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The impact of financial development and trade on environmental quality in Iran

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Abstract Undesirable changes in the environment such as global warming and emissions of greenhouse gases have elicited worldwide attention in recent decades. Environmental problems emanating from economic activities targeted at achieving higher economic growth rate have become a controversial issue. In this study, the effects of financial development and trade on environmental quality in Iran were investigated. To this purpose, statistical data collected between the periods of 1970 and 2011 were used. In addition to using the autoregressive distributed lag model (ARDL), the short-term and long-term relationships between the variables were estimated and analyzed. Moreover, the environmental Kuznets curve (EKC) hypothesis was evaluated using various pollutants. The results show that financial development accelerates the degradation of the environment; however, an increase in trade openness reduces the damage to the environment in Iran. Furthermore, the results did not agree with the EKC hypothesis in Iran. Error correction coefficient showed that in each period, 49% of imbalances were justified and approached their long-run procedure. Structural stability tests showed that the estimated coefficients were stable over the period.

Keywords Financial development · Trade · Autoregressive distributed lag model (ARDL) · Environmental Kuznets curve (EKC)

JEL Classification C51 · F18 · G00 · Q00

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1 Introduction

Pollution and protection of the environment have been among the topical global issues, which has formed the political agenda of countries. According to the contribution of the Working Group II to the IPCC's Fifth Assessment Report (WGII AR5), changes in climate have had an adverse effect on natural and human systems in all continents. Many terrestrial, freshwater and marine species have modified their geographic ranges, seasonal activities, migration patterns, abundances and species interactions in response to ongoing climate change. At present, the worldwide burden of human ill health attributable to climate change is relatively small compared to the effects of other stressors and is not well quantified. The impacts of recent climate-related extreme events, such as heat waves, droughts, floods, cyclones and wildfires, reveal significant vulnerability and exposure of some ecosystems and human systems to the current variability in climate. Owing to the existence of vast reserves of fossil fuels in Iran, the clarion call to save energy is not taken seriously. Climate change induced by an increase in the concentration of greenhouse gases is seen as a crucial factor in changing the world's climate, to the extent that in many cases a small change in the weather condition may culminate in severe changes in the intensity and number of natural disasters and economic loss. Consequently, the conversion and consumption of energy are of grave importance because of the abnormal environmental effects produced at different stages of the energy production process. The pattern of development in the energy sector should only be acceptable if there is a minimal damage to the environment. Pollutants and greenhouse gases stemming from the activities of the energy sector have incontestable effects on the environment at both regional and global levels. Gaseous pollutants cause acid rain, climate change and global warming as well as health risks to humans and biodiversity. In this study, environmental quality index, which is a combination of various contaminants, was obtained by the principal component analysis (PCA).

Many studies have concentrated on the relationship between environmental pollution and economic growth in recent years, but the impact of financial development on the environment has received little attention. However, financial development can influence the quality of the environment through various channels: (1) Financial development through provision of the necessary capitals for industrial and factory activities may lead to environmental pollutions (Sadorsky 2010); (2) financial intermediaries may gain access to new environmentally friendly technologies that can improve the environment (Tamazian et al. 2009); (3) financial development may provide more financial resources with less financial costs, for instance, for environmental projects (Tamazian et al. 2009; Tamazian and Rao 2010).

This study attempts to explore the effects of financial development and trade on environmental quality in Iran between the periods of 1970 and 2011 within the framework of the EKC. In this study, the environmental quality index which is a combination of various pollutants was obtained by the PCA. The paper is organized as follows: The theoretical framework discusses the importance of economic and financial development in environmental quality assurance. Part 3 presents a review of the literature. Part 4 presents data description and the econometric methodology. The last two parts are made up of the study results and conclusions.

2 Theoretical framework

2.1 EKC

Greenhouse gas emissions from fossil fuels and other human activities pose a serious menace to global temperature. Changes in weather patterns may affect the environment and disrupt human activities. Some studies have argued that the relationship between economic growth and environmental degradation takes the shape of an inverted U curve. This inverted U curve is known as the EKC. Accordingly, the use of natural resources and energy to achieve high economic growth increases the primary stages of the industrialization process owing to the high priority for production and employment over clean environment and low technology. This enhances the emission of pollutants into the environment. At this stage, economic agents cannot cover the costs of reducing pollution due to the low per capita income; consequently, the environmental impacts of economic growth are ignored. However, subsequent stages of the industrialization process, an increase in per capita income, leads to an improvement in the quality of the environment when the per capita income reaches a certain level. However, in such situation, taking cognizance of the importance of clean environment, high technology and appropriate environmental laws and regulations, the indicators for pollution of the environment would decrease.

The first experimental study on the EKC was conducted by Grossman and Krueger (1991) and presented as the "Environmental Effects of the North American Free Trade Agreement." They reviewed the relationship between air quality and economic growth in 42 countries and concluded that the relationship between economic growth and concentration of suspended particles and sulfur dioxide in the air was in the form of an inverted U. This study has become the basis for further researches in this field.

Several studies including Shafik (1994), Selden and Song (1994), Cole et al. (1997), Lieb (2004), Aldy (2005), Song et al. (2008), Iwata et al. (2010), Wang (2013) and Lau et al. (2014) tested the hypothesis of the EKC. Although the hypothesis of the EKC has been confirmed in most studies, the results of some investigations suggest the existence of a uniform or third degree form of relationship between pollution emissions and economic growth. The EKC hypothesis assumes that the initial increase in environmental pressure is temporary, but subsequent decrease in environmental pressure is permanent. Some authors have questioned whether this observed decrease could be a temporary phenomenon due to technological constraints (Dinda et al. 2000). The result would be an N-shaped curve. An upswing in the EKC can be attributed to the difficulty in sustaining efficiency improvements (innovation) with continuing growth of production (Dinda 2004).

2.2 Impact of financial development and trade on environmental quality

Despite the numerous studies on the relationship between economic growth and environmental quality, a number of researchers, including Tamazian and Rao (2010), Zhang (2011), Pao and Tsai (2011), Jalil and Feridun (2011) and Shahbaz et al. (2013a, b), have considered financial development as an important factor affecting environmental quality in recent years. Well-developed capital markets and strong banking systems can speed up the progress of technology and productivity. Capital for technologies that require large sums of investment can easily be provided in the developed financial systems (Tamazian et al. 2009). By sharing the risk among investors, the financial markets make the execution of such technologies possible.

Further development of the financial sector can facilitate more investment with low cost, including investment in environmental projects. The ability to increase investments of this nature that are targeted at protecting the environment, which is a responsibility of the public sector, can be of great importance especially for governments at the local, state and national levels (Tamazian and Rao 2010). With financial improvement, companies obtained access to advanced and clean technologies that culminated in a decrease in CO_2 emissions and increase in domestic production, as well as the promotion of financial and investment regulations for the benefit of the environment. (Yuxiang and Chen 2010). Financial systems with better performance abrogate foreign financing restrictions, which preclude industrial and corporative development, and therefore precipitate economic growth (Monsef et al. 2013; Sameti et al. 2012; Shahbazi and Saeidpour 2013). Consequently, financing of the major industrial activities can increase environmental pollutions (Levine 2005).

The effects of trade liberalization on the environment can be grouped into three main types: the scale effect, composition effect and technology effect. The scale effect represents the change in the size of the economic activities. The composition effect represents the change in the composition or basket of the manufactured goods while the technology effect represents the change in the production technology, especially the paradigm shift to clean technologies. The scale effect increases environmental degradation while the technology effect reduces environmental degradation in trade liberalization. The composition effect depends on the type of relative advantage. Therefore, according to the concept of comparative advantage, if a country has advantage in the production of polluting goods, then the composition effect will have negative impact on the environment due to the changes in the composition of the country's manufactured goods in relation to polluting goods. If the composition effect is due to comparative advantage, and the combination of a country's manufactured goods changes to clean ones, then the composition effect on the environment will be positive. Generally, according to trade liberalization, if the influence of technology dominates the scale and composition effects (in a country with a comparative advantage in polluting industries) or if the influence of technology and composition (in a country with a comparative advantage in clean industries) dominates the effect of scale, then trade liberalization will culminate in positive environmental outcomes (Grossman and Krueger 1991).

3 Review of the literature

Numerous studies have been conducted on the relationship between economic growth and environmental quality. A number of researchers have investigated the role of factors such as energy consumption (Ang 2007; Alam et al. 2007), foreign trade (Halicioglu 2009), increase in electricity consumption and population growth

(Tol et al. 2006), human resources and capital (Soytas et al. 2007) in the environment. Also, financial development has been considered as one of the efficacious factors in the environment.

Tamazian et al. (2009) explored the effect of financial development in the BRIC[1] countries employing the modeling approach of the standard reduced form between 1992 and 2004. The results revealed that higher levels of financial and economic development reduced environmental pollution while financial liberalization and financial openness are crucial factors in the reduction in CO_2emissions. In addition, adoption of policies, which are relevant to financial liberalization and openness in order to attract greater levels of research and development, and foreign direct investment may reduce environmental pollution in these countries.

Tamazian and Rao (2010) in their study investigated the effects of financial and institutional development on CO_2 emissions in 24 countries between 1993 and 2004. The results verified the existence of the EKC. The importance of institutional quality and financial development on environmental performance was also confirmed. According to the results, financial development had a positive effect on environmental protection in these countries. The results also indicated that financial liberalization might be inimical to the quality of the environment if it is not implemented under a strong organizational structure. Trade openness in these countries also led to an increase in pollution.

Using panel cointegration and Granger causality test for BRIC countries, Pao and Tsai (2011) investigated the relationship between long-term and dynamic causality of carbon dioxide emissions, energy consumption, foreign direct investment (FDI) and gross domestic product (GDP). The results showed that in the long-run equilibrium, carbon dioxide emissions when compared with energy consumption foreign direct investment was elastic. Moreover, the results confirmed the EKC hypothesis in these countries.

Zhang (2011) investigated the effect of financial development on CO_2emissions in China between the period of 1994 and 2009, and employed techniques such as Johansen cointegration vector, Granger causality test and variance analysis. The results showed that the financial development of China acted as an important stimulus in increasing greenhouse emissions. The size and scale of financial intermediaries were more important than other indicators of financial development. Nonetheless, the effect of financial intermediaries was far weaker. The size and scale of China's stock market have relatively greater effect on carbon emissions, while FDI, due to its small share of GDP, has the least effect on carbon emissions. Using the ARDL model, Jalil and Feridun (2011) investigated the effects of growth, financial development and energy consumption on CO_2 emissions in China within the periods of 1953–2006 and 1987–2006. In their study, the shares of cash debt from GDP commercial bank assets from total assets of the banking system and foreign assets and liabilities from GDP were employed as indicators of financial development. The results showed that financial development contributed to the reduction in the environmental pollution in China. The results also confirmed the existence of the EKC in China.

[1] Brazil, Russian Federation, India and China.

Shahbaz et al. (2013b) investigated the effect of financial development on economic growth, energy consumption and CO_2 emissions in Malaysia within the period of 1971–2011. The results showed that financial development in Malaysia led to a decrease in CO_2 emissions while economic growth and energy consumption increased CO_2 emissions. In another study, Shahbaz et al. (2013a) investigated the effect of economic growth, energy consumption, financial development and trade openness on CO_2 emissions within the period of 1975–2011 in Indonesia. In their study, real per capita domestic credit to the private sector was considered as a measure of financial development. The results showed that economic growth and energy consumption in Indonesia increased CO_2 emissions while financial development and trade reduced it. Furthermore, the inverted U relationship between financial development and CO_2 emissions was confirmed.

Ozturk and Acaravci (2013) investigated the effect of financial development, trade, economic growth and energy consumption of CO_2 emissions within the period of 1960–2007 in Turkey, using the cointegration approach. The results showed that trade increased CO_2 emissions in the long term. The financial development variable was not significant regarding the CO_2 emissions. EKC hypothesis was also confirmed in Turkey (Table 1).

In Iran, many researchers have studied the factors affecting environmental quality. A number of studies have addressed the relationship between environmental quality and economic growth (Pazhouan and Moradhasel 2007; Pourkazemi and Ebrahimi 2008; Salimifar and Dehnavi 2009; Ghazali and Zibaee 2009; Mowlayi et al. 2010), energy consumption (Behboodi and Barghi Golazani 2008; Lotfalipour et al. 2010), trade openness (Barqi Askooei 2008; Behboodi et al. 2010; Agheli et al. 2010; Lotfalipour et al. 2012), factors of the labor force and capital (Sharzaei and Haghani 2009), the value-added share of the industrial sector from GDP (Nasrollahi and Ghaffari Goolak 2009; Vaseghi and Esmaeili 2009). Sadeghi and Feshari (2010) in an article using Johansen's cointegration approach over the period of 1971–2007 with regard to the indices of carbon dioxide emissions and arable land for environmental quality concluded that in addition to long-run equilibrium between the export and environmental quality indices, the variables of exports and foreign direct investment had a significant adverse impact on environmental quality indices.

Fotros and Maboodi (2010) employed the econometric approach of Yamamato in investigating the existence and direction of causality between energy consumption, urbanization, economic growth and carbon dioxide emissions over the period of 1971–2006. The results indicated a causal relationship between energy consumption, GDP, urbanization and carbon dioxide emissions. Estimation of the relationship between carbon dioxide emissions, energy consumption, urbanization and GDP showed that U hypothesis on environmental pollution and GDP in Iran was correct. Sadeghi et al. (2012) addressed the causal relationship between carbon dioxide emissions and FDI variables, per capita energy consumption and GDP in the EKC hypothesis in Iran over the periods of 1980–2008. The results verified the bilateral causal relationship between the variables of CO_2 emissions and per capita energy consumption as well as unidirectional causal relationship between GDP and per capita energy consumption.

Using panel data and generalized method of moments, Barqi Askooei et al. (2012) estimated the impact of variables such as energy consumption, factory products,

Table 1 Summary of the literature review for examination of effective factors in the environmental quality

Study	Variables	Methodology	Period	Country	Impact on environmental pollution	Confirmed hypothesis
Ang (2007)	Energy consumption	Cointegration and vector error correction modeling techniques	1960–2000	France	Rise	EKC
Alam et al. (2007)	Urbanization and energy consumption	Cointegrating vector	1971–2005	Pakistan	Rise	Unexamined (using the linear form)
Halicioglu (2009)	Foreign trade	The bounds testing to cointegration procedure	1960–2005	Turkey	Rise	Not support EKC
Soytas et al. (2007)	Human resources and capital	Generalized impulse response and variance decompositions	1960–2004	USA	Insignificant	Not support EKC
Tamazian et al. (2009)	Financial development	Modeling approach of the standard reduced	1992–2004	BRIC countries	Reduce	EKC
Tamazian and Rao (2010)	Financial and institutional development	Standard reduced form modeling approach and GMM estimation	1993–2004	24 countries in transition	Reduce	EKC
Pao and Tsai (2011)	FDI	Panel cointegration and Granger causality	1980–2007	BRIC countries	Inelastic	EKC
Zhang (2011)	Financial development	Johansen cointegration vector, Granger causality test and variance analysis	1994–2009	China	Rise	Unexamined

Table 1 continued

Study	Variables	Methodology	Period	Country	Impact on environmental pollution	Confirmed hypothesis
Jalil and Feridun (2011)	Financial development	ARDL model	1953–2006 and 1987–2006	China	Reduce	EKC
Shahbaz et al. (2013b)	Financial development	ARDL model	1971–2011	Malaysia	Reduce	Not support EKC
Shahbaz et al. (2013a)	Financial development and trade openness	ARDL model	1975–2011	Indonesia	Reduce	EKC
Ozturk and Acaravci (2013)	Financial development and trade openness	Cointegration approach	1960–2007	Turkey	Trade increases pollution, financial development insignificant	EKC

economic openness, foreign direct investment and economic growth on carbon dioxide emissions for the period between 1990 and 2010 in D8 countries. The results showed that in the fixed effects approach, all variables except FDI had a positive and significant relationship with carbon dioxide emissions (Table 2).

4 Materials and methods

4.1 Data

The ARDL can be employed for short-term and long-term relations between the dependent and explanatory variables of the model. Linear form or quadratic function has been used to investigate the effects of various factors on the quality of the environment in Iran, but the model in this paper is a cubic equation represented as follows:

$$EN = \alpha_0 + \alpha_1 GDP_t + \alpha_2 GDP_t^2 + \alpha_3 GDP_t^3 + \alpha_4 Z_t + \epsilon_t \quad (1)$$

where *EN* is environmental quality index, *GDP* is per capita gross domestic product, and *Z* relates to other variables that affect environmental quality (*FD*: financial development, *OP*: trade openness, *EC*: energy consumption). All variables are logarithmic in the model.

Equation (1) allows us to test several forms of environmental–economic development/growth relationships:

(i) $\alpha_1 = \alpha_2 = \alpha_3 = 0$. A flat pattern or no relationship between *GDP* and *EN*.
(ii) $\alpha_1 > 0$ and $\alpha_2 = \alpha_3 = 0$. A monotonic increasing relationship or a linear relationship between *GDP* and *EN*.
(iii) $\alpha_1 < 0$ and $\alpha_2 = \alpha_3 = 0$. A monotonic decreasing relationship between *GDP* and *EN*.
(iv) $\alpha_1 > 0, \alpha_2 < 0$ and $\alpha_3 = 0$. An inverted U-shaped relationship, i.e., EKC.
(v) $\alpha_1 < 0, \alpha_2 > 0$ and $\alpha_3 = 0$. A U-shaped relationship.
(vi) $\alpha_1 > 0, \alpha_2 < 0$ and $\alpha_3 > 0$. A cubic polynomial or N-shaped figure.
(vii) $\alpha_1 < 0, \alpha_2 > 0$ and $\alpha_3 < 0$. Opposite of the N-shaped curve.

From these, we observe that the EKC was only one of the possible outcomes of Eq. (1).

Using PCA, which is based on a linear combination of the original variables on the variance–covariance matrix and employing the following indices, this study attempts to extract the general index for financial development and address all aspects of financial development.

1. Index of financial development depth (*IFD*): the ratio of cash to GDP in current prices
2. Basic index of financial development (*BIF*): the ratio of domestic bank assets to total assets of commercial banks and the central bank.
3. Index of financial development performance (*IFP*): the ratio of private sector's debt (to the banking system) to GDP

Table 2 Summary of the literature review for examination of effective factors in the environmental quality in Iran

Study	Variables	Methodology	Period	Country	Impacton environmental pollution	Confirmed hypothesis
Pazhouan and Moradhasel (2007)	Economic growth	GLS	1991–2002	67 countries	Rise	EKC
Pourkazemi and Ebrahimi (2008)	Economic growth	Fixed and random effects model	1980–2003	13 countries of the Middle East	Rise	EKC
Salimifar and Dehnavi (2009)	Economic growth	Panel cointegration	1980–2005	24 developing countries and 26 OECD countries	Rise	EKC
Ghazali and Zibaee (2009)	Economic growth	Fixed effects model	1996–2006	Five provinces of Iran	Rise	Not support EKC
Mowlayi et al. (2010)	Economic growth	ARDL model	1974–2004	Iran	Rise	EKC
Behboodi and Barghi Golazani (2008)	Energy consumption	Johansen and Juselius cointegration	1967–2004	Iran	Rise	Unexamined
Lotfalipour et al. (2010)	Energy consumption	ARDL model	1967–2007	Iran	Rise	Unexamined
Barqi Askooei (2008)	Trade openness	Fixed and random effects model	1992–2002	Four groups of countries: high income, high middle income, low middle income and low income countries	In high income and high middle income countries: Reduce in low middle income and low income countries: Rise	Unexamined
Behboodi et al. (2010)	Trade openness	Johansen and Juselius cointegration	1967–2004	Iran	Rise	Unexamined

Table 2 continued

Study	Variables	Methodology	Period	Country	Impacton environmental pollution	Confirmed hypothesis
Agheli et al. (2010)	Trade openness	Cointegration and error correction model	1974–2006	Iran	Rise	Unexamined
Lotfalipour et al. (2012)	Trade openness	ARDL model	2010–2020	Iran	Reduce	Not support EKC
Sharzaei and Haghani (2009)	Labor force and capital	Johansen and Juselius cointegration	1974–2005	Iran	Insignificant	Not support EKC
Nasrollahi and Ghaffari Goolak (2009)	The value-added share of the industrial sector from GDP	GLS	1990–2004	Kyoto Pact countries and the countries of Southeast Asia	Insignificant	Not support EKC
Vaseghi and Esmaeili (2009)	The value-added share of the industrial sector from GDP	ARDL model	1974–2003	Iran	Rise	Not support EKC
Sadeghi and Feshari (2010)	Exports and foreign direct investment	Johansen's cointegration approach	1971–2007	Iran	Reduce	Unexamined
Fotros and Maboodi (2010)	Urbanization	Econometric approach of Yamamato	1971–2006	Iran	Rise	EKC
Sadeghi et al. (2012)	FDI	Vector autoregressive model & Toda Yamamato	1980–2008	Iran	Insignificant	Not support EKC
Barqi Askooei et al. (2012)	Economic openness	The approach of fixed effects	1990–2010	D8 countries	Rise	Unexamined

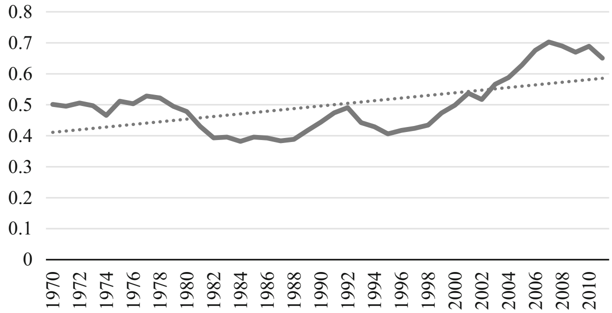

Fig. 1 Financial development and its trend over the period 1970–2011

4. Instrumental index of financial development (*IIF*): the ratio of money held by the public to total money supply
5. Structural index of financial development (*SIF*): the ratio of banking system claim of private sector to total banking system credit

Trade openness index is the ratio of total exports and imports to GDP; environmental quality index (million tons) is a combination of sulfur oxide pollutants, SO_2 and SO_3, nitrogen oxides of NO_x, carbon monoxide, SPM suspended particles and carbon dioxide, which were investigated in the PCA approach. Data on emissions of SO_2, SO_3, NO_X, CO and *SPM* were obtained from energy balance sheet of the Ministry of Energy, Department of Power and Energy; data on CO_2 were collected from the Carbon Dioxide Information Analysis Center; data on *GDP* (million dollars) were obtained from UNCTAD[2]; data on indices of financial development, and the square of financial development and trade have been achieved from economic reports and balance sheet of the central bank while data on energy consumption (million barrels of crude oil equivalent) were extracted from energy balance sheet. In this study, the investigation period was between 1970 and 2011; Microfit 4.0 was used for the estimation.

4.2 Financial development and trade in Iran

Figure 1 shows the trend of financial development in Iran. As seen from the chart, financial development declined and then increased due to the imposed war within the period of 1970 and 2011 (the Iran–Iraq war that lasted from September 1980 to August 1988). In general, there was an upward trend in financial development in Iran. However, the amount of financing for industrial activities increased over the period. As shown in Fig. 2, the ratio of financing for industrial activities to other activities experienced incremental growth indicating that this sector received more attention than other sectors in the financial development process.

Figure 3 shows the amount of export and import in Iran. Export and import increased over the years of the study.

[2] United Nations Conference on Trade and Development.

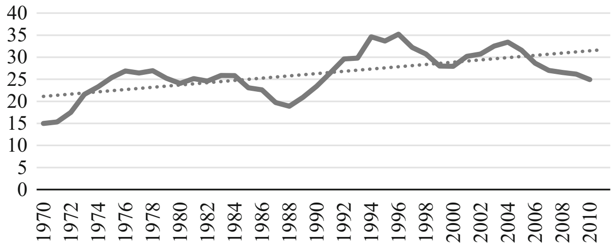

Fig. 2 Ratio of financing for industrial activities to other activities

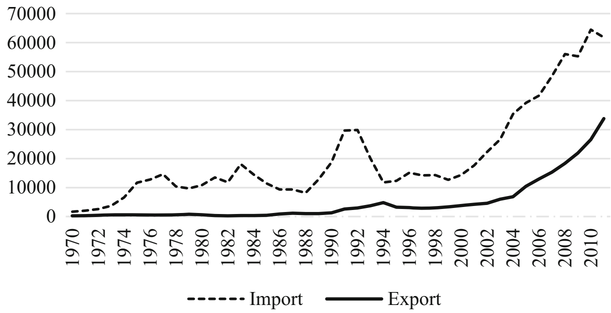

Fig. 3 Export and import over the period 1970–2011 (million dollars)

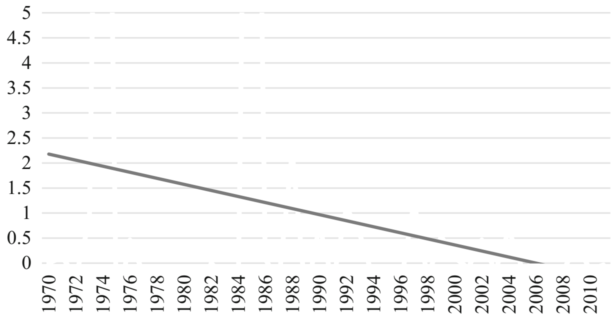

Fig. 4 Trend of exporting polluting goods over the period 1970–2011 (million dollars)

Industries such as cement, glass, ceramics, iron and steel, and pulp and paper cause a broad range of environmental effects and release an enormous amount of oxide of carbon, sulfur and nitrogen into the air.

According to Figs. 4 and 5, the exportation of polluting goods declined within the period of 1970–2011 with a downward trend. However, there was a rise in importation of polluting goods compared to the total imported goods. Therefore, the amounts of pollutants produced during this period experienced a downward trend.

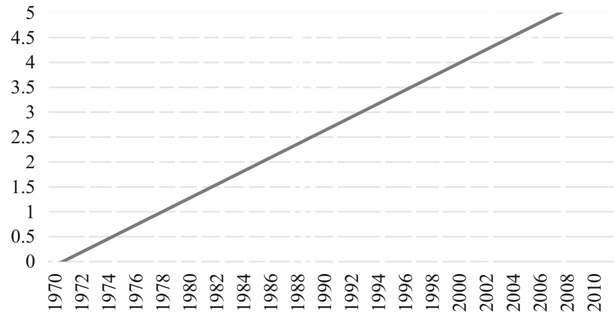

Fig. 5 Trend of importing polluting goods over the period 1970–2011 (million dollars)

4.3 Model

In this study, the ARDL approach proposed by Pesaran and Shin (1999) was employed. Most of the recent studies have suggested that the ARDL approach is preferable to other approaches such as Engle–Granger, in examining the cointegration and long-run relationship between variables. Whether the variables in the model are I(0) or I(1), this approach is applicable, and in small samples, it is relatively more efficient than other approaches. The ARDL model is represented as follows:

$$\varphi\,(L,\,P)\,Y_t = \sum_{i=1}^{k} b_i\,(L, q_i)\,X_{it} + c' w_t + u_t \tag{2}$$

where

$$\varphi\,(L,\,P)\,Y_t = 1 - \varphi_1 L - \varphi_2 L^2 - \cdots - \varphi_p L^p \tag{3}$$

$$b_i\,(L, q_i) = b_{i0} + b_{i1} L + \cdots + b_{iq} L^q \;\; i = 1, 2, \ldots, k \tag{4}$$

In the above relationships, Y_t is the dependent variable and X_{it} is the independent variables. L is Lag operator and w_t is a vector of categorical variables including predetermined variables in the model, such as intercept, dummy variables, time trend and other exogenous variables. P is the number of lags used for the dependent variable and q is the number of lags used for the independent variables. The number of optimal lags for each of the explanatory variables could be set by a measure of Akaike, Schwarz–Bayesian, Hanan Queen or adjusted coefficient of determination. In this study, given the small size of the dataset, Schwartz Bayesian measure was employed. The long-run coefficients were computed as follows:

$$\theta_i = \frac{\hat{b}_i\,(L, q_i)}{1 - \hat{\varphi}\,(L,\,p)} = \frac{\hat{b}_{i0} + \hat{b}_{i1} + \cdots + \hat{b}_{iq}}{1 - \hat{\varphi}_1 - \hat{\varphi}_2 - \cdots - \varphi_p} \quad i = 1, 2, \ldots, k. \tag{5}$$

ARDL approach consists of two steps in the estimation of long-run relationships. First, the dynamic ARDL model is tested for long-run relationship; thereafter, the long-run and short-run coefficients are estimated. The second step is conducted only if the long-run relationship is confirmed in the first step. Having estimated the ARDL dynamic model, the following hypothesis was tested:

$$H_0 = \sum_{i=1}^{p} \varphi_i - 1 \geq 0$$
$$H_1 = \sum_{i=1}^{p} \varphi_i - 1 < 0 \tag{6}$$

The null hypothesis implied the absence of a long-run relationship. Quantity t statistics, which was required to perform the above-mentioned test, was computed using the following equation:

$$t = \frac{\sum_{i=1}^{p} \hat{\varphi}_i - 1}{\sum_{i=1}^{p} S_{\hat{\varphi}_i}} \tag{7}$$

If the t statistics obtained from the absolute critical values provided by Banerjee, Dolado and Mestre is larger, then the null hypothesis based on the absence of cointegration would be rejected, and the long-run relationship would be accepted (Nowferesti 1999). In the second step, if the presence of cointegration is approved, the long-run relationship will be estimated.

5 Study results

Using the method of principal components for each of the indicators, an eigenvalue (γ_i) was obtained, and the weight (w_i) of each indicator in the general index was computed using the following equation:

$$w_i = \frac{\gamma_i}{\gamma_1 + \gamma_2 + \gamma_3 + \gamma_4 + \gamma_5}. \tag{8}$$

Table 3 shows the results of the PCA The results obtained were based on the principal component analysis and variance–covariance matrix. The results of the general index for environmental quality showed that carbon dioxide emissions had the most impact, followed by the proposed indices of NO_X, SO_2, CO, SO_3 and *SPM*.

Among the indicators of financial development with the exception of the instrumental index (*IIF*), higher index values represented higher levels of financial development. In order to coordinate the indicators, the value of the *IIF* was subtracted from one and the values were presented as modified instrumental index (*MIIF*). The results of the general index for financial development showed that structural index (*SIF*) is the most important index as regards the general index for financial development in Iran, followed by the proposed indexes of *IFP*, *BIF*, *MIIF* and *IFD*.

Before the test, reliability of all variables was checked to ensure that none of the variables were I(2). If there is any I(2) variable in the model, the F statistics is not reliable. To ensure that variables of time series used in the model were stationary or

Table 3 Results of PCA, eigenvalues and weight in the general index for environmental quality and financial development. *Source* Research findings

General index for financial development			General index for environmental quality		
Indices	Eigenvalue (γ_i)	Weight	Indices	(γ_i) Eigenvalue	Weight
MIIF	0.002749	0.035892	SO_2	0.0582	0.00000239
IFD	0.000199	0.002597	SO_3	0.0055	0.00000023
SIF	0.037037	0.483641	NO_X	3.1125	0.000128
IFP	0.026345	0.344028	CO_2	24312.3	0.999868
BIF	0.010249	0.133841	CO	0.0166	0.00000068
			SPM	0.00009	0.000000008

Table 4 Results of unit root tests in the level. *Source* Research findings

Variables	With intercept and without trend*			With intercept and trend**		
	Optimal lag	ADF statistics	Test results	Optimal lag	ADF statistics	Test results
LEN	2	−0.28	Non-stationary	1	−4.54	Stationary
LGDP	1	−0.28	Non-stationary	5	−3.00	Non-stationary
$LGDP^2$	1	0.35	Non-stationary	5	−2.84	Non-stationary
$LGDP^3$	0	2.19	Non-stationary	0	−0.55	Non-stationary
LFD	0	−0.83	Non-stationary	1	−2.07	Non-stationary
LEC	3	−1.06	Non-stationary	2	−4.99	Stationary
LOP	1	−0.93	Non-stationary	1	−2.00	Non-stationary

* Critical value at the confidence level of 95% in cases without trend is −2.96
** Critical value at the confidence level of 95% in cases with trend is −3.56

non-stationary, augmented Dickey–Fuller (ADF) test was employed. Table 4 shows the ADF test results for the variables. The Schwarz–Bayesian criterion (SBC) usually saves the number of lags. Therefore, in this study, the number of optimized lags was selected based on SBC. *OP* and GDP^2 variables were at the same level, while those without trend were stationary, but for the variables of *FD*, *GDP* and *EN,* ADF statistic in both cases was smaller than the critical values. Therefore, the variables at the same level were non-stationary and the unit root hypothesis on the variables was not rejected.

To determine the stationary degree of the variables, ADF test was replicated for the first-order difference of the variables. Test results showed that variables became stationary by making one deduction (Table 5).

Result of the estimation of the ARDL model was based on three parts: dynamic, short-run and long-run relationships. The following equation on the dynamic relationships between variables can be specified and estimated:

Table 5 Results of unit root tests on the first difference of the variables. *Source* Research findings

Variables	With intercept and without trend*			With intercept and trend**		
	Optimal lag	ADF statistics	Test results	Optimal lag	ADF statistics	Test results
LGDP	0	−4.26	Stationary	3	−6.07	Stationary
$LGDP^2$	0	−4.15	Stationary	3	−6.47	Stationary
$LGDP^3$	0	−3.98	Stationary	4	−6.38	Stationary
LFD	0	−4.00	Stationary	0	−3.79	Stationary
LOP	0	−3.79	Stationary	0	−3.80	Stationary

* Critical value at the confidence level of 95%, in cases without trend is −2.96
** Critical value at the confidence level of 95%, in cases without trend is −3.57

Table 6 Result of estimation of long-run relationship. *Source* Research findings

Variables	Coefficients	SD	*t* statistics	*P* value
LGDP	−19.77	6.68	−2.96	0.006*
$LGDP^2$	22.15	7.55	2.93	0.006*
$LGDP^3$	−7.82	2.77	−2.82	0.009*
LEC	1.10	0.31	3.52	0.001*
LFD	0.39	0.17	2.28	0.030*
LOP	−0.29	0.09	−3.14	0.004*

* Significant at 95% confidence level

$$EN = \alpha + \sum_{j=1}^{p} \alpha_{1j} EN_{t-j} + \sum_{j=0}^{q_1} \alpha_{2j} GDP_{t-j} + \sum_{j=0}^{q_2} \alpha_{3j} GDP^2_{t-j} + \sum_{j=0}^{q_3} \alpha_{4j} GDP^3_{t-j} + \sum_{j=0}^{q_4} \alpha_{5j} Z_{t-j} + U_t \tag{9}$$

To estimate the relationship, the maximum lags were taken as 2 since the data are on annual basis. Using SBC, dynamic relationships between variables were selected. The optimal lags for each of the variables were set and the model was estimated as ARDL (1, 1, 1, 0, 0, 0, 1). To study the long-run relationship between the variables, the value of computational statistics of Banerjee, Dolado and Mestre was computed in the following way:

$$t = \frac{0.51 - 1}{0.1} = -4.9 \tag{10}$$

The value of Banerjee, Dolado and Mestre table at confidence level of 95% for a model with intercept was −4.43; thus, the existence of long-run relationship between the variables is confirmed. Having determined the long-term relationship, results of the estimation are presented in Table 6.

Since the results of the classic tests showed lack of serial correlation between components of disturbances, properly specified equation and homogeneous variance,

Table 7 Results of estimation of relationships between pollutants and economic growth. *Sources* Research findings

Pollutant	Variables	Coefficients	SD	*t* statistics	*P* value	Confirmed hypothesis
CO_2	*LGDP*	−19.77	6.68	−2.96	0.006***	Inverted N-shaped
	$LGDP^2$	22.15	7.55	2.93	0.006***	
	$LGDP^3$	−7.82	2.77	−2.82	0.009***	
CO	*LGDP*	−40.30	15.81	−2.55	0.017***	Inverted N-shaped
	$LGDP^2$	48.77	18.36	2.66	0.013***	
	$LGDP^3$	−18.58	6.87	−2.70	0.012***	
NO_X	*LGDP*	2.92	3.85	0.76	0.45*	Flat pattern or no relationship
	$LGDP^2$	−2.54	4.45	−0.57	0.57*	
	$LGDP^3$	0.64	1.68	0.38	0.7*	
SO_2	*LGDP*	31.57	13.15	2.40	0.022***	N-shaped
	$LGDP^2$	−37.24	14.99	−2.48	0.018***	
	$LGDP^3$	13.85	5.54	2.50	0.018***	
SO_3	*LGDP*	25.60	14.90	1.72	0.09**	N-shaped
	$LGDP^2$	−30.23	17.03	−1.77	0.086**	
	$LGDP^3$	11.02	6.31	1.74	0.091**	
SPM	*LGDP*	34.51	13.21	2.61	0.014***	N-shaped
	$LGDP^2$	−40.03	15.08	−2.65	0.013***	
	$LGDP^3$	14.76	5.57	2.65	0.013***	

*** Significant at 95% confidence level
** Significant at 90% confidence level
* Insignificant

the results of the long-run relationship are reliable. Results obtained from Table 6 showed that all variables were significant at the 95% confidence interval. The coefficient of financial development, energy consumption and trade liberalization was positive, positive and negative, respectively, which implies that an increase in financial development and energy consumption induces a rise in environmental degradation; however, increase in trade promotes the quality of the environment. The negative coefficient of *LGDP* (−19.77) shows that economic growth in Iran is associated with a decrease in emission. The coefficient of long-term emissions relative to the variables of $LGDP^2$ and $LGDP^3$ was positive and negative, respectively, which indicates that the relationship between environmental quality and per capita GDP is inverted N-shaped, and the EKC hypothesis is correct in Iran.

While some studies have confirmed the inverted U relationship with regard to the quadratic form in Iran, this paper confirmed the inverted N relationship using the third degree form, which combines pollutants and economic growth.

The EKC relationships are more likely to hold water for particular types of environmental damage, e.g., pollutants with local impacts, rather than those with more global and indirect impacts (Arrow et al. 1995; Cole et al. 1997; John et al. 1995). The

Table 8 Results of the estimation of error correction model. *Sources* Research findings

Variables	Coefficients	SD	*t* statistics	*P* value
dLGDP	−7.14	3.10	−2.30	0.028***
dLGDP^2	9.75	3.51	2.78	0.009***
dLGDP^3	−3.82	1.29	−2.97	0.006***
dLEC	0.54	0.13	4.16	0.000***
dLFD	−0.01	0.08	−0.16	0.8*
dLOP	−0.14	0.04	−3.83	0.001***
ECM(−1)	−0.49	0.1	−4.99	0.000***

*** Significant at 95% confidence level;
* Insignificant

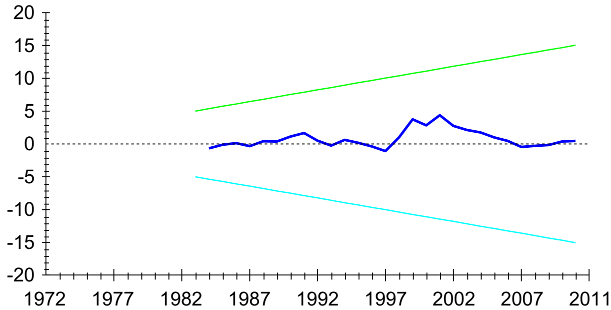

Fig. 6 Plot of cumulative sum of recursive residuals. The *straight lines* represent critical bounds at 5% significance level

significant EKCs exist only for local air pollutants such as SO_2, *SPM*, NO_X and CO (Cole et al. 1997)

In order to separate the local and global pollutants, Kuznets curve was checked for each pollutant. The results in Table 7 indicate that the inverted N-shaped relationship is true for CO_2 and CO as well as for SO_2, SO_3, and *SPM*. There is a flat pattern or no relationship between per capita GDP and environmental quality for NO_X. Therefore, the Kuznets curve hypothesis was not verified for any of the local and global pollutants.

The estimated error correction model to study adjustment of short-run disequilibrium toward long-run equilibrium is presented in Table 8.

A value of −0.49 was obtained for error correction coefficients in the model, which signifies a 49% adjustment in each period to establish a long-run equilibrium. The results of CUSUM and CUSUMSQ tests for evaluation of the estimated coefficients, and the results of stability test for short- and long-run coefficients over the period are shown in Figs. 6 and 7.

Since the statistics were within the 95% confidence intervals in both tests, null hypothesis based on the stability of the coefficients was accepted, and the results obtained were valid at the confidence level of 95%.

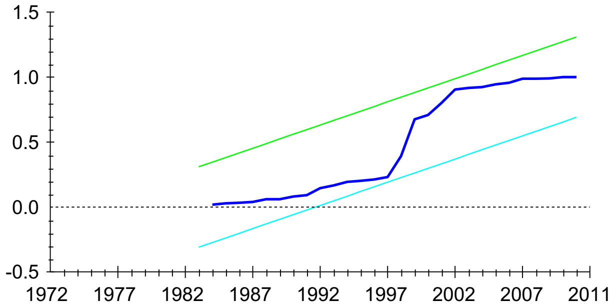

Fig. 7 Plot of cumulative sum of squares of recursive residuals. The *straight lines* represent critical bounds at 5% significance level

6 Conclusion

Financial intermediaries may increase technological innovation through financial development and mobilize financial resources to identify the best production technology and invest in projects involving clean environment. Nevertheless, financial development may increase financing for industrial activities, which harm the environment.

Due to the different degree of reliability of the variables, long-run ARDL model was employed. The results showed that the coefficient of financial development was positive and significant at 0.05% probability level in the long-run suggesting that in addition to economic growth, financial development also affects environmental quality in Iran with a concomitant increase in environmental pollution. Based on Fig. 2, the ratio of financing for industrial activities to other activities increased signifying inefficiency on the part of the industries in protecting the environment. Financial development has made way for devastation of the environment. In fact, the investments were only effective in increasing the size of the industrial activities and did not result in any form of technological advancement in the industry. Therefore, the policy advice is that financial system should take the environment into account in their current operations. For example, banking system may encourage investments in energy efficient technology by offering interest discounts and including carbon-related conditions in their financial products such as business vehicle and investment real estate term loans. Hence, a set of practical policies and incentives that promote more low carbon finance is an imperative part of building up Iran's resource conserving society.

The results suggested that in the long run, energy consumption was the main cause of CO_2 emissions in Iran. The relevant emission reduction policy variable is energy consumption. Reducing energy consumption decreases carbon emissions. Alternative policies such as decreasing energy intensity, increasing energy efficiency in renewable energy use, increasing the utilization of cleaner energy sources (wind, solar, natural gas) may alleviate the pressure on the environment and gain some time for a full switch from fossil fuels to cleaner energy sources due to technological advancements. Results showed that economic growth had a significant and negative impact on emissions. Hence, Iran does not need to accept a reduction in income levels to reduce emissions.

Moreover, EKC hypothesis inverted U-shaped relationship was not correct for any of the local and global pollutants in Iran.

The study results also suggested that an increase in trade openness led to improvement in the country's environmental quality. This may be due to the fact that the goods which produced large quantities of pollutants in the manufacturing process were imported from other countries such as China. As a result, there is an increase in pollution in exporting countries. In Iran, an importing country, pollution reduces because of the reduction in production of polluting goods. Furthermore, it might be due to the decline in export of polluting goods, which reflects low production and reduction in pollution in Iran. Decline in the proportion of heavy polluting export products such as cement, glass, ceramics, iron and steel, which produce large amounts of pollutants in the manufacturing process (Fig. 5) and increased proportion of imports (Fig. 4) confirmed the results of the model. In addition, economic openness triggers an increase in imports of high-tech intermediary and capital goods that create less pollution in production process.

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