Application model of green economic growth and economic gap

Evi Susanti Tasri*, Syafruddin Karimi and Hefrizal Handra

Department of Economics,
University of Andalas,
Kampus Limau Manis, Padang 25163, Indonesia
Email: evitasri@yahoo.com
Email: syafruddinkarimi@gmail.com
Email: hefrizal@yahoo.com
*Corresponding author

Abstract: The aim of this paper is to investigate the conventional model of economic growth derived from the Solow model and, in addition, the green economic growth model adopted from Talberth and Bahora's model. Of the two models investigated, the Gap model represents the difference in value of the Gross Domestic Product (GDP) of conventional and green GDP. Solow's model was tested for inter-country panel data and established variable savings, population growth and technological influence on the formation of the value of GDP, while the green model for GDP consisted of the effect of variable Age Dependency Ratio (ADR), OPENNESS and Gross Fixed Capital Formation (GFCF) on the formation of a green GDP value. Regarding the results, it was ascertained that the value of GDP was conventional and that the green GDP had been affected by GFCF and EMPLOYMENT in the Gap model.

Keywords: GDP; green GDP; gap model; saving; population growth and technology; age dependency ratio; gross fixed capital formation; employment.

Reference to this paper should be made as follows: Tasri, E.S., Karimi, S. and Handra, H. (2016) 'Application model of green economic growth and economic gap', *Int. J. Green Economics*, Vol. 10, No. 1, pp.51–68.

Biographical notes: Evi Susanti Tasri is a Researcher at the Economics Department, University of Andalas, Padang, Indonesia. She has worked as a Lecturer in the Department of Economic Development, Faculty of Economics, Bung Hatta University, Padang, Indonesia, since 1997. Her subject is international economics and statistics in the Indonesian economy. She has interests in the study of fiscal decentralisation, poverty and macroeconomics, and has undertaken research sponsored by the local and central governments of Indonesia.

Syafruddin Karimi is a Professor in the Department of Economics, Economic Faculty, and also a Director of the Graduate Program, University of Andalas, Padang, Indonesia. He was awarded a PhD in Economics from the Department of Economics, Florida State University, USA, in 1995. His research interests are in macroeconomics, international economics, Islamic economics, political economic resettlement and water resource development.

Hefrizal Handra is a Senior Lecturer in the Development Planning Department, Faculty of Economics, University of Andalas, Indonesia. He has also worked as a Chairman of Finance and Development Studies (CSPS), Faculty of Economics, Andalas University, since 2011, and is a Member of the Advisory Board of Regional Autonomy of the Republic of Indonesia, since 2012. He has an MSc in Development Finance, from the University of Birmingham, UK, 1996, and a PhD in the field of Public Finance, Faculty of Social Sciences, Flinders University of South Australia, 2005.

This paper is a revised and expanded version of a paper entitled 'Analysis of green economic growth concept in ASEAN countries' presented at the International Conference on Advance in Business Management and Information Technology, Kuala Lumpur, Malaysia, 1 August 2016.

1 Introduction

The development of the economy has been undertaken in many countries to ensure that economic growth is the actual target instead of being one of the indicators of development. However, the impact of this process sometimes disregards the negative impacts caused during the process of achieving this goal. The negative impacts resulting from economic growth include environmental damage such as global warming (Winter, 1999). Other factors comprise environmental damage caused by human activities related to economic development processes that have a negative impact on people who have been targeted in the process. This occurs partly because of limited natural resources.

The Kyoto Protocol implemented the Clean Development Mechanism (CDM) in which 37 countries committed to limiting the maximum level of greenhouse gas emissions (Newell et al., 2013). They stated that a reduction in greenhouse gases of approximately 75% was to be achieved from 2008 to 2012, although this was offset by an increase in emissions in other countries. Generally, the cause of emissions from environmental damage is in part due to the depletion of non-renewable resources, income inequality and poverty. This can result in the decline in environmental quality with environmental emissions (Saito and Yakita, 2008). Hence, the growth of the environmental crisis must be balanced with changes to human behaviour.

The concept of a green economy has been evolving for a long time, and began with the publication of the '*The limits to growth*' by Meadows (1972), who remarked that if economic growth and the consumption of natural resources remain similar to the 1970s, resources will rapidly be depleted; the environment damaged and natural resources cannot be optimal in achieving economic growth. This marked the emergence of sustainable economic thought (Brundtland Commission), sustainable income and green income. The concept of conventional economics does not take into account the environmental dimension in the form of depletion or damage to natural resources and environmental degradation, even though the contribution of natural capital to economic development is obvious (Ratnaningsih et al., 2006). This is evident in conventional Gross Domestic Product (GDP) shrinkage which only includes man-made capital, but does not yet categorise the depletion of natural resources and environmental degradation as a loss of natural capital in the production process. Then, green GDP concept was first implemented formally in the System of Integrated Environmental and Economic

Accounting (SEEA) in 1993 by the United Nations Statistical Division (Alisjahbana and Yusuf, 2004). The United Nation defined green GDP as the conventional GDP minus the depreciation of fixed assets and the imputed environmental cost (Alisjahbana and Yusuf, 2004).

GDP should be able to provide a comprehensive picture of the state of the economy of a country, not only in relation to the results achieved in the amount of GDP, but also in considering the impact of the development achievement. Thus, the development process must consider sustainable development for future generations. Meanwhile, the continuing development process has led to a scarcity of resources for the subsequent development process. It is very useful to assess the performance of the economy, in addition to the basis for decision-making in economic management (Samuelson and Nordhaus, 1995).

The concept of green economics becomes very important, although it is still challenging for the government and communities to implement. Furthermore, it remains a challenge for researchers involved in further study. The study of economic growth is still limited to the testing of economic growth models, for instance Solow (1956) and Mankiw et al. (1992) on the development of a state reviews, and, moreover, how a country can grow at a different level compared to other countries (Robert, 1990).

Anand et al. (2014) identified the determinants of economic growth, which were similar to those recognised by Barro and Sala-i-Martin (1995), while studies on the green economy is still limited to efforts to calculate the value of the green GDP (Yusuf, 2010) and identification of determinants of the green GDP between regions by researchers such as Talberth and Bohara (2006) and Wang (2011). Saito and Yakita (2008) examined optimal policy in the government budget allocation of emissions reductions. Brock and Taylor (2005) scrutinised the Environmental Kuznets Curve (EKC) by observing the relationship between income per capita and carbon emissions of 173 countries. Furthermore, Ocampo (2011) provided the basic concept of the development of the green economy as a perspective. However, it did not examine very much in relation to the comparison of economic growth with conventional concepts and the concept of a green economy.

Therefore, this paper intends to study the conventional model of economic growth and the green economic growth model, which investigated the Gap model that represents the difference in the value of conventional GDP and green GDP.

2 Literature review

Economic development requires the support of human evolution due to limitations in the natural resources required, together with population growth, so a steady state is expected between resources and the environment over the long term (Bran and Ioan, 2012). This raises efforts to protect resources and limit usage ratio. Therefore, a fundamental change in the economy to reduce the gap between rich and poor countries is needed with a social politics approach and government institutions. Moreover, it is necessary to have a basic model of stability in economic growth. It combines steady-state models of development policy to restrict ecological limitations (Bran and Ioan, 2012). This was also agreed by Winter (1999), who stated that green economic growth needed to address climate change, due to economic growth causing environmental impacts, such as global warming.

2.1 Development of growth theory

According to Barro and Sala-i-Martin (1995), the history of economic growth theory began with the classical Ramsey (1928) article '*A Mathematical Theory of Saving*'. At the beginning of his article, Ramsey asks 'How much of its income should a nation save?' Furthermore, Cobb and Douglas (1928) published a theory known as the Cobb–Douglas Production Function. Prior to this, Keynes (1921) wrote a paper '*A Treatise on Probability*' which contains a critique of classical probability theory, which played a significant role in the development of contemporary economy.

Later on, Harrod (1939) introduced a growth model known as the Harrod–Domar growth model and, moreover, also wrote a book titled 'International Economics'. The Harrod–Domar model stimulated discussion among neoclassical economists, which then led to the origin of a growth model that is now extensively used in macroeconomic analysis: the Solow–Swan model of growth. Solow (1956) published his work '*A Contribution to the Theory of Economic Growth*' in the *Quarterly Journal of Economics*, while Swan also published his work 'Economic Growth and Capital Accumulation'. Their growth model is known as the Solow–Swan growth model, and is commonly used in literature on economic growth. In the Solow–Swan model, technological innovation is as an exogenous variable.

Solow stated that the outstanding characteristic of the Harrod–Domar model was the ability to analyse long-term problems, using short-term tools. Harrod and Domar discuss long-term issues in terms of the multiplier, accelerator and capital coefficient (Solow, 1956). The principle of acceleration and the multiplier principle were raised by Harrod in his '*Essay on the Trade Cycle*'. Solow (1956) brings back the production function, which Harrod processed with Keynesian analysis in the neoclassical models. Solow stated 'all of the above formulation of growth models is on the Neo-classical side' (Solow, 1956). Solow said that in his development model, as a full employment economy. In addition, Brock and Taylor (2005) in their book '*Green Solow Model*' discuss the influence of technological developments on the value of the pollutant, which assumed a constant ratio of workers and capital. Furthermore, Saito and Yakita (2008) tried to analyse the optimal allocation policies of government revenues, i.e. taxes, using the Solow growth model.

The Solow model is an exogenous growth model. Nevertheless, over time, neoclassical economists began to be less impressed with Solow's model, as key factors explaining long-term growth are outside the model (exogenous). Subsequently, the endogenous growth model became more renowned; Romer (1989) and Lucas (1988) were the first generation of neoclassical economists, who laid down the basic idea behind the Endogenous Growth Model.

2.2 Glimpse of the green economy

Barro and Sala-i-Martin (1995) stated that the importance of growth has been present in the thinking of economists for a long time, and thinking about the green economy had long existed. With regard to Kennet and Heinemann (2006), their philosophy of the green economy is '*to manage economics for nature as usual, rather than to manage the environment for business as usual*'. Ocampo (2011) describes the green economy as a model of economic development based on economic or ecological economic knowledge. Kennet and Heinemann (2006) have classified the green economics approach into four main groups: ecological/economical, intellectual, political and moral. They stated that in green economics growth '*things that really grow and are abundant and thus does not seek to destroy or to cost that destruction (as in environmental economics*)'. In addition, GDP growth created the conditions, but which the green economy requires additional environmental quality improvement and allocations of the resources to improve the quality of the environment (Yandle et al., 2002).

The GDP growth now needs urgently to promote the green growth (World Bank, 2012). If many people had been starving, inappropriately processing of their resources and occurred human trafficking especially woman, then this cannot be termed green growth (Kennet and Heinemann, 2006). Therefore, the green GDP growth should be an amalgamation of concerns for many interweaving issues. Kennet (2016) in www.greeneconomics.org.uk/ stated ten key values of green economics:

> "*1. To provision for the needs all people everywhere, other species, nature, the planet and its systems, all as beneficiaries of economics transactions, not as one-off inputs; 2. To reinforce an underpinning of social and environmental justice, tolerance and no prejudice and creating quality of life for everyone, including current and all future generations, and regardless of age; 3. To ensure the recognition and respect of other species' rights and to end the current mass extinction of species and ensure the survival of Earth's biodiversity; 4. To create an economic system which advances non-violence and the inclusion of all people everywhere, regardless of special needs or special ability, more to ensure that all nations have equal access to power and resources on a finite planet, and that local people to have control over their own destiny and resources, also to eradicate poverty, increase life expectancy, human welfare and real well-being in the least developed countries; 5. To guarantee gender equity in all activities, educating, respecting, empowering women and minorities, and ensuring that all people valued and respected equally; 6. To end high mass consumption and the current overshoot of Earth's resources, returning human civilisation to the comfortable bounds of nature in its original climatic conditions, and to choose lifestyle change over techno-fixes and eco-technology, lowering individual carbon usage, living lightly on the earth; 7. Changing how economics is done: from being an abstract mathematical exercise to embracing the real world we all live in, recognizing that we are all concerned as stakeholders; 8. Climate change prevention, adaptation, mitigation, and protecting the most vulnerable from risk, ensuring the future of small island states, quickly reducing carbon per capita globally to 2 tonnes in the next 5 years and zero soon after, limiting and reversing climate change, and moving to renewable energy sources; 9. Future-proofing economics to increase its suitability for the 21st century, solving the current economic downturn and widespread uncertainty. Creating and nurturing an economy based on sharing, rather than greed and profit; 10. Completely reshaping and reforming economics to do all the above*."

Maria et al. (2015) described the global world crisis in 2008, in relation to finance, fuel and food which affected every country, and which lead to the development of the green economy. They stated that '*a common aim for countries during the transition to the green economy is environmentally friendly production that is focused on clean technologies, i.e. technologies related to woods and soils, as these natural resources are highly reproducible and renewable*'. Economic growth has been proposed as an alternative to simultaneously foster the dynamics of the global environmental organisation and provide new energy to the world economy (Park, 2013). In April 2013, a global organisation consisting of the Global Green Growth Institute (GGGI), Organisation for Economic Cooperation and Development (OECD), United Nations Environment Program (UNEP) and the World Bank published a paper, '*The Green Growth Knowledge Platform (GGKP)*'. The program was officially launched in January 2012 in Mexico City and funded by the Swiss Confederation. The GGKP provides the tools to develop and implement economic growth and sustainable development.

A number of studies have been conducted on green economics, which can be seen in Table 1.

Table 1 Selected green economics studies in selected literatures in the latest five years

Literatures	*Keywords*
Omri et al. (2015)	Climate change; economic crisis; green growth; green recovery; green economy; renewable energy; sustainable development.
Zenchanka and Korshuk (2015)	Green economy; innovation; investment; natural capital; energy effectiveness; resource effectiveness; waste management; renewable energy; legislation; forestry; environmental management systems; EMS; ISO 14000; Belarus.
Dinda (2014)	Green growth; climate change; social capital; productive consumption; reciprocity; flood control; watershed development; natural resource; human capital; inclusive growth; sustainable development; sustainability; economic growth; green economics; ecosystem services; employability.
Saidmamatov et al. (2014)	Green economy; renewable energy; investment; emerging economies; Uzbekistan; sustainable development; sustainability; developing countries; green economics.
McManners (2014)	Sustainability reframing; sustainability models; sustainable development; sustainability economics; economic policy; sustainability definition; resilient economy; sustainable economy; sustainability cornerstones; planetary limits; environmental stewardship; ecosystem stewardship; green economics.
Morris et al. (2012)	Feed-in tariffs; user attitudes; user behaviour; energy consumption; green ergonomics; green economics; UK; small-scale renewable energy; residential homeowners; renewable energy generation; human factors.
Islam et al. (2012)	Green economy; sustainability performance; energy conservation; economic transformation; environment; green technology; green economics; Malaysia; economic development; environmental policy; sustainable development.

Source: www.inderscience.com/

3 Methodology

The Solow model is a basic model with the capability to explain the concept of economic growth and can be adapted for current conditions. This particular theory explains that economic growth depends on the supply of factors of production and the accretion rate of technological progress. This view is based on classical analysis that the conditions of full employment in the economy will continue to occur. Solow's model can correct the Domar–Harrod model, where the Harrod–Domar growth model is very unstable for steady-state conditions. Moreover, capital-output ratio in the Harrod–Domar model cannot be considered as exogenous. Solow's model quantitatively explains that the source of economic growth comes from capital, labour and productivity, which can be determined by technological productivity, which in turn explains the differences in growth between countries. Additionally, population growth interacts with technology to determine net pollution (Eriksson, 2008). One solution is to enable sustainable development within the framework of an environmentally sustainable green economy to control growth and balance the output with a potential resource (Bran and Ioan, 2012).

This paper adopted the model of Talberth and Bohara (2006) used for the basic model of the green GDP as this model: (1) is a variant of Solow's model and able to adopt the concept of a green economy with the GDP calculation formula, (2) includes depletion and environmental degradation, (3) considered world economic growth conditions including the concept of economic openness, as one of the components that can determine an economic growth rate, and (4) has been extensively used in studies into green economic growth.

3.1 Solow's growth model

Solow constructed a model with the following assumptions: (1) there is a composite commodity produced, (2) the intended output is the net output, after deducting the cost of depreciation of capital, (3) production function is homogeneous or constant return to scale, (4) production factors capital and labour are paid according to their marginal physical productivity, (5) price and wage flexibility, (6) the economy in a state of full employment, (7) the existing capital stock of full employment, (8) power labour and capital can be substituted by each other, and (9) neutral in technology. With these assumptions, Solow showed coefficients in the model are variable; the capital-labour ratio will tend to adjust them, towards the equilibrium ratio, in the course of time. If the ratio of capital to labour is greater, capital and output will grow more slowly than the growth of labour, and vice versa. Solow's analysis ends at the steady-state equilibrium path from any capital-labour ratio (Jhingan, 1993).

In this paper, Solow's growth model focused on the implications of the model to cross-country data and explored savings rates, population growth and technological progress as being exogenous. There are two inputs that are used, specifically capital and labour, which are derived from its marginal product. Assuming a Cobb–Douglas production function, the output at time *t* is: (Mankiw et al., 1992)

$$Y(t) = K(t)^{\alpha} \{A(t)L(t)\}^{1-\alpha} \quad 0 < \alpha < 1 \tag{1}$$

where *Y* is output, *K* is capital, *L* is labour, and *A* is the level of technology. *L* and *A* are assumed to grow exogenously at rate *n* and *g*.

$$L(t) = L(0)e^{nt} \tag{2}$$

$$A(t) = A(0)e^{gt} \tag{3}$$

The number of effective labour units, $A(t)L(t)$, growth rate $n + g$.

The model assumes a constant proportion of output in *s* (investment), *k* is defined as the stock of capital per unit of effective labour, $k = K/AL$ and *y* as the level of output per unit of effective labour, $y = Y/AL$, evolution *k* is:

$$\dot{k}(t) = sy(t) - (n + g + \delta)k(t) = sk(t)^{\alpha} - (n + g + \delta)k(t) \tag{4}$$

where delta (δ) is the depreciation rate. Equation (4) shows k converges to a steady-state value of k^* which is defined as $sk^{*\alpha} = (n+g+\delta)k^*$, or:

$$k^* = \left[s/(n+g+\delta)\right]^{1/(1-\alpha)} \tag{5}$$

Capital-labour ratio in the steady state is positively associated with negative savings rate and population growth rate. The main prediction of Solow's model is the savings impact and population growth in real income. Equation (5) is amended by inserting log and production function. Subsequently, the steady-state per-capita income is:

$$\ln\left[\frac{Y(t)}{L(t)}\right] = \ln A(0) + gt + \frac{\alpha}{1-\alpha}\ln(s) - \frac{\alpha}{1-\alpha}(n+g+\delta) \tag{6}$$

The model assumes that these factors were obtained from the marginal product; the prediction was not only the signal, but also the magnitude of the coefficients on savings and population growth. In particular, as the capital is part of the income (α), which is one-third, then the model implies a per-capita income elasticity with respect to the savings rate is 0.5 and the elasticity of the $n + g + \delta$ around –0.5.

In the above model, it was assumed that g and δ are constant in all countries. $A(0)$ reflects the technology, climate, institutions and others, which may vary from country to country. It is assumed:

$$\ln A(0) = \alpha + \in,$$

where α is a constant, ε is a country condition on specific issues (country-specific shock). If it is assumed that $t = 0$, then the basic empirical specification equation is:

$$\ln\left[\frac{Y}{L}\right] = \alpha + \frac{\alpha}{1-\alpha}\ln(s) - \frac{\alpha}{1-\alpha}\ln(n+g+\delta) + \varepsilon \tag{7}$$

The assumed savings rate and population growth were independent of the specific factors of a country as a function of production. It was assumed that s and n and g were independent of ε. This assumption implies that we can predict equation (7) using OLS (Ordinary Least Squares).

Mankiw et al. (1992) adopted Solow's model with a constant of g (countries data) values. In this paper, the proposed model adopted the g value, which was not constant. Hence, the g values were assumed to be different among the data for countries. Meanwhile, in this proposed model, the δ (depreciation rate) values were assumed constant among the countries data.

3.2 Measurement of green growth

Green GDP growth is the concept of a sustainable income that will not reduce consumption in the future. This concept is known as the depletion of natural resources and environmental degradation as one of the capitals that must be sacrificed for construction, in addition to man-made, human and social capital. Green GDP is more comprehensive than the conventional GDP in terms of economic measurement. The green GDP calculation in this paper applied the concept of GDP using the expenditure approach, which is the sum of the total income received by all producers in a country

(Talberth and Bohara, 2006): GDP = $C + I + G + (X - b\ M)$, where: C = private consumption, I = gross investment, G = government spending, X = export, M = import and $X - M$ = net export.

The equation of the green GDP growth model can be explained by a variant of the standard, which Solow's model proposes that real output is a function of the state capital stock and labour is also affected by other economic factors of inputs, such as economic openness (Talberth and Bohara, 2006). The formula is as follows:

$$GDP_{grn_t} = f\left(K_t, L_t, O_t\right) \tag{8}$$

where GDP_{grn} is green GDP per capita at time t, K is the size of the state capital stock at time t, L is a measure of labour input at time t, O is the index of economic openness at time t.

Based on Mankiw et al. (1992), the formula can be written in terms of the aggregate production function of type Cobb–Douglas in the form:

$$GDP_{grn_t} = \delta_0 K_t^{\alpha} L_t^{\beta} O_t^{1-\alpha-\beta} e^{u_t} \tag{9}$$

Subsequently, it can be written in log-linear as follows:

$$GDP_{grn_t} = \delta + \alpha K_t + \beta L_t + \left(1 - \alpha - \beta\right) O_t + u_t \tag{10}$$

To test the existence of the unit roots, a Unit Root Test panel version of the Dickey–Fuller extended test was used (Dickey and Fuller, 1979). For each series in a given model, the Dickey–Fuller extended test involved regression as follows:

$$\Delta y_t = \alpha + \beta y_{t-1} + \pi t + \delta_1 \Delta y_{t-1} + \delta_2 \Delta y_{t-2} + \cdots + \delta_k \Delta y_{t-k} + \varepsilon_t \tag{11}$$

Hence, equation (3) was converted to growth rate as the equation below:

$$GGDP_{grn_t} = \delta + \alpha GK_t + \beta GL_t + \left(1 - \alpha - \beta\right) GO_t + u_t \tag{12}$$

where G is the notation indicating growth between year $t - 1$ and t. The green GDP growth model can be shown in the form of the aggregate production function as follows:

$$GGDP_{grn_t} = \alpha_0 + \alpha_1 DGFCF_{pct_t} + \alpha_2 DOPEN_t + \alpha_3 DADR_t + u_t \tag{13}$$

where $GGDP_{grn}$ is the green GDP per-capita growth rate as shown by the first derivative of the log of per-capita green GDP values within a certain time period; $DGFCF_{pct}$ is the first derivative of the ratio of Gross Fixed Capital Formation (GFCF) to GDP; DOPEN is the first derivative of the value of trade to GDP ratio of green; DADR is the first derivative of the Age Dependency Ratio (ADR); and u is the error.

In this model, it was assumed that there is a linear relationship between the openness and growth of green GDP. However, Talberth and Bohara (2006) established that at least five countries demonstrated a non-linear relationship. In particular, the openness was positively correlated with the green GDP to a point, and to an extent the direction of the effects change. Owing to this non-linear relationship, the model was modified to include an openness squared term as follows:

$$GGDP_{grn_t} = \alpha_0 + \alpha_1 DGFCF_{pct_t} + \alpha_2 DOPEN_t + \alpha_3 DOPEN_t^2 + \alpha_4 DADR_t + u_t \tag{14}$$

In this paper, equation (14) was modified to be absolute values of the green GDP. Those were also applied to the variables of the GFCF, OPEN and $OPEN^2$.

Theoretically, the methodology of the green GDP calculation can be divided into three types: (1) the green GDP is based on the reduction of resources, (2) on damage to the environment, and (3) on expenditures for environmental protection. In this paper, green GDP's formula (Wang, 2011) was adopted as follows:

$$\text{Green GDP} = \text{GDP} - \text{depletion of natural resources} - \text{pollution costs}$$

This formula was first adopted by Liu and Guo (2005, cited in Wang, 2011) and popularised by Wang (2011) by introducing the concept of green GDP comparable. 'Advantages of Comparable Green GDP are: that it is comparable to other indexes, Comparable Green GDP is practically easier to calculate; therefore, it is also easy to apply to other countries or regions; practicality and applicability, discussed above, Comparable Green GDP can be also used as a sustainable development indicator for government policies' (Wang, 2011). The rationale for this concept in this paper is due to the limited data on the countries analysed. So, this paper adopted the concept of green GDP using Comparable Green GDP formula due to the availability of data.

3.3 GDP gap model

The gap of GDP model between GDP conventional and green GDP was derived from the model:

$$\text{GDP gap} = f\left(\text{GFCF}, \text{TPF}, \text{employment}\right)$$

Subsequently, it was transformed into a linear regression model:

$$\text{GDP of gap}\, Y_{it} = \alpha_1 + \beta_1 \text{GFCF}_{it} + \beta_2 \text{TPF}_{it} + \beta_3 \text{Employment}_{it} + \mu_{it}$$

Then, it was substituted to Fixed Effects Model (FEM) using the Generalise Least Squares (GLS) method equation as follows:

$$\text{Log}\, Y_{it} = \alpha_1 + \beta_1 \text{LogGFCF}_{it} + \beta_2 \text{TPF}_{it} + \beta_3 \text{Employment}_{it} + W_{it}$$

where $\text{Log}Y_{it}$ = dependent variable of green GDP; α_1= Constanta + value of standard error; $\beta_1, \beta_2, \beta_3$ = coefficient of independent variable; $\text{Log}X_{1it}$, $\text{Log}X_{2it}$, $\text{Log}X_{3it}$ = logarithm of independent variable; W_{it} = un-observable individual effect U_i + Standard Error μ_{it}.

3.4 Data analysis

This paper used the data of time series taken from 2001 to 2013 and cross-section data between countries by means of income level. The data were obtained from the World Bank. In this paper, data analysis on a number of variables can be defined as follows:

Green GDP – Numerous sets of indicators can be used to measure the progress of the green economy. The green GDP can be regarded as an important indicator of the green economy. The green GDP is the most popular for an aggregate macroeconomy based on the green accounting framework. The green GDP is defined as the conventional GDP minus depreciation of all forms of capital (human-made capital and natural capital), which was based on the standard framework of SEEA (System of Environmental-Economic Accounting) produced by the United Nations.

Capital (K) – Physical capital represented by the ratio of GFCF to GDP.

Labour (L) – Input workers represented by the ADR, which is defined as the ratio of non-working age population (<15 and >64) of the working age population. The importance of ADR in the growth model has long been known for a large dependent population that inhibits productivity investment (Holtz-Eakin et al., 2004).

Saving (s) – Proportion of savings to GDP at a certain time (within one year).

Trade Openness – Calculation of the amount of economic openness of a country in terms of international trade $(X + M)$/GDP.

The variables in this paper were analysed using the short data series. Consequently, the analysis process for the time series method cannot optimise the model. To cope with this problem, panel data (pooled data) was applied, as suggested by Ismail (2006). Therefore, the panel data analysis presents enhanced results and efficiency due to an increase in the number of observations, which have implications for increasing the degree of freedom.

4 Results and discussion

4.1 Solow's model of economic growth

The model of panel data regression and classic assumption can be solved by using panel data. The estimation method of the Panel Least Squares (PLS) for the common OLS model and FEM is assumed to have symptoms of classical assumptions. One correction symptom of classical assumptions on the panel data estimation methods is to transform into GLS, which is one of the remedial techniques of regression (Gujarati, 2003). In this paper, the proposed model is assumed free of the symptom of classical assumption. Hence, the FEM based on the PLS estimation method transforms to the GLS method, and was applied in this proposed model. Therefore, the proposed model is free from the symptoms of classic assumption. The data result of the proposed model for Solow's model of economic growth can be seen in Table 2.

Table 2 depicts the results of the panel data regression using the GLS method, which demonstrates that all the coefficients of the independent variables were positive, and all the independent variables significant at $\alpha = 0.05$. R^2 values weighted relatively high at 0.979 and a Durbin–Watson value of 1.334. For un-weighted, the R^2 value was also reasonably high at 0.964 and a Durbin–Watson value of 1.383.

The estimation results of the FEM model of the panel data output with the GLS method showed the magnitude adjusted R^2 of 0.977, meaning 92.3% of the green GDP variation dependent variable (Y) can be explained by the variation of the independent variables this model generated all significant independent variables, specifically LNS and LN $(n + g)$. The remaining 7.7% was explained by other variables outside the model.

The output table obtained values of F-count equal to 558.903 with a probability (Prob. F-statistics) of 0.000. Therefore, the probability is much smaller than 0.05; thus, it can be concluded that H_0 is rejected, which means that the regression coefficient LNS and LN $(n + g)$ simultaneously or jointly affect the dependent variable green GDP (Y).

Table 2 Panel data regression estimation results of the FEM model using the GLS method for Solow's model of economic growth

Dependent variable:	*LNY_L*			
Method:	Panel EGLS (cross-section weights)			
Date:	03/11/15		Time:	14:58
Sample:	2001, 2013			
Periods included:	13			
Cross-sections included:	76			
Total panel (balanced) observations:	988			
Linear estimation after one-step weighting matrix				
Variable	*Coefficient*	*Std. error*	*t-statistic*	*Prob.*
LNS	0.8795	0.0345	25.5218	0.0000
LN_N_G_	0.1498	0.0230	6.5180	0.0000
C	11.2143	0.4068	27.5680	0.0000
Effects specification				
Cross-section fixed (dummy variables)				
Weighted statistics				
R^2	0.9793	Mean dependent var		25.2414
Adjusted R^2	0.9775	SD dependent var		8.3385
SE of regression	0.3785	Sum squared resid		130.3323
F-statistic	558.9037	Durbin–Watson stat		1.3341
Prob. (F-statistic)	0.0000			
Un-weighted statistics				
R^2	0.9646	Mean dependent var		21.5706
Sum squared resid	156.6386	Durbin–Watson stat		1.3834

All variables in this model generated all significant independent variables, specifically LNS and LN (*n*+). This can be seen from the small significance probability of 0.05 (0.000 > 0.05). Consequently, it can be concluded that the variable LNY/L was influenced by variables LNS and LN ($n + g$).

The LNS was the implication of the value of the investment as a determinant factor in the formation of the output of a country. The economic is conventionally known as the concept of capital approach that was just focus on the availability of capital in the basis for development and ignored the scarcity of resources and environmental damage caused by the construction process. It was expressly regarded as a weakness in the conventional GDP.

Then the Ln ($n + g$) was the implication of the value of the population (n) and technology (g) to determine the formation of output (the economic growth) in a country. The value of Ln ($n + g$) was significantly in this study. Therefore, a high population growth and good technology were likely influence the output of a country's productivity, while the value of δ (depresiasi) assumed to be constant for all the countries in this study due to limitations in getting the data.

4.2 Model of the green economy

The proposed model for the green economy adopted Talberth and Bahora's model. Due to the limited data, this research only employed the data for the green GDP (*Y*), GFCF, OPENNESS, OPENNESS^2 and ADR. However, in the estimation process for the selection of the best result, the data value was transformed into log. The proposed model was the FEM using PLS transformed to GLS method estimation. Therefore, the proposed model was assumed no symptom of classical assumption. The data result of the proposed model for the green economy can be noted in Table 3.

Table 3 Panel data regression estimation results of the FEM model using the GLS method for the green economic model proposed

Dependent variable:	*LOG_GREEN_GDP_Y*			
Method:	Panel EGLS (cross-section weights)			
Date:	03/08/15		Time:	01:46
Sample:	2001, 2013			
Periods included:	13			
Cross-sections included:	76			
Total panel (balanced) observations:	988			
Linear estimation after one-step weighting matrix				
Variable	*Coefficient*	*Std. error*	*t-statistic*	*Prob.*
LOG_GFCF	1.0487	0.0178	59.0179	0.0000
LOG_OPENESS	–0.4261	0.1828	–2.3314	0.0199
LOG_OPENESS^2	0.0097	0.0903	0.1076	0.9143
LOG_ADR	–1.8366	0.0920	–19.954	0.0000
C	3.3472	0.3150	10.625	0.0000
Effects specification				
Cross-section fixed (dummy variables)				
Weighted statistics				
R^2	0.9968	Mean dependent var		17.2295
Adjusted R^2	0.9965	SD dependent var		12.0548
SE of regression	0.0944	Sum squared resid		8.0829
F-statistic	3528.079	Durbin–Watson stat		0.8505
Prob. (*F*-statistic)	0.0000			
Un-weighted statistics				
R^2	0.9898	Mean dependent var		10.9586
Sum squared resid	8.5618	Durbin–Watson stat		0.69635

Table 3 demonstrates that the panel data regression result of the independent variable coefficient of LOG_OPENNESS and LOG_ADR was negative (significant). The LOG_OPENNESS^2 of the independent variable was not significant at $\alpha = 0.05$, whereas R^2 values weighted relatively high at 0.996 and a Durbin–Watson value of 0.850. The un-weighted R^2 value was also reasonably high at 0.989 and a Durbin–Watson value of 0.696.

The estimation results of the FEM model of panel data output with the GLS method shows the magnitude adjusted R^2 of 0.996, meaning 99.6% of the green GDP variation dependent variable (Y) can be explained by the variation of the independent variables GFCF, OPENNESS, OPENNESS^2, ADR, while the remaining 0.4% is explained by other variables outside the model.

Based on the output table values obtained F-count equal to 3528.079 with a probability (Prob. F-statistics) of 0.000. Therefore, the probability is much smaller than 0.05; thus, it can be concluded that H_0 is rejected, which means that the regression coefficient of GFCF, OPENNESS, OPENNESS^2, and ADR simultaneously or jointly affects the dependent variable of the green GDP (Y).

From the result of the model, one variable, i.e. OPENNESS^2, was not significant, with a probability value of 0.914 (greater than 0.05). Variables GFCF, OPENNESS and ADR were significant, with a probability value of 0.00 (less than 0.05). As a result, it can be concluded that the variable of the green GDP (Y) was influenced by variables GFCF, OPENNESS and ADR, whereas it was not influenced by the variable OPENNESS^2.

The value of GFCF, OPENNESS and ADR was a significant variable to determine the value of green GDP. The greater value of GFCF in the country indicated the better growing of the technological capabilities; hence, it would increase the productivity.

The economic openness was a significant variable affecting green economic growth in this study. This supported the concept of green GDP was natural resource depletion and environmental degradation influenced the value of the green GDP. The opening of the economy of a country, the economic activity has increased and likely to increase the exploitation of natural resources and damage of natural resources.

An acceleration of the economic growth has occurred rapidly along with the growth of population, which was proxy by the value of ADR in this study. That was also supported by the concept of economic growth raised (Jones and Romer, 2009). They stated that an increasing of market (economic openness) has increased the flow of goods, financial and population. It was also in line with the increase in human capital per worker, which in turn is to boost the growth of the value of GDP.

4.3 Model of GDP gap and green GDP

Based on the FEM model using PLS, the estimation method was transformed into the GLS method, therefore the model was assumed to be free of symptoms of classical assumptions. The data result of the proposed model for the GDP gap and green GDP can be seen in Table 4.

It can be seen in Table 4 that the panel data regression result showed a positive (significant) independent variable coefficients of the GFCF and only independent variable TPF was not significant at $\alpha = 0.05$. R^2 values weighted relatively high at 0.917 with the value of the Durbin–Watson at 0.833. For the un-weighted R^2, the value was also fairly high at 0.905 and a Durbin–Watson value of 0.853.

Estimation results of the FEM model of panel data output with the GLS method demonstrated the magnitude adjusted R^2 of 0.917, with 91.7% of GDP GAP variations dependent variable (Y) explained by the variation of the independent variables GFCF, TPF, and EMPLOYMENT. The remaining 8.3% was explained by other variables outside the model. Table 3 showed an F-count equal to 117.1506 with a probability (Prob. F-statistics) of 0.000. Therefore, the probability was much smaller than 0.05; thus, it can be concluded that H_0 was rejected, which means that the regression coefficient of

GFCF, TPF, and EMPLOYMENT simultaneously or jointly influences the dependent variable GAP GDP (*Y*). All variables were entered into the model, although the variable of TPF was not significant (0.408 > 0.05). The GFCF and EMPLOYMENT variables are significant (0.000 < 0.05). As a result, it can be concluded that the GAP variable GDP (*Y*) was influenced by variables GFCF and EMPLOYMENT, but not influenced by variable TPF.

Table 4 Panel data regression estimation results of the FEM model using the GLS method for the GDP gap and green GDP model proposed

Dependent variable:	*GAP_GDP_Y*			
Method:	Panel EGLS (cross-section weights)			
Date:	03/12/15		Time:	15:10
Sample:	2001, 2012			
Periods included:	12			
Cross-sections included:	61			
Total panel (balanced) observations:	732			
Linear estimation after one-step weighting matrix				
Variable	*Coefficient*	*Std. error*	*t-statistic*	*Prob.*
GFCF	0.0872	0.0028	31.4938	0.0000
TPF	–5.3E+06	6.4E+06.	–0.8279	0.4080
EMPLOYMENT	–5.5E+07	1.0E+07	–5.4149	0.0000
C	–5.4E+09	5.7E+08	–9.4965	0.0000
Effects specification				
Cross-section fixed (dummy variables)				
Weighted statistics				
R^2	0.9170	Mean dependent var		8.4E+09
Adjusted R^2	0.9092	SD dependent var		1.1E+10
SE of regression	3.9E+09	Sum squared resid		1.0E+22
F-statistic	117.1506	Durbin–Watson stat		0.8336
Prob(F-statistic)	0.0000			
Un-weighted statistics				
R^2	0.9051	Mean dependent var		6.3E+09
Sum squared resid	2.5E+22	Durbin–Watson stat		0.8532

The value of GFCF and EMPLOYMENT significantly affected the formation of the GDP Gap between GDP conventional and green GDP. This implied the value of capital and labour force were the decisive variable production levels, as stated in the form of the production function. This study found a negative value of labour force. Hence, many labour forces have a high tendency to exploitation and environmental damage. Conversely, the value of technology (TPF) was not significant in the formation of the value of the GDP gap in this study. This can be justified that the technological used between countries tends to relatively similar for the period of analysis in this study. Furthermore, the TPF did not affect the establishment of the value of GDP gap in this model.

5 Conclusion

In this paper, developed models of conventional economic growth derived from the Solow model, the green economic growth adopted from Talberth and Bahora's model, and the gap for both the conventional and the green economic growth. Those models were tested using inter-country panel data, which variable savings, population growth and technological influence on the formation of the value of conventional GDP, and variables ADR, OPENNESS and GFCF on the formation of a green GDP value. The test models demonstrated that all the variables in the models affect the formation of the model. However, when analysing the gap of value for both the GDP and GDP determinant factor, the paper verified the variables of influence in determining the value of the gap between the two values of GDP which are GFCF and EMPLOYMENT. The variable OPENNESS was negative towards a green GDP. Therefore in the increasing capital/investment and labour force, the pollution levels would increase as well. In other hand, environmental pollution could decrease the productivity of capital and labour force. There were clearly undesirable effects for the green economic development, in this study. However, the extent of the negative effects and what are the possible variables that affect it will be necessary for further study.

Furthermore, the second phase of the ongoing research has been to carry out an examination of the variables that can affect the level of pollution. The framework of 'pollution haven hypothesis (PHH)' is used to investigate and analyse the relationship between these variables. The ongoing study will be proposed to improve the capital/investment and labour force by minimising the level of pollution to the environment. This further study will be distributed when the second phase of the ongoing research is completed.

References

Alisjahbana, A.S. and Yusuf, A.A. (2004) *Green Accounting and Sustainable Development in Indonesia*, Unpad Press, Bandung.

Anand, R., Ceng, K.C., Rehman, S. and Zhang, L. (2014) *Potential Growth in Emerging Asia*, IMF Working Paper No. 14/2, International Monetary Fund, Washington, DC.

Barro, R. and Sala-i-Martin, X. (1995) *Economic Growth*, McGraw Hill Inc., New York.

Bran, F. and Ioan, I. (2012) 'Sustainable development condition for survival of the planet, agro-food and rural economy competitiveness in terms of global crisis', *ProQuets, Economics of Agriculture*, Vol. 59, pp.78–85.

Brock, W.A. and Taylor, M.S. (2005) 'The green Solow model', *Journal Economic Growth*, Vol. 15, pp.127–153.

Cobb, C.W. and Douglas, P.H. (1928) 'A theory of production', *American Economic Review*, Vol. 18, pp.139–156.

Dickey, D.A. and Fuller, W.A. (1979) 'Distribution of estimators for autoregressive time series with a unit root', *Journal of the American Statistical Association*, Vol. 90, pp.268–281.

Dinda, S. (2014) 'A theoretical basis for green growth', *International Journal of Green Economics*, Vol. 8, No. 2, pp.177–189.

Eriksson, C. (2008) *A Knife-Edge Property of Some Pollution and Growth Models*, Departemen of Economics, SLU, Uppsala, Sweden, pp.1–5.

Gujarati, D. (2003) *Basic Econometrics*, McGraw Hill Inc., New York.

Harrod, R.F. (1939) 'An essay in dynamic theory', *The Economic Journal*, Vol. 49 , No. 193, pp.14–33.

Holtz-Eakin, D., Lovely, M.E. and Tosun, M.S. (2004) 'Generational conflict, fiscal policy and economic growth', *Macroeconomic*, Vol. 26, pp.1–26.

Islam, R., Siwar, C., Ludin, N.A., Chowdhury, M.S. and Ibrahim, Y. (2012) 'Green economy: assessing the greenness of the Malaysian economy', *International Journal of Green Economics*, Vol. 6, No. 3, pp.226–242.

Ismail, A. (2006) 'Is economic value added more associated with stock return than accounting earnings? The UK evidence', *International Journal of Managerial Finance*, Vol. l, No. 2, pp.343–353.

Jhingan, M.L. (1993) *Ekonomi Pembangunan dan Perencanaan*, P.T. Raja Grafindo Perkasa, Jakarta.

Jones, C. and Romer, P. (2009) *Based on the New Kaldor Facts: Ideas, Institution, Population, and Human Capital*. Available online at: www.econ.nyu.edu/user/benhabib/jones-romer.pdf (accessed on 2 June 2016).

Kennet, M. (2016) *11th Annual Green Economics 3 Day Conference*. Available online at: www.greeneconomics.org.uk/ (accessed on 2 January 2016).

Kennet, M. and Heinemann, V. (2006) 'Green economics: setting the scene: aims, context, and philosophical underpinning of the distinctive new solutions offered by green economics', *International Journal of Green Economics*, Vol. 1, Nos. 1/2, pp.68–102.

Keynes, J.M. (1921) *A Treatise on Probability*, MacMillan, London.

Lucas, R.E.J. (1988) 'On mechanics of economic development', *Journal of Monetary Economics*, Vol. 22, pp.3–42.

Mankiw, N.G., Romer, D. and Well, D.N. (1992) 'A contribution to the empirics of economic growth', *The Quarterly Journal of Economics*, Vol. 107, No. 2, pp.407–437.

Maria, E., Marina, P. and Pavel, G. (2015) 'Global trends of "green" economy development as a factor for improvement of economical and social prosperity', *Procedia – Social and Behavioral Sciences*, Vol. 166, pp.194–198.

McManners, P. (2014) 'Reframing economic policy towards sustainability', *International Journal of Green Economics*, Vol. 8, Nos. 3/4, pp.288–305.

Meadows, D. (1972) *The Limits to Growth: A Report for the Club of Rome's Project on the Predicament of Mankind*, 2nd ed., Universe Books, New York.

Morris, R.W., Stedmon, A.W. and Langley, A. (2012) 'Green ergonomics and green economics: the effect of feed-in tariff schemes on user behaviours and attitudes towards energy consumption', *International Journal of Green Economics*, Vol. 6, No. 4, pp.375–389.

Newell, R.G., Pizer, W.A. and Raimi, D. (2013) 'Carbon market 15 year after Kyoto: lesson learned, new challenges', *Journal of Economic Perspective*, Vol. 27, No. 1, pp.123–146.

Ocampo, J.A. (2011) *The Transition to a Green Economy: Benefits, Challenges and Risks from a Sustainable Development Perspective*, Report by a Panel Expert Second Preparatory Committee Meeting for United Nations Conference on Sustainable Development: UN-DESA, UNEP, UNCTAD.

Omri, E., Chtourou, N. and Bazin, D. (2015) 'Rethinking the green recovery through renewable energy expansion', *International Journal of Green Economics*, Vol. 18, Nos. 1/2, pp.59–76.

Park, J. (2013) 'The evolution of green growth policy: an unwelcome intrusion on global environmental governance?', *Journal of East Asian Economic Integration*, Vol. 17, No. 2, pp.207–241.

Ramsey, F.P. (1928) 'A mathematical theory of saving', *The Economic Journal*, Vol. 38, No. 152, pp.543–559.

Ratnaningsih, M., Apriliani, A.T., Sudharto, D. and Suparmoko, M. (2006) *PDRB Hijau (Produk Domestik Regional Bruto Hijau)*, BPFE_YOGYAKARTA, Yogyakarta.

Robert, E.L.J. (1990) 'Why doesn't capital flow from rich to poor countries', *AER Paper and Proceedings*, Vol. 80, pp.92–96.

Romer, P. (1989) 'Capital accumulation in the theory of long run growth', in Barro, R.J. (Ed.): *Modern Business Cycle Theory*, Harvard University Press, Cambridge, MA, pp.51–127.

Saidmamatov, O., Salaev, S., Eshchanov, B. and Shimin, L. (2014) 'Renewable energy potential of developing countries: the drivers towards a green economy (a case study from Uzbekistan)', *International Journal of Green Economics*, Vol. 8, No. 2, pp.134–143.

Saito, K. and Yakita, A. (2008) *Optimal Environmental Policy in Developing Economies*, Association for Public Economic Theory, Tsukuba, Japan.

Samuelson, P.A. and Nordhaus, W.D. (1995) *Economics*, 15 ed., MCGraw Hill Inc., Singapore.

Solow, R.M. (1956) 'A contribution to the theory of economic growth', *The Quarterly Journal of Economics*, Vol. 70, No. 1, pp.65–94.

Talberth, J. and Bohara, A.K. (2006) 'Economic openness and green GDP', *Ecological Economic*, Vol. 58, No. 4, pp.743–758.

Wang, X. (2011) 'Green GDP and openness: evidence from China provincial comparable green GDP', *Journal of Cambridge Studies*, Vol. 6, No. 1, p.1.

Winter, J.G. (1999) 'Bigger, badder, but not better a new breed economist exposes the myth of unlimited growth', *ProQuets, Biology Journal*, Vol. 20, No. 4, pp.32–36.

World Bank (2012) *Inclusive Green Growth – The Pathway to Ustainable Developmen*t, World Bank, Washington, DC. Available online at: www.inderscience.com/ (accessed on 4 January 2016).

Yandle, B., Vijayaraghavan, M. and Bhattarai, M. (2002) *The Environmental Kuznets Curve: A Primer*, PERC Research Study, Bozeman, MT.

Yusuf, A.A. (2010) *Estimates of the 'Green' or 'Eco' Regional Domestic Product of Indonesia Provinces for the Year 2005*, Working Paper in Economics and Developement Studies, Universitas Padjadjaran, Bandung, Indonesia, No. 201004, pp.1–15.

Zenchanka, S. and Korshuk, E. (2015) 'The "green economy" concept in Belarus: today and tomorrow', *Progress in Industrial Ecology, An International Journal*, Vol. 9, No. 1, pp.33–45.