Environmental pollution and economic growth elasticities of maritime and air transportations in Iran

Mohamad Taghvaee, Vahid and Agheli, Lotfali and Assari Arani, Abbas and Nodehi, Mehrab and Khodaparast Shirazi, Jalil

Tarbiat Modares University

2019

The current issue and full text archive of this journal is available on Emerald Insight at:
www.emeraldinsight.com/2516-158X.htm

Environmental pollution and economic growth elasticities of maritime and air transportations in Iran

Received 6 September 2019
Accepted 9 October 2019

Vahid Mohamad Taghvaee, Lotfali Agheli and Abbas Assari Arani
Department of Economic Development and Planning, Faculty of Management and Economics, Tarbiat Modares University, Tehran, Iran
Mehrab Nodehi
Department of Civil Engineering, Engineering Faculty, Islamic Azad University, Gorgan Branch, Gorgan, Iran, and
Jalil Khodaparast Shirazi
Department of Economics, Islamic Azad University, Shiraz Branch, Shiraz, Iran

Abstract

Purpose – The purpose of this paper is to examine the effects of maritime and air transportation on the environment and economy of Iran. The authors specify two dynamic models of the environmental pollution and the economic growth. Then, the authors estimate the environmental and economic elasticities of maritime and air transportation in short run and long run in Iran during 1978–2012.
Design/methodology/approach – The authors estimate the environmental and economic elasticities of maritime elasticities in short and long run, using simultaneous equations system.
Findings – The findings indicate that the short- and long-run environmental pollution elasticities of maritime transportation are higher than those of the air ones. In addition, the economic growth elasticities are greater in the air transportation compared to maritime one. As a result, the maritime transportation is more pollutant and less productive in Iran in comparison with the air transportation.
Originality/value – The policymakers are advised to improve the infrastructure of maritime transportation from both the environmental and economic point of views. Consequently, the air transportation is considered as a cleaner and more beneficial transportation mode in Iran, where geographical position limits the maritime transport as a widespread transportation mode.

Keywords Iran, Economic growth

Paper type Research paper

1. Introduction

Transportation plays an important role in the environmental pollution and economic growth. According to IEA (2009), about 25 percent of the world's energy is attributed to transport and about 5 percent of this energy is responsible for the whole environmental changes, while projecting that this amount will be likely to increase 50 percent by 2030 and 80 percent by 2050. As shown in Figure 1, transportation boosts the international trade and

The authors express deep gratitude to the Department of Economic Development and Planning, Faculty of Management and Economics, Tarbiat Modares University, which supports the research technically.

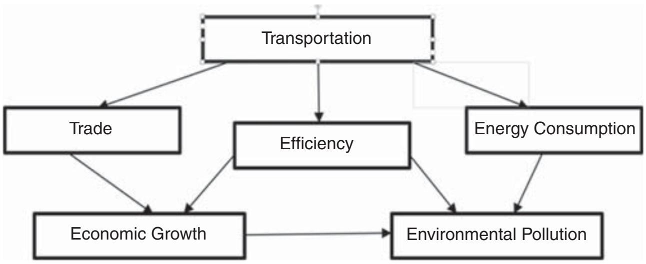
Marine Economics and Management
Vol. 2 No. 2, 2019
pp. 114-123
Emerald Publishing Limited
2516-158X
DOI 10.1108/MAEM-09-2019-0008

technical efficiency, and stimulates the economic growth. Economic growth, in turn, causes the environmental pollution. In addition, transportation has conflicting effects on the environmental pollution. It consumes a high volume of fuels and pollutes the environment; whereas it can reduce the environmental pollution with higher efficiency in carrying the cargos, like maritime transportation (Farhani *et al.*, 2014; Taghvaee *et al.*, 2017).

There are four modes of transportations including road, rail, air and maritime transportation. Among them, maritime transportation has the highest potential for carrying goods in high volume; and air transportation is the fastest mode of transportation, boosting the economic growth. Nonetheless, both pollute the environment due to consumption of high volumes of fossil fuels (IEA, 2009; Taghvaee and Hajiani, 2015; IMO, 2016; Larkin *et al.*, 2016; IATA, 2014). Globally, transport energy use increased steadily at between 2 and 2.5 percent per year during 1971–2006. Figure 2 shows transport energy use by mode in the world in 2008. Maritime and air transportations show the highest shares, after road transportation which ranks the first (IEA, 2009).

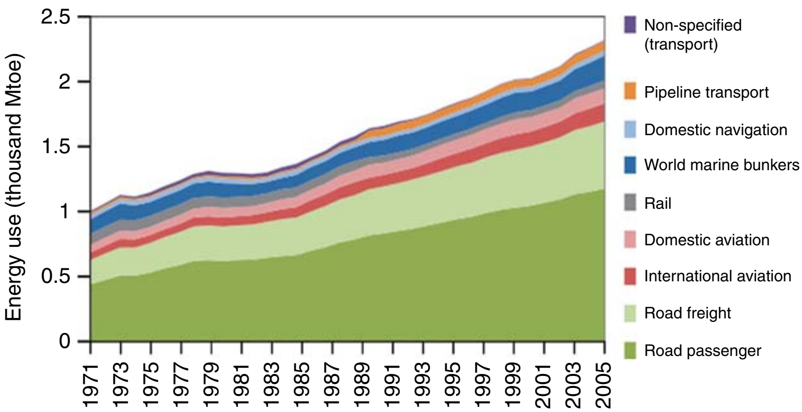
Maritime transportation is of the largest capacity for shipping commodities; and the air one is the most rapid mode. Both maritime and air transportation modes increase the flows of the international trade, and encourage the economic growth (Taghvaee and Hajiani, 2015; IMO, 2016; Larkin *et al.*, 2016; IATA, 2014).

As mentioned earlier, these modes of transportation increase the environmental pollution. Figure 2 shows the extrapolation of CO_2 emissions among the modes of transport



Source: Researchers' elaboration based on Farhani *et al.* (2014) and Taghvaee *et al.* (2017) findings

Figure 1. Transportation, environmental pollution and economic growth



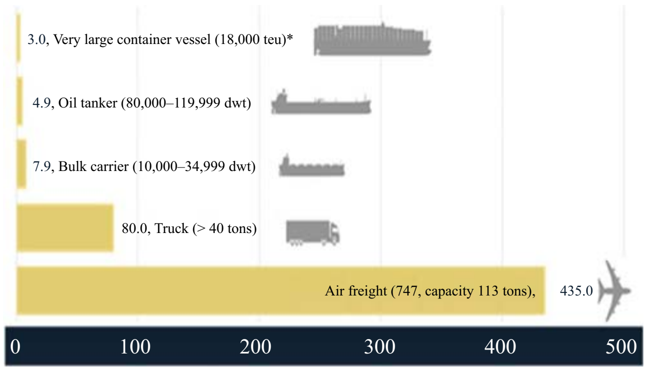
Source: IEA (2009)

Figure 2. World energy consumption, by transportation mode in 2008

(Grames per ton-KM) (IMO, 2009). Based on Figure 3, the air mode burns high volume of fuel to operate at high speed, emitting intensive carbon dioxide (CO_2) (IATA, 2014).

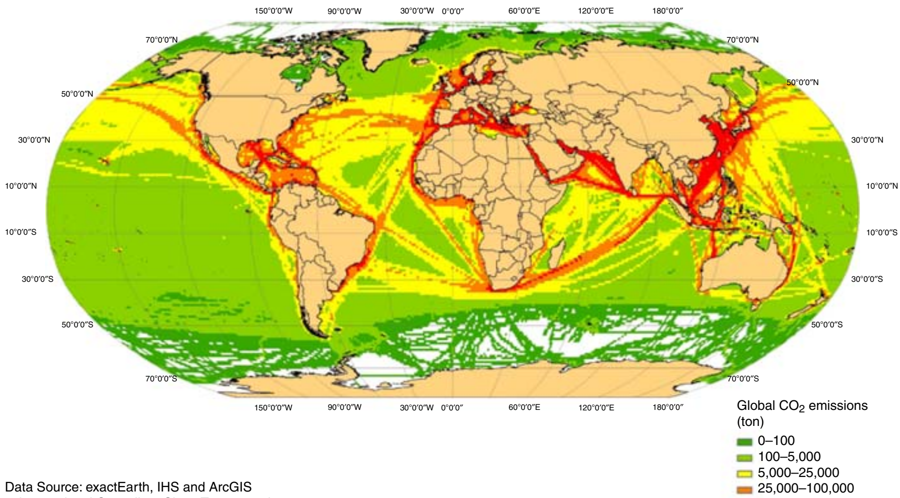
Maritime transportation plays a dual role in the CO_2 emissions, especially in the countries, which have access to the open seas like Iran. As Figure 4 shows, Iran is among the most pollutant countries in terms of CO_2 emissions from maritime transportation. On the one hand, it can increase carbon dioxide emissions due to the high volume of cargos, since cargo shipping requires burning an extremely high volume of fuels, which emits considerable CO_2 (Taghvaee and Hajiani, 2015). On the other hand, it can mitigate environmental pollution because of economies of scale in carrying bulk cargos (IMO, 2016).

Thus, transportation by ships and aircrafts has various effects on the economic growth and environmental pollution, specifically in the geo-strategic countries such as Iran, which connects the East to the West. In this regard, the environmental and economic effects of air and sea transportation are comparable with each other (Larkin *et al.*, 2016; IATA, 2014).



Source: IMO (2009) GHG Study (*AP Moller-Maersk, 2014)

Figure 3. CO_2 emissions from various modes of transportation in the world



Source: IMO (2009) GHG Study (*AP Moller-Maersk, 2014)

Figure 4. Global CO_2 emissions

The purpose of this study is to compare the maritime transportation effects with air transportation ones on the environment and economy of Iran in order to seek the most efficient and the cleanest transportation mode.

2. Methodology and model

We compare the environmental and economic effects of maritime and air transportation in the short and long run in Iran during 1978–2012 using two dynamic log-linear models. Following Farhani *et al.* (2014), Taghvaee *et al.* (2017) and Taghvaee and Hajiani, we specify the models as follows (IMO, 2016; Larkin *et al.*, 2016; IATA, 2014):

$$LCO_{2t} = \alpha_0 + \alpha_1 LM_t + \alpha_2 LA_t + \alpha_3 LY_t + \alpha_4 LCO_{2t-1} + \alpha_5 D_t + \varepsilon_t, \quad (1)$$

$$LY_t = \beta_0 + \beta_1 LM_t + \beta_2 LA_t + \beta_3 TR_t + \beta_4 LY_{t-1} + \beta_5 D_t + \mu_t, \quad (2)$$

where CO_2 is carbon dioxide emissions. M and A denote maritime and air transportation modes, respectively. Y is GDP, and TR is trade volume. α_s and β_s show the parameters of models. D is the dummy variable which is set 0 for the war years (1980–1989) and 1 for the remaining years. L is the natural logarithm; t is year; ε and μ are the error terms. α_1, α_2 and α_3 are the short-run elasticities of environmental pollution and β_1, β_2 and β_3 give the short-run elasticities of the economic growth. The long-run elasticities are $\alpha_1/1-\alpha_4$, $\alpha_2/1-\alpha_4$, and $\alpha_3/1-\alpha_4$ for the environmental pollution; and $\beta_1/1-\beta_4$, $\beta_2/1-\beta_4$ and $\beta_3/1-\beta_4$ for the economic growth (Sene, 2012). Before running the models, we check the variables for the unit root, preventing the spurious regression. The regressions with non-stationary variables are not reliable statistically. This study applies the Augmented Dickey–Fuller (ADF) unit root test as the most common test for stationarity (Taghavee and Hajiani, 2014; Taghvaee *et al.*, 2017).

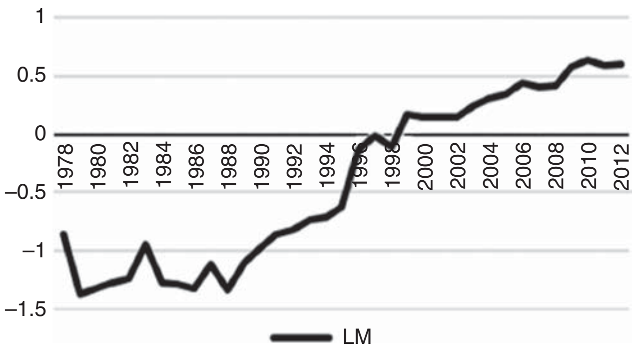
3. Data

The annual data are derived from World Development Indicator (2014), except for the maritime and air transportation variables, which come from the Central Bank of Iran (Economic Research and Policy Department of Iran, 2016). The per capita sea and air transportation of goods are measured in metric ton per person. The per capita CO_2 emission, measured in metric ton per person, is the proxy for the environmental pollution. The per capita GDP, measured in constant 2005 US$ per person, is the proxy for the economic growth. Trade, measured as the percentage of GDP, is the proxy for trade openness.

All data are in natural logarithm, which are represented in the appendix of the paper after the references. Figures 5 and 6, respectively, display the logarithms of per capita maritime and air transportation volume. With regard to Figure 5, maritime transportation has grown substantially over the period 1978–2012, raising a question: whether its growth is consistent with environmental and economic infrastructure (Parsa *et al.*, 2019). Figure 6, however, displays that the air transportation has not experienced higher growth rates. This might be caused by misallocation of budget for this transportation mode. Figure 6 is another evidence for the low investment in air transportation in comparison with the maritime transportation.

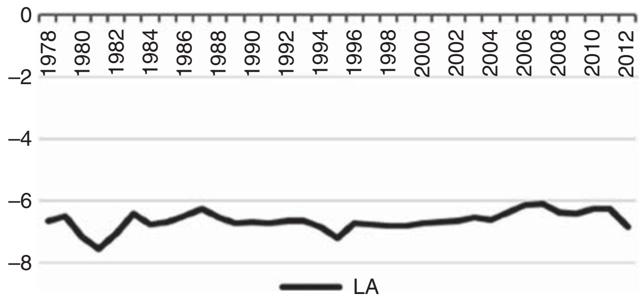
Figure 7 represents the number of ships and planes in proportion to the number of ports and airports in Iran in 2015. It shows a high intensity of maritime transportation in comparison with the air mode, supporting the lower investment in the latter mode.

Figures 8 and 9 exhibit the per capita CO_2 emissions and GDP in natural logarithms. Based on Figure 8, per capita CO_2 emission has increased moderately in the period under study, which is an evidence against the sustainable development in Iran. In other words, the development process of Iran is inconsistent with the environmental considerations, urging regulations that are more stringent, specifically in the transportation infrastructure. Figure 9, however, does not show a considerable increase in economic growth in Iran in the



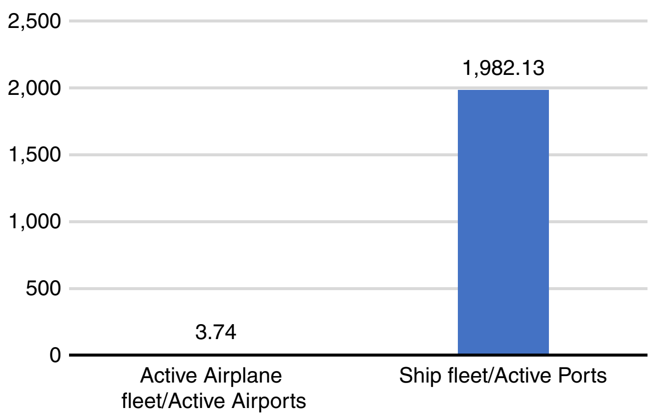
Source: Central Bank of Iran, 2018 (Economic Research and Policy Department of Iran, 2016)

Figure 5.
Logarithm of per capita maritime transportation volume



Source: Central Bank of Iran, 2018 (Economic Research and Policy Department of Iran, 2016)

Figure 6.
Logarithm of per capita air transportation volume in Iran



Source: Comprehensive Transport Statistics (2015)

Figure 7.
The ratio of ship/airplane fleet to air/ports in Iran (2015)

same period. It suggests that the development process does not match economic growth. Transportation infrastructure, for example, should be reformed to support economic growth efficiently in Iran. In general, the development process in Iran lacks considerable growth and environmental sustainability.

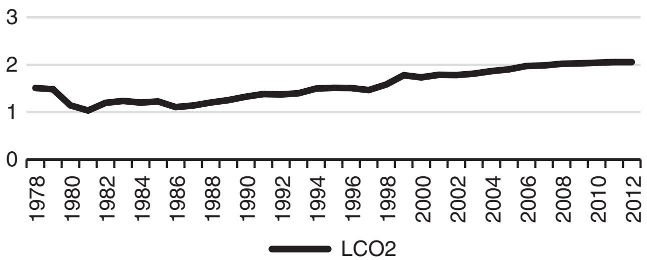
For a more accurate analysis, we run Models (1) and (2) to estimate the environmental pollution and economic growth elasticities of maritime and air transportation.

4. Results

As earlier said, testing against unit root is the first stage of estimation of a time series model. Table I reports the results of ADF unit root test. In this test, the null hypothesis implies unit root and non-stationarity of a series.

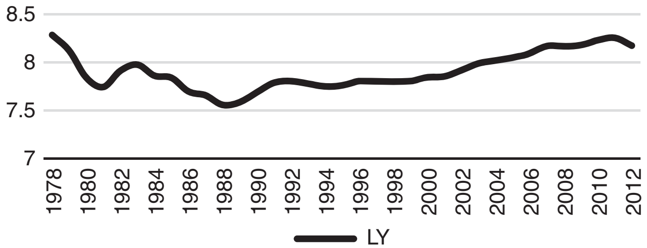
Based on the results, all variables are stationary in level. Accordingly, it confirms that the regressions are not spurious and thus, we run the models without concerning about the spurious regression results.

Table II represents the estimation results of the environmental pollution model. All coefficients are statistically significant at the 5 percent level of significance. These coefficients show that the environmental pollution is inelastic with respect to maritime and



Source: World Bank, World Development Indicator, 2018 (World Development Indicator, 2014)

Figure 8. Logarithm of per capita CO_2 emissions in Iran



Source: World Bank, World Development Indicator, 2018 (World Development Indicator, 2014)

Figure 9. Logarithm of per capita GDP in Iran

Table I. Results of the Augmented Dickey–Fuller unit root tests (intercept and trend in level, max lags = 6)

	LTR	LM	LA	LCO_2	LY
t-stat.	−5.16	−4.02	−3.77	−4.34	−3.77
Prob.	0.00	0.01	0.03	0.00	0.03
Stationarity	I(0)	I(0)	I(0)	I(0)	I(0)

Source: Authors' findings

air transportation modes and per capita GDP, both in the short and long run. The short-run elasticities of environmental pollution with respect to maritime and air transportation are 18 and 6 percent, respectively; and the long-run ones are 27 and 9 percent, respectively. In addition, the environmental pollution elasticities of maritime transportation are three times of the air transportation ones.

Table III shows the estimation results of the economic growth model. In this model, all coefficients are again statistically significant. The coefficients indicate that the per capita GDP is inelastic with respect to maritime and air transportation modes and trade volume both in the short and long run. The short-run elasticities of per capita GDP with respect to maritime and air transportation are 5 and 10 percent, respectively; and the long-run ones are 12 and 25 percent, respectively. As a result, the elasticities of economic growth, denoted by per capita GDP, with respect to air transportation are twice as those of the maritime transportation.

5. Discussion

Based on Table IV, the maritime transportation is more pollutant than the air one. The resulted elasticities in Table IV suggest that the maritime transportation is more pollutant than it would be economically beneficial. Air transportation, however, generates

Table II. Results of the CO_2 model estimation

Variable	Coefficient	*t*-statistic	Prob.
LM	0.18	4.75	0.00
LA	0.06	1.69	0.10
LY	0.24	2.30	0.02
LCO_{2t-1}	0.35	3.09	0.00
$\alpha_1/1-\alpha_4$	0.27		
$\alpha_2/1-\alpha_4$	0.09		
$\alpha_3/1-\alpha_4$	0.36		

Source: Authors' findings

Table III. Results of the GDP model estimation

Variable	Coefficient	*t*-statistic	Prob.
LM	0.05	2.56	0.01
LA	0.10	2.78	0.00
LTR	0.15	3.42	0.00
LY_{t-1}	0.60	9.21	0.00
$\beta_1/1-\beta_4$	0.12		
$\beta_2/1-\beta_4$	0.25		
$\beta_3/1-\beta_4$	0.37		

Source: Authors' findings

Table IV. Estimated elasticities of environmental pollution and economic growth in the short and long run

Elasticities	Environmental pollution		Economic growth	
Period	Short run	Long run	Short run	Long run
LM	0.18	0.27	0.05	0.12
LA	0.06	0.09	0.10	0.25
LY	0.24	0.36	na	na
LTR	na	na	0.15	0.37

Source: Authors' findings

more economic benefits with lower environmental contaminants. These results originate from the higher investment in the maritime infrastructure in comparison with the air one, leaving low scope for the investment in the aviation mode.

Not only the long-run elasticities confirm the above-mentioned claims, but also the short run ones provide us with the evidence for the selection of air rather than maritime transportation, since the former mode is a cleaner and economic choice for developing transportation network in Iran. The geographical position of Iran is another evidence for this suggestion, since the majority of the country has no direct access to the sea transportation, which can offer the capacity for more growth in comparison with the air transportation.

Certainly, the above-mentioned discussion does not mean ignoring investment in maritime transportation; but rather, it gives a comparative analysis between maritime and air transportation modes. In another word, the air transportation has higher priority for investment and development, compared with the maritime one. However, the policy makers are recommended to reform the infrastructure of maritime transportation to make it more consistent with the environment and economic aspects.

6. Conclusion

This study compared the environmental and economic effects of maritime and air transportation in Iran.

Using econometric methodology, it employed two log-linear models to estimate the environmental pollution and economic growth elasticities of maritime and air transportation in the short and long run in Iran during 1978–2012. The data were derived from the Central Bank of Iran and the World Bank.

The results show the higher maritime transportation elasticities of environmental pollution and lower elasticities of the economic growth, compared with the air transportation. Given the results, it is implied that the maritime transportation is more pollutant and less productive in Iran, in comparison with the air transportation.

The policymakers are advised to improve the infrastructure of maritime transportation from both the environmental and economic point of views. The air transportation is a cleaner and more beneficial alternative for development as a public transportation in Iran, where geography offers less capacity for selecting the maritime transport as a widespread transportation mode. Furthermore, policy makers can provide the air transportation industry with more investment to achieve its goals.

For future research, it is recommended to analyze comparatively the four modes of transportation, adding the road and rail transportation. It clears the way for revealing the best alternative mode of transportation for inclusive development in Iran.

References

Comprehensive Transport Statistics (2015), "Ministry of Roads and Urban Development of the Islamic Republic of Iran".

Economic Research and Policy Department of Iran (2016), "Central Bank of the Islamic Republic of Iran, Economic Time Series, Database", available at: http://tsd.cbi.ir/

Farhani, S., Chaibi, A. and Rault, C. (2014), "CO2 emissions, output, energy consumption, and trade in Tunisia", *Economic Modelling*, Vol. 38, February, pp. 426-434, doi: 10.1016/j.econmod.2014.01.025.

IATA (2014), "Aviation economic benefits", International Air Transportation Association.

IEA (2009), *Transport, Energy, and CO2: Moving Toward Sustainability*, International Energy Agency, Paris, available at: www.iea.org/publications/freepublications/publication/transport2009.pdf (accessed December 25, 2018).

IMO (2009), International Maritime Organization, available at: www.imo.org/en/OurWork/Environment/PollutionPrevention/AirPollution/Documents/SecondIMOGHGStudy2009.pdf

IMO (2016), International Maritime Organization, available at: www.imo.org/en/OurWork/Environment/PollutionPrevention/AirPollution/Pages/Default.aspx

Larkin, A.B., Mander, S.L., Traut, M.B., Anderson, K.L. and Wood, F.R. (2016), "Aviation and climate change-the continuing challenge", *Encyclopedia of Aerospace Engineering*, doi: 10.1002/9780470686652.eae1031.

Olmer, N., Comer, B., Roy, B., Mao, X. and Rutherford, D. (2017), "Greenhouse gas emissions from global shipping, 2013-2015", International Council on Clean Transportation.

Parsa, H., Keshavarz, H. and Taghvaee, V.M. (2019), "Industrial growth and sustainable development in Iran", *Iranian Economic Review*, doi: 10.22059/IER.2018.68571.

Sene, S.O. (2012), "Estimating the demand for gasoline in developing countries: Senegal", *Energy Economics*, Vol. 34 No. 1, pp. 189-194, doi: 10.1016/j.eneco.2011.04.014.

Taghavee, V.M. and Hajiani, P. (2014), "Price and income elasticities of gasoline demand in Iran: using static, ECM, and dynamic models in short, intermediate, and long run", *Modern Economy*, Vol. 5, pp. 939-950, doi: 10.4236/me.2014.59087.

Taghvaee, S.M., Omaraee, B. and Taghvaee, V.M. (2017), "Maritime transportation, environmental pollution, and economic growth in Iran: using dynamic log-linear model and Granger causality approach", *Iranian Economic Review*, Vol. 21 No. 2, pp. 185-210, doi: 10.22059/IER.2017.62100.

Taghvaee, V.M. and Hajiani, P. (2015), "Environment, energy, and environmental productivity of energy: a decomposition analysis in China and the US", *Second European Academic Research Conference on Global Business, Economics, Finance and Banking, July 3–5*.

World Development Indicator (2014), "World Bank", available at: www.data.worldbank.org

Appendix

	LCO_2	LY	LM	LTR	LA
1978	1.508	8.286	−0.854	3.822	−6.637
1979	1.483	8.123	−1.371	3.757	−6.478
1980	1.141	7.843	−1.320	3.749	−7.154
1981	1.033	7.745	−1.276	3.697	−7.526
1982	1.194	7.913	−1.230	3.639	−7.020
1983	1.235	7.977	−0.935	3.657	−6.427
1984	1.200	7.862	−1.267	3.330	−6.750
1985	1.225	7.841	−1.290	3.143	−6.696
1986	1.105	7.698	−1.321	2.649	−6.477
1987	1.139	7.658	−1.116	2.884	−6.262
1988	1.201	7.559	−1.332	3.072	−6.513
1989	1.252	7.587	−1.106	3.330	−6.738
1990	1.324	7.688	−0.973	3.613	−6.689
1991	1.381	7.788	−0.861	3.789	−6.711
1992	1.371	7.806	−0.814	3.699	−6.641
1993	1.397	7.780	−0.734	3.830	−6.661
1994	1.497	7.751	−0.713	3.728	−6.840
1995	1.512	7.761	−0.628	3.559	−7.177
1996	1.507	7.806	−0.133	3.562	−6.715
1997	1.464	7.802	−0.013	3.486	−6.749
1998	1.581	7.803	−0.105	3.375	−6.794
1999	1.776	7.805	0.177	3.552	−6.806
2000	1.733	7.845	0.151	3.720	−6.717
2001	1.787	7.855	0.142	3.702	−6.667
2002	1.782	7.919	0.150	3.875	−6.643
2003	1.810	7.990	0.240	3.926	−6.543
2004	1.865	8.021	0.312	3.972	−6.606
2005	1.901	8.050	0.340	4.026	−6.375
2006	1.973	8.095	0.447	4.002	−6.121
2007	1.983	8.171	0.405	3.942	−6.097
2008	2.019	8.169	0.421	3.910	−6.373
2009	2.027	8.180	0.581	3.816	−6.405
2010	2.041	8.232	0.636	3.823	−6.250
2011	2.054	8.256	0.587	3.743	−6.268
2012	2.054	8.175	0.600	3.763	−6.857

Table AI. Data used in the econometric models

Corresponding author
Lotfali Agheli can be contacted at: aghelik@modares.ac.ir