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Role of Energy Supply and demand Fluctuations in Macroeconomic Development of Iran

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Abstract
Energy plays an essential role in the economic and social development of all countries around the world, and its consumption is rising considerably due to the fast industrial development and increasing the standards of living. However, due to the high dependency on fossil fuel resources by all the developed and developing countries around the world to cover their energy supply needs, fluctuations in supply and demand of energy as well as the energy prices would definitely lead to considerable macro- and micro-economic effects for both the energy exporter and importer countries. Therefore, the necessity of stability of economy and its understanding is becoming more and more popular among policy-makers and researchers around the world. As many energy consuming industries in Iran such as services and products are highly dependent on energy prices, understanding the economic robustness relationships with the supply and demand fluctuations of fossil fuel resources is important for the researchers and also policy-makers. In this paper, the effect of oil price fluctuations on several macro-economic parameters as well as energy sector's resilience and electricity market as the main Iranian energy economics issues are discussed.

Keywords: *Energy System Resilience, Energy Price Fluctuations, Macro-economic, Fossil Fuels, Elasticity Method.*

1. Introduction

The importance of energy for any society around the world is increasing rapidly. Almost all the human activities as well as every economic sector like communication, transportation, delivery systems, security, and health require a reliable and constant energy supply.

Although by the rapid population growth and also the improvement of life quality around the world the consumption of energy has increased considerably, having various energy resources as well as the proper access to these resources is completely essential for creatures and civilizations around the world [1]. In the recent years, the over-consumption of energy resources like fossil fuels by industrialized countries around the world has reduced these resources considerably, and serious environmental problems such as the climate change, water and air pollutions, and health risks have occurred [2].

However, different renewable resources such as the hydropower, geothermal, biomass, solar, wind, and marine energies by providing 19.3% of the world final energy consumption in 2016 proved to have the capability to supply a great portion of the human being energy needs as the inexhaustible and clean sources of energy [3, 4]. According to many researchers around the world, the fluctuations of oil price through the transmission mechanisms including both the energy supply and energy demand channels have different consequences on economic factors in both the oil importing and exporting countries. In the case of energy supply, as the production sector is highly dependent on the crude oil, the increase in oil price leads to an increase in the production cost, and as a result of this situation, many firms and producers are induced to reduce their outputs. Moreover, the oil price changes can have different consequences in the investment and consumption sectors [5, 6].

Iran based on the statistics is one of the countries enriched with natural resources which by having the 21.4 billion metric Ton oil equivalent (Btoe) of Crude oil reserves ranks 4th in the world and in the terms of natural gas, ranks 1st and totally by having more than 82.5 Btoe of fossil fuels including natural gas, crude oil and coal, ranks 3rd in the world. Moreover, Iran according to the Economic Complexity Index (ECI) has the 66th most complex economy in the world which is the 3rd most natural gas consumer and 12th most crude oil consumer in the world [7,8]. In addition, Iran in 2017 by having the GDP amount of $454B and GDP per capita of $20.8k was considered as the 46th largest export economy in the world which by having the total export amount of around $53.7B and the import amount of $49.9B, has the trade balance of $3.84B. Crude Petroleum, Ethylene Polymers, Acyclic Alcohols, Refined Petroleum and Iron Ore each by the total amount of $38.5B, $2.75B, $1.36B, $1.32B and $1.19B respectively are the top exports of Iran which are mostly sent to China, India, South Korea, Italy and Japan as the top export destinations respectively [9-11]. In addition, Cars, Vehicle Parts, Corn, Rice and Broadcasting Equipment each by the share of $2.7B, $1.71B, $1.08B, $891M and $808M are the Iran's top imports which are mostly imported form China, South Korea, Germany, Turkey and India respectively [12]. During the years 2012 to 2017, the exports of Iran with the decreasing rate of -3.5% annually reduced from $63.6B to $53.7B and Crude Petroleum and Ethylene Polymers each by the share of 71.7% and 5.12% of the total exports of Iran are the most Iran's recent exports. In addition, between the years 2012 to 2017 the imports of Iran with the decreasing rate of -0.6% annually decreased from the amount of $51.2B to $49.9B respectively [13,14]. Moreover during the recent years Cars and Vehicle Parts each by the share of 5.42% and 3.42% of the total imports are the most recent imports in Iran [15]. Iran's energy structure comprises of three main sectors: Production (net export, production energy use, and losses), Transformation and distribution (energy use of power plants and refineries, energy distribution lines and losses) and consumption (buildings, industry, transportation, agriculture and petrochemical), the share of each main sector from 382 Mtoe energy production being 28.7 %, 23.7 % and 47.6 % correspondingly. As it is shown in figure 1, industry, transportation and building subsectors are the major consumers (more than 80 % of total primary energy supply is consumed in these subsectors) [16]. Iran's energy consumption will increase 60 % by 2021 and this results in becoming a net importer of energy shortly after that and this is a threat for the energy security [17].

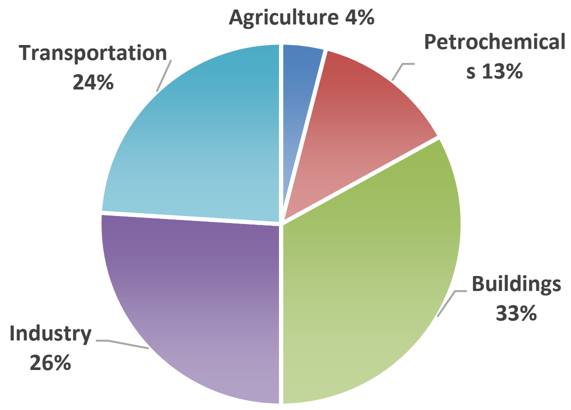

Figure 1. Share of energy consumption by sectors.

2. Energy Policies

As it is mentioned in IEA's Energy Efficiency Market report (EEMR) 2016, government policies play a fundamental role to improve energy efficiency and have a major role in improving energy efficiency despite decreasing the oil price up to 60 % in the recent years [18-20]. The status of energy intensity in Iran is the consequence of several factors such as energy subsidies (as the most important), old equipment and bad behavior of consumers (which is also consequence of low prices of energy). In the recent years, various acts and policies have been developed to decrease these negative impacts. Iran has been working on development of policies, acts and regulation in the recent 15 years. Providing the most adequate, affordable, and reliable energy sources for the future energy consumption and economic growth demand requires establishing the proper energy policies, which play an essential role in developing the economy. In the following section, the energy policy actions and programs that have been established by the Iranian government in order to boost the economic development is reviewed thoroughly [21-24]

2.1 Third to Sixth National Economic, Social and Cultural Development Plan (2001–2020)

Diversification of Energy Supply, promotion of energy efficiency and development of CCHP, drivers for energy conservation and application of

Specific Energy Consumption (SEC) for processes and equipment, prioritizing of research and development on renewable energy technologies.

2.2 Feed-in tariff financial support (2005)
Established by the Ministry of Energy and Renewable Energy Organization of Iran (SUNA) for electricity sector in order to guarantee the purchase of renewable electricity by subsidiary companies of Ministry of Energy [25,26].

2.3 General Policies of Energy Consumption Reform (2011)
Based on this policy by the year of 2021 the energy intensity should be halved (with comparison to base year of 2011) with prioritizing improvement of energy efficiency and productivity, incentives and penalties for improving Specific Energy Consumption (Process & Equipment), Development of Energy Standards and Labelling, enhancement of Energy Efficiency and Productivity awareness.

2.4 Financial supports policies (2011)
It is a persuasion policy designated by SUNA for in order to increase investment in renewable energies.

2.5 Renewable technologies awareness increase policy (2011)
Designated by Science and technology deputy of presidency and Renewable energies technology development headquarters for allocation of research and development funds for renewable projects

2.6 Energy consumption reform Act (2011)
This Act has different outlines to result in reduction of energy intensity such as Supply and Demand Management, Standards and Criteria of Energy Consumption, Incentives for R&D, Energy Consumption in Industrial, Agricultural, Transportation and Residential Sectors, Energy Supply and Distribution, Renewable Energies, Awareness and Training.

2.7 Renewable portfolio standards (2012)
Designated by Ministry of Energy and SUNA for 5000 MW of wind and solar electricity installation by the year of 2020.

2.8 Renewable energy development fund (2013)
Designated by Renewable Energy Organization of Iran and Ministry of Energy for the tariff introduction of 30 Rials/KWh to develop rural electricity grids.

2.9 Liquid fuel exchange purchase (2013)
Designated by Ministry of Energy SUNA for optimizing the energy consumption, developing renewable energies and increasing the energy efficiency of private and governmental power plants.

2.10 Fossil fuels conservation benefit payment (2015)
Designated by Energy Efficiency Organization (SATBA) for energy efficiency improvement in all sectors, renewable energy development, electric hybrid cars production encouragement, and electricity production from waste plants.

2.11 Supplying 20% of the electricity consumed by public and governmental organizations from renewables (2016)
Designated by SATBA for supplying the electricity demand of public and governmental buildings up to the 20% from renewable energies.

3. The Analysis of Energy structure of Iran based on the designated Economic Factors

As it was mentioned previously, oil price fluctuations would affect Iranian economic factors significantly. In this work the elasticity method which is one of the mostly used economic methods to evaluate the oil prices impact on various economic sectors is used. Moreover, different economic factors such as oil prices impact on the total and industrial energy consumption, inflation rate and GDP were analyzed. Generally, the elasticity method can be used in the economic studies in order to measure how economic variables change in response to the change in the amount of one or several other economic variables [27-30]. In this work, stating the share of oil consumption in the total GDP in Iran was calculated based on the elasticity measurements taken on the energy consumption of the consumers against changes in a country's GDP [31]. However as in Iran energy consumption is very important for the development and as with an increase in the production and population growth, energy consumption increases subsequently, therefore, sustainable energy consumption is very essential in optimizing the efficiency of energy for most developing countries like Iran [32,33]. In addition, by having the two amounts of GDP and the consumption of energy in the previous years, using the elasticity approach, the amount of energy consumption and GDP in the upcoming years can be forecasted. Based on the elasticity standards, an energy consumption elasticity >1 demonstrates that the share of oil in GDP is low, and changes in the oil prices has a trivial change in the GDP, whereas the elasticity amount < 1 shows that the share of oil in GDP is high. In this work, the relationship between the crude oil price and GDP and also the effect of energy consumption on GDP and GDP on the industrial energy consumption was investigated based on the elasticity concept [34,35].

Table 1 shows the elasticity analysis data between the years 2000 and 2018. The energy consumption prediction based on the GDP growth and the elasticity concept is shown in equation (1):

$$E_n = \frac{\frac{(Energy_n - Energy_{n-1})}{Energy_{n-1}}}{\frac{GDP_n - GDP_{n-1}}{GDP_{n-1}}} \quad (1)$$

where in the above equation ***E*** stands for the elasticity, ***n*** represents the year, *Energy* in here shows the total energy consumption, and gross domestic product is shown as *GDP*. The data obtained from equation (1) is shown in table 1.

Table1. Elasticity analysis of Iran's total energy consumption and oil price fluctuations between the years2000 to 2018 (source of data: world bank data: https://data.worldbank.org/)

Year	P_{Oil} ($)	GDP (BUS$)	Energy use per capita	Elasticity (P_{Oil}-GDP)	Elasticity (E_{Total}-GDP)
2000	27.6	109.5917	1874.671	-1.029021506	0.453088874
2001	23.12	126.8788	2008.655	3.892751181	1.558608978
2002	24.36	128.6269	2051.789	0.792528124	0.106874027
2003	28.1	153.5448	2094.269	1.190199369	0.325807612
2004	36.05	190.0434	2256.463	2.105264934	0.505730592
2005	50.59	226.4521	2475.088	1.169415787	0.189833001
2006	61	266.2989	2557.764	0.419932212	0.148026861
2007	69.04	349.8816	2676.6	2.26020466	0.373584617
2008	94.1	406.0709	2837.185	-17.95660916	-0.657016374
2009	60.86	414.0591	2800.515	1.539412845	-0.062880314
2010	77.38	487.0696	2769.464	1.963470412	0.039474538
2011	107.46	583.5004	2791.108	0.703807918	1.065164879
2012	109.45	598.8534	2869.333	0.149027078	-0.031403452
2013	105.87	467.4149	2889.11	1.284007612	-0.841220742
2014	96.29	434.4746	3060.387	4.345021158	-0.222779977
2015	49.49	385.8745	3136.652	-2.056297802	0.479906642
2016	40.76	418.9767	3265.784	3.447289891	0.118424102
2017	52.51	454.0128	3298.125	-4.97733832	-0.580590341
2018	69.78	424.0128	3424.654	-1.740895202	1.175147939
2019	64.05	444.0128	3614.482		
Geometry mean				0.498035314	0.177376082

According to this table, it can be perceived that oil exports do not have very negative effects on GDP, and this is because of the non-elasticity of crude oil price to GDP, which is smaller than one, and this means that GDP is dependent on the oil prices.

In Iran, the share of the renewable energies, including solar energy and hydropower energy has continued to rise considerably and the country has a plan to decrease the consumption of oil gradually, and also the coal production for domestic uses and exports has also increased. Moreover, based on the elasticity measurements, it was also revealed that the energy productivity in Iran, which is the ratio of gross domestic product to energy consumption, has risen considerably, which is due to the fact that Iran is trying to use more efficient systems and the total GDP elasticity (ETotal-GDP) that is smaller than one and shows that GDP does not have an intense dependence on the total energy consumption.

In addition, the latest statistics reveal that the government regulation actions have had a good effect on the optimal energy consumption, and as a result of that, the energy consumption has had a declining trend in most states and territories in Iran. Moreover, the amount of elasticity for the industry ($E_{Industry}$-GDP) is smaller than one and shows that the Iranian industrial systems are using the energy in a more optimal way and that the Iranian GDP does not rely on the industry sector, and it relies more on services, businesses and investment, etc. However, residential is considered as the largest energy consumer in Iran.
In this work, elasticity can also be used for estimation of the total energy consumption for Iran in 2020. According to the data taken from World Bank, the amount of GDP for Iran in 2020 is estimated to be about 1720 BUS$, and according to the equation number (2), the total energy consumption of Iran based on having the GDP data, can be forecasted in the year of 2020. Therefore based on the elasticity method the total energy consumption of Iran in the year of 2020 is estimated to be around 9277.27 PJ.

$$E_n = \frac{\frac{(Energy_{2020} - Energy_{2014})}{Energy_{2014}}}{\frac{GDP_{2020} - GDP_{2014}}{GDP_{2014}}} = Elasticity = |1.3927| \Longrightarrow Energy_{2020} = 9277.27\ (PJ) \quad (2)$$

4. Electricity Market

The economic growth and the electricity consumption in different economic sectors have a direct relationship with each other. Figures 2 and 3 show the electricity generation capacity mix and the share of consumed electricity by different economic sectors in 2017 respectively [36,37]. As it is perceived from figure 2, gas turbines, combined cycle and steam power plants each by the share of 35.2%, 25.4% and 22.5% respectively are the top most electricity generation sectors in Iran. In addition, diesel power plants supply less than 1% of the total network capacity and the share of renewables (except hydropower power plants which supply 14.5% of the total electricity supply) is very small (0.2%). Moreover, nuclear power plant installed in the south part of Iran with the capacity of 1020 MW supply 1.45% of the electricity supply side [38-40].
Moreover, based on figure 3, industrial sector, residential sector and agricultural sector consume 34%, 32% and 16% of the total electricity supply.

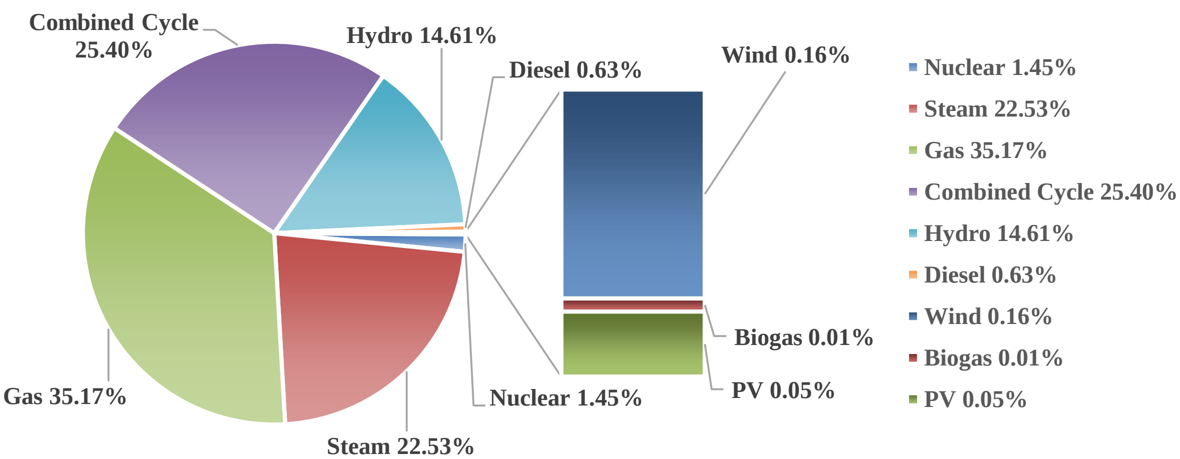

Figure 2. Electricity generation capacity mix in Iran.

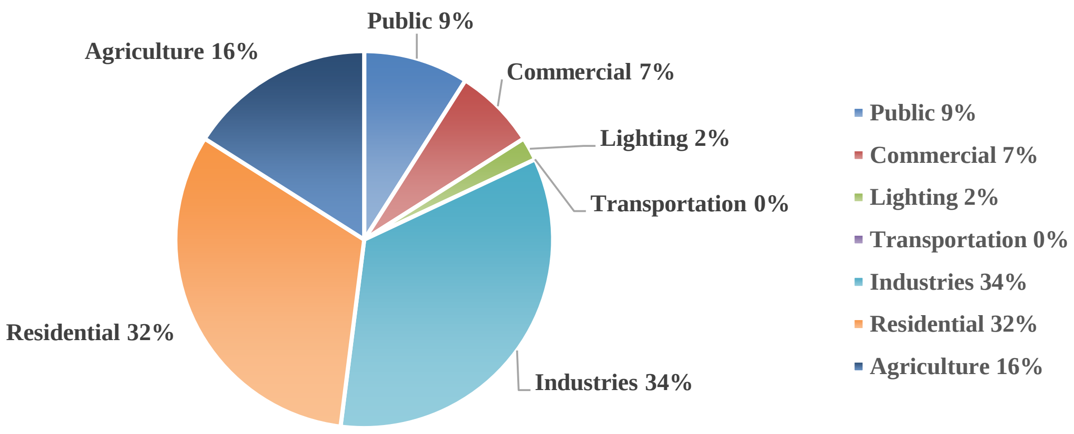

Figure 3. Share of electricity consumption per sector

In addition, Iran's annual gross electricity production by 9.1 TWh growth per year increased from the amount of 55TWh in 1990 to the amount of 282 TWh in 2015. In the same period, the electricity generation capacity increased at an average rate of 2.4 GW per year. It is worth mentioning that the power generation capacity of Iran relies considerably on natural gas power plants that the mean efficiency of these thermal power plants by the average energy efficiency growth rate of 0.27% annually improved from 30.9% in 1990 to the amount of 37.7% in 2015. Given the sizeable share of low-efficiency plants (i.e., old and/or simple cycle power stations), Iran has a significant potential for capacity addition through upgrading and modernization of its existing power plants. Of particular importance is adding steam turbine generators to the existing large-scale simple cycle gas turbine plants and revamping (or dismantling) old steam and gas turbine plants. For example, some 9 mcm/d of natural gas will be saved by upgrading 7.5 GW of low-efficiency power plants (i.e., less than 30%efficiency) to modern simple cycle combustion turbine (SCCT) with 40% efficiency [41].

5. Conclusion

In this work it was perceived that although a great portion of the Iran's energy needs is supplied from the domestic energy production (around 73% of TPES) and its GDP is considerably dependent on export earnings of natural and mineral sources like crude oil and natural gas, based on the designated method in this study (Elasticity Method), the oil prices impact on the total and industrial energy consumption, GDP, inflation rate and unemployment rate were analyzed. Through the elasticity calculations, it was realized that the elasticity of energy consumption in Iran by is less than 1 (Etotal - GDP < 1), which shows that the energy productivity of the country which is the total gross domestic product (GDP) divided by the total energy consumption (GDP/TEC) had increased significantly more, and highly efficient systems were being used in different industries. In addition, through the statistics, it was realized that although the energy consumption in Iran had slightly decreased, the government actions such as regulations and policies had a great effect on the optimal energy consumption in the country.

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