The Relationship among Income, Openness and Environmental Quality: An ARDL Approach for the case of Iran

Mohsen Mehrara
Faculty of Economics, University of Tehran, Tehran, Iran
Email: mmehrara@ut.ac.ir

Abbas Rezazadeh Karsalari
Department of Management, Islamic Azad University, Tafresh Branch, Tafresh, Iran
Email: rezazadeh296@yahoo.com

Maysam Musai
Faculty of Social Sciences, University of Tehran
Email: *mousai@ut.ac.ir*

DOI: 10.6007/IJARBSS/v4-i5/821 URL: http://dx.doi.org/10.6007/IJARBSS/v4-i5/821

Abstract
The objective of this paper is to examine the relationship among environment, economic growth and openness in Iran for the period 1970-2011, based on the autoregressive distributed lag (ARDL) approach. The study finds a cointegrating relationship among these variables with co2 emission as dependent variables. The results imply GDP contribute most to long- as well as short-run CO2 emission growth. Estimating error correction model revealed that the speed of adjustment to restore equilibrium is -0.54 which confirms that there is a stable long-run relationship. Regarding weak impact of openness on long run CO2 growth, it seems that foreign trade in Iran stimulated by oil booms play trivial role in domestic energy consumption after controlling the income variable.

Keywords: ARDL, Environment, openness, CO2 emission, Iran Economy

JEL classification: Q00, F1, F18

1. Introduction

The forms of economic globalization have significantly intensified the relationship between economy and ecology in the past few decades. This correlational trend is stressed on a debate between ecologists and economists regarding the effects of economic development upon the environment. In the following quotation from the World Commission on Environment and Development, this ambiguous relation is successfully illustrated: “We have in the past been concerned about the effects of economic growth upon the environment. We are now forced to concern ourselves with the effects of ecological stress upon our economic prospects. We have

in the more recent past been forced to face up to a sharp increase in economic interdependence among nations. The World Development Report (World Bank 1992) offered cross-sectional evidences on the relationship between different indicators of environmental quality and per capita national income across countries. Other studies (Grossman and Krueger, 1991; Selden and Song, 1994; Rothman, 1998; Suri and Chapman, 1998) documented an inverted U-shaped relationship between environmental degradation and income. The common point of all these studies is the assertion that environmental degradation increases initially, reaches a maximum level and after that declines as an economy develops. This systematic inverted-U relationship has been termed as the Environmental Kuznets Curve (EKC) following the work of Kuznets (1955), who postulated a similar relationship between income inequality and economic development. The EKC relates to the issue of the effects of economic growth or development on the environment of a country.

Environmentalists fear that liberalized trade might make it harder for high-standard countries to keep their stringent environmental requirements in the face of market-access demands from trade partners. The essential difficulty lies in separating legitimate environmental standards from protectionist regulations advanced under the guise of environmental protection. Few would argue, for example, that emission-control standards for cars are an unwarranted barrier to trade. However, the fear of protectionism in an environmental disguise is not unfounded and needs to be addressed, particularly if developing countries are to retain confidence in the fairness of the international trade system. The smooth functioning and efficiency of the international economic system cannot be maintained unless there are clear rules of engagement for international commerce, including environmental provisions .

In this paper we examine the short- and long-run relationships between environment, income and openness for Iran over the period 1970-2011, using Autoregressive Distributed Lag (ARDL) approach to cointegration and error correction models (ECM).The rest of the paper is organized as follows. Section 2 describes data and methodology. Results are reported in Section 3. Section 4 concludes

2. Literature Review

Economic and environmental problems display few symbols of improvement for a large share of the world's people but when comes to foreign debt levels, weak export and real GDP, it often arrive a mutually destructive relationship with environmental and resource degradation which linked to the agriculture and urban activity. The important connection between economic and environmental problems can be clearly seen in the widespread social and economic effects towards soil erosion, deforestation, urban congestion, unmanaged chemical such as heavy metals, air pollutants, solid and liquid industrial and residential waste. According to Huber (1982) and Simonis (1989), ecological modernization was one of the primary modes of sustainable development which comprised both a theory and a policy or political programme based on the view that comprehensive political and economic change could be implemented to achieve a less material and energy-intensive economy through the application of integrated and preventive resource and pollution-reduction strategies . Environmental quality could decline through the scale effect as increasing trade volume (especially export) would expand the size of the economy thereby increasing the extent of pollution. Thus, trade might be a cause of

environmental degradation, ceteris paribus. Many economists have long argued that trade is not the root cause of environmental damage (Birdsall and Wheeler 1993, Lee and Roland-Host 1997, Jones et al. 1995). However, free trade has the contradictory effects on environment, both increasing pollution and motivating reductions in it. Antweiler et al. (2001) and Liddle (2001) argue that trade may be good for environment. Trade may improve the environmental quality through technological effect. As income rises through trade, environmental regulation is tightened that spurs pollution reducing innovation. And as trade relates one country with international communities, one underdeveloped economy may rely on technology transfer through foreign direct investment that may reduce pollution.

The effect of developing countries in questions of environmental degradation and economic growth has been on the center stage by critics of free trade. The following quotation is retrieved from the World Commission on Environment and Development, and successfully illustrates this problematic encounter: "Developing countries must operate in a world in which the resources gap between most developing and industrial nations is widening, in which the industrial world dominates in the rule-making of some key international bodies, and in which the industrial world has already used much of the planet's ecological capital. This inequality is the planet's main "environmental" problem; it is also its main "development" problem. Notwithstanding, neoliberal economists argue on the contrary, claiming that environmental degradation is not a by-product of economic growth, rather being a phenomenon directly related to poverty (Lechner and Johni, 2011). Considerations regarding national economic growth and the increase of environmental degradation usually include an illustration of what is known as the environmental Kuznets curve. Elaborated by Simon Kuznets, the curve is a graphic representation predicting that as countries develop and societies become richer, the pollution per unit of production wills reduction. According to this model, environmental degradation will decrease because money becomes available for developing countries to spend on environmental mitigation and because the immediate material needs of societies have been or are being met.

Actually the major argument of neoliberal advocates is that air and water quality can deteriorate in the early stages of industrial production. Pollution such as smog and lead will rise along with economic growth; in fact this occurs because governments focus on increasing industrial growth and national income rather than on pollution controls. Yet, according to neoliberal economists, this is a temporary phenomenon. Once per capita income reaches high levels, pollution begins to fall. This occurs partly because citizens demand better living environments, and partly because firms and governments now have the financial and institutional capacity to respond effectively. Another possible explanation for the model of the Environmental Kuznets Curve is that it works naturally via the composition of output. In theory, the model could result from the usual stages of economic development: the transition from an agrarian economy to manufacturing, and then from manufacturing to services. Services tend to generate less pollution than heavy manufacturing. This explanation is less probably than the conventional view to require the mechanism of effective government regulation. If the Kuznets curve in practice resulted solely from this composition effect, however, then high incomes should lead to a better environment even when externalities arise at the dioxide, for example.

Even though emissions per unit of GDP do tend to fall, this is not enough to reduce overall emissions, in the absence of a multilateral effort.

Many researchers, including Cernat and Vranceanou (2003) and Liang (2006), suggested that environmental quality will be improved by free trade agreements and foreign direct investment because they increase the scale of production and enhance production efficiencies by improving production technologies. Dean (2002) analyzed water pollution in China and found that trade liberalization increased environmental pollution but mitigated this effect through income growth. At the same time, Dean found income and terms of trade to be negatively correlated with pollution emissions. Lucas et al. (1992) showed that among rapidly growing economies trade reduces the growth rate of the toxic intensity of output. This may be a reflection of more rapid introduction of cleaner technology.

3. Data and Methodology

To allow for causality and dynamics and given that not all of our time-series may be stationary to the same order (some are I(0) while others are I(1)), the cointegration technique suggested by Pesaran et al. (2001), the autoregressive distributed lag model (ARDL) procedure will be used. The approach can be implemented regardless of whether the variables are integrated of order (1) or (0) and can be applied to small finite samples. Based on empirical literature and diagnostic tests, the long run relationship between CO2 emission, GDP per capita and openness can be specified as:

$$\ln CO2_t = \beta_0 + \beta_1 \ln GDP_t + \beta_2 \ln OPEN_t + u_t \qquad (1)$$

Where CO2 is Per capita carbon dioxide as a measure of environmental quality, GDP is real GDP per capita and OPEN stand for ratio of the value of total trade to GDP. ε_t is an stationary error term. All variables are expressed in natural logarithm (ln stands for logarithm). The main sources of variables are from World Development Indicators (WDI). The time period of the study is over the years 1970 to 2011.

To examine long run relation among the series we implement ARDL bounds testing approach to cointegration developed by Pesaran et al., (2001). The bounds testing approach has several advantages: it applies irrespective of the order of integration for independent variables, I(0) or I(1); is better suited to small samples; and a dynamic error correction model (ECM) can be derived from the ARDL model through a simple linear reparametrization. The version of error correction model of ARDL approach is given by:

$$\Delta \ln CO2_t = \alpha_0 + \sum_{i=1}^{p} \phi_i \Delta \ln GDP_{t-i} + \sum_{i=0}^{p} \theta_i \Delta \ln OPEN_{t-i} + \delta_1 \ln CO2_{t-1} + \delta_2 \ln GDP_{t-1} + \delta_3 \ln OPEN_{t-1} + \varepsilon_t \qquad (2)$$

Where $\phi \, and \, \theta$ refer to short run and δ_1 to δ_3 to long run parameters. The null hypothesis of no cointegration is H_0: $\delta_1 = \delta_2 = \delta_3 = 0$ against the alternative hypothesis H_1: $\delta_1 \neq \delta_2 \neq \delta_3 \neq 0$. The rejection of the null based on the F-statistic suggests cointegrating relationship. The critical bounds have been tabulated by Pesaran et al. (2001). The upper critical bound (UCB) is based

on the assumption that all series are I(1). The lower bounds (LCB) applies if the series are I(0). If UCB is lower than the calculated F-statistic, the null of cointegration is sustained. If the F-statistic is less than the LCB then there is no cointegration. The decision about cointegration will be inconclusive if the F-statistic lies between UCB and LCB. In such situation, we will have to rely on the lagged error correction term to investigate long run relationship.

The orders of the lags in the specification (2) are selected by the Schwarz Bayesian criterion (SBC). For annual data, Pesaran and Shin (1999) recommended choosing a maximum of 2 lags. From this, the lag length that minimizes SBC is selected.

If a long run relationship exists, the ARDL representation of equation (1) is formulated as follows:

$$\ln CO2_t = \alpha_1 + \sum_{i=1}^{p+1} \phi_{1i} \ln CO2_{t-i} + \sum_{i=0}^{p+1} \rho_{1i} \ln GDP_{t-i} + \sum_{i=0}^{p+1} \theta_{1i} \ln OPEN_{t-i} + \varepsilon_t \qquad (3)$$

The ARDL method estimate $(p+1)^k$,number of regressions in order to obtain the optimal lags for each variable, where p+1 is the maximum number of lags to be used and k is the number of variables in the equation (Shrestha and Chowdhury, 2005). The model is selected based on the Schwartz-Bayesian Criterion (SBC) that use the smallest possible lag length and is therefore described as the parsimonious model.

The ARDL specification of short run dynamics is investigated using ECM version of ARDL model of the following form:

$$\Delta \ln CO2_t = \alpha_2 + \sum_{i=1}^{p} \phi_{2i} \Delta \ln CO2_{t-i} + \sum_{i=1}^{p} \rho_{2i} \Delta \ln GDP_{t-i} + \sum_{i=0}^{p} \theta_{2i} \Delta \ln OPEN_{t-i} + \psi ECM_{t-1} + \varepsilon_t \qquad (4)$$

The lagged residual term (ECM) in equation 4 shows the disequilibrium in long renrelationship (u_t in equation 1).

4. Empirical Results

Pesaran et al. (2001) critical values are based on the assumption that the variables are integrated of order I(0) or I(1). Unit root tests insure that none of the series is integrated of I(2) or higher. Both the augmented Dickey–Fuller (ADF) (1979) and Phillips–Perron (PP) (1988) unit-root tests have been employed for that purpose and the results are summarized in Tables 1. Test for stationarity shows that all variables are integrated of order 1 and thus stationary in difference.

Table 1: Unit Root Test

	ADF test statistic (with trend and intercept)		PP test statistic (with trend and intercept)	
Variables	**Level**	**First Difference**	**Level**	**First Difference**
ln GDP	-1.22	-4.19**	-1.51	-3.92**
ln CO2	-1.15	-4.18**	-1.02	-3.99**
ln OPEN	-2.19	-5.73***	-2.10	-6.88***

Notes: ** and *** denote significantly at 5% and 1% levels respectively. The optimal lag structure is determined by SBC

To investigate the presence of long-run relationships among the variables, testing of the bound under Pesaran, et al. (2001) procedure is used. The results of the bound test are given in Table 2. The critical values used in this paper are extracted from Narayan (2004). The calculated F-statistics is 5.23 while upper critical bound at significance level 1% is 4.83. This implies that there is long run relationship among GDP, INV, oil revenues, labor force and human capital proxy over the period of 1970-2010 in Iran.

Table 2: Bounds Test Results

F-statistics	**Lag**	**Significance Level**	**Bound Critical values**	
			I(0)	I(1)
5.23	2	1%	3.64	4.83
		5%	2.75	3.64
		10%	2.23	3.15

The next stage of the procedure would be to estimate the coefficients of the long-run relations and the associated error correction model (ECM) using the ARDL approach. The optimal lags on variables were selected by the Schwartz Bayesian Criterion (SBC) and turned out to be the ARDL (1, 0, 1). The long-run estimated coefficients are shown in the Table 3. As can be seen, all the coefficients are significant. One percent rise in GDP is expected to increase CO2 by just 1.63 percent. The OPEN contribute much less (0.12) to long-run CO2 growth.

Table 3: Estimated long run coefficients based on ARDL approach

Regressor	**Coefficient**	**p-value**
constant	1.10	0.00
ln GDP	1.63	0.00
ln OPEN	0.12	0.00

The results of error correction model, reported in Table 4. The short-run coefficients are less than the long-run ones. The results suggest that the short-run impact of OPEN on the CO2 are small and insignificant. The coefficient for GDP have the expected sign and is significance. Moreover, the coefficient of the ECM is negative and strongly significant at 1% level. This corroborates the existence of a stable long-run relationship and points to a long-run cointegration relationship among variables. The ECM represents the speed of adjustment to restore equilibrium in the dynamic model following a disturbance. The coefficient of the ECM is around -0.62, implying that a deviation from the long-run equilibrium is corrected by 62% after each year.

The diagnostic tests e.g., Lagrange Multiplier (LM) for serial correlation, ARCH effects, normality of residual terms, white heteroskedasticity and Ramsy RESET for functional form reported in Table 5 suggest that the short-run model passes all diagnostic tests. We find no evidence of serial correlation, autoregressive conditional heteroskedasticity and white heteroskedasticity. The residual terms are normally distributed and the functional form of the model appears well specified.

Table4: Error correction representation for the selected ARDL model

Regressor	Coefficient	p-value
Δln GDP	1.16	0.00
Δln OPEN	0.06	0.12

ECM	-0.62	0.00
Serial Correlation LM = *0.53 (0.82*)		
ARCH Test = *0.35 (0.62*)		
Normality Test = *1.91(0.21)*		
Heteroscedisticity Test = *0.31 (0.81)*		
Ramsey RESET Test = *1.90 (0.29)*		

Notes: The probability values for the diagnostic tests are given in parenthesis

4. Conclusion

This paper has investigated the determinants of CO2 emissions in Iran using annual data for the period 1970-2011 applying autoregressive distribute lag (ARDL) approach. According to the results, we found a cointegration relationship among CO2, GDP per capita and openness. Estimating error correction model revealed that the speed of adjustment to restore equilibrium is -0.62 which confirms that there is a stable long-run relationship. The findings show that GDP would contribute to CO2 growth particularity in long-run, while the openness proxy affected mostly by oil revenues has the least important effect on CO2 in long as well as short- run. So. After controlling GDP, foreign trade contributes least to CO2 emission.

Acknowledgements

The authors would like to acknowledge the financial support of University of Tehran for this research under grant number 4401012/1/26

References

[1] Antweiler, W., B. R. Copeland and M. S. Taylor (2001): "Is Free Trade Good for the Environment?", American Economic Review 91(4), 877 – 908.

[2] Birdsall, N. and Wheeler, D. (1993) Trade policy and industrial pollution in Latin America: where are the pollution havens? Journal of Environment and Development, 2, 137–49.

[3] Cernat. L, Radu V, (2003). "Globalization and development: New evidence from Central and Eastern Europe". Comparative Economics Studies,44(4), 119-136.

[4] Dean, Judith. 2002. "Does trade liberalization harm the environment? a new test" Canadian Journal of Economics, 35(4): 819-842.

[5] Dickey, D., Fuller W., 1979. Distribution of the Estimators for Autoregressive Time Series with a Unit Root, Journal of the American Statistical Association 74, pp. 427-431.

[6] Dickey, D. A., W. A. Fuller, 1981. Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root, Econometrica 49, pp. 1057-1072.

[7] Grossman, G. M. and A. B. Krueger (1991): "Environmental impacts of the North American Free Trade Agreement", NBER working paper 3914.

[8] Huber, J. (1982). Die Verlorene Unschuld der okologie. Neue Technologien und superindustriele Entwicklung. Frankfurt is Main: Fisher Verlag.

[9] Jones, R. G., J. M. Murphy and M. Noguer, 1995: Simulation of climate change over Europe using a nested regional-climate model. I: Assessment of control climate, including sensitivity to location of lateral boundaries. Q. J. R. Meteorol. Soc. 121:1413-1449.

[10] Kuznets, Simon (1955): "Economic Growth and income inequality", American Economic Review 45, 1 – 28.

[11] Lechner, Frank & John Boli, 2011. The Globalization Reader. Oxford: Blackwell Publishing.

[12] Lee, H. and Roland-Host, D. 1997. "The Environment and Welfare Implications of Trade and Tax Policy. " *Journal of Development Economics,* 52:62-85.

[13] Liang, Feng Helen. 2006. "Does foreign direct investment harm the host country environment? Evidence from China". Hass School of Business, UC Berkeley.

[14] Liddle, B. (2001): "Free trade and the environment-development system", Ecological Economics 39, 21 – 36.

[15] Lucas, Robert E.B., David Wheeler, and Hemamala Hettige. 1992. "Economic Development, Environmental Regulation, and the International Migration of Toxic Industrial Pollution: 1960-1988." In P. Low (Ed.), International Trade and the Environment, World Bank discussion paper no. 159.

[16] Narayan, P.K. (2004), "Reformulating critical values for the bounds F-statictics approach to cointegration: an application to the tourism demand model for Fiji", Department of Economics Discussion Papers N0.02/04, Monash University, Melbourne.

[17] Perron, p., 1989. The Great Crash, The Oil Price Shock and The Unit Root Hypothesis, Econometrica 57, pp. 1361-1401.

[18] Pesaran, M. H., & Pesaran B., 1999. Working with Microfit 4.0: Interactive Econometric Analaysis New York: Oxford University Press.

[19] Pesaran, M.H., Shin, Y., & Smith, R.J., 2001. Bounds Testing Approaches to The Analysis of Level Relationships, Journal of Applied Econometrics 16, 289–326.

[20] Phillips, P.C.B., & Perron, P., 1988. Testing for a Unit Root in Time Series Regression, Biometrica 75, 335-46.

[21] Rothman, D. S. (1998): Environmental Kuznets curve- real progress or passing the buck?: A case for consumption-base approaches, Ecological Economics 25, 177-194.

[22] Selden, T. M. and D. Song (1994) "Environmental quality and pop development: Is there a Kuznets curve for air pollution?" Journal of Environmental Economics and Environmental Management, Vol. 27, pp. 147-162.

[23] Shrestha MB, Chowdhury K. 2005. Forthcoming. A Sequential Procedure for Testing Unit Roots in the Presence of Structural Break in Time Series Data: An Application to Nepalese Quarterly Data 1970–2003, International Journal of Applied Econometrics and Quantitative Studies 2.

[24] Simonis, U. (1989). 'Ecological modernization of industrial society: three strategic elements,' International Social Science Journal 121, 347-361.

[25] Suri, V. and D. Chapman (1998): Economic growth, trade and the energy: implications for the environmental Kuznets curve, Ecological Economics 25, 195 – 208.

[26] World Bank (1992): World Development Report 1992, Oxford University Press, New York.