwin: Boston, MA/New York.
Saci, K., Giorgioni, G., and K. Holden (2009). Does Financial Development affect Growth? Applied Economics, 41, 1701–1707.
Scherer, F. (1982). Inter-Industry Technology Flows and Productivity Growth, Review of Economics and Statistics, 64, 627-34.
Schumpeter, J. A. (1912). Theories Der Wirtschaftlichen Entwicklung. (The Theory Of Economic Development), Leipzig: Dunker And Humblot; Translated by Redvers Opie, Cambridge, MA: Harvard University Press, 1934.
Shleifer, A., and L. Summers (1988). Breach of Trust in Hostile Takeovers, in Corporate Takeovers: Causes and Consequences, (Eds) A., Auerbach, Chicago, University of Chicago Press, 33–56.
Solow, R. M. (1956). A Contribution to the Theory of Economic Growth. Quarterly Journal of Economics, 70, 65–94.
Stiglitz, J. E. (1985). Credit Markets and the Control of Capital, Journal of Money, Credit and Banking, 133-152
Stern, D. I. (2004). The Rise and Fall of the Environmental Kuznets Curve. World Development, 32(8), 1419–1439.
Temple, J. R. W. (1999a). The New Growth Evidence, Journal of Economic Literature, 37(1), 112-156.
Tran, A. T. (2008). Financial Development and Economic Growth in the Case of Vietnam, Journal of International Business and Economics, 8(2), 135-153.
Zachariadis, M. (2004). R&D Induced Growth in the OECD, Review of Development Economics, 8, 423-439.

Annex

Variable Construction

Table 6: Variable Description for EKC estimation

Variables	Description
CO_2	CO_2 emissions (metric tons per capita)
GDP	GDP per capita
Education	Enrolment in primary education
GCF	Gross capital formation (% of GDP)
GDS	Gross domestic savings (% of GDP)
High-tech	High-technology exports (% of manufactured exports)
FDI	Foreign direct investment inflow

Finance	Domestic credit provided by financial sector (% of GDP)
EnImport	Energy imports (% of energy use)
EnCons	Energy consumption (kg of oil equivalent per capita)
Patent	No of patent applicants
R&D	Expenditure on research and development (% of GDP)
PopGro	Population growth rate
PopDen	Rate of urbanization (Population density)
Openness	Trade openness
Trade Intensity	Ratio of sum of export and import to GDP
Technical progress	Rate of technical progress. It is coefficient of trend (t) in a regression in panel where explained variable is the intensity of economy in CO2 and explanatory variables are GDP per capita, intensity of trade and energy as in the table () using Hausman-Taylor estimation.

Measuring Technical progress

Table 7: Hausman-Taylor estimation of technical progress

Variables Ln(Co2)	**Coefficient**	**Std. Err.**	**p**
TV exogenous			
Real GDPpc	0.32**	0.03	0.017
Trend	0.22***	0.00	0.000
TV endogenous			
Energy intensity	-0.67**	0.04	0.173
Trade intensity	0.01***	0.00	0.002
TI exogenous			
id	-0.11	0.09	0.250
Constant	-42.91***	4.05	0.000
No of observations	451		
No of groups	12		
Sigma_u	1.28		
Sigma_e	0.35		
rho	0.93		
Wald chi2	432.54		0.000

Note: TV refers to time varying; TI refers to time invariant. a * denotes statistical significance at the 10 percent level and a ** denotes statistical significance at the 5 percent level and a *** denotes statistical significance at the 1 percent level. Both time and year fixed effects are used. The residuals of the model are considered as technical progress.

Table 8: List of Countries in the Study

ASEAN plus China, Japan and Korea
Brunei Darussalam
Cambodia
China
Indonesia
Japan
Korea, Rep.
Lao PDR

Malaysia
Myanmar
Philippines
Singapore
Thailand
Vietnam