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Vector Autoregressive Analysis of Economic Growth, International Trade and Environment in Iran

Hossein Sharifi-Renani
Department of Economic,
Islamic Azad University of Khorasgan, P.O. Box 81595-158,
Arghavanieh, Khorasgan,
Isfahan, Iran

***Abstract*—A most significant cause of pollution is the diffusion of carbon-dioxide due to industrial production. In the past few decades, the production and export of industrial products which are mostly constituted by pollution-causing goods have enhanced economic growth in various countries. On the other hand, with the increase of national income and an increasing demand for less pollution, certain regulations have been implemented by governments limiting the manufacture and export of industrial products.**

The aim of this study is to determine the relation between economic growth, international trade and environmental regulations in Iran during the period 1990Q1-2006Q4. Therefore, using the vector Autoregressive approach, the effects of each of these elements in relation to the others was systematically studied. Results showed that economic growth has enhanced carbon-dioxide diffusion, whereas export has not had any effect. It was also determined that environmental regulations induced a decrease in production, export and carbon-dioxide diffusion with the effect on Co2 diffusion being negligible. It can, therefore, be concluded that in Iran the income resulting from economic growth and exports and the implementation of environmental regulations has not been effective in terms of a significant decrease in the pollution of the environment.

Keywords- Carbon-dioxide diffusion, Economic growth, International Trade, Environmental regulations, Vector Autoregressive model

I. INTRODUCTION

During the past decade advocates of environmental protection and economic policy-makers have been increasingly worried about the effects of economic growth and free trade on the environment. They would like to know the relation between economic growth, international trade and the environment in order to make wise decisions in their policies and administrations. The two international institutions NAFTA and WTO have expressed concern over issues such as global warming, the devastation of space and industrial pollution due to So2, Co2 and Nox Although during the past decade, various researchers have studied the theoretical and empirical aspects of the relation between economic growth, trade and environment; nevertheless this is not a new issue and has been a topic in academic circles for a long time. Generally speaking, from a historical perspective, in advanced countries, industrial pollution was under focus during the 1960's, the effects of trade on environment, during the 1970's, environmental concerns on an international basis, the 1980's and the effect of environmental regulations on industrial competition and economical globalization in the 1990's.

In most of the studies, one aspect of the many aspects of the relation between economic growth, international trade and environment has been focused and few are the studies which have challenged the issue holistically. Economic growth is, according to the environment Kuznets curve, effective in terms of the effect of economic growth income on the quality of the environment. Alongside the effects of economic growth on the environment, rules implemented by governments concerning the environment also have effect on economic growth. On the other hand, international trade is another important factor concerning environmental issues. Some countries due to their advantage in producing pollution-causing goods produce these types of goods and export them to other countries. Due to excessive use of natural resources, the environment is devastated but on the other hand, a percentage of economic income is used to diminish pollution and enhance the technology of low-pollution goods production. In addition, the severity of environmental regulations and the degree to which environmental standards are observed in any country are important indexes of the kind of goods produced there. The softer the measures the more relative advantage for the production of pollution-causing goods and vice versa.

In this article, following the introduction, literature review on the subject will be presented. Then, with a brief reference to the vector Autoregressive model, we will study empirical results related to Iran and we will end with summary and conclusion.

II. LITERATURE REVIEW

A. The Effects of Economic Growth on Environment Quality

If we consider income per-capita as a measure of economic growth, we can study it's relation with environment quality. Grossman Krueger (1993) studied the effect of economic growth on environment for NAFTA within the framework of the environment Kuznets curve and reached the conclusion that the relation between income and Co2 is in the form of inverted U shape ($\cap$). Increase in income level causes increase in pollution level in poor countries and pollution level decrease in rich countries. In

other words initially, pollution increases with economic growth but decreases later with rise in per-capita income.

Selden and Song (1994) gained similar results for So2. In addition Selden and Song (1994) and Shafik and Banyopadyay (1992) concluded from their studies that with increase in per-capita income pollution shows uniform decrease, but in the case of Co2, shows increase with the increase of income per-capita. There has been much research done especially in the past decade on the issue, the results of which are close. From a theoretical perspective, the effects of economic growth or the economic growth resulting from the practice of free trade, on the environment can be studied from scale, structure and technique perspectives. Accordingly Copeland and Taylor (2004) present a general model by which the calculation of the supply and demand of pollution would lead to the determination of pollution balance level and subsequently the factors enhancing pollution due to economic growth - with consideration of the growth source - could be focused on. On the side of demand, when tax on pollution decreases, there is an increase in pollution and goods causing pollution. On the side of supply, the spread of pollution depends on the type of policies implemented. That is increase in per-capita income stimulates an increase in the demand for environment quality. As a result the government feels the responsibility of responding to public demand and enforces stricter measures by limiting pollution allowal or increasing pollution tax.

B. Effects of Scale, Structure and Technique

Economic growth needs increase in the total level of production which becomes possible through an increased manipulation of natural resources - including the environment - which leads to pollution increase. Therefore the increase in pollution is due to production increase. This is termed the "Scale Effect". Also when the share of pollution-causing goods in the national income increases, following the use of natural resources of such goods, we are faced with what is termed "Structural Effect". Finally when it becomes possible, in any way (for instance technical development) to lessen pollution, the pollution decrease is due to what is termed "Technical Effect".

In addition to Copeland and Taylor (1994), Grossman and Krueger (1993) also studied these three effects in order to show the effect of economic growth on environment quality. They assert that economic growth and international trade increase in real income and lead to a bigger economic scale.

C. Environment Kuznets Curve

Kuznets (1955) established a inverted U shape (∩) relation between injustice and per-capita income. He asserted such a relation for the first time in economic matters. During the past decade, many articles and projects have been endeavored based on the environmental Kuznets curve, to determine the effects of per-capita income on pollution. Copeland and Taylor (2004) assert that physical capital increases income and pollution causes the deterioration of the environment. On the other hand income increase due to the accumulation of human capital leads to a decrease in pollution and the improvement of environment quality.

D. Environmental Regulations Effect on Economic Growth

Increase in per-capita income increases the demand for environment quality; the government responds by stamping limits on pollution-making activities or demanding higher pollution taxes. Obviously such measures would affect economic growth; there are two views regarding this issue. The common view is implementing environmental regulations causes a rise in the price of making pollution which in turn causes a rise in the price of pollution-causing goods lessening the relative advantage of producing such goods. Subsequently income per-capita falls and pulls down economic growth. Porter's view; Porter and Linde (1995) assert that implementing environmental regulations stimulates new management strategies and technological advances, thus leading to higher total profit and economic growth. According to Porter's theory with the implementation of tax regulations for pollution production, technical advance brings about a higher total yield and in this way production is enhanced indirectly. These two perspectives differ in their interpretation of the effect of environmental regulations on economic growth and both interpretations seem valid.

E. The Effect of International Trade on the Environment

There is no doubt that trade – especially international trade – has been a major issue of economic discussion during the past two centuries. The debate on international trade was initiated by Adam Smith and furthered by David Ricardo. Other economists also have emphasized the importance of trade in economy presenting it as the root of much economic profit. However environmentalists have raised the topic of free trade as being the cause of environmental pollution. Their argument purports that the scale of economic activities increases the level of pollution and in addition it is possible that the production of pollution-causing goods be taken over from northern countries which have higher standards of environmental protection by southern countries whose regulations are looser in this respect. Conversely, free trade advocates argue that due to the normality of environment quality in the role of a commodity, the income gained through trade brings about a stricter adherence to environment-protection regulations and thus the negative effects of free trade are compensated for. Many studies have been carried out concerning the issue, of which the empirical work of Grossman and Krueger (1993) and the theoretical work of Copeland and Taylor (1994), Yues (1996) and Dean (2000) can be mentioned. They showed that the income gained by trade can alleviate pollution. In order to show the effect of free trade on the environment, they applied the trade limitation factor to the national income equation through its effect on total profit; higher trade limitation leads to a lower total profit of production factors.

When the economic scale rises due to increase in economic activities, the national income grows and is

followed by a higher demand for environment quality, the citizens demanding a higher tax levels. Therefore due to a rise in the economic scale, the share of pollution-causing goods in the total amount of production decreases. In addition, in countries which enjoy a relative advantage in producing pollution-causing goods, any kind of trade limitation would lead to a decrease in the share that pollution-causing goods have of the overall production amount. Generally, free trade raises the level of pollution at first, then – under specific conditions – the income gained from it can indirectly lead to a higher level of environment quality.

F. The Effects of Environmental Regulations on Trade

The limitations brought about by implementing environmental regulations affect international trade in the same manner that they affect economic growth. Enforcing environmental standards through the limitation of pollution production or taxes on pollution-causing goods increase the relative cost of environment as a production factor; since the cost of producing pollution-causing goods rises, according to the Hekshur-Ohlein trade model, the country loses its relative advantage in the production of these goods. On the other hand, the alleviation or complete lift of regulations increases the country's relative advantage in producing such goods. This is known as the "Pollution Haven Hypothesis".

In this relation, Pething (1979) also using Ricardo's model showed that countries with weaker environmental policies are exporters of pollution-causing goods. Therefore it can be said that countries harbouring weaker environmental regulations become specialized in the production of pollution-causing goods and conversely, countries with high environmental standards specialize in non- pollution-causing goods.

III. MATERIALS AND METHODS

Macroeconomic models usually represent significant economical relations. Accordingly, in the traditional methods, macroeconometric scholars used large and small-scale structural econometric models and reduced form models in order to estimate their own theoretical models. With the presentation of Lucas' (1976) criticism which discussed the change of economic policy-makers decisions due to change in their expectations – which results in a wrong estimation of model parameters – Sims (1980) introduced the VAR model. Enders (1995) also considers the VAR model as a suitable econometric technique for the study of the dynamic relations between variables.

A. The VAR Model

Lutkepohl (2005) introduces the VAR model as follows:

$$y_t = A_1 y_{t-1} + \ldots + A_p y_{t-p} + B_0 x_t + \ldots + B_q x_{t-q} + CD_t + u_t \quad (1)$$

In which $y_t = (y_{1t}, \ldots, y_{Kt})'$ is the endogenous variables k×1 vector, $x_t = (x_{1t}, \ldots, x_{Mt})'$ is the exogenous variables M×1 vector and Dt includes all pre-determined variables such as the intercept, linear trend and seasonal dummy variables. ut is the residual with normal distribution, an average of zero and white noise. The covariance matrix is $E(u_t u_t') = \Sigma_u$. Ai , Bj and C are the coefficient matrices with suitable dimensions.

B. Model Specification

Since we want to determine the mutual effects of economic growth, international trade, pollution and environmental regulations, we can show the variables' vector as follows:

$$\begin{bmatrix} cq \\ y_t \\ x_t \\ d_t \end{bmatrix} = \sum_{i=1}^{p} \begin{bmatrix} a_{11} & a_{12} & a_{13} & a_{14} \\ a_{21} & a_{22} & a_{23} & a_{24} \\ a_{31} & a_{23} & a_{33} & a_{34} \\ a_{41} & a_{42} & a_{43} & a_{44} \end{bmatrix} \begin{bmatrix} cq_{t-i} \\ y_{t-i} \\ x_{t-i} \\ d_{t-i} \end{bmatrix} + \begin{bmatrix} b_{11} & b_{12} & b_{13} & b_{14} & b_{15} \\ b_{21} & b_{22} & b_{23} & b_{24} & b_{25} \\ b_{31} & b_3 & b_{33} & b_{34} & b_{35} \\ b_{41} & b_{42} & b_{43} & b_{44} & b_{45} \end{bmatrix} \begin{bmatrix} c \\ s_1 \\ s_2 \\ s_3 \\ t \end{bmatrix} + \begin{bmatrix} \hat{u}_1 \\ \hat{u}_2 \\ \hat{u}_3 \\ \hat{u}_4 \end{bmatrix}$$

(2)

In this equation the spread of carbon-dioxide (Co), gross domestic production (y), export (x) and environmental regulations (d) have been considered as the main variables. In relation to environmental regulations in Iran, the "prevention of air pollution" law passed 3/5/1995, the "hunting" law passed 16/6/2005, the "protection and exploitation of water resources" law passed 14/9/1995 and the "protection and preservation of natural resources and forests" law passed 5/10/1992 have been included in the model as the dummy variable.

IV. RESULTS AND DISCUSSION

In this section, in order to study the empirical results of the estimation of the relations between variables for the period 1990Q1-2006Q4, we first determine the optimum lag and then analyze the residuals. At this point, with the VAR model estimation, we will continue with the analysis of the impulse response and decomposition of the forecast error variance.

Table 1: Optimum Lag test

AIC	4
FPE	4
HQC	2
SC	2

A. Determination of Optimum Lag

Determining the optimum lag in the specification of VAR model is very important. For this aim we use the "Akaike information criterion (AIC)", "Schwartz criterion (SC)", "Hannam-Quinn criterion (HQC)" and "final prediction error (FPE)". Table 1 shows the results of each criterion for optimum lags 2 and 4. Here we can determine one of them based on the diagnostic tests' results.

B. Diagnostic Tests

We use the "Portmanteau test" and the "Breusch-Godfrey LM test" to determine the autocorrelation of the residuals, the "Jarque-Bera test" to determine nonnormality and the multi variable ARCH-LM test to determine heteroskedasticity of the residuals. Considering the results in Table 2, it is in lag 4 that the data of the diagnostic tests determine absence of autocorrelation, nonnormality and the heteroskedasticity.

Table 2: Diagnostic Tests of the Residuals

Test	Q_{12}		LM_1		LM_2		LJB_2		$MARCH_{LM}$ (2)	
Lag	2	4	2	4	2	4	2	4	2	4
Test statistic	214.2	181.0	104.4	92	191.4	127	1009.0	634	530.0	529.0
p-value	0.02	0.25	0.03	0.16	0.04	0.15	0.01	0.06	0.17	0.17

Notes: - The null hypothesis is actually rejected only for p-values smaller than 0.1 or 0.05.(see lutlepohl and kratzig, 2004)
- Q_h: Portmanteau test for residual autocorrelation - LM_h: Breusch-Godfrey LM test for autocorrelation
- LJB_k: Lomnicki–Jarque-Bera test for nonnormality - $MARCH_{LM}$ (q): ARCH–LM test for heteroskedasticity

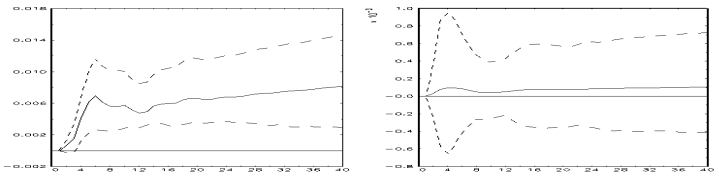
C. Impulse Response Analysis and Forecast Error Variance Decomposition

Based on Eq. 1, the presented sample was estimated. According to Hall (1992) the number of the bootstrap replications is set to be 500 and confidence intervals for the individual impulse response coefficients are estimated at the 90% significant level. Fig. 1 shows the results of the impulse response. In Table 2 the forecast error variance decomposition of this estimation can be seen. The (a) section of the Fig. 1 shows the effects of economic growth and international trade on the spread of carbon-dioxide, the (b) section shows the environmental regulations effect on economic growth and international trade and the (c) section, the effect of the environmental regulations on the spread of carbon dioxide.

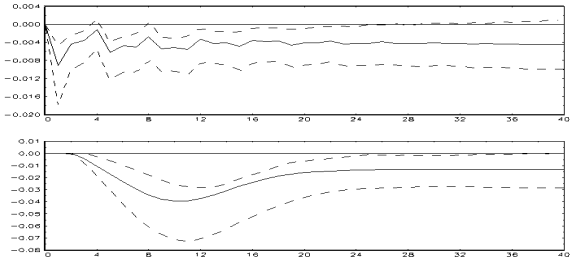
Considering the (a) section, it is obvious that economic growth on a short-term, medium-term and long-term basis has caused significant spread of carbon-dioxide; but in the case of international trade, no significant effect can be seen. The (b) section shows that, over a short-term, medium-term and long-term basis environmental regulations caused decrease in production level and international trade. Finally in section (c), it can be seen that regulations significantly (albeit to a small degree) caused decrease in carbon-dioxide spread.

The forecast error variance decomposition is shown in Table 3. The share of production shock on a long-term basis is 19%; the export shock has no share in the fluctuations of carbon-dioxide. The impulse response analysis also shows this point clearly. Environmental regulations have a small share (5%) on pollution control on a long-term basis.

a) y, x → co



b) d → y, x



c) d → co

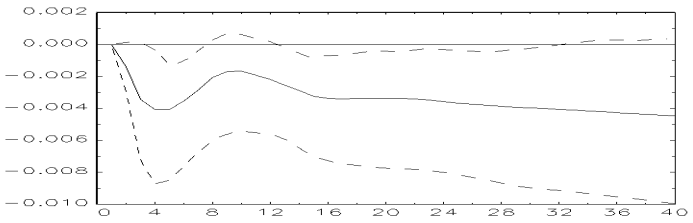


Fig. 1: The impulse response vector

Table 3 : Forecast Error Variance Decomposition

		co		
h	v^{co}	v^{y}	v^{x}	v^{d}
4	0.99	0.00	0.00	0.01
12	0.88	0.11	0.00	0.03
24	0.81	0.15	0.00	0.04
40	0.76	0.19	0.00	0.05
		y		
	v^{co}	v^{y}	v^{x}	v^{d}
4	0.06	0.86	0.00	0.08
12	0.27	0.63	0.00	0.10
24	0.40	0.50	0.00	0.10
40	0.51	0.40	0.00	0.09
		x		
	v^{co}	v^{y}	v^{x}	v^{d}
4	0.01	0.03	0.96	0.00
12	0.21	0.11	0.51	0.16
24	0.21	0.22	0.35	0.20
40	0.33	0.24	0.25	0.18

V. CONCLUSION

The utilization of natural resources alongside workforce and capital for production is one of the most important factors causing environmental deterioration. One most significant cause of pollution is the spread of carbon-dioxide in industrial production. In the past few decades, industrial products which are mainly pollution-causing goods have had a significant effect in the economic growth of countries. On the other hand with increase in per-capita income and increase in the demand for the environment, certain regulations were implemented by policy-makers which limited the production and export of industrial goods.

Considering the status of international trade and economic growth in the economic arena, especially in developing countries and considering the increasing concern for the natural environment, an extensive study of the relation between economic growth, international trade and environment can give a comprehensive insight into these issues and bring about the implementation of suitable measures and policies. Many empirical and theoretical studies have been carried out on the issue since 1960, each of which has focused on a certain perspective of the relations involved and few are the studies which look at the problem as a whole.

The aim of this study was to determine the relation between economic growth, international trade and environmental regulations in Iran for the period 1990Q1-2006Q4. With this aim, the effects of each one of these three factors on the others was studied systematically using the VAR model. Results showed that economic growth caused the increased spread of carbon-dioxide whereas exports had no effect on it. Results also showed that the implementation of environmental regulations caused a decrease in production, export and spread of carbon-dioxide but its effect in the last instance is very small. Therefore it can be concluded that in Iran the income gained from econ3omic growth and export did not cause substantial decrease in environment pollution. On the other hand the implementation of environmental regulations caused a decrease in production and export but did not attain its ultimate aim – decrease in the spread of carbon – dioxide.

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