An Empirical Study on the Interrelationship between Trade Openness and Carbon Emission in Bangladesh

Mohammad Zillur Rahman*

Abstract

This study attempts to test empirically the causality between trade openness and carbon dioxide emission in Bangladesh, applying time-series econometric techniques covering 1972-2007 period. The author tests this interrelationship in a Vector Autoregressive (VAR) framework followed by Granger causality, variance decomposition and impulse response function, to find the plausible causal relationship, direction of causality and the likely impact of one variable on the other. The VAR was tested for its stability also. The study finds inconclusive causal relationship from the Granger causality analysis. But variance decomposition and impulse response function derived through the stable unrestricted VAR model resulted in significant impact of trade liberalization on carbon emission but not vice versa. This study is important for policy makers of Bangladesh and the countries alike.

Keywords: Causality, vector autoregressive, trade openness, CO_2 emission

Introduction

Global warming and mitigation of greenhouse gases, of which carbon dioxide (hereafter CO_2) is the most significant one, are presently the major issues of international concern. It has put CO_2 emission into the energy policy spotlight. It poses a terrible threat of scientific and economic uncertainties affecting the globe for decades or even for centuries (Nordhaus, 2007).

China, the fastest growing economy of the world, has been largely emitting greenhouse gases to spur its growth. By 2050, China, the USA, India, the EU will generate 25%, 14%, 12% and 9% of total global carbon emission respectively (Haksworth, Price water house coopers; 2006). According to the Energy Information Administration (EIA), under a 'business as usual' (BAU) scenario, from 2004 until 2030, the global emissions rate will grow 37% i.e. about 1.8% annually and for China it will be 3.4% per year- nearly double the global average(Energy Outlook, 2007). The EIA estimates suggest that 850 coal power plants to be built by China, India and USA between 2004 and 2012 will put more than five times as much carbon dioxide into the atmosphere as the Kyoto Protocol aims to reduce.

* *Associate Professor, Institute of Modern Languages, Dhaka University.*

On the Bangladesh front, the global warming phenomenon is of special concern since this country is said to be the most vulnerable one to this problem. Intergovernmental Panel on Climate Change (IPCC), in its Fourth Assessment report, has mentioned that between 1985 and 1998 average temperature rise in Bangladesh in May and November have been 1^0C and 0.5^0C respectively. IPCC also states that changing climate and its adverse effects on demand, supply and water quality have further worsened water shortages in Bangladesh resulting from population growth, rapid and unplanned urbanization and industrialization. Bangladesh has experienced more than 90 major disasters between 1991 and 2000 having losses of around 200,000 lives, and USD5.9 billion worth of losses in agriculture and infrastructure(Sep 2007,DoE, GOB**).** Due to climate change, a sea level rise of 0.5 meter over the last 100 years has already eroded 65 percent landmass of 250 sq. kilometers of Kutubdia, 227 sq.km. of Bhola and 180 sq.km. of Sandwip islands(Sep 2007,CDMP,GOB). Scientists of the country have assessed that the coastal area has already experienced coastal inundation and erosion, saline intrusion, deforestation, loss of bio-diversity and agriculture and large scale in-country migration. Reaching Millennium Development Goals (MDGs) for Bangladesh that include eliminating extreme poverty and hunger by 2015 is also threatened by effects of climate change (Sep 2007,CDMP,GOB). According to the OECD and the World Bank estimates, 40% of overseas development assistance (ODA) to Bangladesh is climate sensitive. Analyzing the causes of CO_2 emission and ways to address those are important for this nation also at this critical juncture.

The Factor-proportions (Hecksher-Ohlin) trade theory suggests that, under free trade, developing countries, endowed with cheaper labor and natural resources would specialize in the production of goods intense in these inputs. And the developed nations would specialize in products with high intensity of human as well as manufactured capital.

As a populous nation, Bangladesh is home to cheap labor drawing attention of various global firms for producing final products as well as processing semi-finished goods for the foreign markets. Also due to increase in purchasing power on a regular basis, Bangladesh is destination for many imported finished goods and also input materials and intermediary goods are imported for the need of local industries. The following table represents the growing international trade pattern of Bangladesh in terms of trade openness. Trade openness rose fast from 29.16 percent in FY1998-99 to 42.22 percent in FY2006-07 according to Bangladesh government data.

Table 1: Trade openness of different fiscal years

Financial year	Trade openness
2000-01	33.63
2001-02	30.54
2002-03	31.22
2003-04	32.76
2004-05	36.11
2005-06	38.90
2006-07	42.22

Source: Bangladesh Bank and Ministry of Commerce, Government of Bangladesh

Following Chinese growth as a global manufacturing powerhouse along with its level of carbon emission, as is also evident in the next section of this paper, and the context of Bangladesh, already discussed above, may justify evolving academic interest in researching the interplay between trade openness and carbon emission with a view to finding the plausible causality in an empirical manner.

Objective of the study

This paper aims at studying whether any of trade openness and CO_2 emission causes the other and if so how greater is the effect of one on the other. The author also aims at making policy suggestions for Bangladesh based on findings of econometric analysis.

Literature Review

Researchers have been working on energy consumption-economic growth, carbon emission-trade and also energy consumption-trade openness and carbon emission-trade openness and of course electricity consumption and economic growth relationships for quite sometime now and the reason is evident in the initial discussion of this paper. Hence, in this section the review will cover researches on the above-mentioned relationships considering the similarity in the core areas of those studies.

The empirical studies have so far found all four types of causality namely, no causality, uni-directional causality from energy to growth and vice-versa and bidirectional causality taking data from various economies covering different time-periods. And also the modified Kuznets (1955) curve considering per capita income growth and environmental degradation, known as environmental Kuznets curve (EKC) has been tested in different countries covering various time-period with findings of various kinds both in favor of and against the EKC. The first empirical work in analyzing trade-environment nexus, assuming negative effect of trade on environment, was carried out by Grossman and Krueger (1993). Grossman and Krueger (1995) divide the environmental outcome of NAFTA into three effects, namely the scale effect, the composition effect and the technique effect, and such a division has been widely used in empirical studies

on the trade– environment nexus. Findings of numerous researchers in this area have not been consistent and have been attributed by Chen et al. (2007) to variations in countries' characteristics such as different indigenous energy supplies, political and economic histories, cultures, and different institutional arrangements. The developed countries do not exhibit causality between energy and level of economic prosperity as evident in the studies of Akarca and Long (1980), Yu and Hwang (1984), Stern (1993), and Cheng (1995). Fatai et al. (2002), Yu and Choi 1985), (Erol and Yu, 1988) covering the USA, the UK, New Zealand and France. Studies on Argentina (Soytas and Sari, 2003), South Korea (Masih and Masih,1997), Glasure (2002), Cyprus (Zachariadis and Pashourtidou 2007), Japan (Erol and Yu, 1988), Malawi (Jumbe 2004), and Pakistan (Masih and Masih 1996), the Philippines and Thailand (Asafu-Adjaye, 2000) have found bidirectional causality between energy and economic growth. The nature of this phenomenon in Bangladesh has not been studied much. But Mozumder and Marathe (2007) tried to put light in this regard taking Bangladeshi data. They have found the causality to run from per capita GDP to per capita electricity consumption covering 25 years' data. In another study on Bangladesh, Hye and Mashkoor (2010) obtain positive bidirectional causality between economic growth and energy consumption covering 1971-2008 data. For India Ghosh (2009) finds similar result.

Wyckoff and Roop (1994) estimates that 13% of the total carbon emissions of the six largest OECD countries are embodied in their imported manufactured goods, which is further supported by Mongelli et al. (2006). CO2, the main Green House Gas (GHG), alone accounts for about 72% of the global warming effects and researches have been conducted to find CO_2 emissions embodied in international trade (Yunfeng and Laike, 2010). It is well known today that through the globalized trading framework, the movement of goods takes place among the economies either for consumption or for further processing and pollution across nations is thus generated in this process. Frankel (2008) thus argues that relocation of production across nations increases global greenhouse burden.

Effects of trade on environments have been subjects of various theoretical models already. Copeland and Taylor (1994,1995) using their North-South trade model have shown that free trade improves the developed countries' environment as these countries import certain products from the developing world which exacerbates environment of the latter. In case of China, it is observed that developed countries transferred their pollution-intensive industry to China considering labor costs, marketing, environmental regulation and other factors (Yunfeng and Laike, 2010). Adamowicz and McCarney (2005) also revealed that richer economies better protect their environment from pollution (like CO_2 emission) at the cost of environmental degradation of their poorer counter parts (exporters).

Some authors have not found trade openness to be bad altogether in deteriorating environment. For example, Taskin and Zaim (2000) find that at the initial stage of

economic growth trade liberalization pollutes environment and as it achieves a certain level of development it starts consuming environmental goods. Antweiler et al. (2001), investigating SO_2 concentrations resulting from trade openness, also yielded the good effects of trade openness on the environment. On the other hand, Frankel and Rose's (2005) study finds support for environmental Kuznets curve stating trade's contribution to generate CO_2. Study on China, Japan and Korea by Choi et al (2010) reveals that for Korea, trade openness ultimately directed towards more concern for environmental protection due to increased standard of living resulting from economic growth. And China also represents a typical developing economy, as found in the aforesaid paper, that in the stage of economic growth it is not much concerned about pollution, since it focuses more on fast growth capitalizing on cheap labor and there by worsening its environment. For Japan, Choi et al (2010) found positive relationship between trade openness and CO_2 emission.

Very recently Paul and Uddin (2010), working on output and energy consumption, found that output growth does not increase rather decrease energy consumption in Bangladesh and praised its performance in achieving energy efficiency as were also found by few others.

Data and methodology

In this study, international trade is represented by trade openness measured as ratio of export and import to gross domestic product, all in real values from World Development Indicators (WDI) database. And data on carbon emission (metric tons per capita) is sourced from the same database. The period covered is between 1972 and 2007 due to availability from the source.

At first, the data have undergone logarithmic transformation to compress the scale of measurement. To check for the unit roots in both series, as is done to analyze time-series data, the argument made by Perron (1989) has been duly considered and both the series have been detrended first assuming those to be TSP (trend stationary processes) in stead of DSP(difference stationary processes). After detrending, both the series are found to be stationary and integrated of order one i.e. I(0), using both Augmented Dickey-Fuller (ADF) test (Dickey-Fuller, 1979,1981)

and Phillips-Perron test (Phillips and Perron, 1988). To test the unit roots, two specifications with such tests namely; neither intercept nor trend and an intercept, are used, because the series have already been detrended.

Since there is uncertainty about level of interdependence between carbon emission and trade openness, the vector autoregressive (VAR) is probably an appropriate model to test the interrelationship between these variables. It is well known that VAR treats the variables to be in symmetry, so the issue of their interdependence needs not be considered.

Result and discussion

The correlation finds coefficient of these variables to be -0.234. Even though the coefficient is negative, the p-value is 0.69 and it is insignificant. And prior to running both the series in a VAR model, Granger causality tests are run to test the direction of causality between trade openness and carbon emission. The F-statistics and corresponding p-values up to 4 lags are presented in the following table.

Table 2: Granger Causality Tests Of Trade Openness And Co_2 Residuals: 1972-2007

Null hypotheses	Lag 1	Lag 2	Lag 3	Lag 4
Trade openness residuals don't cause CO_2 residuals				
F-statistics	0.51641	1.37824	2.24789	1.59643
p-values	0.47759	0.26804	0.10651	0.20905
CO_2 residuals don't cause Trade openness residuals				
F-statistics	0.60034	0.60870	0.54578	0.77881
p-values	0.44414	0.55086	0.65537	0.55039

It can be seen from the table that only at lag 3 the F-statistics is significant (10%) pointing towards the unidirectional causality running from trade openness to carbon emission.

The next step is to determine the order of variables in VAR estimation and also to select the lag order, as VAR estimates are sensitive to these two factors (Paul & Uddin, 2010), and run both the series in VAR model. Sims (1980) recommends trying different orderings and Evans (1989) also changes the prior variable in the VAR while analyzing interplay between output growth and unemployment rate, and this process is followed in this paper also.

In selecting order of lag, based on Schwartz Bayesian Criterion (SBC) and Hannan-Quinn information criterion, one lag is taken to estimate VAR. The VAR (1) model is found to be stable as no roots of the polynomial in the VAR estimation lie outside the unit circle.

The variance decomposition analysis of both trade openness residuals and CO_2 residuals reveals that the most important sources of variation in these variables are their own innovations. For example, innovations in CO_2 residuals explain more than 99% (upto100% in period 1) of its forecast error variance. And in case of trade openness residuals, innovations in the variable itself explain more than 98% of its forecast error variance. Detail on this analysis is not presented to conserve space.

Then impulse response functions have been deployed to uncover more information, like how a one-standard deviation impulse in the innovation of one variable will determine the response path of the other variable. In this paper, generalized impulse response

analysis is applied which is invariant to the ordering of variables in the VAR (Pesaran and Shin, 1998).

LCR2 and LTR2 in the following figures denote logged series of CO_2 residuals and trade openness residuals respectively.

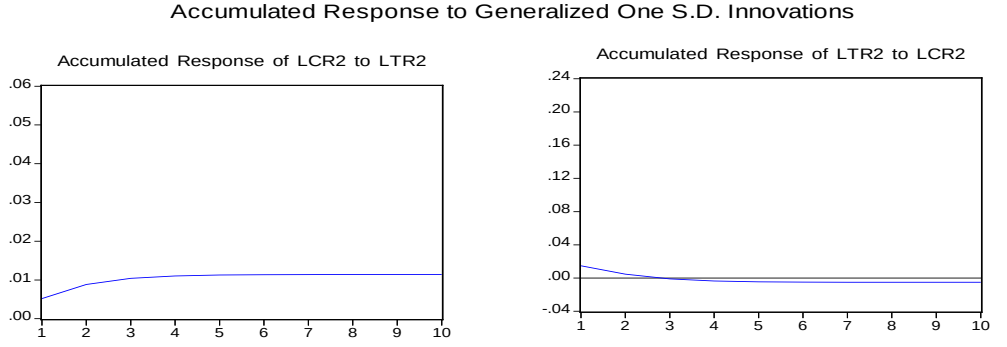

Figure 1A: Impulse response function { VAR(1)}

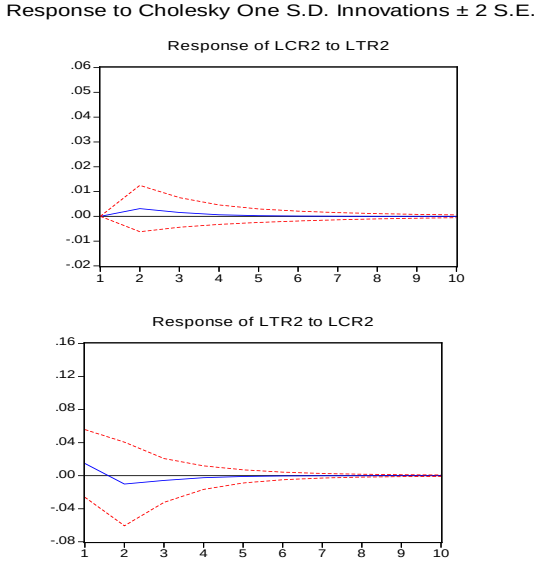

Figure 1B: Impulse response function

Of the two figures above, figure 1A depicts the accumulated responses of trade openness residuals to CO_2 residuals in the right panel and the CO_2 residuals responses to trade openness residuals in the left one. The response of CO_2 residuals seems to be slightly significant to trade openness residuals since the beginning of the study period and

increasing gradually it dies off after 3 years. On the other hand, trade openness is not significantly responding to CO_2 since the initiation and by three years, innovation in CO_2 does not result in response of the other.

The other figure shows that trade openness has significant positive impact on carbon emission from period one and increases up to second period before starting to decline and dies off immediately in the fourth period. Compared to that the innovation in CO_2 has slight impact on trade openness initially before dying off even before the completion of the first year of observation. It can be said from this analysis that trade openness may have impact on carbon dioxide emission but it is not the other way round.

Policy implication

Trade has a positive effect on the environment (and perhaps a net welfare benefit more broadly) only if environmental policy advances alongside trade liberalization (Anderson, 1992, 1998; Esty, 1994). However, institutional failures in the environmental realm often mean that the requisite strengthening of environmental performance in parallel with trade liberalization may not occur (Chichilnisky, 1994; Zhao, 2000). Again Frankel and Rose(2005) opine that this purely global externality needs regulation at multinational levels.

As evident in the literature that economic growth for many developing nations has come at the cost of environment, Bangladesh should build capacity and develop skills in trading environment-friendly goods and there by achieve economic development and also keep watch on environmental well-being at the same time. The carbon emission data of Bangladesh (CDIAL data, 2010) reveals that gas and liquid fuel consumption cause significant CO_2 emission among the variables responsible for this effect. So reducing dependence on these sources of energy, Bangladesh needs to look for alternative sources of energy, such as thermal energy and other renewable energy to further reduce the effect of global warming in Bangladesh. And volume of trade in such goods and services that emit CO_2 should be reduced to avert the possible environmental pollution from international trade. This country should always keep in mind the vulnerability to environmental pollution and devise growth programs being concerned with ways towards fast and sustainable development.

Bangladesh needs concerted efforts from people from all walks of life including academics, professional experts dealing with relevant issues, administrators and managers for effective management of adaptation and mitigation programs undertaken by government and above all a mass awareness needs to be generated to face the challenges of global warming, in which, it is an innocent victim with 145 kilograms of annual carbon emission (one of the lowest per capita in the world).

Conclusion

Expecting possible addition to the existing literature of trade and environmental degradation nexus, in this paper, the author empirically studies the relationship between trade openness and carbon dioxide emission. Researchers have found that the developing economies are more vulnerable than their developed counter parts to the global warming phenomenon also due to manufacturing products for the latter taking advantage of poor or lack of regulations for environmental protection on the part of those developing nations (Smarzynska and Wei, 2005).

And the composition effect of trade on environment will shift production between environmentally beneficial or damaging goods, depending on the competitive advantages enjoyed by the MNCs (multinationational companies) between trading partners (McCarney and Adamowicz, 2005).

To find the potential interrelationships between trade openness and CO2 emission, initially the author has checked the order of integration using stationarity tests, and then the relationship between these variables are tested in the VAR (vector autoregressive) framework to avoid the direction of interdependence between them. Then Granger causality is tested but the direction of causality between the two is not conclusively identified. The variance decomposition finds that each variable explains innovation by its own variance. However, further employing impulse response function to check for effect of innovation in one variable on the other, the study reveals that trade openness significantly enhances the growth of CO2 emission initially and continues for up to three years. But carbon emission does not significantly influence trade openness though it has effect on trade openness. The variance decomposition reveals that the respective variables are mostly explained by the variables themselves.

The relationship between the variables studied in this paper can further be tested covering more periods of data and also considering other variables in a multivariate framework to make the findings more conclusive.

References:

Akarca, A.T., Long, T.V., 1980. On The Relationship Between Energy And GNP: A Reexamination. Journal Of Energy And Development 5, pp. 326–331.

Anderson, Kym And Richard Blackhurst. 1992. Trade , The Environment And Public Policy, The Greening Of World Trade Issues. Kym Anderson And Richard Blackhurst, Eds, Ann Arbor; University Of Michigan Press, pp. 3-18.

Antweiler, W., B.R. Copeland And M.S. Taylor. 2001. Is Free Trade Good For The Environment? *The American Economic Review* 91(4): , pp. 877-908.

Asafu-Adjaye, J., 2000. The Relationship Between Energy Consumption, Energy Prices And Economic Growth; Time Series Evidence From Asian Developing Countries. Energy Economics 22, pp. 615–625.

Chen, S.-T., Kuo, H.-I., Chen, C.-C., 2007. The Relationship Between GDP And Electricity Consumption In 10 Asian Countries. Energy Policy 35, pp. 2611–2621.

Chichilnisky, Graciela. 1994. North-South Trade And The Global Environment. American Economic Review. 84(5) , pp. 851-75

Chien, Taichen And Hu, Jin-Li, (2008), Renewable Energy: An Efficient Mechanism To Improve GDP, Energy Policy, 36, pp. 3045-3052.

Choi, E., Heshmati, A., Cho, Y., 2010. An Empirical Study Of The Relationships Between CO2 Emissions, Economic Growth And Openness. IZA DP No. 5304, Discussion Paper Series, pp.

Dickey, D., Fuller, W.A., 1981. Likelihood Ratio Statistics For Autoregressive Time Series With A Unit Root. Econometrica 49, pp. 1057–1072.

Dickey, D., Fuller, W.A., 1979. Distribution Of The Estimates For Autoregressive Time, pp.

Series With A Unit Root. Journal Of The American Statistical Association 74, pp. 427–431.

Erol, U., Yu, E.S.H., 1988. On The Causal Relationship Between Energy And Income For Industrialized Countries. Journal Of Energy Development 13, pp. 113–122.

Esty,C.,Daniel, 2001. Bridging The Trade-Environment Divide. The Journal Of Economic Perspectives 15(3):, pp. 113-130.

Fatai, K., Oxley, L., Scrimgeour, F., 2002. Energy Consumption And Employment In NewZealand: Searching For Causality. Paper Presented At NZAE Conference, Wellington, pp. 26–28. June 2002.

Frankel, Je¤Rey A., 2008, .Global Environmental Policy And Global Trade Policy, For The Harvard Project On International Climate Agreements, pp.

Frankel, Je¤Rey A., And Andrew K. Rose, 2005, .Is Trade Good Or Bad For The Environment? , pp.

G. Mccarney And W. Adamowicz, 2005. The Effects Of Trade Liberalization On The Environment: An Empirical Study.Paper Presented The Canadian Agricultural Economics Society Annual Meeting, San Francisco**,** California, July 6-8, 2005, pp.

Glasure, Y.U., 2002. Energy And National Income In Korea: Further Evidence On The Role Of Omitted Variables. Energy Economics 24, pp. 355–365.

Ghosh, S., 2009. Electricity Supply, Employment And Real GDP In India: Evidence From Cointegration And Granger-Causality Tests. Energy Policy 37 (8), pp. 2926–2929.

Grossman, G.M. And A.B. Krueger. 1993**.** Environmental Impacts Of A North American Free Trade Agreement. The Mexico-U.S. Free Trade Agreement, Edited By P. Garber.Cambridge, MA: MIT Press, pp.

Grossman, G.M. And A.B. Krueger. 1995**.** Economic Growth And The Environment. The Quarterly Journal Of Economic*s* 110(2): , pp. 353-377.

Jumbe, C.B.L., 2004. Cointegration And Causality Between Electricity Consumption And GDP: Empirical Evidence From Malawi. Energy Economics 26, pp. 61–68.

Kuznets, S., 1955. Economic Growth And Income Inequality. American Economic Review 45, pp. 1–28.

Masih, A.M.M., Masih, R., 1997. On Temporal Causal Relationship Between Energy Consumption, Real Income And Prices; Some New Evidence From Asian Energy Dependent Nics Based On A Multivariate Cointegration/Vector Error Correction Approach. Journal Of Policy Modeling 19, pp. 417–440.

Mongelli, I., Tassielli, G., 2006. Global Warming Agreements, International Trade And Energy/Carbon Embodiments: An Input–Output Approach To The Italian Case. Energy Policy 34, 88–100.

Mozumder, P., Marathe, A., 2007. Causality Relationship Between Electricity Consumption And GDP In Bangladesh. Energy Policy 35, 395–402.

Nordhaus, W.(2007) The Challenge Of Global Warming: Economic Models And Environmental Policy.

Paul, B.P., Uddin, G.S., (2010)Energy And Output Dynamics In Bangladesh, Energy Econ,

Pesaran, H.H., Shin, Y., 1998. Generalized Impulse Response Analysis In Linear

Multivariate Models. Economic Letters 58, pp. 17–29.

Smarzynska-Javorcik, Beata, And Shang-Jinwei, 2005, .Pollution Havens And Foreign Direct Investment: Dirty Secret Or Popular Myth?. Contributions To Economic Analysis & Policy, Berkeley Electronic Press, 3:2, pp. 1244-1244.

Soytas, U., Sari, R., 2006b. Can China Contribute More To The Fight Against Global Warming?. Journal Of Policy Modeling 28 (8) , pp. 837–846.

Stern, D. (1993). Energy And Economic Growth In The USA, A Multivariate Approach. Energy Economics 15:, pp. 137-150.

Wyckoff, A.W., Roop, J.M., 1994. The Embodiment Of Carbon In Imports Of Manufactured Products. Energy Policy 22, pp. 187–194.

Yan Yunfeng, Yang Laike, 2010. China's Foreign Trade And Climate Change: A Case Study Of CO2 Emissions. Energy Policy 38, pp. 350-356.

Yu, E.S.H. And Hwang, B.K., 1984. The Relationship Between Energy And Economic Growth In Korea. Applied Energy 83, pp. 1181-1189.

Yu, E.S.H., Choi, J.Y., 1985. The Causal Relationship Between Energy And GNP: An International Comparison. Journal Of Energy Development 10, pp. 249–272.

Zachariadis, T., Pashourtidou, N., 2007. An Empirical Analysis Of Electricity Consumption In Cyprus. Energy Economics 29, pp. 183–198.

Zhao, J. 2000. Trade And Environmental Distortions: Coordinated Intervention, Environmental And Development Economics, 5(4), pp. 361-76.

Climate Change And Bangladesh, 2007: Climate Change Cell, Department Of Environment, Government Of Bangladesh, pp.

CO_2 emission data of Bangladesh, 2010, Carbon Dioxide Information Analysis Center-http:// cdiac.ornl.gov.

Energy Outlook 2007, Supra Note 10, At 93, pp.

Haksworth,J., Pricewaterhousecoopers, The World In 2050: Implications Of Global Growth For Carbon Emissions And Climate Change Policy 44 Tbl.3.1, pp.

Intergovernmental Policy On Climate Change Working Group I Summary For Policymakers (SPM). Climate Change 2007: Synthesis Report, pp.