THE IMPACT OF TRADE LIBERALIZATION ON ENERGY CONSUMPTION IN IRAN

[a] BAHRAM SAHABI, [b] ALIREZA SARANJ, [c] MEHDI ZOLFAGHARI

[a]*Faculty of Management and Economics, University of Tarbiat Modares, Tehran, Iran*
[b]*Faculty of Management and Accounting, Farabi College, University in Qom, Iran*
[c]*Faculty of Management and Economics, University of Tarbiat Modares , Tehran, Iran*

email: [a]sahabi_b@modares.ac.ir, [b]alisaranj@ut.ac.ir, [c]m.zolfaghari@modares.ac.ir

Abstract: Energy resources play an essential role in economic and industrial development of different countries in recent decades. The global trend is moving toward trade liberalization. Following this trend, the consumption of energy carriers, has affected the economic activities. Various models are utilized in energy demand analysis. Some have designed only to study energy demand and other to assessment for its relationship with other factors. This paper surveyed the effect of trade liberalization on final energy consumption using Antweiler et al (2001) model based on Auto Regressive Distributed Lag (ARDL) Modeling Approach for 1971 - 2015. Energy carriers include oil products, natural gas, electricity, other (coal, solid biomass, coke…). Results suggest that trade liberalization may cause to increase final energy consumption. According to the respective variable coefficients, PHH hypothesis can be valid for the country.

Keywords: Trade Liberalization, Per capita energy Consumption, Energy Intensity, Antweiler et al (2001) model.

1 Introduction

The Liberalization and globalization are among the events that are evolving and are going in the all areas of life modern. In general, the process of trade liberalization provides the benefits resulting from the development of international trade. Further, the trade liberalization strengthens the competitiveness of the domestic economy, and improves the flow of knowledge, technology and investment. Regard to the environmental damage caused by the energy sector is deemed necessary on the path of global community movement towards sustainable development. In recent years, a number of papers have examined empirically the relationship between trade liberalization and the environment degradation (for increased energy). In this context, various theories and models have introduced that related to phenomena of trade liberalization and environmental issues. Antweiler and et al (2001) pattern is one of the most famous models that have accepted by many economists in this literature.

Antweiler and et al (2001) analyzed the impacts of trade liberalization on the environment in terms of three scales, Technique and Composition effects.

The scale effect is an increase in the size of economic activity that has a positive relationship with environmental degradation and energy consumption. The technique effect is an improvement in production technology which reduces energy consumption and protects the environment. The composition effect depends on the comparative advantage of countries in pollution-intensive production.

From this perspective, two hypotheses; the Pollution Haven Hypotheses (PHH) under the Environmental Kuznets Curve (In economic literature, the relationship between per capita income and environmental degradation is in form of U reverse that it is known Environmental Kuznets Curve (EKC)) and the Factor Endowment Hypotheses (FEH) have extracted and tested for different countries.

The Pollution Haven Hypotheses indicates that following trade liberalization, given the existence of strong environmental regulations in developed countries with high per capita income (on base of EKC, by increasing per capita income at different stages of economic development, the demand for a clean environment as luxury products increase and thus will make increasing the environmental strictness), their polluting industries move to the developing countries that have weak environmental regulations. This event will increase energy consumption by developing countries. Following this increase, these countries will face a lot of environmental pollution.

Factor Endowment Hypotheses indicates that following trade liberalization, the countries that have Capital intensive industries (developed with high per capita income) increase their production. Following this increase, Energy consumption in these countries will increase compared with the countries that have labor intensive industries (mostly in developing countries with low per capita income). This situation will lead to a worsening of environmental pollution in the country. Given the strategic importance of energy resources in Iran, proper planning is essential for the country's energy consumption, especially due to the high dependence of budget to oil revenues and the need to coordinate the country's foreign policy in line with other countries to reduce tariffs and entry into the World Trade Organization.

The main objective of this study is to investigate the effect of trade liberalization on energy consumption in terms of three scales, technique and composition effects on base of Antweiler model. This research seeks to answer this question that does trade liberalization increase national energy use? The basic assumption of this article is that trade liberalization increases the production of energy intensive-goods and thus energy consumption will increase in country.

In this article, in the second part, the Literature is reviewed. In the third part, the final energy consumption is discussed during the years of 1971-2015. After introducing Antweiler model, the effect of trade liberalization on final energy consumption is examined. The estimation and interpretation of the model discussed in sixth section and finally conclusions are presented.

2 Review of a sample of literature

Over the past decades, extensive studies have been done on the effects of trade liberalization on the environment and energy. These topics peaked in the '70s follow by energy supply crisis and in the 80s and 90s, the incidence of environmental issues such as the ozone hole, the global warming, and the climate change trends that led to be held international conferences and meetings concerning this issue. All of these events indicate that the international community was apprehensive. In most of these studies, the various effects of economic phenomena have been researched on energy and environment such as: energy consumption, greenhouse emissions, soil degradation, water pollution and loss of natural resources. The main results of these studies confirmed that trade liberalization will destroy the environment and also will increase energy consumption (Proops and et al, 1999).

In recent years, studies have been conducted on this topic, but haven’t been obtained the same results about the effects of trade liberalization on the environment and energy consumption. Some researchers believe that trade liberalization leads to a reduction of pollution in developed countries and an increase in developing countries.

These economists believe that economic change makes rich developed countries transferring polluting industries to developing countries and this event, generally led to the pollution of the world (Grossman and Krueger, 1991). Some also believe that if the environmental regulations be incorporated on economic activity, trade liberalization on economic will lead to growth and economic prosperity and improvement of the welfare of the nation.

According to their argument, due to the country’s response to competitive pressures from the expansion of free trade and access to comparative advantage, use of resources will be efficient and thus waste and energy consumption will be reduced (Gauri and et al, 2008). In this approach, for example, He, J(2005) Using the Countable General Equilibrium, indicated that due to replacement of the labor and capital production factors rather than energy in the process of trade liberalization in China's, Country's accession to the WTO has left a positive impact on the environment and has reduced the per capita energy consumption.

Some also believe that the expansion of free trade and increasing competitive pressures between domestic firms and foreign competitors lead to more moderate the good environmental policy and even is delayed adoption and enforcement of national environmental laws, in the face of trade liberalization process (Pandej and et al, 2006). Some of their studies didn’t find any relationship between trade liberalization and environmental degradation (Alpay and et al, 2005).

One of the comprehensive studies done on the impact of trade liberalization on economic growth and environmental is owned by Grossman and Krueger (1991). In their study, these effects include; the scales, technique and composition effect. The scale effect is representative of the changes in the size of economic activities, the technique effect, is representative of the changes in the production technology and the composition effect representative of the changes in the structure of producing commodities. Then these Topics developed by Antweiler and et al in the form of a theoretical model.

In later years, some researchers have used his model in many research fields. Some of them are mentioned in the following. Antweiler, Copeland, and Taylor(2001) In answer to the question; Is free trade good or bad for the environment? Believe that this effect is small and the trade effects on the environment through the scales, technique and composition effect.

Tsigas and et all (2002) in a study, were introduced the four mechanisms which trade policy and the environment are related to each other. These mechanisms include: international mobility of industry, changes in the composition of the national product, intensity of production and change in consumer demand for the Environment. They used the Antweiler model plus theory of consumer behavior and estimated the environmental effects of trade liberalization in the Western Hemisphere (North and South America). The results showed that liberalization has caused the development of the sectors producing metal and chemical industries. Therefore Trade liberalization has intensified environmental pollution.

Frankel and Ross (2003) used the Antweiler model for estimating the impact of trade liberalization on environmental measures, including; carbon dioxide, nitrogen dioxide, sulfur dioxide, energy consumption, deforestation, and clean water. Results showed that given criteria nitrogen dioxide, sulfur dioxide, and trade liberalization would lead to a positive effect on reducing pollution and energy consumption and providing access to clean water, but Taking into account criteria carbon dioxide, the previous results are violated. Matthias busse (2004) used the Antweiler model for investigating the income effectiveness on environmental regulations that were mentioned as an important factor. According to him, environmental regulations have a little effect on trade patterns and liberalization.

Research results of Copland and Taylor (2004) show that, firstly, the increase in per capita income has a positive effect on environmental quality, second, the environmental policies affect on the trade flows, also there is no sufficient evidence to prove the Pollution Haven Hypotheses (PHH). Chntrakarn and Millimet (2006) used the Antweiler model for investigating the defects Analysis of Kuznets Environmental Curve and proving the existence contradicts among its hypothesis. Matthew A. Cole (2007) used the Antweiler model for investigating the effect of trade liberalization on national energy consumption in 32 developed and developing countries. Results suggested that per capita energy use is subject to a scale effect which, for the mean country, outweighs the negative technique effect, indicating that regulations and technological improvements are not keeping pace with the growth of GNP. With regard to the trade-induced composition effect, evidence is found to suggest that energy intensive industries are subject to conflicting forces as postulated by the factor endowment and the pollution haven hypotheses. Finally, the results indicate that trade liberalization is likely to increase per capita energy use for the mean country within the sample.

Lopez and et al (2008) used the Antweiler model for investigating the effects of Government consumption expenditure (regardless of subsidies). The results of this study showed that countries with liberalization specialize in the polluting industries, the impact of technique is more than the impacts of scale and composition and for countries that specialize in clean industries the impacts of technique and composition more than impact of scale. Managi and et al (2007) used the Antweiler model for investigating the effects of trade liberalization on the environment in 32 countries during 1971-1996. They rejected the Pollution Haven Hypothecs and showed that the composition effect have positive effects on the environment and this effect more than scale effects.

Bin Hu (2008) used the Antweiler model for investigating the Pollution Haven Hypotheses and the Factor Endowment Hypotheses in 32 countries. He rejected the Pollution Haven Hypotheses and confirmed the Factor Endowment Hypotheses. He showed that the trade composition effect only depends on the stringency of environmental regulations. In Iran hasn’t taken place a comprehensive study of the relationship between energy consumption and trade liberalization.

On the relationship between trade liberalization and environmental Oskuyi and Yavari (2007) examined the Pollution Haven Hypotheses, trade pattern and net exports of the member countries of the Organization for Economic Cooperation and Development (OECD) with Iran in the field of the emissions and clean productions during the years 1999-2003. Finally, they rejected the Pollution Haven Hypotheses for Iran.

In another study, Oskuyi (2008) examined the trade liberalization on greenhouse gas emissions at the Environmental Kuznets Curve for 4 groups of countries in terms of per capita income during years 1992-2002.In this study, the trade liberalization in countries with high per capita income and medium to higher per capita income, reduces the carbon dioxide emissions and in countries with low per capita income and medium to lowly per capita income, increases the carbon dioxide emissions.

Mobarak and Mohammadlou (2009) assessed the impact of trade liberalization on emissions of carbon dioxide, nitrogen and investigated relationship between the environmental Kuznets curve and Pollution Haven Hypothesis in developed and developing countries. Results showed that increasing trade liberalization lead to reduce emissions of carbon dioxide and other polluting gases in developed countries, but emissions will increase in less developed and developing countries. Sadeghi and Eslami (2011) investigated the relationship between carbon dioxide emissions, fossil energy consumption and economic growth using dynamic OLS (DOLS) for large member of the Kyoto Protocol during 1990-2007. The results of this study showed that there is a long-term and positive relationship between energy consumption, carbon dioxide emissions and economic growth and was confirmed the environmental Kuznets curve hypothesis.

3 The trend of energy consumption

Table (1) shows the energy consumed in the country (separation of energy carriers) with changes in the energy intensity and per capita energy. Consumption of energy carriers increased dramatically during the decades 70 and 80 the following of the structural changes in the economy, growing urbanization, replacement or use of industrial machinery rather than labor. So that the average annual growth of final energy consumption during the period of 1971-1982 was equivalent to %127 that the share of oil products, gas, electricity and other, respectively was equivalent to %804, %0856, %0489 and %0612%, with an average annual growth rate of %128, % 89, % 149/0and %014.

After the Revolutionary, in during the war, the growth of final energy consumption decreased to %056 that the damage has been created in supply side and the lack development of this section was the main reasons for this reduction. In this period, the share of oil products, gas, electricity and other, respectively was equivalent to %8197, %0883, %0613 and %0306 with an average annual growth rate of %0497, %108, %088 and %051.

Since 1993 with the Beginning of the development period, the average annual growth of final energy consumption increased to %094 during the First Development Plan. During this period, the share of oil products decreased to %6465, In front the share of the share of natural gas, electricity respectively increased to %2117 and %0704. The average annual growth rate of oil products, gas, electricity and other, respectively, were equivalent to %056, %283, %089 and%11 that natural gas had highest growth in this period. The average annual growth of final energy consumption decreased to%03 during the Second Development Plan that its reason was the government's plan to reduce the of energy carriers consumption. during this period, the measures was done such as national audits and energy management projects in some industries, replacement fuels (natural gas replace petroleum), granting the Banking facilities interest subsidy To saving projects in the industrial sector, Promoting quality and performance of transportation, reduction of fuel consumption with an emphasis on function of vehicle manufacturing, Culture, education and information in the transport sector. In the years between 2004- 2011 the average annual growth of final energy consumption increased to %06 that the share of oil products decreased to %5273, In front the share of natural gas, electricity respectively increased to %3747 and %0878. The average annual growth rate of oil products, gas, electricity and other, respectively, were equivalent to %03, %108, %073 and%06. About the petroleum products, Amount of LPG of CNG cars and gasoline increased with an increasing trend due to increasing car supply and inappropriate technology. Also In front consumption of kerosene has been declining since 2000.

During years 2012- 2015 the average annual growth of final energy consumption decreased to %022 that the share of oil products decreased to %527, In front the share of natural gas, electricity respectively increased to %381 and %0892. The average annual growth rate of oil products, gas, electricity and other, respectively, were equivalent to %01, %11, %06 and %02. Gasoline rationing in 1387 led to a significant reduction in consumption of petroleum products. In recent years the gas supply to the rural and urban areas and electrification of the agriculture wells has led to the growth of the two carriers. Also following the implementation of the energy subsidy purposivism policy seems a significant reduction in energy consumption. Of course, according to the last published balance sheets of Energy (2011), the recent statistics are not available.

According to table (2) the major consumers of energy in the country respectively, are the residential and commercial sectors and then the transportation and industry sector. Table (3) shows the share of energy consumption in each of the sections. In residential and commercial sectors, petroleum products had the highest share of total energy consumption before the Revolution, but in the last period were replaced by natural gas. In industry sector, the petroleum products and electricity respectively, had the highest share of total energy consumption before the Revolution, but in the last period respectively were replaced by natural gas and petroleum products.

Energy intensity is a measure that can be represented the energy consumption efficiency. Table 4 shows the average annual energy consumption per capita and the energy intensity during the period of the study. Statistical analysis revealed the fact that the energy intensity has been increasing over the past years. Among the reasons for this increase can be referred to cheap energy prices, population growth, resource abundance, lack of proper planning, and lack of appropriate policies to improve the structure of consumption, production and distribution that have led to severe loss energy in the country.

It is worth noting that the energy intensity decreased in the last period. The main reason for the decline in energy intensity can be the rationing of gas and relative adjustment of energy prices in these years.

Table 1: The energy carrier consumption (1967-2001)

Year	Average annual growth			The share of energy resources				Average annual growth of energy consumption			
	Final energy consumption	Per capita energy	Energy intensity	Petroleum products	Natural Gas	Electricity	Other	Petroleum products	Natural Gas	electricity	Other
71-82	0.127	0.095	0.039	80.44	8.56	4.89	6.12	0.128	0.89	0.149	0.014
83-92	0.056	0.031	0.075	81.97	8.83	6.13	3.06	0.0497	0.108	0.088	0.051
93-98	0.094	0.087	0.031	64.65	21.17	7.04	2.98	0.056	0.028	0.089	0.11
99-2003	0.03	0.014	-0.002	61.02	29.15	7.37	2.45	0.0086	0.08	0.062	-0.015
2004-2011	0.06	0.052	0.003	52.73	37.47	8.78	1.33	0.03	0.108	0.073	0.06
2012-2015	0.022	0.01	-0.01	51.7	39.1	8.92	1.58	0.01	0.11	0.06	0.02

Source: Energy Balance (2015)

Table 2: Share of energy consumers from energy carries

Year	Residential and commercial	Industrial	Transport	Agricultural	Other
71-82	0.33	0.24	0.25	0.06	0.12
83-92	0.35	0.25	0.26	0.07	0.07
93-98	0.34	0.26	0.23	0.07	0.1
99-2003	0.38	0.21	0.25	0.05	0.11
2004-2011	0.41	0.2	0.28	0.04	0.07
2012-2015	0.37	0.23	0.25	0.03	0.12

Source: Energy Balance (2015)

Table 3: Share of energy consumers from energy carriers

Year	residential and commercial				Industrial				transport			agricultural		
	Petroleum products	Natural Gas	electricity	Other	Petroleum products	Natural Gas	electricity	Other	Petroleum products	Natural Gas	electricity	Petroleum products	Natural Gas	electricity
71-82	0.82	0.005	0.06	0.115	0.795	0.08	0.12	0.005	100	-	-	0.996	0.033	-
83-92	0.791	0.141	0.10	0.04	0.784	0.122	0.088	0.006	100	-	-	0.953	0.047	-
93-98	0.61	0.227	0.12	0.028	0.534	0.361	0.083	0.022	100	-	-	0.925	0.75	-
99-2003	0.458	0.423	0.10	0.016	0.397	0.449	0.126	0.028	100	-	-	0.878	0.122	-
2004-2011	0.288	0.59	0.10	0.014	0.341	0.489	0.145	0.25	0.903	0.006	0.001	0.741	0.253	0.006
2012-2015	0.165	0.7	0.12	0.015	0.218	0.648	0.132	0.01	0.852	0. 148	0.001	0.617	0.06	0.32

Source: Energy Balance (2015)

Table 4: Average annual per capita energy and energy intensity

Average annual energy intensity * *	Average annual per capita energy *	Year
0.684	3.691	71-82
1.41	6.061	83-92
1.96	8.324	93-98
2.13	10.091	99-2003
2.11	12.16	2004-2011
1.97	14.01	2012-2015

Source: Energy Balance (2015)

*Barrels of crude oil equivalent per person & ** Barrels of crude oil equivalent per million Rials

4 Theoretical framework

Antweiler model examines the impact of trade liberalization on the environment through three of scale, technique and composition effects that it can be considered equivalent to the energy use (Matthew, 2007).

Scale effects: occur when that trade liberalization has led to the development of economic activities, so that does not change the nature of these activities. Such a result would be an increase in pollution and energy consumption.

Technique effects: occur when that trade liberalization has led to the technological changes in production and reduction in the rate of input to output. However, the increase in revenue due to liberalization increases the public demand for clean technologies. Thus, it is considered a positive effect on reducing pollution and reducing energy consumption (Antweiler, 2001).

Composition effects: expresses the composition of product in the process of trade liberalization so that Depending on the structure of the industry, can be positive or negative. In other words, the countries in the face of trade liberalization specialize in sectors where they have comparative advantage. In this field, there are two hypotheses:

A) The Pollution Haven Hypotheses (PHH)

The PHH predicts that differences in the stringency of pollution regulation are the main factor of comparative advantage of countries. Thus, with trade, less developed countries, having weaker environmental policy, become dirtier as they will specialize in dirty-goods production. The underlying reasons for developing countries to set lower standards are threefold. Firstly, the costs of monitoring and exerting pollution standards are relatively higher in developing countries. This is caused, for example, by a scarcity of trained personnel, the high costs of implementing new pollution standards, the difficulty of obtaining modern equipment, corruption (all in comparison to developed countries). Second, developed countries with high incomes generate a larger demand for clean water and air. Developing countries with low levels of income are more focused on extra earnings and jobs, rather than health and pollution. Third, growth in developing countries implies a shift from agriculture to manufacturing, resulting in rapid urbanization and large investments in urban infrastructure, which raises the pollution intensity. In developed countries, however, growth implies a shift from manufacturing to services, which leads to a decrease of pollution intensity.

B) The Factor Endowment Hypotheses (FEH)

The FEH, on the contrary, asserts that it is differences in endowments and technology, not the differences in pollution regulation that determines trade. It states that the capital intensity is highly correlated with pollution intensity of production (see, e.g. Copeland and Taylor, 2003). Therefore, according to the Hecksher-Ohlin theory of international trade, under the FEH, the capital abundant country exports the capital intensive (dirty) goods, which stimulates its production, thus raising pollution in the capital abundant country. Conversely, pollution falls in the capital-scarce country as a result of contraction of the production of pollution-intensive goods, because there is no comparative advantage in dirty goods production in the developing world.

The paradox of these two hypotheses is quite evident. In this regard, researchers have examined these two hypotheses. Some approved and some rejected the Pollution Haven Hypotheses.

Based on the Antweiler analysis, the capital-intensive industries have large share in production of pollution. Similarly, energy use is one of the topics of environmental regulations that are matched with environmental pollution (Matthew, 2007).According to this theory, environmental pollution (energy use) as a function of per capita income, the capital-labor ratio, trade intensity, the interaction of capital-labor ratio with relative per capita income (TRI), the interaction of trade intensity with relative capital-labor ratio (TRKL), the interaction of trade intensity with relative per capita income (TRI).

In this regard, uses of the per capita income variable into the energy consumption function for assessing the scale and technique effect. For assessing the composition effect is used in the capital-labor ratio variable. For assessing PHH and FEH respectively is used of the interaction of trade intensity with relative per capita income (TRI) (Represent the environmental regulation) and the interaction of trade intensity with relative capital-labor ratio (TRKL) (plus capital-labor ratio variable).

In this study to evaluate paradox of mentioned Hypotheses, the energy consumption was examined based on Antweiler theoretical principles. Data used in this study are time series data for 42 years (1971-2015) that has extracted from the central bank, the energy balance sheet (2015). Working population statistics has extracted from the Management and Planning Organization (former).

In this paper, we assessed the effect of trade liberalization on energy consumption using Antweiler model and Because of the time series data are the predetermined variables, we select the ARDL approach for estimation of models.

5 Model introduction

Based on previous studies and provided theoretical basis, the desired function is defined as follows:

E=f (KL, I, T, KLI, TRKL, TRI)

E = the final energy consumption that is defined in two forms of energy consumption per capita (SE [1]) and energy intensity (SHE[2]).

KL = capital–labor ratio

I = income per capita

KLI = an interaction of KL with I

T[3]= trade intensity that Indicates the degree of openness of the economy.

Because there are different criteria for measuring economic openness this criteria has used in most studies in the field of energy.

TRKL = an interaction of trade intensity with relative capital-labor ratio
TRI = an interaction of trade intensity with relative per capita income

If the dependent variable is defined as energy consumption, the per capita income captures both the scale and technique effect. If the dependent variable is defined as energy intensity, the per capita income captures only a technique and not a scale effect. Composition effect is explained by the capital-labor ratio. TRKL and TRI are respectively Represent the endowments and quality of environmental regulations.

All variables are expressed in logarithms.

5.1 Time series of model variables

Table 5 shows the average annual rate of change in considered variables of Antweiler model for different periods. The highest annual growth in capital[4] and the lowest annual growth in labor are seen during the period 1971-1982. This has led to an average annual growth of %11 in the capital-labor ratio. Considering the average annual growth of %089 of GDP, energy intensity was encountered by an average annual growth of %039. In this period has occurred the highest average annual growth rate of energy consumption by %095.

During the 1983- 1993 the average annual growth of capital was negative because of war and the cases mentioned in the previous section. This situation led to the average annual of capital - labor ratio was encountered with a negative growth.

Since in this period, the average annual rate of change in GDP has been in the lowest rate with negative growth, the average annual growth rate of energy intensity have been in the highest (%074) rate over of the study period. During this period the average annual growth rate of energy consumption remained positive.

During the 1993-1998, although the average annual growth of the labor has increased, the average annual growth of capital-labor ratio increased to %035. The average annual growth of capital was %066. During this period the average annual of the changes in trade intensity improved that its reason can be increased at the average annual growth rate of energy consumption (%07).

During the 1999- 2003, the Average annual growth of capital increased to % 08. Due to the relatively small changes in average annual growth of labor, the average annual of capital-labor ratio changes increased to %053. During this period the average annual of energy intensity changes was negative that its reason was a negative average annual growth of energy consumption (about %013).

During the 2004- 2011, a decline in average annual growth rate of capital to %07 and a substantial increase in the average annual growth rate of the labor to %037, led to a decrease in the average annual growth of capital-labor ratio to %039. Trade intensity improved due to an increase in the average annual growth rate of energy consumption. The average annual per capita income growth was fluctuating during the period. This rate had the highest growth in the period 1971-1983, but was negative in the later period. This could be due to the war, the Islamic Revolution and population growth. This rate significantly improved in the period 1993-1998.

The main reason for this improvement was the increase in oil revenues (and thus increasing GDP (growth of %063)). The mentioned rates significantly decreased during the period 1993-1998, but was observed a positive mutation of it during the 2004-2012 that it can be explained with respect to increase in the average annual rate of the labor changes (%0374). There is a significant point about per capita income; in total study period (except for the period 1983 to 1992) is observed a direct relationship between the average per capita income and average energy intensity. Finally the average annual changes of trade Intensity as the average annual changes of per capita income was faced with a fluctuating over this period, so that the highest rate related to period 1971-1983 (%0129) and the lowest rate related to period 1992-2003(due to the government exchange control policies).

[1] $\frac{\text{Total energy consumption (million barrels of crud oil)}}{\text{total population (thousands)}}$

[2] $\frac{\text{Total energy consumption (million barrels of crud oil)}}{\text{GDP in basic prices (1997) (billion rials)}}$

[3] $\frac{\text{exports+imports}}{\text{GDP in basic prices (1997)}}$

[4] Gross fixed capital

Table 5: Average rate of the variables changes in the model

Year	Average rate of change in capital	Average rate of change in labor	Average rate of change in capital-labor ratio	Average rate of change in per capita income	Average rate of change in trade intensity	Average rate of change in GDP	Average rate of change in energy intensity	Average rate of change in energy
71-82	0.138	0.022	0.112	0.12	0.012	0.088	0.038	0.095
83-92	-0.047	0.023	-0.069	-0.071	-0.037	-0.015	0.074	0.019
93-98	0.066	0.027	0.035	0.077	0.004	0.063	0.030	0.072
99-2003	0.084	0.028	0.53	-0.006	-0.042	0.032	-0.002	0.0113
2004-2011	0.078	0.037	0.039	0.04	0.023	0.057	0.003	0.044
2012-2015	0.041	0.041	0.025	0.02	0.025	0.032	-0.009	0.022

Source: Energy Balance (2016) & the Statistical Center of Iran (2016)

6 Models Estimation

6.1 Unit root test of Augmented Dickey - Fuller (ADF)

It is important the stationary analysis for estimation of regression models for time series. The unit root null hypothesis is not rejected for all variables based on the statistical values of ADF (in compare with critical values (Table 6)). In other words, all the variables are nonstationary. The unit root null hypothesis was rejected for all variables based on 1st difference at a confidence level of 99%. In other words, all the variables with 1st difference are stationary.

Table 5: Unit root test of Augmented Dickey - Fuller (ADF)

Variable name	Abbreviation	Dickey - Fuller Statistics	Critical value	Intercept	Trend
Energy intensity	DLnSHE	-5.42	-3.61	*	-
Per capita Energy	DLnSE	-4.11	-3.62	*	-
Per capita income	DLnI	-4.42	-3.61	*	-
Trade intensity	DLnT	-5.05	-3.61	*	-
Capital – labor ratio	DLnKL	-3.98	-3.61	*	-
Interaction of KL with I	DLnKLI	-3.79	-3.61	*	-
Interaction of RKL with T	DLnTRKL	-4.11	-3.61	*	-
Interaction of RI with T	DLnTRI	-4.67	-3.61	*	-

Source: Research findings

6.2 Estimating the functions of per capita energy consumption and energy intensity

In this paper, we assessed the changes in per capita energy consumption and energy intensity by using Autoregressive Distributed Lag (ARDL) and Error Correction Model (ECM). To investigate the long-term and short-term relationships between the dependent variable and the other explanatory variables, can be used the co-integration methods such as Engel - Granger and Error Correction Models.

However, due to limitations in the methods of Engel - Granger and ECM models and also to avoid the shortcomings of these models, including the existence biased in small samples and the lack of testing the statistical hypothesis, appropriate methods to analyze and short-term relationships between variables have been proposed that ARDL approach can be noted in this field. ARDL methods are unbiased and efficient due to avoid problems like autocorrelation and endogenously. Therefore, in this study, we used the ARDL model.

Augmented ARDL model can be demonstrated as follows:

$$\boldsymbol{\alpha}(\mathbf{L},\mathbf{p})\mathbf{y}_\mathbf{t} = \boldsymbol{\alpha}_\mathbf{0} + \sum_{\mathbf{i}=\mathbf{1}}^{\mathbf{k}} \boldsymbol{\beta}_\mathbf{i}(\mathbf{L},\mathbf{q}_\mathbf{i})\mathbf{x}_{\mathbf{it}} + \mathbf{u}_\mathbf{t}, \qquad i = 1,2,....,k$$

(1)

Where $\boldsymbol{\alpha}_\mathbf{0}$ is the intercept, $\mathbf{y}_\mathbf{t}$ is the dependent variable and L is lag operator the defined as follows:

$$L^j y_t = y_{t-j}$$

(2)

Therefore

$$\alpha(L,P) = 1 - \alpha_1 L^1 - ... - \alpha_P L^p$$

$$\beta_i(L,P) = \beta_{i0} + \beta_{i1}L + \beta_{i2}L^2 + ... + (\beta_{iq}L_i^q)$$

6.2.1 Estimating the long-term functions of per capita energy consumption and energy intensity

To estimate the long-run relationship can be used the Two-step method as follows:

First step is testing the long-term relationship between the variables. In this case, if the sum of the estimated coefficients of the dependent variable lags were less than one, the dynamic model moves towards long-run equilibrium.

Therefore, the convergence test is required to be done under the following hypothesis (Novfrsty, 1999):

$$H_0 : \sum_{i=1}^{m} \beta_i - 1 \geq 0$$

$$H_1 : \sum_{i=1}^{m} \beta_i - 1 \langle 0$$

T-statistic is calculated as follows:

$$t = \frac{\sum_{i=1}^{m} \hat{\beta}_i - 1}{\sum_{i=1}^{m} S\hat{\beta}_i}$$

(3)

By comparing the calculated t-statistic and the critical values (provided by Banerjee, Dolado & Master) in desired confidence level, can be realized in the presence or absence of long-run equilibrium relationship between the variables of the model. If there is a stable, long-run relationship between the variables of the model, in second step, the estimated long-run coefficients are analyzed and the conclusion is made about their value. The long run relationships between the variables of the model are as follows:

(4)

$$SHE_t = SHE_{t-1} = ... = SHE_{t-n},$$
$$T_t = T_{t-1} = ... = T_{t-f},$$
$$KLI_t = KLI_{t-1} = ... = KLI_{t-f},$$
$$TRKL_t = TRKL_{t-1} = ... = TRKL_{t-f}$$

$$SE_t = SE_{t-1} = ... = SE_{t-m},$$
$$I_t = I_{t-1} = ... = I_{t-k},$$
$$KL_t = KL_{t-1} = ... = KL_{t-k},$$
$$TRI_t = TRI_{t-1} = ... = TRI_{t-k},$$

Therefore, long-term relationship of per capita energy consumption and energy intensity can be demonstrated as follows:

(5)

$$LnSE_t = \delta_0 + \delta_1 lnI_t + \delta_2 lnKL_t + \delta_3 lnT_t + \delta_4 lnKLI_t + \delta_5 lnTRKL_t + \delta_6 lnTRI_t + u_t$$

(6)

$$LnSHE_t = \delta_0 + \delta_1 lnI_t + \delta_2 lnKL_t + \delta_3 lnT_t + \delta_4 lnKLI_t + \delta_5 lnTRKL_t + \delta_6 lnTRI_t + u_t$$

There is a convergence between a set of economic variables that provides the basis of error correction models.

Presence or absence of long-term relationship between the dependent variable and the other explanatory variables can be evaluated using by F-test that is written as follows:

$$H_0 : \beta_2 = \beta_5 = \beta_6 = \beta_7 = 0$$

H_1: At least one of the coefficients is zero

Pesaran & Pesaran (1997) have presented the critical values for F-test. In this method, if the calculated F value was greater than the F table (critical value), without knowing the convergence degree of variable or time series can be judged that there is the long-run relationship between the variables of the equation. In this study the F-statistic for both models were tested and the long-run relationship between variables was detected.

To estimate the long-run coefficients of the per capita energy consumption and energy intensity functions, the error correction form of the ARDL model considered as follows:

(7)

$$\Delta lnSE_t = \alpha_0 + \sum_{i=1}^{m} \beta_i \Delta lnSE_{t-i} + \sum_{i=1}^{n} \varepsilon_t \Delta lnI_{t-i} + \sum_{i=1}^{k} \gamma_t \Delta lnKL_{t-i} + \sum_{i=1}^{f} \mu_i \Delta lnT_{t-i} + \sum_{i=1}^{g} \delta_i \Delta lnKLI_{t-i} + \sum_{i=1}^{h} \sigma_i \Delta lnTRKL_{t-i} + \sum_{i=1}^{z} \tau_i \Delta lnTRI_{t-i} + u_{1t}$$

(8)

$$\Delta lnSHE_t = \alpha_0 + \sum_{i=1}^{m} \beta_i \Delta lnSHE_{t-i} + \sum_{i=1}^{n} \varepsilon_t \Delta lnI_{t-i} + \sum_{i=1}^{k} \gamma_t \Delta lnKL_{t-i} + \sum_{i=1}^{f} \mu_i \Delta lnT_{t-i} + \sum_{i=1}^{g} \delta_i \Delta lnKLI_{t-i} + \sum_{i=1}^{h} \sigma_i \Delta lnTRKL_{t-i} + \sum_{i=1}^{z} \tau_i \Delta lnTRI_{t-i} + u_{2t}$$

In the above equations, m, n, k, f, g, h and z are the optimal lags of variables, respectively $lnKL_t$, lnT_t , $lnKLI_t$,($lnSHE_t$)$lnSE_t$, lnI_t, lnTRK and $lnTRI_t$, also $\hat{\beta}_i$ ، $\hat{\varepsilon}_i$ ، $\hat{\gamma}_i$ ، $\hat{\mu}_i$ ، $\hat{\delta}_i$ ، $\hat{\sigma}_i$ و $\hat{\tau}_i$ are the short-term dynamic estimates of ARDL model. In this model, there is no any convergence relationship based on the null hypothesis. The Long-term ARDL mode results of the per capita energy consumption and energy intensity have shown in Tables (7) and (8).

Table 7: Estimation of long-run coefficients of the per capita energy consumption function; ARDL (2,2,2,1,2,1,1)

Variable	Coefficient	T-Student

C	1.2	4.62
Ln I	0.10	2.09
Ln KL	0.37	6.12
Ln T	-0.15	*-1.87
LKLI	-0.28	-6.56
LTRKL	0.11	3.36
LTRI	0.045	2.62
R^2	0.87	
D.W	1.99	

Source: Research findings *Significant at 0.90, all other variables are significant at 0.99

Table 8: Estimation of long-run coefficients of the energy intensity function; ARDL (2,2,2,1,2,1,1)

Variable	Coefficient	T-Student
C	0.26	0.19
Ln I	-0.24	-3.25
Ln KL	-0.29	-2.08
Ln T	0.47	3.75
LKLI	0.18	2.77
LTRKL	-0.25	-3.85
LTRI	0.11	4.22
W*	0.02	1.98
R^2	0.71	
D.W	2.01	

Source: Research findings Significant at 0.99 *war variable

According to Table (7), all signs of the variables in per capita energy consumption function (excluding the trade intensity and the interaction of trade intensity with relative capital-labor ratio (TRKL)) and all signs of the variables in per capita energy consumption function (Except for the capital-labor ratio) are similar with the Matthew, A (2007) finding.

In his study, R-square of the per capita energy and the energy intensity were respectively %79 and %68 which is somewhat similar to the present model.

In the energy consumption model, the per capita income coefficient is positive and statistically significant. This means that the positive effects of scale have been dominated the negative effects of technique. In the energy intensity model, the per capita income coefficient is negative and statistically significant. This means that technique effects has a negative impact on energy consumption.

The coefficient of capital-labor ratio is significant in both models, which is indicative of composition effects. In the energy consumption model, Since based on the theory FEH, the capital-intensive goods consume more energy than the labor-intensive goods, the coefficient of this variable is positive. Also, since the share of the capital- intensive goods value add is more than labor- intensive goods, an increase in capital-labor ratio will lead to a substantial increase in GDP. As a result, Despite the increase in the energy consumption, the energy intensity decreases (increase in GDP due to fixed increase in the capital-labor ratio is more than increases in energy consumption[1]). In Table (5) also was noted to the negative relationships between the capital-labor ratio and the energy intensity. Therefore coefficient of the capital-labor ratio in energy intensity function is negative. The trade intensity coefficient is statistically significant in both models. In the model of per capita energy consumption, it has a negative coefficient.

Since a large share of energy consumption in Iran has subsidies, following the trade liberalization and Elimination of subsidies on energy, domestic per capita consumption of energy due to energy price signals will decrease sharply. On the other hand, given that the share of energy-intensive goods (often capital-intensive) in GDP is significant, following its decline, GDP will decrease sharply. This event will lead to an increase in the energy intensity. This issue is confirmed by the positive coefficient in the energy intensity function.

Coefficient of the interaction of capital-labor ratio with income (KLI) variable is statistically significant in both models with the difference that it is negative in per capita energy consumption function and is positive in energy intensity function. Coefficient of the interaction of relative capital-labor ratio with trade intensity (TRKL) variable is significant and positive in per capita energy consumption function. Since this variable is representative of the factor endowment effect and its coefficient is positive, therefore FEH hypothesis can be verified for Iran. This coefficient is negative and significant in the energy intensity function. It is natural the negative coefficients for each variable of capital-labor ratio and trade intensity.

Coefficient of the interaction of trade intensity with the relative per capita income (TRI) variable is statistically significant in both models. The positive coefficient for this variable in the per capita energy consumption model (that is represents the environmental regulations), indicates that environmental regulations haven't a significant effect on reducing energy consumption. Given these results, we can reject the Pollution Haven Hypotheses.

Another reason for rejecting the PHH hypothesis goes back to its basic principles.

According to this hypothesis, after transfer of polluting industries to developing countries with a weak environmental regulations (such as Iran), the goods of this industries will be transferred to developed countries again. Consequently, According to the comparative advantage of developing countries, their exports will increase. Along with the increase in energy consumption, this event leads to an increase in the trade intensity. But since the country's trade intensity is negative, so there is no such relationship (confirmation of PHH hypothesis) in the case of Iran.

In evaluating the two PHH and FEH hypotheses, since Iran is rich in oil and gas and Considering the significant coefficient of TRKL, following trade liberalization, It seems Iran is a comparative advantage in the production of the pollution and energy-intensive goods (such as petrochemicals). However, regard to the positive coefficient of the capital-labor ratio, the negative coefficient of the trade intensity in per capita energy consumption function, lack of the enough environmental protection laws (in comparison with developed countries) and significant positive coefficient of TRI, seems to increase per capita consumption of energy following the trade liberalization in the country. Table (9) presents the estimated elasticities for scale and technique effects (I), composition effects (KL) and trade effects (T), calculated for Iran.

[1] if GDP and E (energy) be regressed in terms of KL, the following results are obtained:

Ln E = 6.74 +.21lnkl ln GDP = 14.56 +.44lnkl

(3.9) (.50) (16.39) (2.53)

R^2 =%02 R^2 % 15

Table 9: Estimated elasticity of scale, technique and composition effects

Elasticity	Per capita energy consumption function-Model (1)	Trade intensity function-Model (2)
Scale and technique effects	0.10	-
Technique effect	-	-0.24
Composition effect	0.37	-0.29
Trade intensity effect	-0.15	0.47

Source: Research findings

The scale and technique elasticities are positively implying that the scale effect is dominating the technique effect. In model (2), where only the technique effect is being captured, a negative elasticity is found, as expected.

The composition effect elasticity is positive in models (1), but is negative in models (2) and also the trade intensity elasticity is negative in models (1), but is positive in models (2).

These elasticities allow an assessment of the impact of trade liberalization on energy consumption for Iran. With regard to per capita energy consumption, if trade liberalization leads to a 1% increase in per capita income, there will be an increase in per capita energy consumption of 0.1% as a result of scale and technique effects. Also, if trade liberalization leads to a 1% increase in the capital-labor ratio, there will be an increase in per capita energy consumption of 0.37% as a result of composition. But if trade liberalization leads to a 1% increase in Trade intensity, there will be a reduction in per capita energy consumption of 0.15% as a result of Trade intensity. Given that the summation of positive elasticities of composition and scale/technique effects are more than the negative elasticity of trade intensity, so with trade liberalization, the country's final energy consumption will increase

In the case of energy intensity, the results are more equivocal. If trade liberalization leads to a 1% increase in per capita income, there will be a reduction in energy intensity of 0.24% as a result of technique effects. Also if trade liberalization leads to a 1% increase in capital-labor ratio, there will be a reduction in energy intensity of 0.29% as a result of composition. But if trade liberalization leads to a 1% increase in trade intensity, there will be a reduction in energy intensity of 0.47% as a result of trade intensity.

6-3. ECM test results

Table (10) and (11) show the results of estimated ECM in the ARDL approach

Table 10: Estimated long-run coefficients of per capita energy consumption function ARDL(2,2,2,1,2,1,1)

Variable	Coefficient	T-Student
dC	1.20	4.67
dLn SE(-1)	0.35	2.08
dLn I	0.015	2.06
dLn I(-1)	-0.25	-1.99
dLn KL	0.38	6.06
dLn KL(-1)	-0.12	1.97
dLn T	-0.17	-2.33
dLKLI	0.25	6.50
dLKLI(-1)	-0.14	-2.23
dLTRKL	0.10	3.31
dLTRI	0.09	2.72
ECM(-1)	-0.31	-2.56
R^2	0.92	
D.W	1.99	

Source: Research findings Significant at 0.99

According to the above results, the ECM coefficient is statistically significant in the per capita energy consumption function. ECM coefficient shows a significant long-run relationship between the variables in the model.

According to the theoretical expectations, if we move from the period (t) to period (1+t), 31 percent of the per capita energy consumption deviation (from it's the long-term path) is corrected by the model variables in the next period. So move toward equilibrium roughly occurs after three years.

Table 10: Estimated long-run coefficients of energy intensity function ARDL(2,2,2,1,2,1,1)

Variable	Coefficient	T-Student
dC	1.56	4.90
dLn SHE(-1)	0.65	2.36
dLn I	0.32	2.41
dLn I(-1)	–0.19	–2.31
dLn KL	0.45	6.95
dLn KL(-1)	–0.22	–2.36
dLn T	–0.23	–2.32
dLKLI	0.42	–6.93
dLKLI(-1)	–0.23	3.01
dLTRKL	0.12	3.42
dLTRI	0.07	2.41
ECM(-1)	–0.38	–2.42
R^2	0.71	
D.W	2.01	

Source: Research findings Significant at 0.99

Such as the previous case and accordance with table (5), the ECM coefficient in energy intensity function is significant and equal to -0.38;

This means that 38 percent of the energy intensity deviation (from it's the long-term path) is corrected by the model variables in the next period. So move toward equilibrium roughly occurs after three years.

6-4 Stability and Diagnostics tests

Diagnostic tests are used to detect the model stability and to determine the structural stability. In this study, the stability of the estimated coefficients of the model was evaluated with Q, CUSUM and CUSUM tests.

The results showed that the estimated regression coefficients are stable during the study period

Also was performed the tests of Heteroskedasticity, Correlation of errors series and Equation Specification Error *Test* (Ramsey RESET test).

7 Conclusion

Energy carriers as one of the key factors of production, have an essential role in the dynamics of economic activity. Following the global move toward liberalization of economies and the need to coordinate with other countries to enter the WTO, it is essential the proper planning for energy consumption. In this paper, we examined the impact of the trade liberalization on energy consumption using the time series data for 45 years (1967-2011) according to Antweiler model.

The results of the models estimated using the approach of ARDL, showed that the per capita energy consumption due to the income fluctuations in the form of both the scale and technique effects is positive and significant. Technique effects alone have a significant impact on reducing energy consumption. Also composition effects have a positive and significant impact on increasing energy consumption and reducing energy intensity. Given the positive and significant coefficient of variation of the capital-labor ratio (composition effect) and the interaction of trade intensity with the relative capital-labor ratio (TRKL) in the energy function, the FEH hypothesis was confirmed. However, given the positive and significant coefficient of variable of the interaction of trade intensity with the relative per capita income (TRI) in the energy function, the PHH hypothesis wasn’t confirmed.

Finally, we suggest that policy makers and the macro planners of energy should consider the long-term and stable programs to provide of the growing energy consumptions in line with trade liberalization for energy-intensive activities. In this regard, access to advanced technologies, will help to reduce the energy intensity in the industries. Strengthening environmental laws and regulations are deemed as a necessity.

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