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The Effects of Economic, Financial and Political Developments on Iran's CO2 Emissions

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Abstract

This study examines dynamic interrelationships and causality relationships among CO2 emissions, economic, political and financial variables over the period of 1971-2011 for the case of Iran as one of the top CO2 emitting countries in the world. The results of ARDL and Johansen cointegration approaches confirm the existence of long run relationship among CO2 emissions, energy consumption, GDP, financial development, trade openness and political development. The results of variance decomposition analysis show that energy consumption, GDP and democracy can explain the big parts of the CO2 variations in the first year after initial shock but after ten years the roles of financial development, trade openness and energy consumption are more important. The estimation of long run and short run equations using ARDL approach indicates that the effects of GDP and energy on CO2 emissions are positive in both long run and short run. The effects of democracy although are minor but they are negative in short run and positive in long run. Our results confirm the existence of an inverted U-shaped relationship between trade openness and CO2 emissions and also a U-shaped relationship between CO2 emissions and financial development both in long run and short run.

Keywords: Iran, CO2 Emissions, Development, Energy Consumption, Political Changes.

JEL Classification: Q5, G2, C2, C3, O1.

1. Introduction

Air pollution and its environmental effects such as global warming and climate changes have become serious threats for human societies. The scientists believe that one important reason for environmental instability and global warming has been increases in the level of

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greenhouse gasses and in particular Carbon Dioxide (CO_2) emissions (Bacon and Bhattacharya, 2007; Stewart & Hessami, 2005). Different determinants of air pollution have been suggested and considered in the existent literature. The environmental Kuznets curve (EKC) was introduced by Kuznets (1955) and suggests an inverted U-shaped effect of GDP per capita on air pollution. At the beginning of the economic development process, a small part of excess income is typically allocated for environmental problems and therefore at the beginning, the industrialization process is likely to be accompanied by environmental problems. When GDP per capita exceeds a certain threshold, people and authorities pay more attention on their next priorities such as environmental quality (Grossman and Krueger 1995, Cole et al., 1997). There are a few studies confirming an N-shaped relationship between GDP and CO_2 emissions (Moomaw and Unruh, 1997; Friedl and Getzner's 2003). Chang (2010) using a multivariate causality test finds that economic growth Granger causes energy consumption and this increases CO_2 emissions.

Financial development may also reduce energy pollutants by providing superior financial services for eco-friendly programs at decreased costs (Claessens and Feijen, 2007; Halicioglu, 2009). Zhang (2011) reexamines the finance-environment nexus and finds that financial development raises CO_2 emissions due to inefficient allocation of financial resources to enterprises. Copeland and Taylor (2001) argue that free trade may cause three types of effects on environment. The first is the technology effect which is helpful for improving the environmental quality. The second is the scale effect. Free trade expands world trade volume and increases each country's output, which in turn worsens the environmental quality. The third is the composition effect. Developing countries have most likely attracted pollution-intensive industries while developed countries try to keep away from such industries to attract foreign direct investment. Therefore decreases in pollution depend on the relative size of these effects (Choi et al., 2010).

Payne (1995) suggests four key reasons why more democratic governments will provide better environmental outcomes: 1) Accountability; Democratic governments are more accountable. Thus, they pay more attention to the environmental concerns of constituents.

2) Information; Free presses and other forms of information will provide more information about environmental issues and discoveries for the citizens in democracies. 3) Civil society; Environmentalists most likely tend to associate in democracies. Where freedom of speech and association exist, citizens can more efficiently argue on environmental issues. 4) International cooperation; Democratic governments have more cooperation among each other and more likely tend to collaborate on international agreements to take care of the environment (see also Gallagher & Thacker, 2008). However, Desai (1998) argues that "as political development is dependent on economic development, and since economic growth generally causes environmental degradation and ecological destruction, democracy would not necessarily improve the quality of environment."

This study investigates the existence of long run and short run relationships among economic growth, energy consumption, financial and political development, trade openness and carbon emissions in Iran using autoregressive and cointegration techniques for the period of 1971-2011.

Among the Middle Eastern countries, Iran is the greatest emitter of CO2 and it recorded the 9th largest emitter of total greenhouse gases in the world in 2010. Iran provides a good case for considering the effects of political variables on environmental quality, as it has experienced different political regimes. Before the Islamic revolution in 1979, Iran encountered the autocracy of Pahlavi in which Mohammad Reza Shah Pahlavi was the most powerful political figure, and after the revolution the country has dealt with factionalized semi-democracy (Dizaji, 2016; Dizaji et al., 2016). The diversity in Iran's political history encourages us to consider the role of political institutions as another determinant of CO2 emissions. Section 2 presents methodology and data description. The estimation results are covered in Section 3. Section 4 represents conclusions.

2. Methodology and Data Description

To reach the purposes of this study some helpful econometrics techniques such as vector error correction model (VECM) and autoregressive distributed lag (ARDL) model will be applied to establish dynamic interrelationships and cointegration relationships among the variables. Vector Autoregressive (VAR) techniques presented by Sims (1980), are useful methods particularly when there is not an adequate theory to determine the specific relation among variables (Enders, 1996). The mathematical representation of a VAR model is:

$$y_t = A_t y_{t-1} + \cdots + A_p y_{t-p} + Bx_t + \varepsilon_t \qquad (1)$$

where y_t is a k vector of endogenous variables[1] x_t is a d vector of exogenous variables[2], A_1, …, A_p and B are matrices of coefficients to be estimated, and ε_t is a vector of disturbance terms that may be contemporaneously correlated but are uncorrelated with their own lagged values and uncorrelated with all of the right-hand side variables.

The VECM is restricted form of unrestricted VAR that builds on Johansen's test for cointegration. The restriction is based on the existence of the long run relationship among the series. Variance decomposition analysis in VAR systems presents an examination of the entire system. Variance decomposition attributes the variance of forecast errors in a given variable to self-shocks, as well as those of the other variables in the VAR system (Brown et al., 2004). We adopt the Choleski decomposition method to construct our variance decompositions. For the most part, this procedure implicitly assumes recursivity in the VAR model as it is estimated.

The autoregressive distributed lag ARDL method suggested by Pesaran, Shin, and Smith (2001) is applied to establish cointegration relationships among the variables. The (ARDL) approach is a more statistically significant approach for determining cointegrating relationships where the samples are small (Ghatak and Siddiki, 2001). We can apply this method irrespective of the regressors' order of integration while other cointegration techniques require all of the regressors to be integrated of the same order (Pesaran et al., 2001). Furthermore, the ARDL method estimates only a single reduced form equation while VAR methods deal with the long run relationships

1. Such as co2 emissions, trade openness, financial development, political index, energy consumption and economic growth in this paper.
2. Such as dummy variable for Iran-Iraq war in this paper.

within a context of a system of equations (Pesaran and Shin, 1998). The ARDL method does not require the large number of specification to be provided in the standard cointegration test. These include decisions with respect to the optimal number of lags to be specified, as well as the number of endogenous and exogenous variables (if any) to be included. Overall, the ARDL method includes two steps. First, we need to determine the existence of a long-run relationship among the variables of interest. For this purpose, the calculated F-statistic is compared with the critical value tabulated by Pesaran et al. (2001). We will reject the null hypothesis of "no cointegration among the variables" if the calculated F-statistic is larger than the upper bound. The null hypothesis of "no cointegration among the variables" cannot be rejected if the calculated F-statistic is smaller than the lower bound. If the calculated F-statistic stays between the lower and the upper bound, the result will be indecisive. Second, we estimate the long-run coefficients of the ARDL model. The conditions for an appropriate and correctly specified ARDL model is determined by test criteria such as the Schwarz–Bayesian criterion (SBC), adjusted R^2 and various diagnostic tests. The cumulative sum of recursive residuals (CUSUM) and the cumulative sum of squares of the recursive residuals (CUSUMQ) tests are applied to examine the stability of the ARDL models.

To examine the dynamic interconnections between CO2 emissions and its determinants in Iran, we use the following general model (L indicates the logarithmic form of the variable):

$$Lc_t = f(Le_t, Lg_t, Lf_t, Ltr_t, pol_t) \qquad (2)$$

Where c_t is CO2 emissions per capita, e_t is energy consumption per capita, g_t represents real GDP per capita which is used as a proxy of economic growth, f_t is financial development proxied by real domestic credit to private sector per capita and tr_t represents real trade openness (exports + imports) per capita. We multiple GDP series by domestic credit to the private sector as share of GDP and divide it by consumer price index (CPI) to convert it into units and real terms. Then, population series is used to convert the series of real GDP, real domestic credit to private sector and real trade into their per capita forms. We use annual data from 1971 to 2011. The data has been collected from the Central Bank of Iran (CBI) and the World Development Indicators (WDI). In this study except for pol_t which represents Polity 2 index as a measure of democracy, we use the logarithmic form of the level of other variables so that each coefficient can be interpreted as elasticity. Polity2 index is widely used as a measure of political institutions (Dizaji and Bergeijk, 2013). This variable depicts combinations of democratic and autocratic features of the institutions of government (Marshall et al., 2012). For the robustness checks of our final results in this study we also use the objective democracy indicator of Vanhannen. Moreover as another proxy for financial development, we also use the logarithmic form of money and quasi money per capita (Lm2). To capture the effects of 8 year's Iran-Iraq war (1980-1988) we use war80 as a dummy variable. In order to reach a more precise equation among the variables of interest and taking into account the suggested forms of the specifications in the literature review we try to specify different models using the linear and non-linear forms of the variables. For this purpose we use GDP, trade openness, financial development and polity in their linear and quadratic forms in different models to check their monotonic, U-shaped or inverted U-shaped effects.

3. Empirical Results

The results of Phillips–Perron and ADF tests indicate that all of the variables are integrated of order 1, i.e. I (1).[1] A vector of variables integrated of order one can be cointegrated if there exists linear combination of the variables, which are stationary. The result of trace test suggests the existence of at least one cointegrating vector among the variables while the result of maximal eigenvalue test shows that at least two cointegrating vectors exist among the variables. Overall both tests confirm the existence of long run relationships among the variables; therefore a vector error correction (VEC) model is justified[2].

The number of cointegrating vectors in estimating a VEC model is very important. Since trace and Maximum eigenvalue tests suggest

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1. The unit root tests results are available upon request.
2. These results are available upon request.

different numbers for cointegrating vectors, we will try another approach based on ARDL specification. Taking into account the necessary diagnostic criteria, we choose two lags as the maximum order of the lags in the following ARDL model. The error correction version of this ARDL model is given by

$$DLc = \alpha_0 + \sum_{i=1}^{2} \theta_i DLc_{t-i} + \sum_{i=1}^{2} \varepsilon_i DLe_{t-i} + \sum_{i=1}^{2} \rho_i DLtr_{t-i} + \sum_{i=1}^{2} \omega_i DLf_{t-i} \sum_{i=1}^{2} \beta_i DLg_{t-i} + \sum_{i=1}^{2} \gamma_i Dpol_{t-i} + \delta_1 Lc_{i-1} + \delta_2 Le_{i-1} + \delta_3 Ltr_{i-1} + \delta_4 Lf_{i-1} + \delta_5 Lg_{i-1} + \delta_6 pol_{i-1} \quad (3)$$

The first part of the equation represents the short-run dynamics of the model while the parameters $\delta_1, \dots, \delta_6$ stand for the long-run relationship (See also Pesaran and Pesaran, 1997). The null hypothesis is 'non-existence of the long-run relationship' defined by

$H_0: \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = 0$

Against

$H_1: \delta_1 \neq 0, \delta_2 \neq 0, \delta_3 \neq 0, \delta_4 \neq 0, \delta_5 \neq 0, \delta_6 \neq 0$

The F-statistics for testing the joint null hypothesis that coefficients of these level variables are zero (namely there is no long-run relationship between them) by assuming each of the variables as the dependent variable have been considered. This test results confirm the existence of cointigrating equation only in one case and this is consistent with the result of the trace test.[1]

Therefore we estimate a Vector error correction model (VECM) by assuming one cointegration equation. The variance decomposition results related to our estimated VECM are presented in Table 3. In our restricted VAR model, we will adopt the following ordering of the variables; Le, Ltr, Lf, Lg, pol, Lc. This ordering, indicates that energy consumption, trade openness and financial development have an influence on economic growth and these economic variables can affect the political system and finally all of them have influences on CO2 emissions. We define the vector of exogenous variables as x_t = [constant, war80]. According to Schwarz information criterion (SC) we choose 1 as the lag order in our VEC model. Also we have

1. These results are available upon request.

examined the stability of the VAR model. The VEC residual serial correlation LM test and VEC residual heteroscedasticity tests are carried to show lack of auto-correlation and heteroscedasticity of residuals[1].

Table 1: Vector Error Correction (VEC) Estimates Variance Decomposition

	Le	Ltr	Lf	Lg	pol	Lc
Variance decomposition of Le						
1 year	100.00	0.00	0.00	0.00	0.00	0.00
2 years	93.38	2.12	2.31	0.59	1.57	0.01
5 years	86.59	9.69	1.92	0.34	1.4	0.03
10 years	81.45	14.34	2.44	0.26	1.39	0.1
Variance decomposition of Ltr						
1 year	2.41	97.58	0.00	0.00	0.00	0.00
2 years	17.7	76.39	3.62	0.14	0.4	1.73
5 years	15.89	67.88	11.72	0.34	0.44	3.68
10 years	15.81	67.00	12.47	0.34	0.47	3.89
Variance decomposition of Lf						
1 year	0.31	2.45	97.22	0.00	0.00	0.00
2 years	1.60	7.58	90.04	0.12	0.63	0.00
5 years	3.37	10.52	84.84	0.19	0.81	0.25
10 years	3.67	11.35	83.60	0.16	0.88	0.32
Variance decomposition of Lg						
1 year	8.6	27.01	0.11	64.26	0.00	0.00
2 years	21.74	32.78	2.04	42.39	0.34	0.00
5 years	25.76	42.00	7.86	21.91	0.49	1.96
10 years	26.87	45.44	8.64	16.37	0.50	2.15
Variance decomposition of pol						
1 year	0.00	0.51	1.01	2.28	96.18	0.00
2 years	4.55	8.32	0.89	6.31	79.77	0.13
5 years	10.10	24.20	0.95	5.79	58.68	0.26
10 years	13.54	31.81	1.48	4.86	47.83	0.44
Variance decomposition of Lc						
1year	44.11	0.14	0.03	15.08	7.63	32.99
2 years	50.67	0.19	13.38	14.69	3.82	17.21
5 years	33.58	7.06	43.12	7.02	1.56	7.63
10 years	21.05	22.87	43.54	4.99	1.04	6.48

1. These results are available upon request.

Table 1 shows that almost for all of the variables the biggest portion of variations is typically explained by the variables' own trend in the first year. The exception is for CO2 emissions, as about 44% of its variations in the first year are explained by energy consumption and this amount increases to about 51% after 2 years. This can attribute to the strong effects of energy consumption on CO2 emissions in short run. In the first year, energy consumption, economic growth and political index are main determinants of CO2 together with its own variations. After 10 years, financial development, trade openness and energy consumption are the main determinants of CO2 emissions. The contribution of financial development to CO2 emissions shocks was about 13% in the second year rising to about 44% in the tenth year. The contribution of CO2 emissions in explaining the variations of other variables is very minor both in short run and long run. This point indicates that while there is some evidence of strong causality from other variables to CO2 (in short or long runs) we cannot confirm the reverse causality from CO2 emissions to other variables. Regarding to the political variable, the results of variance decomposition analysis show that, the shocks to trade, energy consumption and GDP have the most important roles (after second, 5^{th} and 10^{th} years) in explaining the shocks to democracy following its own variations.

3.1 Analysis of Various Models Specifications

After applying different specifications using both linear and nonlinear forms of the variables and after taking into account the significance of the variables both in long run and short run and with respect to the diagnostic tests, our final model is reported in table 2 and indicates that we should use quadratic forms of trade openness and financial development in CO2 emissions equation whereas the other variables should be used in their linear forms.[1]

Moreover, to reach more confidence about the goodness of our model, we tried to use money and quasi-money (M2) in its per capita

1. Other specifications using quadratic forms for other variables are available upon request. We also tried to examine the existence of N-shaped (cubic) relationship between GDP and CO2 emissions as suggested by Friedl and Getzner's (2003). Due to the existence of multicollinear regressors we could not confirm this kind of relationship for Iran.

form as our financial development index and also we used Vanhanen index to control the political changes of the system.[1] The overall results by and large agree.[2]

Selected Model Based on Different ARDL Specifications

The optimal ARDL model is estimated using the optimal number of lags for each of the variables which is presented as ARDL (2,1,0,1,0,0,0,1). The results of diagnostic tests for our model are satisfying. This means that, there is absence of significant autocorrelation or heteroscedasticity based on related LM tests. The error term is normally distributed based on the Jarque–Bera test thus making the standard t and F tests of the estimated equation theoretically valid. The Ramsey's RESET test indicates the lack of misspecification problem. The power of the model is high given the very high values of the R^2, adjusted R^2 and F value.[3]

Table 2 shows the long-run coefficients of the variables under investigation. All of the variables are significant. The estimated coefficient of energy consumption and economic growth entail that 10 percent increase in energy consumption and GDP will respectively lead to 2.8 and 4 percent increase in CO_2 emissions in long term, all else the same. Both trade variables Ltr and $(Ltr)^2$ are significant and have positive and negative signs respectively confirming the hypothesized inverted U-shape impact of trade openness on CO_2 emissions. Very high trade openness leads to lower CO_2 emissions while moderate trade openness increases CO_2 emissions. This entails that initially CO_2 emissions are positively linked with trade openness and trade openness starts to decline it once trade sector matures. Both financial development variables Lf and $(Lf)^2$ are significant and have negative and positive signs confirming the hypothesized U-shape impact of financial development on CO_2 emissions. Very high financial development leads to increased CO_2 emissions while moderate financial development leads to lower CO_2 emissions.

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1. The Vanhanen index of democratization is defined as the product of two underlying indices for political competition and political participation (Vanhanen, 2011).
2. This results are available upon request.
3. This results are available upon request.

Table 2: Results of Estimated Long-Run Relationship (Derived from the Optimal ARDL Model for CO2 Emissions)

Regressor	coefficient	T-Ratio	prob
Dependent variable Lc			
Le	0.28	1.86	0.07
Ltr	3.16	2.12	0.04
$(Ltr)^2$	-0.1	-2.15	0.04
Lf	-3.18	-2.7	0.01
$(Lf)^2$	0.08	2.73	0.01
Lg	0.4	3.92	0.00
Pol	0.005	2.49	0.02
Intercept	0.01	2.88	0.00
War80	-0.47	-7.12	0.00

The positive effects of democracy on CO2 emissions although is significant but it is very minor. Stable democracies are also likely to promote economic liberalizations and reforms, which in turn would have a positive effect on the overall economic performance and therefore on CO2 emissions in long run. The negative effect of war on CO2 emissions is significant and very considerable. Iran-Iraq war damaged the structure of the Iranian economy and therefore by reducing the economic activities, it decreased the CO2 emissions.

The estimated error correction model selected using SBC is given in Table 3 and all of the variables are significant. Unlike the long-run in the short- run, the political variable has negatively affected the CO2 emissions although its effect on CO2 is very minor. As the robustness check we have used Vanhanen index to show the quality of democracy. Although its coefficients are positive in long run and negative in short run but they are not significant indicating the negligible effect of democracy on CO2 emissions in Iran. The estimated coefficient of energy consumption and economic growth in Table 3 entail that 10 percent increase in energy consumption and GDP will respectively lead to 4.8 and 3.8 percent increases in CO2 emissions in short term. Therefore the magnitude of the Energy consumption impact in the short-run is much higher than that of the long-run impact while this is reverse for GDP. The error correction term (ecm) shows how quickly/slowly variables return to equilibrium and it should have a statistically significant coefficient with a negative sign. The error correction coefficient, estimated at -0.93 is statistically highly significant, has a correct sign and suggests a relatively high speed of convergence to equilibrium (suggesting that deviation from the long-term CO2 emissions path is corrected by 93 percent over the following year). The larger the error correction coefficient (in absolute value) the faster will be the economy's return to its equilibrium, after an exogenous shock (Dizaji, 2012).

Table 3: Error Correction Representation for the Selected ARDL Model

ARDL (2,1,0,1,0,0,0,1) based on Schwarz Bayesian Criterion Dependent Variable: dLc			
Variables	**Coefficients**	**t-Values**	**Prob-Values**
dLc(1)	0.33	4.17	0.00
dLe	0.48	3.53	0.00
dLtr	2.96	2.21	0.03
$d(Ltr)^2$	-0.09	-2.18	0.03
dLf	-2.98	-2.82	0.00
$d(Lf)^2$	0.07	2.85	0.00
dLg	0.38	3.61	0.00
dpol	-0.005	-1.83	0.07
d(intercept)	0.014	2.60	0.01
dwar80	-0.44	-7.67	0.00
ecm(-1)	-0.93	-9.24	0.00
R^2=0.89	Adjusted R^2=0.84		
Akaike Info. Criterion=87.21 DW-statistic=2.35	Schwarz Bayesian Criterion= 55.75 F-stat=21.32(prob=0.00)[1]		

The underlying ARDL equation also passes all the diagnostic tests that are automatically computed by Microfit software. The existence of an inverted U-shape relationship between trade and CO2 emissions and a U-shaped relationship between financial development and CO2 emissions also are confirmed in short run. As the robustness check we also used real money and quasi money per capita (Lm2) as our financial development indicator. Again both financial development variables Lm2 and $(Lm2)^2$ were significant and respectively had negative and positive signs in both short run and long run confirming

1. According to the probability (or P) value which is less than 5%, our F-statistics is that the overall regression model is significant.

the hypothesized U-shape of financial development impact on CO2 emissions[1].

4. Conclusion

This study has investigated the short run and long run determinants of CO2 emissions in Iran. For the purpose of this study we applied some helpful econometric techniques such as ARDL and VECM approaches to consider the dynamic interrelationships among CO2 emissions, trade openness, energy consumption, GDP, financial development and democracy. The results of ARDL and Johansen cointegration approaches reveal that there is one cointegration vector among the variables. The results of variance decomposition analysis show that energy consumption, GDP and democracy can explain the big parts of the CO2 variations in the first year after initial shock but after ten years the roles of financial development, trade openness and energy consumption are more important. Using ARDL approach we tried to specify long run and short run equations for CO2 emissions taking into account the other variables as independent ones. In this way we tried to find linear and non-linear effects of the variables on CO2 emissions. Quadratic forms were confirmed only for financial development and trade openness. We could find an inverted U-shaped relationship between trade and CO2 emissions and also U-shaped relationship between CO2 emissions and financial development. The effects of economic growth and energy consumption on CO2 emissions are positive and considerable both in long run and short run. The short run effect of energy consumption on CO2 emissions is bigger than its long run effect while this is reverse about GDP. Iran-Iraq war has caused a very meaningful break on the increasing trend of the Iran's CO2 emissions. Democracy has negative effect on CO2 emissions in short run but its effect is positive in long run indicating that a well-organized political system can improve the environment quality in the short run, but its positive effects on economic growth in the long run may increase the volume of CO2 emissions.

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1. These results are available upon request.

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