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Green growth: theory and evidence

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Abstract

What are the major determinants of green growth? What role can the government play to promote green growth? To address these questions, this paper develops a simple Green Solow model that sheds light on the role of finance and technology in the process of green growth. The empirical section of the article augments this canonical green growth model to include structural variables relating to finance, technological development, trade openness, natural resource exploitations, and areas where the government can play an important role. In addition, the use of the spatially-corrected generalized method moments approach affords us to explore the role of such factors as growth performance of the neighbouring countries, domestic learning or determination to achieve its national desired target, and political and economic shocks in the process of green growth. It is hoped that research reported in the paper will stimulate further research in the area.

Keywords: green growth, convergence, neighbouring effects, political and economic structural reforms, political and economic shocks
JEL classification: O44, Q50, F60

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1 Introduction

Sustainable development must be anchored in environmental protection and social inclusion.[1] However, the twin challenges of human-induced climate change and rising inequity pose a serious threat to sustainable development today. It is critical for the world to transit onto a sustainable development path or an inclusive green growth trajectory. This article focuses on green growth—that is, growth which is efficient in its use of natural resources, which minimizes pollution and environmental impacts, and which is resilient in that it accounts for natural hazards and the role of environmental management and natural capital in preventing physical disasters.

Recent history of economic growth demonstrates that although considerable economic progress has been achieved, humanity has paid a heavy price, and now faces a range of environmental problems such as ecosystem disturbance, climate change, water and air pollution, and sea level rise.[2] For a long time, there has existed a misconception that there is a trade-off between economic development and environmental conservation. In recent years, the good news has been that these two seemingly incompatible demands can be integrated into a new development strategy.

The 'business as usual' development path is likely to exacerbate existing environmental problems and compromise the wellbeing of the present and future generations.[3] The ever-worsening environmental crisis has sent a serious alert to the global community on the urgency of embarking on a new development path before it is too late. Green growth, which aims to achieve a balance between economic growth and environmental sustainability, is just what the world needs to obtain long-term and eco-friendly development.

Green growth is not intended to be a holistic substitute for sustainable development.[4] Rather, it seeks to integrate the economic and environmental pillars of sustainable development into the heart of a country's economic development planning and implementation. More specifically, green growth seeks to pursue economic growth and development, while preventing costly environmental degradation, climate change, biodiversity loss, and unsustainable natural resource use.[5] It is about growth that is cleaner and greener, but not

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[1] The concept of sustainable development, which was first introduced by the Brundtland Commission in 1987, 'captures three major dimensions of economic development namely, economic development, social equity and environmental protection. The most widely accepted definition of sustainable development is given as follows: development which meets the needs of the present without compromising the ability of future generations to meet their own needs' (WCED 1987: 43).

[2] For example, the Chinese Academy of Social Sciences reports that the annual damage of China's environmental degradation to the country's economy is equivalent to 9 per cent of GDP; similarly, a World Bank report suggests that the damage from India's environmental pollution is about 6 per cent of its national income (*The Economist* 2012).

[3] Bowen (2012) argues that environmental degradation will harm human productivity and welfare, and hence the traditional economic growth pattern cannot be sustained. As pointed out by Jänicke (2011), the resource-intensive model of growth of the past fails, not only because of lack of cheap raw materials, but also due to the earth's limited capacity to absorb carbon emissions and waste.

[4] When green growth is inclusive, it is the pathway to sustainable development (World Bank 2012a).

[5] Hallegatte et al. (2011) define green growth as 'fostering economic growth and development, while ensuring that natural assets continue to provide the resources and environmental services on which our wellbeing relies'. By maximizing the synergy between economic development and environmental protection, green growth

slower, while simultaneously taking into account both short-term economic growth and long-term environmental sustainability.

Green growth, as the type of growth that stays within the limits of the earth's natural systems, marks a radical, conceptual and material departure from the traditional resource-intensive growth model to an eco-friendly growth model. In many developing countries greening growth is constrained by social and political inertia as well as by a lack of financial instruments. Governments can play a key role in fostering green growth, which requires fundamental changes in the development strategy.[6] With appropriate governmental policies, there can be a win-win situation where both greener growth and prosperity can flourish at the same time. However, there is a lack of systematic analysis of what determines green growth and the role of governments in fostering the process of green growth.

This paper seeks to contribute to the literature in three distinct ways. First, it develops an analytical framework for green growth. More specifically, it develops a canonical Green Solow model that emphasizes the crucial roles of green investment and climate-friendly technological development in stimulating green growth. Second, it generates an aggregate index for green development based on the green growth indicators proposed by OECD (2012). Third, it uses an augmented empirical version of the canonical model to explore the role of policies and other structural determinants in fostering green growth. It is hoped that our research yields some useful insights for greener growth. The insights will be important for designing national polices which can, however, vary, depending on different national and local circumstances, such as preferences and resources, as well as different stages of development.

The remainder of the paper proceeds as follows. Section 2 presents a simple canonical Green Solow model. Section 3 describes measures and data that are used in this study. Section 4 presents the empirical model and estimation method. The empirical results are presented in Section 5. Section 6 concludes.

2 Theoretical framework: the Green Solow model

In the following, we develop a canonical Green Solow model, according to Brock and Taylor (2010), to explore the simple analytics of the Environmental Kuznets Curve (EKC). However, we believe that our formulation, which deviates from the Brock-Taylor formulation in the specification of the emission function, is analytically much simpler and intuitively more straightforward.

The production function is assumed to be Cobb-Douglas and is given by:

$$X = AK^{a}L^{(1-a)} \tag{1}$$

emphasizes the fact that strategic environmental policies not only foster environmental sustainability at a low cost but also have the potential to boost long-term economic growth (Toman 2012).

[6] As suggested by ESCAP-ADB-UNEP (2012), the transition towards green growth calls for bridging at least two gaps: (i) the time gap 'between short-term costs and long-term benefits of investments that reduce environmental pressures'; and (ii) the price gap 'between market prices and the economic value of ecosystem goods and services, which reduces the incentives for resource savings or investment in natural capital'.

Where X, K, L, A represent output, capital, labour and total factor productivity respectively. Eq. (1) can be expressed in intensive form:

$$x = Ak^{a} \tag{2}$$

where $x = X / L,$ is gross output per worker; and $k = K / L,$ capital per worker . Finally, as is well-known, $0 \prec a \prec 1,$ which implies that there are diminishing returns to output per worker.

The (net) output is defined by

$$y = x(1-\lambda) \tag{3}$$

where $Y =$ net output and $y = Y / L,$ net output per worker; and $\lambda =$ a fixed proportion of the domestic (gross) output devoted to emission control.

The capital accumulation equation is given by:

$$dk / dt = sAk^{a}(1-\lambda) - (\delta + n) \tag{4}$$

where dk / dt = change in capital per worker. It is assumed that a proportion of net output is saved and invested. The first term in the right-hand side, $sAk^{a}(1-\lambda),$ represents gross investment; the second term, $\delta + n,$ is the sum of depreciation rate and the labour force growth rate. In other words, we have assumed that

$$\hat{L} \equiv (1/L)(dL/dt) = n$$

Eq. (4) can be rewritten as follows:

$$dk / dt = sAk^{a}(1-\lambda) - (\delta + n)k \tag{5}$$

With respect to pollution, we have assumed the following emission function:

$$e = \phi x / Az, \qquad \text{with} \qquad 0 \prec \phi \prec 1. \tag{6}$$

where, as in the rest of the paper, we have expressed emission, $e,$ in per worker units.

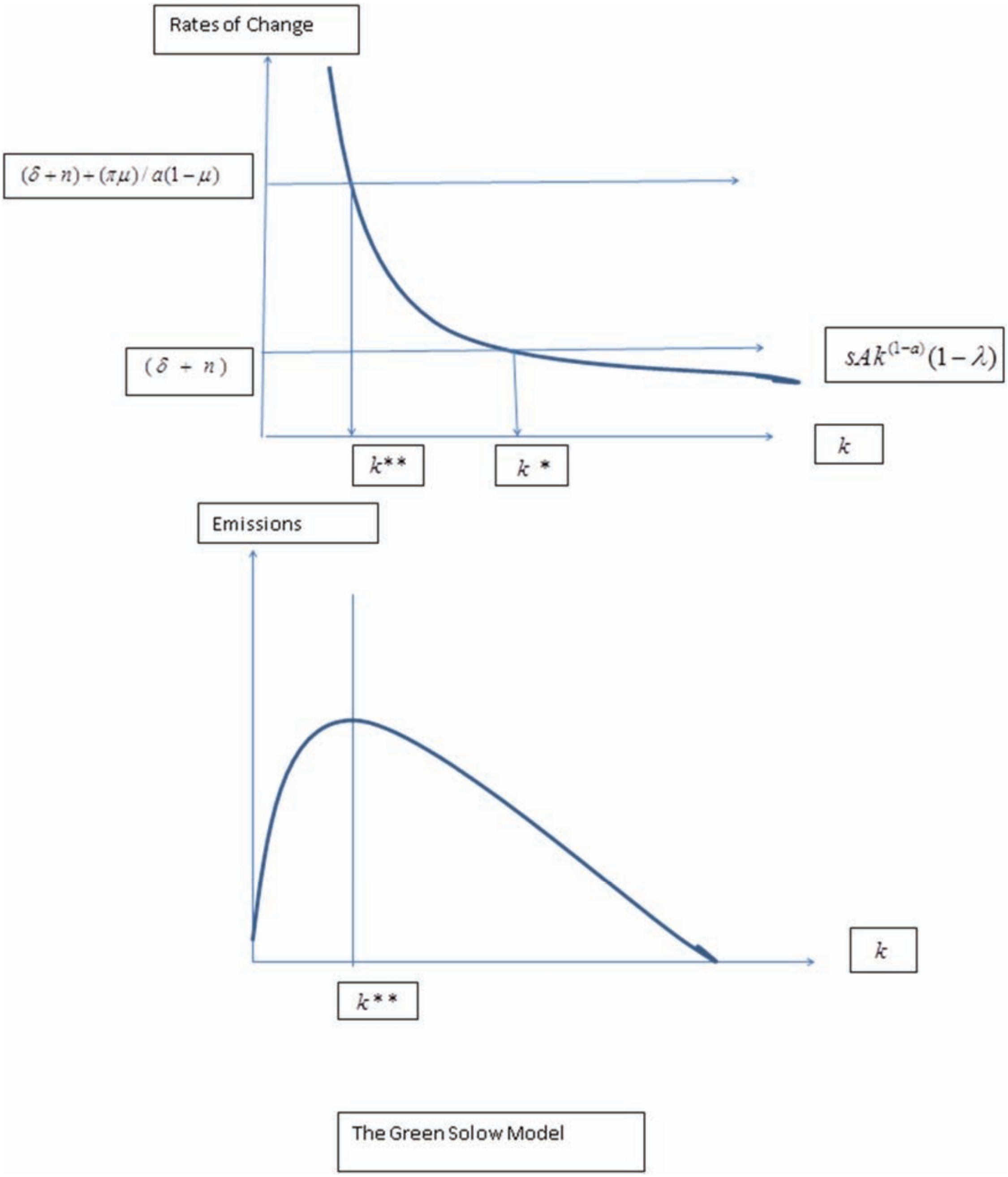
A number of observations are in order with respect to the emission eq. (6):

- First, it is assumed that emission varies proportionately with gross output $x,$ the scale of activity. The proportion is given by ϕ. This is a standard assumption in the literature, used among others by Brock and Taylor (2010).
- Second, we assume that abatement of emission varies inversely with technology. As Reis (2001) suggests, the higher value of A indicates cleaner technology. We have further assumed that technological progress takes place exogenously at a rate π. In other words, $\hat{A} = \pi$.

— Finally, it is assumed that emission decreases with resources devoted to abatement. We have assumed that a fixed proportion of gross output, λx, is devoted to abatement. The abatement function is given by:

$$z = (\lambda x)^{\mu} \qquad \text{with } 0 \prec \mu \prec 1 \tag{7}$$

Eq. (7) states that resources expenditures for pollution control have a positive but diminishing impact on abatement. This assumption, which is plausible, is consistent with the existing literature.



Source: Authors' own work.

Eq. (4) would imply :

$$\hat{k} \equiv \dot{k} / k = sAk^{a-1}(1-\lambda) - (\delta + n) = 0 \tag{8}$$

Thus, the steady-state solution $k*$ is given by:

$$k* = \{sA(1-\lambda) / (\delta + n)\}^{1/(1-a)}$$

This expression shows that the higher the proportion of output devoted to abatement, the lower the steady-state $k*$. As $k*$ decreases, $y*$ the steady-state per capita income decreases. However, this does not affect the steady-state growth rate.

Next, we will seek to relate the Solow steady-state with the EKC. However, to do so, let us consider eq. (6). Substituting $z = (\lambda x)^{\mu}$ from eq. (7) into eq. (6) and simplifying, we can derive:

$$e = \theta k^{(1-\mu)a} / A^{\mu} \lambda^{\mu} \tag{9}$$

The equation can be rewritten in the proportionate-rate-of-change form:

$$\hat{e} = \hat{\theta} + (1-\mu)a\hat{k} + \mu\hat{A} - \mu\hat{\lambda} \tag{10}$$

This can be rewritten by:

$$\hat{e} = \hat{\theta} + (1-\mu)a\hat{k} - \mu\pi - \mu\hat{\lambda} \tag{11}$$

As it is evident from eq. (11):

(i) Growth in emission is negatively related to technological progress as well as increase in the rate of expenditures in abatement;

(ii) Other things remaining the same, the emission curve mirrors exactly the Solow fundamental equation of growth and produces the Environmental Kuznets Curve (EKC);

(iii) When $\hat{k} = \hat{\theta} = \hat{\lambda} = 0$, $\hat{e} = -\mu\pi \prec 0$. This implies that the EKC reaches its downward sloping part before the model reaches the Solow steady-state solution if there is technological progress, assuming other parameters remain the same. However, the maximum point of the EKC will approach faster if there is growth in expenditure in abatement or if there is an improvement in technology that reduces the emission parameter related to output, θ ;

(iv) When $\hat{e} = (1-\mu)a\hat{k} - \mu\pi = 0$, that is, when growth in emission stops, it can be seen: $\hat{k} = \mu\pi / (1-\mu)a \succ 0$. In other words, the emission growth rate reaches zero at a capital per worker or income level that lies below the corresponding Solow steady-state levels.

The above relationship between the Solow steady-state solution and the EKC can be seen from the following geometric exposition. From eq. (8), we can define the steady solution as follows:

$$k^* \equiv \{k : sAk^{a-1}(1-\lambda) - (\delta + n) = 0\} \tag{12}$$

Assuming $\hat{\theta} = \hat{\lambda} = 0$ and substituting $\hat{k}$ from eq. (8) into eq. (11), we can define k^{**}, the capital per worker where the EKC reaches its maximum, as follows:

$$k^{**} = \{k : sAk^{(1-a)}(1-\lambda) - (\delta + n) - (\pi\mu)/a(1-\mu) = 0\} \tag{13}$$

It can be easily seen that $k^{**} \prec k^*$.

The above exposition shows that a natural outcome of the Solow model is the EKC. It also shows that appropriate domestic policies, such as higher expenditures on pollution abatement or technological innovations in green technology, can help usher in a greener phase of the EKC faster than a stance of benign neglect.

3 Measurement and data for green growth

Though the concept of green growth has been widely discussed for some time, development of a green growth index is still at its infancy. There is no universally accepted single aggregate index of green growth in the literature.

OECD (2011) has developed a conceptual framework as well as a set of indicators for green growth. These indicators could be useful in helping governments monitor their progress towards green growth and identifying key areas of national concern. However, the green growth indicators developed by OECD are not in terms of traditional growth rates. More specifically, they capture the level of green development, but do not necessarily reflect the growth rate or relative change of green development. In Section 4 on the empirical model, we use the changes of green growth index as the dependent variable.

The set of 22 indicators proposed by OECD (2011) is 'able to track central elements of green growth and be representative of a broader set of green growth issues'. These proposed indicators can be grouped into five categories: (i) environmental and resource productivity, (ii) natural asset base, (iii) environmental quality of life, (iv) economic opportunities and policy responses, and (v) the socioeconomic context and characteristics of growth.[7] The definition of each specific indicator can be found in Appendix Table 1.

[7] The first group (environmental and resource productivity) measures the extent to which economic growth is becoming greener with more efficient use of natural capital and captures aspects of resource production that are rarely quantified in economic models and accounting frameworks; the second group (natural asset base) measures the risks of a declining natural asset base to growth; the third group (environmental quality of life) gauges the extent environmental conditions affect the quality of life and wellbeing of people; the fourth group of (economic opportunities and policy responses) indicates the effectiveness of policies in delivering green growth and describes the societal responses needed to secure business and employment opportunities; and the final group captures the conventional socioeconomic context and characteristics of growth (OECD 2011).

Table 1: Aggregate indices of green development

	Component 1	Component 2	Component 3
Proportion of sample variance explained	96.60%	1.80%	1.10%
Variables			
A11	0.037	-0.022	-0.066
A24	0.042	0.838	0.529
B12	0.000	-0.001	0.002
B21	0.000	0.004	-0.001
B22	-0.001	-0.006	0.012
B26	-0.001	-0.067	0.047
B32	0.022	-0.061	-0.086
B33	0.000	0.002	0.003
B35	0.001	0.013	0.014
B36	0.002	0.043	0.035
C11	-0.026	-0.534	0.838
E110	0.000	0.001	0.001
E111	0.000	-0.002	-0.002
E112	0.000	0.001	-0.001
E113	0.000	0.000	-0.002
E114	0.000	0.000	-0.002
E19	0.000	0.000	0.000
E41	0.000	0.001	0.002
C13	0.000	-0.001	0.000
D20	0.002	-0.011	0.043
E13	0.000	0.000	-0.003
E17	0.998	-0.047	0.004

Notes:
This table presents the first three principal components based on the OECD Green Growth Indicators available (2012). It reports the proportion of sample variance explained and its eigenvectors which give the coefficients of standardized variables. See Appendex Table 1 for definitions.
Source: Authors' own calculation.

These OECD indicators are comprehensive, and capture different aspects of green development. We use the principal components analysis to produce a new aggregate index of green development, based on the whole set of green growth indicators proposed by OECD (2011). Essentially, the principal components analysis takes N specific indicators and produces some principal components, X_1, X_2,., , that are mutually uncorrelated. As a linear combination of N indicators, each principal component corresponds to a different dimension of the data. Typically the variances of a small number of principal components are considerably large as opposed to the remaining principal components, and hence the majority of the variation in the data will be captured by those indices. Usually, the first principal component accounts for the greatest amount of the variation in the original set of indicators, in the sense that its corresponding linear combination has the highest sample variance, subject to the constraint that the sum-of-squares of weights placed on (standardized) indicators is equal to one.

Table 1 shows how we construct the aggregate index of green development, denoted by **GG,** based on raw data from OECD's Database on Green Growth Indicators (2012). The dataset covers OECD countries as well as BRICS economies (Brazil, Russian Federation, India, Indonesia, China and South Africa) over 1990-2009.[8] Appendix Table 2 gives the list of 42 sample countries. **GG** is the first principal component of these indicators over the period of 1990-2009 and accounts for the greatest amount, 96.6 per cent, of the variations in original indicators. The eigenvectors in Table 1 give the weights that the aggregate index places on each of the (standardized) variables.

4 Empirical model

4.1 Baseline specification

We model green growth or changes in the green development level as a function of its lagged value, its spatial lag (neighbouring effects or regional diffusion), domestic adjustments, structural reforms and shocks as follows:

$$\Delta GG_{it} = \alpha_1 \Delta GG_{i,t-1} + \alpha_2 \sum_{j=1}^{N} w_{ij} \Delta GG_{it} + \alpha_3 (GG^*_{it} - GG_{i,t-1}) + \alpha_4 SR_{i,t-1} + \alpha_5 SHOCK_{it} + \varepsilon_{it} \quad (14)$$

Dependent variable, ΔGG_{it}, measures changes in the green development level, the difference between the natural logarithm of the level of green development in period t, GG_{it}, and the natural logarithm of the level of green development in period $t-1$, $GG_{i,t-1}$. The level of green development in a given country can be measured by the aggregate index of green development as discussed in Section 3. The regression uses the 4-year averages of natural logarithms of GG_{it} and $GG_{i,t-1}$ from 1990 to 2009.

The first term on the right-hand side is the one-period time lag of the dependent variable. Its coefficient α_1 measures the extent of time dependence.

The second term measures neighbouring effects or regional diffusion.[9] α_2 is spatial autoregressive coefficient or spatial interdependence coefficient, measuring the extent of endogenous interaction effects among neighbours. More specifically, it measures if any changes of green development level in one country are (positively or negatively) determined by those of its neighbouring countries. w_{ij} is the (i, j) element of the matrix W_N, an $N \times N$ spatial weights matrix that reflects neighbouring relationships. $\alpha_2 \sum_{j=1}^{N} w_{ij} \Delta GG_{it}$ is known as a spatially lagged dependent variable, or a spatial lag of ΔGG_{it}, picking up the potential spatial lag dependence due to the presence of social and spatial interactions.

[8] Many countries in this database have a large number of missing values for 2010 and 2011; updated to May 2012. Data on green growth used in this paper are downloadable from www.yongfu-huang.net/research.html.

[9] In the growth literature, regional diffusion is usually modeled by using the differences between a particular economy and the regional (or global) leader in terms of the level of GDP per capita. A particular economy is significantly affected by its regional or global leader. In the context of green growth, the current leader, either regional or global, does not necessarily represent the regional or global standard because green growth is a relatively new concept in research. Each country is, in fact, heavily affected by its neighbouring nations that learn from or compete with each other.

The third term is used to examine whether domestic adjustments or domestic determination matter for green growth. The coefficient, α_3, is the adjustment factor or convergence parameter. It is a measure of the degree of policy status quo bias or resistance to policy changes. A lower value of α_3 is associated with more resistance to action-taking towards green growth and a greater bias to maintain current economic development path. GG^{*}_{it} is the desired level of green development, which can be the national target of green development. GG^{*}_{it} is not observable; therefore some assumptions should be made to facilitate regression analyses.

$SR_{i,t-1}$ is a vector of structural reforms in the previous period, either economic or political, carried out by governments to promote green growth. In the context of green growth, structural reform variables are likely to be endogenous with respect to the error term. To avoid endogeneity problem, we consider the effects on green growth of structural reforms undertaken before the current period.

This analysis focuses on a few major structural reform variables related to green growth, namely investment, technological development, trade openness and natural resource exploitations.[10] Specific variables are discussed in what follows:

- Government consumption, denoted by **GOVCON**, is the 4-year averages of the natural logarithm of government consumption from 1990 to 2009. Raw data on government consumption share of PPP converted GDP per capita at 2005 constant prices are taken from the Penn World Table 7.1 (Heston, Summer and Aten 2012).

- Aggregate investment, denoted by **KI**, is the 4-year averages of the natural logarithm of aggregate investment from 1990 to 2009. Raw data on investment share of PPP converted GDP per capita at 2005 constant prices taken from the Penn World Table 7.1.

- Trade openness, denoted by **OPENK**, measures the extent of openness to external trade in a given country. It is the 4-year averages of the natural logarithm of trade openness from 1990 to 2009. Raw data on trade openness at 2005 constant prices (per cent of GDP) are taken from the Penn World Table 7.1.

- Natural resources rents, denoted by **NRRENT**, are the sum of oil rents, natural gas rents, coal rents (hard and soft), mineral rents, and forest rents that are generated from the exploitations of those natural resources. Data on total natural resources rents (per cent of GDP) are taken from the World Bank (2012b). The regression uses the 4-year averages of **NRRENT** in log from 1990 to 2009.

- Combustible renewables and wastes, denoted by **RENEW**, comprise solid biomass, liquid biomass, biogas, industrial waste, and municipal waste, and are measured as a

[10] Governance is at the root of the success of a green growth strategy. Addressing governance challenges requires effective legal, regulatory and institutional frameworks, sound public sector management, and a supportive governance environment which brings about transparency, accountability and stakeholder consultation (ESCAP-ADB-UNEP 2012). When institutional variables are included, this analysis finds no evidence for such institutional variables as bureaucracy quality, corruption, governance stability, and law and order taken from indicators taken from the International Country Risk Guide (2012). With a larger sample, our future research will include some governance variables specifically designed to facilitate climate change mitigation and adaptation activities.

percentage of total energy use. Data on annual combustible renewables and waste (per cent of total energy use) are taken from the World Bank (2012b). The regression uses the 4-year averages of **RENEW** in log from 1990 to 2009.

$SHOCK_{it}$ is a vector of exogenous variables of shocks or crises, either political, economic or natural, which could trigger action towards green growth or reversal towards a 'brown' economy. Any political shocks or crises could change the pattern of decision-making and the balance of power. For example, a new government has the incentive or determination to initiate green growth process. Economic and political shocks or crises tend to influence the existing cooperation relationship among different interest groups, having an adverse impact on green growth strategies and actions. Natural disasters or economic crises tend to weaken the capability of the government and private sector to pursue green growth strategies. The following variables are considered in this analysis:[11]

- Extreme weather events, denoted by **EXEVENT**, is the dummy variable that tables 1 if estimated damage costs exist from extreme temperature occurrences over 4-year interval from 1990 to 2009 and 0 otherwise. Data on estimated damage costs from extreme temperature are taken from the EM-DAT (2012).
- Political shocks, denoted by **PSHOCK**. It is the first principal component of three indicators taken from the International Country Risk Guide (2012), including internal conflict, external conflict, ethnic tensions, and religious tensions.[12] The generated index accounts for 66.9 per cent of the variations based on a sample of 42 economies over the period 1990-2009. The weights resulting from principal component analysis are 0.45 for internal conflict, 0.69 for external conflict, 0.44 for ethnic tensions and 0.37 for religious tensions. The regression uses the 4-year averages of **PSHOCK** in log from 1990 to 2009.

4.2 Two assumptions and full specification

The desired level of green development, GG^*_{it}, can be the national green development target. Since it is quite likely that GG^*_{it} is decreasing in the level of emission intensity of previous period, it is reasonable to assume that:

$$\text{Assumption 1: } GG^*_{it} = a - b \, {CO_2}/{GDP_{i,t-1}}$$

The baseline specification can be rewritten as:

$$\Delta GG_{it} = \alpha_1 \Delta GG_{i,t-1} + \alpha_2 \sum_{j=1}^{N} w_{ij} \Delta GG_{it} + \alpha_3 (a - b \, {CO_2}/{GDP_{i,t-1}} - GG_{i,t-1}) + \alpha_4 SR_{i,t-1} + \alpha_5 SHOCK_{it} + \varepsilon_{it} \tag{15}$$

Moreover, there is a possibility that economic and/political shocks, $SHOCK_{it}$, exert indirect effects on the changes of green development level, ΔGG_{it}, in addition to the direct effect

[11] This research finds no evidence on the effects of economic shocks or crises measured by output volatility, i.e., the standard deviation over 4-year interval from 1990 to 2009 of the natural logarithm of one plus annual growth rate divided by 100. Future research should make use of other variables to explore the effects of economic shocks.

[12] Available at: www.prsgroup.com/Default.aspx.

modelled in the above specification. More specifically, these shocks can have an indirect effect on ΔGG_{it} via their impact on the degree of status quo bias. To reflect this possibility, we assume that the adjustment factor or convergence parameter, α_3, is a function of $SHOCK_{it}$ as follows:[13]

Assumption 2: $\alpha_3 = \lambda SHOCK_{it}$

With this assumption, we redefine the coefficients of the above specification, yielding the following full specification.[14]

$$\begin{aligned}\Delta GG_{it} &= \theta_1 \Delta GG_{i,t-1} + \theta_2 \sum_{j=1}^{N} w_{ij} \Delta GG_{it} + \theta_3 SR_{i,t-1} + \theta_4 SHOCK_{it} \\ &- \theta_5 SHOCK_{it} \times {CO_2}/{GDP}_{i,t-1} - \theta_6 SHOCK_{it} \times GG_{i,t-1} + \varepsilon_{it}\end{aligned} \tag{16}$$

The convergence parameter is now taking the form of $-\theta_6 SHOCK_{it}$.

4.3 Estimation method: spatially-corrected system GMM estimator

The rewritten baseline specification (15) and full specification (16) can be simplified as the following spatial dynamic panel data model with fixed effects:

$$\begin{aligned}&Y_{it} = \alpha Y_{i,t-1} + \beta \sum_{j=1}^{N} w_{ij} Y_{it} + X_{i,t-1}\gamma + Z_{it}\phi + \eta_i + v_{it} \\ &i = 1,2,..42; t = 2,..,5\end{aligned} \tag{17}$$

where Y_{it} denotes ΔGG_{it}. $Y_{i,t-1}$ is the one-period time lag of dependent variable and its coefficient α measures the time dependence. We assume $|\alpha| < 1$ to ensure the stability of the model.

β is the spatial autoregressive coefficient or spatial interdependence coefficient and w_{ij} is the (i, j) element of the matrix W_N, which is an $N \times N$ spatial weighting matrix, as explained earlier. W_N is a symmetric matrix of non-negative and exogenously-given constants in row-standardized form with zero across diagonals, which define the functional forms of the weights between any pair of locations. Both the symmetric binary contiguity matrix—based on whether one pair of units shares common borders or within a certain geographic distance—and the symmetric inverse-distance matrix—based on physic distance between units—are

[13] The convergence parameter α_3 might also be affected by the lagged green growth rate ($\Delta GG_{i,t-1}$), regional diffusion and structural reforms. For simplicity, this analysis assumes that these variables only exert direct effects on green growth (ΔGG_{it}).

[14] α_1, α_2 and α_4 are renamed as θ_1, θ_2 and θ_3. $\lambda a + \alpha_5$ is renamed as θ_4. $-\lambda b$ and $-\lambda$ are renamed as $-\theta_5$ and $-\theta_6$, respectively.

commonly used. We assume that the spatial weights matrix is time-invariant since distances are time-invariant.

$X_{i,t-1}$ is a vector of predetermined (or weakly exogenous) variables with respect to the error ε_{it}.[15] For the baseline specification (15), $X_{i,t-1}$ is made up of $CO_2/GDP_{i,t-1}$, $GG_{i,t-1}$ and $SR_{i,t-1}$ while for the full specification (16), it comprises $SR_{i,t-1}$, $SHOCK_{it} \times CO_2/GDP_{i,t-1}$ and $SHOCK_{it} \times GG_{i,t-1}$.

Z_{it} is a vector of exogenous shocks such as extreme weather events and extreme political shocks in both specifications.

η_i is an unobservable individual specific time-invariant effect. η_i is assumed to be independently and identically distributed (*iid*) with variance σ_η^2, which is assumed to be constant across units and time periods. v_{it} is the error term, which is assumed to be *iid* (0, σ_v^2).[16] η_i and v_{it} are assumed to be independent of each other and among themselves.

Following Arellano and Bond (1991), the first-differencing is used to remove fixed effects (η_i) in eq. (17) yielding the following first-differenced equation:

$$\begin{aligned} &\Delta Y_{it} = \alpha \Delta Y_{i,t-1} + \beta \sum_{j=1}^{N} w_{ij} \Delta Y_{it} + \Delta X_{i,t-1} \gamma + \Delta Z_{it} \phi + \Delta v_{it} \\ &i = 1,2,..42; t = 3,4,5 \end{aligned} \tag{18}$$

For the spatial dynamic panel data model with fixed effects, a number of estimation methods have been proposed in the literature.[17]

For the non-spatial dynamic panel data model, Arellano and Bond (1991) propose the 'first-differenced GMM estimator', which uses all lagged values of the dependent variable and independent variables dated from *t*-2 and earlier as suitable instruments for the differenced values of original regressors.

Elhorst (2010) extends the work of Arellano and Bond (1991) to study the spatial dynamic panel data model with endogenous interaction effects and (weakly) exogenous independent variables.[18] He proposes using all lagged values of independent variables dated *t*-1 and earlier

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[15] The exclusion of X_{it} rules out the possibility of reverse causality or joint determination.

[16] Since we examine the effects of shocks explicitly on the changes of green development level and are particularly interested in the spatial dependence among countries, we focus on a spatial lag model, which is without a spatial error structure.

[17] See Elhorst (2012) for a review of recent literature.

[18] Baltagi, Fingleton and Pirotte (2013) and Cizek et al. (2011), based on Arellano and Bond (1991), study the spatial dynamic panel data model with spatial errors and strictly exogenous independent variables. They propose using all lagged values of independent variables as suitable instruments for the differenced values of original

as suitable instruments for the differenced values of original (weakly) exogenous regressors. For the differenced values of the spatially lagged dependent variable, following Kelejian and Prucha (1998) he proposes to use all lagged values of spatially lagged dependent variable dated t-2 and spatially lagged independent variables dated t-1 and earlier as suitable instruments. Following Elhorst (2010), this work uses all lagged values of spatially lagged dependent and predetermined (or weakly exogenous) independent variables dated t-2 and earlier as suitable instruments.

More specifically, for the 'spatially-corrected first-differenced GMM estimator' denoted by SPATIAL-DIF-GMM, this analysis makes use of the following moment conditions for the spatial dynamic panel data model in the first difference (18):

$$E\left[\begin{pmatrix} Y_i^{t-2} \\ \sum_{j=1}^{N} w_{ij} Y_i^{t-2} \\ \sum_{j=1}^{N} w_{ij} X_i^{t-2} \\ \sum_{j=1}^{N} w_{ij} Z_i^{t} \\ X_i^{t-2} \\ Z_i^{t} \end{pmatrix} (\Delta v_{it})\right] = 0 \qquad (19)$$

$$t = 3,4,5$$

where $Y_i^{t-2} = (Y_{i1}, Y_{i2}, .. Y_{it-2})'$, $X_i^{t-2} = (X_{i1}, X_{i2}, .. X_{it-2})'$, and $Z_i^{t} = (Z_{i1}, Z_{i2}, .. Z_{it})'$.

Based on Arellano and Bover (1995), Blundell and Bond (1998) and Elhorst (2010), this analysis employs for the 'spatially-corrected System GMM estimator', denoted by SPATIAL-SYS-GMM, the additional moment conditions, in addition to the moments described in (19):

$$E\left[\begin{pmatrix} \Delta Y_{i,t-1} \\ \sum_{j=1}^{N} w_{ij} \Delta Y_{i,t-1} \\ \sum_{j=1}^{N} w_{ij} \Delta X_{i,t-1} \\ \sum_{j=1}^{N} w_{ij} \Delta Z_{it} \\ \Delta X_{i,t-1} \\ \Delta Z_{it} \end{pmatrix} (\eta_i + v_{it})\right] = 0 \qquad (20)$$

$$t = 3,4,5$$

strictly exogenous regressors. Lee and Yu (2010a, b) propose an optimal GMM estimator based on linear moment conditions and quadratic moment conditions for the spatial dynamic panel data model with strictly exogenous independent variables when T is small relative to N. They show that this GMM estimator is consistent. Yu, De Long and Lee (2008, 2012) propose the quasi-maximum likelihood estimators (QMLE) for the spatial dynamic panel data with fixed effects, but they consider the case of strictly exogenous independent variables.

The Monte-Carlo investigation conducted by Kukenova and Monteiro (2008) compares the performance of spatial QMLE by Yu, De Long and Lee (2008), SPATIAL-DIF-GMM and SPATIAL-SYS-GMM for the spatial dynamic panel data model in terms of bias, root mean squared error and standard-error accuracy.[19] Their simulations suggest that SPATIAL-SYS-GMM substantially reduces the bias in the parameter estimate of β. Moreover, they suggest that the SPATIAL-SYS-GMM outperforms the SPATIAL-DIF-GMM. To save space, this research only reports the SPATIAL-SYS-GMM estimates.

5 Evidence

This section provides the empirical results obtained from the statistical model of green growth for 42 countries over 1990-2009. Recall that the green growth process in a country could be directly affected by its lagged level, regional diffusion, domestic determination and structural reforms undertaken by the government. It could also be subject to direct and indirect effects of exogenous shocks.

In Table 2, a binary spatial weights matrix is employed which gives one when the distance between two sample points is less than 1000 km and 0 otherwise. The spatial weights matrix is row-standardized of one. Information on latitude and longitude of each country used to calculate distance is taken from the CIA World Factbook. Table 3 uses an inverse-distance spatial weights matrix which gives the inverse of the distance between two sample points.

The first column of Table 2 refers to the rare scenario where no structural reform has been undertaken by the government and no economic and/or political crisis or uncertainty exists. The Sargan test suggests that the instruments used are valid. As suggested by SPATIAL-SYS-GMM estimates, Table 2 shows that a significantly positive spatial autocorrelation exists among neighbouring countries, suggesting that neighbouring effects can play an important part in boosting green growth in a given country.

The evidence on ${CO_2}/{GDP}_{i,t-1}$ and $GG_{i,t-1}$ together sheds light on the domestic determination of the government towards its national target or desired level of green growth.[20] Emission intensity has a significantly negative impact on changes in the green development level, implying that rapid economic growth together with considerable emissions does not necessarily lead to green growth. Reduction of energy intensity could be a primary national target in the process of achieving green growth. The coefficient on $GG_{i,t-1}$ is negatively signed, suggesting the existence of conditional β-convergence in this context. In the global transition towards a green economy, nations with lower levels of green development are more likely to grow faster and greener which, in many ways, may bring other countries along over the coming years.

[19] In their analysis, Kukenona and Monteiro (2008) do not use the lagged values and lagged first-differences of spatially lagged independent variable as instruments.

[20] As *The Economist* (2012) puts it, many developing countries fully aware that they need to take urgent actions to save the environment from further degradation but at the same time, recognize that they cannot reduce the growth rate, which can be politically costly.

Table 2: the determination of green growth: a binary spatial weights matrix

Dependent Variable ΔGG_{it}	No structural reform No shock	Structural reforms No shock	Structural reforms With shocks
Lagged Green Growth $\Delta GG_{i,t-1}$	-0.079 ***	-0.101 ***	-0.130 ***
	[-7.68]	[-8.27]	[-6.16]
Spatially Lagged Green Growth $\sum_{j=1}^{N} w_{ij} \Delta GG_{it}$	0.287 *	0.026 ***	0.015
	[1.96]	[3.39]	[1.57]
Emission Intensity $CO_2/GDP_{i,t-1}$	-0.044 ***	-0.051 **	
	[-2.72]	[-2.49]	
Lagged Level of Green Growth Index $GG_{i,t-1}$	-0.116 ***	-0.079 ***	
	[-16.60]	[-20.94]	
Government Consumption $GOVCON_{it}$		0.102 ***	0.109 **
		[4.60]	[2.14]
Aggregate Investment KI_{it}		0.012	0.080 **
		[0.76]	[2.51]
Trade Openness $OPENK_{i,t-1}$		-0.055 ***	-0.036 *
		[-3.66]	[-1.88]
Natural Resources Rents $NRRENT_{i,t-1}$		-0.012 ***	-0.009 ***
		[-6.01]	[-3.25]
Combustible Renewables $RENEW_{i,t-1}$		0.017 ***	0.024 **
		[3.08]	[2.57]
Extreme Weather Events $EXEVENT_{it}$			-0.206 *
			[-1.82]
Political Shocks $PSHOCK_{it}$			0.171 ***
			[2.70]
Extreme Weather Events × $GG_{i,t-1}$			0.036 **
			[2.24]
Political Shocks × $GG_{i,t-1}$			-0.027 ***
			[-8.56]
Extreme Weather Events × $CO_2/GDP_{i,t-1}$			0.043 ***
			[3.53]
Political Shocks × $CO_2/GDP_{i,t-1}$			-0.031 ***
			[-3.82]
Sargan test (p-value)	0.23	0.99	1.00
Number of countries	42	42	42
Observations	210	210	210

Note: This table focuses on 42 countries over 1990-2009 taken from the OECD Green Growth Indicators Database (2012). Averages or standard deviations are calculated based on 4-year-period. The dependent variable is the changes of the log of green growth index. See text for definitions. This table reports the spatially-corrected system GMM estimates for key determinants of green growth. Sargan test is used to examine the null that over identification restrictions are valid. T-ratios are reported in the brackets. *, **, *** significant at 10%, 5%, 1%, respectively.
Source: Authors' own calculations.

The second column of Table 2 presents evidence on the direct effects of structural reforms in the absence of exogenous shocks. The evidence on the lagged green growth, a spatial lag, emission intensity and lagged level of green development has been confirmed.

The SPATIAL-SYS-GMM estimate shows that an increase in government consumption has a significantly positive impact on green growth while aggregate investment is positively signed. Government expenditure and investments could contribute to important productive, technological and human capacity for future economic development, especially for strategic sectors, and ultimately affect how well the country is equipped both financially and technologically to protect the environment. This could catalyse and support private finance and investment, the key drivers of green growth, which are effective in reducing carbon emissions, increasing energy and resource efficiency and limiting the loss of biodiversity and ecosystem services. Countries are encouraged to invest in strategic sectors or projects for incentivizing private sectors to get involved into the low carbon development process.[21] Another course of action is for governments to structure official development assistance more efficiently so that it can mobilize much larger amounts of domestic and foreign finance to invest in resource-efficient industries and projects.

The third structural reform variable, trade openness, is observed to have a significantly negative impact on green growth. This result is perhaps due to the fact that more open policies contribute to increased CO_2 emissions and natural resources depletion. On the effect of trade openness on greenhouse gas emissions, trade economists have developed a framework that decomposes the impact of trade openness into three elements: scale effect, composition effect, and technique effect (Copeland and Taylor 2004).[22] Managi (2004) finds that more trade openness results in increased emissions with a greater contribution from the scale effect than from the technique effect. Managi, Hibiki and Tsurumi (2008) suggest that the effect of trade openness on pollution emissions may differ between developed countries and developing countries.[23] On the effect of trade openness on natural resource stock, environmentalists argue that when there is open-access problem, trade openness is likely to lead to overexploitation or rapid depletion of natural resources (Copeland and Taylor 2009). Governments should endeavour to create the right enabling policy and institutional environments that support green growth activities.

The fourth structural reform variable, rents generated from natural resource exploitations, is found associated with significant slowdowns of green growth. Green growth strategy must respect the limited capacity of our planet, implying that economic development should stay within environmentally and ecologically feasible boundaries. This finding highlights the importance of government action for the prevention of natural resource over-exploitation and protection of the environment, both of which play an essential role in sustaining economic development. For developing countries, especially poor agricultural nations highly dependent on natural resources for livelihoods, considerable action needs to be taken to enhance the value of natural capital and build an environmentally more sustainable basis for long-term economic development. With sound protection and management, natural capital can yield considerable economic dividends for these low-income nations (Hallegatte et al. 2011).

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[21] With the increasing awareness of the value of green growth, an increasing number of developed and developing countries have made serious efforts to transiting to a green economy. For instance, China has put green growth as a key strategy in its national development agenda with more than US$468 billion committed to such areas as renewable energy, clean technologies and waste management (UNEP 2011). Other countries including Barbados, Cambodia, Indonesia, the Republic of Korea and South Africa have set national green growth plans to pursue the strategy of green growth (ibid.) .

[22] Scale effect refers to the rise in GHG emissions as a result of increased economic activities and associated transportation costs. Composition effect refers to the way that trade openness, together with consequent changes in relative prices, may affect the relative size of various sectors, especially emission-intensive sectors. Technique effect refers to the decline in GHG emissions as a result of improvements in production methods for goods and services.

[23] More specifically, they find that trade openness leads to CO_2 emission reductions in OECD countries because the technique effect dominates, while in non-OECD countries it reduces CO_2 emissions, due to the fact that scale and composition effects prevail over the technique effect.

A significantly positive effect of combustible renewables and wastes, the fifth structural reform variable, on green growth is noted, suggesting that green industrial policies including those related to green technology are important. A shift towards a greener development mode depends crucially on green industrial policies that spur innovation in environmentally-friendly technologies. Policies need to promote technologically more sound and energy-efficient options, such as green transport, infrastructure and cities, for example. Moreover, renewable energy and sustainable infrastructure schemes are good examples of the opportunities opened by the green growth concept in a global context. Renewable energy options represent exciting opportunities for the individual and private sector. Sustainable infrastructure development covering clean energy, water and sanitation, sustainable transport and solid waste management can bring about multiple environmental, economic and social benefits. Green growth is not just about the limitations of natural resources, but also about opportunities.

The third column of Table 2 presents the results for the scenario where structural reforms have been undertaken to promote green growth, and the country is subject to direct and indirect effects of exogenous economic and political shocks. The SPATIAL-SYS-GMM estimates confirm the significant impacts of government consumption, trade openness and natural resources rents. A significantly positive impact of aggregate investment on green growth is clearly supported.

The coefficient on extreme weather events is significantly negative. However, the coefficient on its interaction term with $GG_{i,t-1}$ is significantly positive, which implies that, apart from a significantly negative direct effect on green growth, extreme weather events also exert an indirect effect on green growth via $GG_{i,t-1}$. Extreme weather events can hamper green growth when the green development level is low, but this negative effect tapers off as the level of green development increases. One plausible explanation is that extreme weather events have a dramatic impact on people and countries, and could induce necessary green growth strategy and actions. The coefficient on its interaction term with $CO_2/GDP_{i,t-1}$ is also significantly positive, indicating that via the channel of $CO_2/GDP_{i,t-1}$ extreme weather events can also indirectly affect green growth. In the process of improving energy efficiency, extreme weather events tend to spur green growth.

The coefficient for political shocks is significantly positive; however, the coefficients on its interaction terms with $GG_{i,t-1}$ and $CO_2/GDP_{i,t-1}$ are significantly negative. This suggests that political shocks exercise both a direct and an indirect effect on green growth. The indirect effect is transmitted either through the level of green development or emission intensity. Political shocks in general can stimulate reforms for green growth when the level of green development is low or the level of energy intensity is high. Once green development reaches a certain level or energy efficiency is improved sufficiently, political shocks can only impede the process of green growth.

With an inverse-distance spatial weights matrix, Table 3 presents some interesting findings with a similar pattern. For the structural reform variables, Table 3 shows no significant evidence for aggregate investment and trade openness. Nor does it find significant evidence for extreme weather events and the interaction term with $GG_{i,t-1}$. However, the table does highlight the importance of reducing natural resources exploitations and developing renewable options for green growth. It further confirms that green growth is subject to natural and political shocks, which yield both direct and indirect impacts on green growth.

In sum, the process of green growth depends on the country's lagged level, regional diffusion, domestic determination, and exogenous shocks. 'Greening' the economy means a profound transformation that requires comprehensive structural reforms and policy changes, especially in policies related to investment, trade, natural resources, industry, and technology, etc.

Table 3: The determination of green growth: an inverse-distance spatial weights matrix

Dependent Variable ΔGG_{it}	No structural reform No shock	Structural reforms No shock	Structural reforms With shocks
Lagged Green Growth	-0.081 ***	-0.106 ***	-0.098 ***
$\Delta GG_{i,t-1}$	[-8.52]	[-12.17]	[-4.25]
Spatially Lagged Green Growth	0.281 ***	0.242	0.193
$\sum_{j=1}^{N} w_{ij} \Delta GG_{it}$	[2.62]	[1.43]	[1.09]
Emission Intensity	-0.038 **	-0.028 **	
$CO_2/GDP_{i,t-1}$	[-2.16]	[-2.17]	
Lagged Level of Green Growth Index	-0.112 ***	-0.083 ***	
$GG_{i,t-1}$	[-23.43]	[-16.94]	
Government Consumption		0.085 ***	0.086 ***
$GOVCON_{i,t-1}$		[3.86]	[3.04]
Aggregate Investment		-0.007	0.021
KI_{it}		[_0.39]	[0.77]
Trade Openness		-0.034 **	-0.020
$OPENK_{i,t-1}$		[-2.25]	[-1.20]
Natural Resources Rents		-0.012 ***	-0.010 ***
$NRRENT_{i,t-1}$		[-7.97]	[-4.86]
Combustible Renewables		0.011 **	0.020 **
$RENEW_{i,t-1}$		[2.22]	[2.32]
Extreme Weather Events			-0.148
$EXEVENT_{it}$			[-1.28]
Political Shocks			0.162 ***
$PSHOCK_{it}$			[3.36]
Extreme Weather Events × $GG_{i,t-1}$			0.027
			[1.58]
Political Shocks × $GG_{i,t-1}$			-0.025 ***
			[-8.83]
Extreme Weather Events × $CO_2/GDP_{i,t-1}$			0.042 ***
			[3.76]
Political Shocks × $CO_2/GDP_{i,t-1}$			-0.030 ***
			[-5.87]
Sargan test (p-value)	0.23	0.99	1.00
Number of countries	42	42	42
Observations	210	210	210

Note: This table uses an inverse-distance spatial weights matrix. See Table 2 for more notes.
Source: Computed by authors.

6 Conclusions

In view of the global climate change crisis and the pressing development needs of the world's poor, it is vital that the world becomes greener while still retaining its current growth rate. Green growth offers the best hope of achieving both prosperity and greenery. Through an environmentally sustainable manner, it paves the ways for feeding the world and supplying with power, but with a much lighter claim on the planet.

The canonical Green Solow growth model regards the environment as capital of sorts that makes a sizeable contribution to the economic output and which therefore should be preserved and nurtured. The model highlights the importance of green finance and green technology for green growth. The empirical analysis shows that there is a convergence of green growth among the nations in the sample. The extent of green growth in a given country depends on not only its earlier green growth development and on the growth performance of its neighbouring countries, but also on domestic learning or determination to achieve the national politically-desired target. The analysis also demonstrates the significant role of governmental structural reforms and exogenous shocks in achieving green growth goals. This research offers useful insights and lays the foundation for a policy framework tailored to different national and local circumstances as well as to different development stages.

A transition towards green growth will entail a broad change in institutions, policies and values. Important structural reforms should be initiated, covering increased green investment, reduced exploitations of natural resources, enhanced development and deployment of climate-friendly technologies, transformed industries, etc. Strategic climate policies should be promoted to achieve the synergy that exits between economic development and environmental protection.

Achieving this transition requires the participation of the whole society. A vigilant and active private sector is essential in order to respond to new market incentives, identify new growth opportunities and realize growth potential within natural physical barriers. However, the transition is a deeply political process that involves identification of the barriers, removal of old incentives and the introduction of new ones. This will require participation of a strong civil society and efficient governments. In addition, a transition towards green growth would also benefit from enhanced international coordination, via external trade and knowledge exchanges.

Appendix

Appendix Table 1: The variables of OECD's green growth indicators

Variable	Description	Source
A11	Real GDP, Index 1990=100	OECD Green Growth Indicators (GGI) (updated 15 May 2012)
A24	Population density, inhabitant per km2	- " -
B12	Production-based CO_2 productivity, US$ per kg of CO2	- " -
B21	Energy productivity, US$ per ktoe	- " -
B22	Energy intensity, toe per capita	- " -
B26	Renewable energy supply, % TPES	- " -
B32	Non-energy material consumption - DMC, 1990=100	- " -
B33	Non-energy material productivity, US$ per kg	- " -
B35	Biotic material productivity incl. wood/biomass for food and feed, US$ per kg	- " -
B36	Abiotic material productivity incl. industrial minerals and metals, US$ per kg	- " -
C11	Available freshwater resources,1000m^3 per capita	- " -
C13	Total freshwater abstraction, 1000m^3 per capita	- " -
D20	Population connected to public sewerage, % total population	- " -
E13	Public spending in environment-related RD, % total public spending	- " -
E17	Green Patents, Index 1990=100	- " -
E19	Patents - Electric and hybrid vehicles, % total PCT patents	- " -
E110	Patents - Energy efficiency in buildings and lightning, % total PCT patents	- " -
E111	Patents - Renewable energy, % total PCT patents	- " -
E112	Patents - Air pollution, % total PCT patents	- " -
E113	Patents - Water pollution, % total PCT patents	- " -
E114	Patents - Waste management, % total PCT patents	- " -
E41	Total environment related taxes, % GDP	- " -
GG	First principal component of A11, A24, B12, B21, B22, B26, B32, B33, B35, B36 C11, C13, D20, E13, E17, E19, E110, E111, E112, E113, E114, E41. The regression uses log(GG).	See text
ΔGG	The change of green growth index in log, the difference between the current level of green development and its level at the previous time period.	See text

Source: Compiled by the authors.

Appendix Table 2: List of countries in the sample

Country code	Country name	Country code	Country name
ARG	Argentina	IRL	Ireland
AUS	Australia	ISL	Iceland
AUT	Austria	ISR	Israel
BEL	Belgium	ITA	Italy
BRA	Brazil	JPN	Japan
CAN	Canada	KOR	Korea, Rep.
CHE	Switzerland	LUX	Luxembourg
CHL	Chile	MEX	Mexico
CHN	China	NLD	Netherlands
CZE	Czech Republic	NOR	Norway
DEU	Germany	NZL	New Zealand
DNK	Denmark	POL	Poland
ESP	Spain	PRT	Portugal
EST	Estonia	RUS	Russian Federation
FIN	Finland	SAU	Saudi Arabia
FRA	France	SVK	Slovak Republic
GBR	United Kingdom	SVN	Slovenia
GRC	Greece	SWE	Sweden
HUN	Hungary	TUR	Turkey
IDN	Indonesia	USA	United States
IND	India	ZAF	South Africa

Note: This table lists country codes and country names for 42 countries available in the OECD Green Growth Indicators Database (2012).

Source: Compiled by the authors.

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