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The Effect of Gross Domestic Product and Energy Consumption on Water Pollution in Iran

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Abstract

Nowadays, water pollution is one of the most serious environmental challenges in managerial policies of the world. On the other hand, the effect of economic development of the countries on pollution emission is undeniable. The mail goal of this study is to investigate the amount and direction of the effect of gross domestic production and energy consumption on water pollution in Iran. The investigation was performed using 1973-2007 time series data and the vector error correction model (VECM). The results showed that, when gross domestic product rises, although the amount of pollution increases at the beginning, eventually the amount of water pollution decrease as this process goes on. The results also showed that a 1% increase in energy consumption results in 0.55% increase in water pollution. Considering this positive effect of energy consumption on water pollution, the implementation of policies for increasing energy efficiency should result in a pollution decrease. Estimation of the error correction coefficient indicated that it would take more than 1.54 year to adjust the shocks caused by water pollution in Iran.

Key words: Gross domestic production, Energy consumption, Water pollution, Vector error correction model.

اثر تولید ناخالص داخلی و مصرف انرژی بر آلودگی آب‌های ایران

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چکیده

آلودگی آب در عصـر حاضـر به عنوان یکی از چالش های اصـلی زیسـت محیطی در سـیاسـت های مدیریتی جهانی مطرح اسـت. از سـویی دیگر اثرگذاری فرایند رشـد اقتصـادی کشـورها بر انتشـار آلودگی موضـوعی انکار ناپذیر اسـت. هدف اصـلی این مطالعه نیز آزمون بررسـی میزان و جهت اثر تولید ناخالص داخلی و مصـرف انرژی بر آلودگی آبها در ایران است. این بررسی با استفاده از داده های سری زمانی ۸۶-۱۳۵۲ و تحت الگوی تصحیح خطای برداری (VECM) صورت گرفت. براساس نتایج گرفته شـده، با افزایش تولید ناخالص داخلی ، اگر چه در ابتدا میزان آلودگی افزایش یافته ولی در نهایت با ادامه این روند، میزان آلودگی هوا کاهش خواهد یافت. همچنین نتایج این مطالعه نشـان داد که افزایش یک درصدی در میزان استفاده از انرژی منجر به افزایش ۰/۵۵ درصـدی در میزان آلودگی آب خواهد شـد. با توجه به اثر مثبت اسـتفاده از انرژی در آلودگی آب، اعمال سـیاسـت هایی در جهت افزایش بهره‌وری انرژی باعث کاهش آلودگی خواهد شـد. در نهایت برآورد ضـریب تصـحیح خطا نشان داد که برای تعدیل شوک¬های وارده ناشی از آلودگی آب در ایران، به بیش از ۱/۵۴ سال زمان نیاز خواهد بود.

کلمات‌کلیدی: محیط زیسـت، تولیدناخالص داخلی، مصـرف انرژی، آلودگی آب، الگوی تصحیح خطای برداری.

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1. Introduction

The main objective of many economic policies is to attain higher economic growth, while the environmental dangers caused by economic activities have become a global problem. One of the instances of pollution is water pollution. Nowadays, water pollution is one of the major issues facing big cities all over the world. The mankind every day discharges a huge amount of pollutants into water not compatible with natural process. A 2013 report by WHO and UNICEF concluded that 768 million people remain without access to an improved source of water and 2.5 billion people are without access to improved sanitation, respectively[1]. The High-level Panel on the Post-2015 Development Agenda has indicated that 2 billion people do not have access to safe water[2]. The number of people whose right to water is not guaranteed is even greater, probably in the order of 3.5 billion [3].

From an economist's point of view, pollution occurs when environmental damage harms human health or somehow affects human welfare. In economic terms, pollution takes place when the emission of pollutants in such environments as water and air imposes external costs (health damage, increase of disease, death, and so on) to human welfare. In this sense, the physical presence of pollution alone does not mean economic pollution. In social terms, it is impossible that the amount of external costs reaches zero (zero pollution), because environmental capacities demand that some damage occurs and some costs be spent for controlling pollution. Therefore, the meaning of environmental protection and sustainable development is not the prevention of the occurrence of pollution; the good condition is when the amount of pollution equals the absorption capacity of the environment.

What has added to the importance of pollution over recent decades and led to greater attention paid to it by many governments is the issue of sustainable development. In the framework of sustainable development, economic growth is not only relying on the process of production and services; combining growth and environmental protection at the same time is the ideal of many governments in the world. The disadvantage of economic systems at present is that environmental materials and services used in the production process are not taken into consideration. In fact, according to sustainable development system, production cannot be considered as a function of capital and labour that but also that environmental goods and services must be considered in production function.

Also, attention should be paid to products, waste and garbage in designing and planning the production process: Destruction and pollution of environmental resources must be considered as production or consumption cost. One of the main environments widely used by countries for waste discharge is water resources such as seas and rivers, whereas the preservation of these resources is one of the most vital necessities of the mankind. Waste is one of the most important resources of the environment and one of the parameters of development, playing a crucial role in the people's lives. An increasing population and the need of water for the food supply have increased the importance of water as a vital factor. Especially in our country which has a semi-arid climate together with a vast desert; water is of extreme importance as a scarce resource, the shortage of which in future will be one of the most serious threats for the country. Average per capita water consumption is 1300 cubic meters for each person per annum, whereas this amount globally is about 580 cubic meters annually per person, which indicates the lost of water resources and excessive use of this vital substance in our country. The issues of water resource consumption do not only concern excessive use of water; sometimes, humans change the nature of water as a result of using incorrect methods, which is known as water pollution. Water pollution involves physical, chemical and microbiological changes in water. Each year, about 2 billion people around the world suffer water-related diseases as the result of water pollution.

In addition to causing diseases for the mankind, water pollution results in environmental destruction. According to World Bank reports, environmental damages resulting from water pollution in Iran are 20,000 billion Rials or, in other words, 1.7% of domestic gross production. Water is generally used in the three sectors of industry, agriculture and for drinking. Therefore, water pollution is originates from these three sectors. Statistics show that about 90% of water resources of our country are used in the agricultural sector, and so agricultural wastewater is one of the main factors of pollution. Also, about 5% of waters of the country are being used in the industrial sector. Despite the low share of this sector in water consumption, however, the pollution it causes is every dangerous [4].

In view of the above explanations, restriction of water resources and their pollution warns healthy water shortage in the future. Water consumption management is the best choice for facing this problem and, in fact, water consumption must be managed in such a manner that excessive consumption and pollution are prevented as far as possible. To fulfil this goal, it seems necessary to identify and investigate water pollution agents more accurately. Based on a materials balance model the growth of production and consumption directly increase use of the environment and the creation of pollution. Population growth and, consequently, an increase in consumption increase pollution as well. Another factor is an increase in the production and services which appears in gross domestic product growth and entails an increase of natural resources consumption, which results in more waste. Therefore, national production growth could be deemed as the cause of environmental pollution as well.

Another important parameter is energy consumption density which influences the amount of environmental pollution. In fact, this parameter is one of the main indicators of the issue of pollution. In an experimental analysis of environmental policies in some developing countries using macroeconomic indicators, Focacci (2003) investigated the two indicators “emission intensity” and “energy consumption intensity” in three countries (Brazil, China and India) [5]. He analyzed the differences in trend of these indexes in the aforesaid countries and, finally, reached the conclusion that the difference between these trends is the result of the type and amount of industries in these countries. Warr and Ayres (2009) concluded that the energy amount and consumption, whether in the short- or long-term, has a close relationship with the amount of growth in gross domestic product[۶]. To improve economic growth in the long-term, therefore, it is necessary either to increase energy consumption or improve energy consumption efficiency. Also Chebbi (2009) concluded that economic growth depends on energy consumption and an increase of energy consumption results in an increase in pollution. In particular, economic growth increases air pollution[7]. Therefore, it is recommended that energy consumption efficiency be increased rather than energy consumption.

In Iran, most studies have focused on air pollution in spite of the fact that water is always considered as a limiting factor, some examples of which are described here. Moazami and Morad Hasel (2006) tested the effect of consumption on economic growth and of environmental destruction on health as well as the relationship between the indicators for pollution, economic growth and health for a selection of middle income countries (Iran, Turkey and China) for the period between 1995 and 2002, in the form of case study for air pollution by using the mixed data method (panel) [8]. The results showed that the three countries are in the first stage of economic growth, in which the relationship between income and pollution is positive and the effect of income on health is positive but the effect of pollution on health is negative. In a study of the effect on economic growth on air pollution using the mixed data method, Pajouyan and Morad (2007) tested this effect for 67 countries with different income levels (including Iran) in the form of the Kuznets environmental curve theory[9]. In this study, the effect of economic growth, urban population, environmental laws, number of vehicles and the level of economic openness on the amount of air pollution was investigated and the presence of the Kuznets environmental curve theory in the countries being studied was confirmed. Fetres (1998) addressed the environment and economics by conducting a theoretical study of the relationship between environmental pollution and losses and major economic parameters such as population and national production[10]. He employed economic theories and considered environmental commodities as an essential part of production; through the principle of materials balance and by using an analytical method, he reached the conclusion that environmental loss and pollution is potentially in a direct relation with such parameters as population and national production.

In view of the above statements and the importance of water resources in Iran, the present research studies the effect of some major economic variables, such as gross domestic product and energy consumption, on water pollution in Iran.

2. Materials and Methods

A vector error correction model, which is generally offered in the form of a vector auto regressive model (VAR), is written under a VAR system with k as an endogenous integrated variable of order (1) with P lags, in matrix form as follows:

$$\Delta y_t = \pi y_{t-1} + \Gamma_1 \Delta y_{1,t-1} + \ldots\ldots + \Gamma_{P-1} \Delta y_{1,t-P+1} + u_t \quad (3)$$

$$\Pi = -(I_K - A_1 - A_2 - \ldots\ldots A_P) \quad (4)$$

In the above relations, we can consider $\pi=\alpha\beta'$ in which β is the co-integration matrix and α is the adjustment or feedback matrix. In fact, the β coefficient indicated long-term coefficients between the model's variables. The Γ_{P-1} coefficients indicate short-term coefficients between model variables and the α coefficient indicates the speed of adjustment of short-term relationships to long-term ones. The water pollution criterion is the level of BOD emissions (calculated in kilogram/day) which mean the amount of oxygen necessary for the survival of airborne bacteria in the period of nutrition from organic matters present in the aquatic organic pollution environment as well as the analyzable and nutritious organic matter of these bacteria, investigated under rubric of oxygen required for biochemical reactions. Gross domestic product in the model is also the gross domestic production for the base price year of 1998. This information is of the time series data type, relating to the period between 1979 and 2007 and has been collected form World Bank information, Central Bank statistics and the nationmaster.com website.

3.Results and Discussion

Diagram 1 shows the trend of water pollution in Iran. The curve of this trend indicates that there have been fluctuations in the level of water pollution, being close to descending in the recent years.

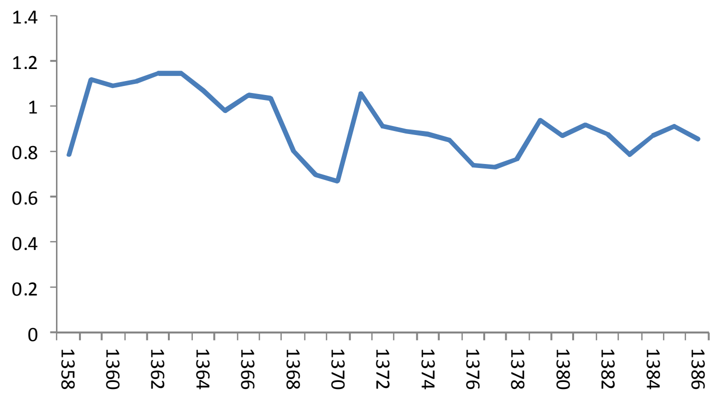

Fig 1. Water pollution trend in Iran.

As a next step, this research investigated the factors influencing the level of emission and the correctness of Kuznets' theory in Iran under the vector error correction model (VECM) [11]. In VECM estimation, the first step is to test stationary variables by using the augmented Dicky-Fuller test, the results of which are shown Table 1. These results show that all the three variables are non stationary (in real terms) but are stationary at the first differences. In another words, all variables are integrated or order (1).

Table 1. Results of the Dicky-Fuller Test.

Philips Peron		Augmented DF		
First difference	**Level**	**First difference**	**area**	**parameter**
-۹.۵۰*	-۲.۷۳	-۶.۵۲*	-۲.۶۶	LW
-۷.۰۴*	-۱.۵۱	-۵.۷۸*	-۱.۵۷	$LGDP$
۴.۰۴*	-۰.۵۳	-۴.۰۳*	-۱.۸۶	$LGDP_2$
-۵.۰۳*	-۱.۱	-۵.۹۳*	-۱.۲۲	EC

*: meaningful in the level of 5 percent

Before estimating the VECM coefficients, it is necessary to test the existence and number of long-term relations between variables. Based on the Johansson Test whose results are shown in Table 2, based on λ_{MAX} and Trace tests, the existence of a single equilibrium relationship was confirmed.

Table2. Results of the Johansson test.

Critical value (5% level)	Trace	Critical value (5% level)	λ_{MAX}	H1	H0
۲۷.۵۸	۴۷.۵۳	۴۷.۸۵	۶۶.۴۰	R>0	R=0
۲۱.۱۳	۱۴.۹۳	۲۹.۷۹	۱۸.۸۷	R>1	R≤1
۱۴.۲۶	۳.۳۳	۱۵.۴۹	۳.۹۳	R>2	R≤2
۳.۸۴	۰.۵۹	۳.۸۴	۰.۵۹	R>3	R≤3

To determine the appropriate lag length of the model's differences, three lags were compared with different criteria, the results of which are shown in Table 3. As we can see, the Schwartz criterion confirms lags 1 for the VAR model. Based on Jvanvi and Killian (2005), the most appropriate criterion for models with a sample volume of less than 120 observations is that of Schwartz. Also, in cases where the purpose is VECM estimation, the Schwartz criterion for each sample is the best criterion for selecting model lags. So, the result of this criterion has been used for lags determination.

Table 3. Result of model lags selection criteria.

Maximum Trueness Criterion	Hanan Coein Criterion	Acaic Criterion	Schwartz Criterion	Number of Pauses
---	-۷.۶۳	-۷.۶۸	-۷.۴۸	0
۱۳۵.۵۰*	-۱۳.۲۲	-۱۳.۴۸	-۱۲.۵۰*	1
۱۴.۶۶	-۱۲.۶۵	-۱۳.۱۲	-۱۱.۳۶	2
۲۶.۰۷	-۱۳.۴۸*	-۱۴.۱۶*	-۱۱.۶۱	3
۸.۳۰	-۱۳.۱۳	-۱۴.۰۱	-۱۰.۶۷	4

*: Optimal lag length in the level of 5 percent

The results of VECM estimation are reported in Table 4. As shown in this table, the coefficient for the gross domestic production variable is 20.78 and its square term is -10.27. The significance and signs of these coefficients indicate that Kuznets' environmental theory regarding water pollution is wholly correct. On the other hand, the coefficient of energy consumption is 0.55 that is significant at a statistical level of 1% indicating the positive effect of this variable on water pollution. In other words, an increase in energy consumption results in increased water pollution: a 1% increase in energy consumption will result in a 0.55% increase in water pollution.

The log-run adjustment coefficient is -0.67. The negative and significant coefficient of this variable confirms the presence of a long-term relationship between variables, and its quantity shows that 67% of the effects of shocks in the level of water pollution are adjusted over a period and reach long-term equilibrium. Therefore, if a shock or change takes place in any of the variables, it would take more than 1.54 years to adjust its effect and reach long-term equilibrium. The coefficient of the Dummy variable is not significant at the 0/05 level, which indicates that development plans have not had any meaningful effect on the amount of water pollution.

Table 5. VECM estimation results (normalized in respect of the pollution level logarithm).

t-statistic	coefficient	Description	variable
-۵.۰۲	-۰.۶۷	Long-run adjustment coefficient	ECT
۲.۲۶	۲۰.۷۸	Coefficient of (GDP)t-1	β_1
-۲.۲۲	-۱۰.۲۷	Coefficient of (GDP2)t-1	β_1
۲.۷۵	۰.۵۵	Coefficient of (energy consumption)t-1	β_2
-۰.۱۵	-۰.۰۰۳	Dummy variable (development plan)	α_1
۲.۷۲	۴.۰۱	Intercept	C

4.Conclusion

The results from this study indicate the potentially positive effect of gross domestic product on the level of water pollution. This variable affects water pollution in both the short- and long-terms. It is recommended, therefore, to take measures to control production activity with respect to water pollution. In fact, it is necessary for government to control water pollution by regulating and supervising the consumption pattern in production and services. Also, achieving water prices in line with a plan for targeted subsidies can explain the importance of this economic component further. Following this line of thinking, it is necessary to levy fines from polluting industries that are proportionate to the real price. It is evident that possible damages to the welfare of future generations must also be taken into consideration in the determination of the appropriate rate for such fines, since the water resources of the country belong to all generations, both present and future. In addition, the use of technologies which lead to a reduction in energy consumption can lead to a degree of decrease in pollution.

Many research studies have been conducted in this field and scientists have been always searching for methods to reduce energy consumption. The attainment and utilization of these methods not only reduces production costs, but can also reduce environmental pollution and losses. In this matter, a plan of targeted subsidies and normalization of the fuel price, if conducted well, will also result in a reduction in energy and fuel consumption; this, in turn, will lead to a decrease in water pollution. The use of policies of incentives and sanctions by the government to replace fossil fuels with clean energy resources such as wind, sun and water energy, and reduce pollution, especially from those industries that cause dangerous and highly persistent pollutants, are also among the factors influencing equilibrium in pollution levels and the absorption capacity of the environment. It is recommended that other studies be conducted in this field in order to investigate with accuracy the different factors influencing environmental pollution and losses. In this line, water pollution must be given a greater priority due to the limited resources of this vital substance.

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References

[1] WHO/UNICEF. *Progress on Sanitation and Drinking-Water: ;2013; Update.* New York, WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation

[2] UN. The Report of the High-Level Panel of Eminent Persons on the Post-2015 Development Agenda. ;2013;. New York, UN.

[3] Onda, K., LoBuglio, J. and Bartram, J. Global access to safe water: Accounting for water quality and the resulting impact on MDG progress. *International Journal of Environmental Research and Public Health*; 2012., doi:10.3390/ijerph9030880

[4] World bank reports . Report of state unexpected disasters organization. ;2007; (in Persian)

[5] Focacci A .Empirical Analysis if The Environmental and Energy Policy in Some

Developing Countries, using employed Macroeconomics Indicator, Energy Policy journal ;2003;.vol33,pp 543-554

[6] Warr. B. S, and Ayres. R. UEvidence of causality between the quantity and quality of energy consumption and economic growth. International Institute for Applied Systems Analysis. ;2009 ; (IIASA).

[7] Chebbi. H. E. Investigating linkages between economic growth, energy consumption and pollution emission in Tunisia, Agricultural Economic Conference, 2009;Beijing, Chaina, Agust 16-

[8] Moazzami.A, & Moradhasel.N. Investigating the effect of the economic growth and environmental degradation on health, the case study: air pollution ; 2006; oral presentation on the second national conference of the air pollution and its effect on the health.

[9] Pajoyan. J. & Moradhasel.N. Investigating the effect of economic growth on air pollution. Iranian journal of economic researches. ; 2007; No 7.(in Persian)

[10] Fetres.M,. "Issues of Environment and Economics. The Iranian Journal of agricultural economics and development. 1998; No 21. P; 78. . [In Persian]

[11] Martinez-Zarzoso, I., Bengochea-Morancho, A.,. Testing for an Environmental KUZNETS Curve in Latin-American Countries. Revista deAnalisis Econo'mico ;2003;18, No. 1, 3-26.