Global Journal Of Biodiversity Science And Management, 2(1): 54-59, 2012
ISSN 2074-0875

Climate Change Performance and Economic Growth: Evidence from Panel Data Model

[1]Ahmad Jafari Samimi, [2]Saman Ghaderi, [3]Moslem Rahmanian, [4]Salahaddin Ghaderi

[1] University of Mazandaran, Babolsar, Iran.
[2] Islamic Azad University, Sanandaj Branch, Sanandaj, Iran.
[3] University of Mazandaran, Babolsar, Iran.
[4] Young Researchers club, Islamic Azad University, Tabriz Branch, Tabriz, Iran

ABSTRACT

The purpose of this paper is to estimate and evaluate the relationship between Climate Change Performance Index and economic growth for 56 countries. Climate change will affect the accumulation of capital and savings. Climate change reduces the productivity of capital and, faced with a lower rate of return, agents may prefer to invest less and consume more today and hence reduces growth and future GDP. Climate Change Performance Index (CCPI) evaluates and compares the climate protection performances of the about 58 countries that, together, are responsible for more than 90 percent of global energy-induced CO_2 emissions. This index measures via thirteen different composite indicators and varies between zero to 100 in such a way that a higher index means a better climate protection performance. Our findings regarding the estimated panel regression analysis during 2008-2010 show that more the climate protection performance has a positive impact on economic growth and encourage this.

Key words: Climate Change Performance Index (CCPI), Economic Growth, Panel Data.

Introduction

1.1 Climate Change: A Global Problem:

Over the past 150 years, global average surface temperature has increased 0.76°C, according to the Intergovernmental Panel on Climate Change (IPCC 2007). This global warming has caused greater climatic volatility, such as changed precipitation patterns and increased frequency and intensity of extreme weather events including typhoons, heavy rainfall and flooding, and droughts; and has led to a rise in mean global sea levels. It is widely believed that climate change is largely a result of anthropogenic greenhouse gas (GHG) emissions and, if no action is taken, likely to intensify. Under the most pessimistic emissions scenario developed in IPCC (2000), by the end of this century temperatures could rise to more than 4°C above 1980–1999 levels, ranging from 2.4–6.4°C (Figure 1). This would have serious consequences for the world's growth and development. Climate change is a global problem and requires a global solution. In recent years, addressing climate change has been high on the international policy agenda. There is now a consensus that to prevent global warming from reaching dangerous levels, action is needed to control and mitigate GHG emissions and stabilize their atmospheric concentration within a range of 450–550 parts per million (ppm) (IPCC 2007). The lower bound is widely considered a desirable target and the upper bound a minimum necessary level of mitigation (Stern, 2007).

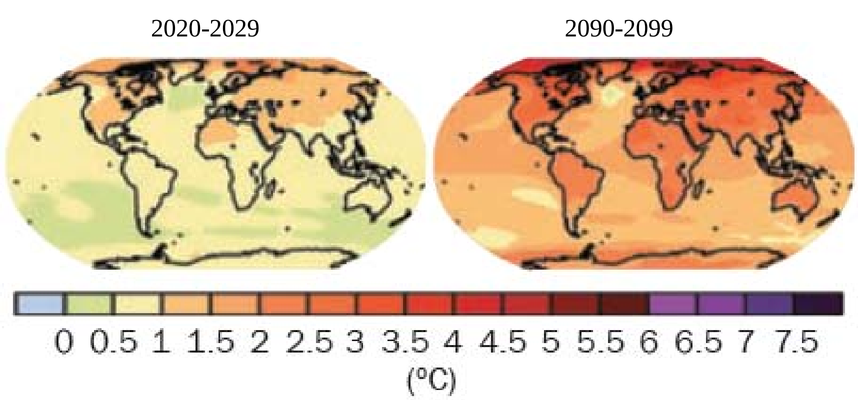

Fig. 1: Temperatures at the end of 21ist century
Source: IPCC (2007)

Corresponding Author: Ahmad Jafari Samimi, University of Mazandaran, Babolsar, Iran.
E-mail: jafarisa@umz.ac.ir.

The global climate is changing, and will continue to do so even if greenhouse gas emissions are dramatically curbed. Economies are therefore faced with the challenge of adapting to climate change. This challenge is particularly important in developing countries, which, due to a combination of unfortunate geography and high sensitivity, are most vulnerable to climate change. From a macro-economic point of view, there remains much to learn about the characteristics of optimal adaptation. In particular, it is unclear whether the best way to adapt to climate change is simply to focus on traditional growth and development goals, or to divert significant investment into ‘climate-proofing’ productive capital (Millner, Antony and Simon Dietz, 2011).

Many studies demonstrate that human activity is contributing in important ways to climatic changes, and that those changes have far reaching effects on plants, animals, ecosystems, and humanity now and in the future. Among a wide range of negative effects, climate change tends to exacerbate the scarcity of important natural resources, such as freshwater, may trigger mass population dislocations (migration) due to extreme weather events, desertification and rising sea-levels, and may thus also increase the risk of violent conflict within and between countries.

Climate change may – or may not – be a central issue for the world economy. Yet assessing the economic impact of climate change faces a fundamental challenge of complexity: the set of mechanisms through which climate may influence economic outcomes, positively or negatively, is extremely large and difficult to investigate comprehensively. Even if the effect of climate on each relevant mechanism were known, one would still be faced with the challenge of how various mechanisms interact to shape macroeconomic outcomes (Dell *et al*, 2008).

The CCPI Framework:

The Climate Change Performance Index (CCPI) is an innovative instrument that enhances transparency in international climate politics. On the basis of standardized criteria the index evaluates and compares the climate protection performances of the about 58 countries that, together, are responsible for more than 90 percent of global energy-induced CO_2 emissions.

The objective of the index is to increase the political and societal pressure on those countries, which up to now have failed to take initiatives in climate protection and which still neglect the importance of the issue.

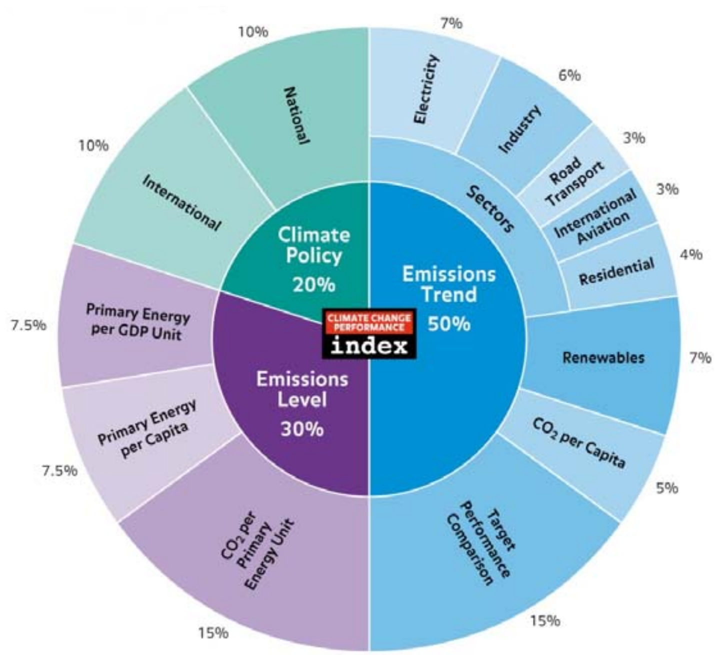

Fig. 2: Components of the CCPI
Source: Germanwatch (2011)

Every year, the CCPI evaluates how far countries have come in achieving this goal. With the help of the Index, the climate change policy, emissions level and emissions trend of a country can swiftly be accessed and judged. The CCPI was developed to accompany countries along this path and to show the strengths and weaknesses in the development of their national and international climate policies.

Glob. J. Biodivers. Sci. Manag., 2(1): 54-59, 2012

The climate change performance is measured via thirteen different composite indicators (Electricity, Industry, Road Transport, International Aviation, Residential, Renewables, CO_2 per capita, Target-Performance Comparison, and CO_2 per Primary Energy Unit, Primary Energy per Capita, and Primary Energy per GDP Unit, International Policy and National Policy). They are classified into three categories, 'emissions trend', 'emissions level'and 'climate policy'. Together, these three composite indicators form a differentiated picture of the climate change performance of each country.

The CCPI's final ranking is calculated from the weighted average of the achieved scores in the separate indicators. An absolute evaluation is not made. The CCPI does not evaluate the country's performance in absolute terms, but only in comparison with one another.

The following formula is used to calculate the index:

$$I = \sum_{i=1}^{n} w_i X_i$$

I: Climate Change Performance Index;
X_i: normalised indicator;
w_i: weighting of X_i

$$0 \leq w_i \leq 1 \ \& \ \sum_{i=1}^{n} w_i = 1$$

i: 1,...., n: number of partial indicators (currently 13)

$$\text{Score}=100\left(\frac{\text{actual value - minimum value}}{\text{maximum value - minimum value}}\right)$$

Theoretical Background and Empirical Research:

Thus the global climate is changing, and even dramatic curbs to emissions will not prevent it from continuing to do so (Solomon *et al*., 2009). This immediately raises the question of how economies should adapt to changing climatic conditions. The challenge of adapting to climate change is widely thought to be most important in developing countries (e.g. Tol *et al*., 2004; Mendelsohn *et al*., 2006). Terminology varies, but there are in general three reasons for this. The first reason is geography. Many developing countries are located in tropical and sub-tropical regions and as such are already hotter than is optimal for various forms of economic activity. Further increases in temperature will lead to conditions that are less optimal still. As Mendelsohn & Schlesinger (1999) showed, if the relationship between temperature and the output of an economic sector can be approximated with an 'n-shaped' parabola (a so-called 'hill function'), as appears to be the case in a series of important climate-sensitive sectors, then small changes in temperature in hot countries can lead to large losses in that sector's output.

The economic impact of climate change is usually measured as the extent to which the climate of a given period affects social welfare in that period. This static approach ignores the dynamic effects through which climate change may affect economic growth and hence future welfare. (Fankhauser, Samuel and RichardS.J.Tol, 2005)

In most studies of the economic impact of global warming the effects of climate change are assessed and valued separately sector by sector and then added up to form an estimate of the overall change in social welfare (e.g., Nordhaus, 1991; Cline, 1992; Fankhauser, 1995; Tol, 1995; Mendelsohn and Neumann, 1999). This is known as the enumerative approach. It is well known and widely documented in the literature that this method ignores potentially significant "horizontal interlink ages", that is, the interaction of sectoral impacts such as the connection between agriculture (where irrigation needs may go up) and water (where supply may decrease). Less well documented is the fact that the enumerative approach also neglects dynamic inter linkages. Enumerative studies are concerned with only one time period and ask how the climate observed in that period affects social welfare at that particular point in time. In doing so, they ignore intertemporal effects and fail to provide information on how climate change may affect welfare in the longer term. This paper seeks to close this gap by exploring, both theoretically and numerically, the dynamic effects that link climate change and economic growth.

The main dynamic effect is via *capital accumulation.* If we assume a constant savings rate, the amount of investment in an economy will be reduced if climate change has a negative impact on output (and vice versa if impacts are positive). Over the longer term this will lead to a reduction in the capital stock, a lower GDP and, in most cases, lower consumption per capita. In an endogenous growth context, this capital accumulation effect may be exacerbated if lower investment also slows down technical progress and improvements in labour productivity or human capital accumulation. A second dynamic effect has to do with *savings*. In a world with perfect foresight we can expect forward-looking agents to change their savings behavior in anticipation of future climate change. This, too, will affect the accumulation of capital and hence growth and future GDP. It is unclear, a priori, whether this savings effect will be positive or negative. On the one hand, savings rates may go up because agents wish to compensate for the shortfall in future income. On the other hand, climate change reduces the productivity of capital and, faced with a lower rate of return, agents may prefer to invest less and consume more today.

Integrated assessment models with an economic foundation (e.g., Nordhaus, 1994; Peck and Teisberg, 1992; Tol, 1999) usually incorporate the capital accumulation effect and sometimes the savings effect because their design is based on neo-classical growth theory. But they do not normally separate the dynamic effects explicitly. (Fankhauser, Samuel and Richard S.J.Tol, 2005)

Model and Data:

In this section we develop the empirical framework for the analysis of climate change performance. Our empirical framework follows the derivation in Dell *et al*. (2007). To fix ideas, consider the following economy with a simple Cobb Douglas production function:

$$Y_{it} = A_{it} K_{it}^{\beta_1} L_{it}^{\beta_2} CCPI_{it}^{\beta_3} OPEN_{it}^{\beta_4} FDI_{it}^{\beta_5} INDUST_{it}^{\beta_6} GS_{it}^{\beta_7}$$

The model can be rewritten as follows:

$$\begin{aligned} LnY_{it} = \alpha + \beta_1 LnK_{it} + \beta_2 LnL_{it} + \beta_3 LnCCPI_{it} + \beta_4 LnOPEN_{it} \\ + \beta_5 LnFDI_{it} + \beta_6 LnINDUST_{it} + \beta_7 LnGS_{it} + \varepsilon_{it} \end{aligned}$$

$$i = 1,2,\ldots,N$$
$$t = 1,2,\ldots,T$$
$$\beta_1 > 0, \beta_2 > 0, \beta_3 > 0, \beta_4 > 0, \beta_5 > 0, \beta_6 > 0, \beta_7 < 0$$

Y represents gross domestic product per capita.
K is gross fixed capital formation
L measures labor force
CCPI is the Climate Change Performance Index
OPEN: ratio of trade (imports + exports) to GDP as the measure of trade-openness.
FDI is Foreign Direct Investment (net outflows + net inflows) as share of GDP
INDUST: Industry value added (% of GDP) as Industrialization.
GS is Government Size that is represented by the share of government consumption in GDP
We used overall CCPI data from Germanwatch website and other variable from WDI.

Empirical Results:

In this paper, we use panel data model and for choosing between OLS the pooled model, Fixed Effects (FE) and Random Effects (RE) employ Chow, Lagrange Multiplier (LM) (by Breusch-Pagan) and Hausman tests (For more details about panel technique and the related tests, see Baltagi, 2005 , Hsiao, 2005 and Gujarati, 2004) by Stata 9.1 and Eviews 7.

Table 3 presents Chow, Lagrange Multiplier and Hausman tests for model.

Table 3: Chow, Lagrange Multiplier and Hausman Tests

Test	Test-Statistic	P-value	Result
Chow	62.61	0.0000	FE
LM	38.20	0.0000	RE
Hausman	00.00	1.0000	RE

Based on result of table 3, model is RE and the results of random effects panel data model are presented in table 4.

Table 4: Results of Estimation of Model

Depended Variable: Gross Domestic Product Per Capita

$$LnY_{it} = \alpha + \beta_1 LnK_{it} + \beta_2 LnL_{it} + \beta_3 LnCCPI_{it} + \beta_4 LnOPEN_{it} + \beta_5 LnFDI_{it} + \beta_6 LnINDUST_{it} + \beta_7 LnGS_{it} + \varepsilon_{it}$$

Independent Variable	Coefficient	t-Statistic	Prob.
K	0.167549	2.830598	0.0056
L	0.335874	2.413015	0.0176
CCPI	0.077263	0.144046	0.0857
OPEN	-0.001838	1.772409	0.8892
FDI	0.347789	2.778014	0.0065
INDUST	0.364559	12.81276	0.0000
GS	-0.114400	-6.840915	0.0000
C	30.17204	5.090755	0.0000
F	4.15		
P-value	0.0004		
R^2	0.2170		
Adjusted R^2	0.1648		

Results of table 4 show that according to the theoretical priors, the coefficients of K and L are positive and statistically significant with the expected signs. The coefficient of the Climate Change Performance Index (CCPI) is positive and statistically significant with the expected signs.

Also, we find that the coefficients of industrialization and foreign direct investment are positive and significant. The coefficient of openness and government size are negative but openness is statistically insignificant.

Conclusion:

In this paper, we estimated the relationship between Climate Change Performance Index and economic growth for 56 countries. The results regarding the estimated panel regression analysis during 2008-2010 show that more the climate protection performance has a positive effect on economic growth and encourage this.

However, the latest data shows an alarming trend towards a massive increase in CO_2 emissions. The global financial crisis in 2009 put only a minor dent in the continuously rising emission trend. It is especially worrying that the global trend towards more coal has not been stopped. On the other hand we see encouraging efforts in the expansion of renewable energies. These efforts have to be pushed and combined with strong energy efficiency measures in all countries.

Hence, result suggests that while conventional policies in developed and developing countries focus more on pollution control, they need to be combined with policy options focusing on eco-efficiency in the process of economic development.

References

Baltagi, H.B., 2005. "Econometric Analysis of panel Data". Johnwiley and Sonc, Third Edation. *Change Part A* 14(3): 259-272.

Cline, W.R., 1992. The Economics of Global Warming", Institute for International Economics, Washington, DC.

Dell, Melissa and Benjamin F. Jones and Benjamin A. Olken, 2008. “Climate Change and Economic Growth: Evidence from the Last Half Century”, NBER (National Bureau of Economic Research) Working Paper Series, No. 14132.

Fankhauser, S., 1995. Valuing Climate Change. The Economics of the Greenhouse. Earthscan, London.

Fankhauser, Samuel and Richard S.J. Tol, 2005. “On Climate Change and Economic Growth”, Resource and Energy Economics, 17: 1-17.

Grossman, Gene M. and Alan B. Krueger, 1995. “Economic Growth and the Environment”, Quarterly Journal of Economics. CX(2): 353-77.

Gujarati, D.N., 2004. Basic Econometrics. Forth Edition, McGraw-hill.

Harbaugh, W., A. Levinson and D.M. Wilson, 2002. “Reexamining the empirical evidence for an environmental Kuznets curves”, Review of Economics and Statistics., 84(3): 541-551.

Hsiao, 2005. Analysis of panel Data. Cambridge University Press, Second Edition.

Glob. J. Biodivers. Sci. Manag., 2(1): 54-59, 2012

IPCC., 2007. Climate Change 2007: Impacts, Adaptation and Vulnerability. M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. van der Linden and C. E. Hanson, eds. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press.

Jafari Samimi, A., S. Ghaderi and M. Ahmadpour, 2011. “Environmental Sustainability and Economic Growth: Evidence from Some Developing Countries”, Advances in Environmental Biology, 8(4): 961-966.

Mendelsohn R., *et al*., 2006. “The Distributional Impact of Climate Change on Rich and Poor Countries”, *Environment and Development Economics.*, 11(2): 159-178.

Mendelsohn, R. and M. Schlesinger, 1999. “Climate-response functions”. *Ambio* 28(4): 362-366.

Mendelsohn, R.O., J.E. Neumann, (Eds.), 1999. “The Impact of Climate Change on the United States Economy”. Cambridge University Press, Cambridge.

Mendelsohn, Robert, 2009. “Climate Change and Economic Growth”, Commission on Growth and Development, World Bank, Working, pp: 60.

Millner, Antony and Simon Dietz, 2011. “Adaptation to Climate Change and Economic Growth in Developing Countries”, Centre for Climate Change Economics and Policy, Working pp: 69.

Nordhaus, W.D., 1991. “To slow or not to slow: the economics of the greenhouse effect”, Economic Journal, 101: 920-937.

Nordhaus, W.D., 1994. Managing the Global Commons: the Economics of Climate Change. The MIT Press, Cambridge.

Palmer, K., W. Oates, and P. Portney, 1995. “Tightening environmental standards: The benefit-cost or the no-cost paradigm?” Journal of Economic Perspectives., 9: 119-132.

Peck, S.C., T.J. Teisberg, 1992. “CETA: a model for carbon emissions trajectory assessment”. Energy Journal, 13(1): 55-77.

Porter, M. and C. van der Linde, 1995. “Toward a new conception of the environment competitiveness relationship”, Journal of Economic Perspectives., 9: 97-118.

Smith, J.B., H.-J. Schellnhuber, M.Q. Mirza, E. Lin, S. Fankhauser, R. Leemans, L. Ogallo, R.G. Richels, U. Safriel, R.S.J. Tol, J.P. eyant, G.W. Yohe, 2001. “Vulnerability to climate change and reasons for concern: a synthesis. In: IPCC (Ed.), Climate Change 2001: Impacts, Adaptation and Vulnerability”. Contribution of Working Group II to the Third Assessment Report. Cambridge University Press, Cambridge.

Solomon S., *et al*., 2009. “Irreversible climate change due to carbon dioxide emissions”. Proceedings of the National Academy of Sciences, 106(6): 1704-1709.

Stern, N., 2007. *The Economics of Climate Change: The Stern Review*. Cambridge: Cambridge University Press.

Thurlow, James and Tingju Zhu and Xinshen Diao, 2009. “Climate Change, Economic Growth and Poverty in Zambia”, International Food Policy Research Institute (IFPRI), working Paper, NO. 890.

Tiro, Wendel, and Klaus Milke, 2011. “Climate Change and Performance Index” Germanwatch (updated yearly), www.germanwatch.org/ccpi

Tol, R.S.J., 1999. “The marginal damage costs of greenhouse gas emissions”. The Energy Journal, 20(1): 61-81.

Tol, R.S.J., *et al*. 2004. ‘Distributional aspects of climate change impacts”. *Global Environmental*

Tol, R.S.J., S. Fankhauser, R.G. Richels, J.B. Smith, 2000. “How much damage will climate change do? Recent estimates”. World Economics., 1(4): 179-206.

Wood, Duncan, 2010. “Environment, Development and Growth: U.S.-Mexico Cooperation in Renewable Energies”, Woodrow Wilson International Center for Scholars, Working Paper, No.15.

World Bank, 2011. World Development Indicators CD-ROM 2011, Washington, DC.

Xepapadeas, A. and A. de Zeeuw, 1999. “Environmental policy and competitiveness: The Porter hypothesis and the composition of capital”, Journal of Environmental Economics Management., 37: 165-182.