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A Computable General Equilibrium model for the Decomposition of the Energy Carriers Rebound Effect in the Iranian Economy

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Abstract

Statistical evidence of energy carriers (which are used in the production of goods and services and final demand components) indicates that their consumption in Iran is higher than the average in the world and is less energy-efficient, so demand side management (DSM) is essential. Among DSM methods, improving energy efficiency is an important approach in the global economy. Assuming an improvement of 5% efficiency of energy carriers, the purpose of this paper is to provide (1) Estimating the total rebound effect (RE) of the economy and its decomposition by product and final demand (2) decomposition RE of the manufacturing sectors by the substitution and output effects. Methodology based on a two-stage approach, including the analysis of the economic RE on the segmentation of the manufacturing sectors and final demand, as well as the decomposition of economic sector's RE on the substitution and output effects. The results show that the overall economic RE for coal, gasoline, diesel, electricity and natural gas is 34, 30, 26, 23 and 18 percent, respectively, so that expected energy savings are not achieved after energy (especially coal, gasoline, diesel, electricity and natural gas) efficiency improvement. The results indicate that the most energy-dependent parts also had the most RE. Also, the findings show that, in the short term, economic firms, in order to have the most benefit from improving the efficiency of energy carriers), use a substitution approach between energy carriers (including coal, gasoline, diesel, electricity and natural gas) and other inputs, and development of production capacity is transferred to a long period of time.

Keywords: Rebound Effect, Economic Modelling, CGE, Efficiency Improvement, Energy Carriers

JEL Classification: C23, C68, Q41.

1. Introduction

Statistical evidence of energy carriers (used in the production of goods and services and final demand components) indicates that energy consumption in Iran is higher than the global average and is less energy-efficient. Therefore, energy demand management is essential. Among energy demand management methods, improving efficiency is considered as one of the most important

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approaches in the global economy. In this article, taking into account the shock of improving efficiency for gasoline, diesel, electricity, coal and natural gas, while measuring the economy-wide rebound effect, the rebound effect was separately analyzed according to production and final demand. At the same time, an attempt was made to decompose the rebound effect of the manufacturing sectors into substitution and output effects.

2. Methodology

Considering the important role of coal, gasoline, gas oil, electricity and natural gas in the Iranian economy, the paper focuses on these energies. For this purpose, the research method consists of two parts. In the first section, using the CGE, a 5% energy efficiency shock is given to the model and the economy-wide rebound effect (calculated by energy carriers) is calculated. In the second section, using the outputs of the CGE model, the rebound effect is calculated by dividing the production sectors and the final demand. In addition, decomposition of the rebound effects of the manufacturing sectors into the substitution and output effects is also discussed in the second part of the method.

According to the objectives pursued in the paper, the research method consists of two parts. The first part of the model is the CGE based on Lofgren et al. (2002) and the execution of the model by applying a 5% shock to improve the efficiency of the various carriers of energy. Based on the results of the first part, the second part deals with the decomposition of the economy-wide rebound effect into production and final demand. Also, the decomposition of the rebound effect of the manufacturing sectors into the substitution and output effects is addressd in the second part.

Part One: Computable general equilibrium model

To design a well-balanced general equilibrium model, Social Accounting Matrix (SAM) was used. The social accounting matrix used in this paper relates to the matrix of 2008 prepared by the Central Bank. The matrix was manufactured and assembled and included 53 manufacturing units and 112 products or services. According to the purpose of the paper, which relates to energy carriers, the matrix was aggregated and a matrix with 15 manufacturing units and 18 products or services were obtained. Fifteen manufacturing sectors included agriculture; mines; production of food and beverage products; textile production; production of petroleum products (refineries); production of chemicals and chemicals; production of other non-metallic minerals; production of basic metals; production, transmission and distribution of electricity; collection, treatment and distribution of water; treatment and distribution of gas; other industries; commercial and various repair services; transportation; and other services.

The structure related to the production sections is layered. This structure illustrates how the primary production factors, the types of energy carriers and non-energy commodities are combined to create value-added, energy commodities, and non-energy commodities, as well as how to value-added, energy commodities and non-energy commodities are combined to form the output of each manufacturing sector. In the first layer, the incremental value of each production segment is obtained from the combination of production factors (including labor and capital) and energy is formed from the combination of different energy carriers (including coal, gasoline, gas oil, electricity, natural gas and other petroleum products). Also, in the first layer, the formation of a non-energy commodity is shown as a combination of the total all non-energy commodities (including non-energy goods from 1 to n). In the second layer, the output of each production sector, which is a combination of value added, energy commodity and non-energy commodities, is shown. Obviously, each of the energy carriers can be either imported or from the domestic production. Non-energy goods are imported into the model as a combination of imports and domestic products. It should be noted that manufacturers in each of the layouts perform optimization behavior, which maximizes their profits.

The structure of the utility of households is also in layers. It is assumed that households use two energy and non-energy commodities. Energy commodity is a combination of energy carriers including coal, gasoline, gas oil, electricity, natural gas and other petroleum products, and non-energy commodities include all other goods consumed by households.

Part II: Decomposition of recursive effect

In the second part of the methodology, using the approach taken by Zhou et al. (2018), in the form of a set of mathematical equations, an attempt was made to separately analyze the economy-wide rebound effect for production and the components of the final demand, and, at the same time, an attempt is made to separately analyze the rebound effect related to the production sections for the substitution and output effects.

3. Results

The findings show that considering the share of energy consumption (coal, gasoline, diesel, electric power and natural gas) of the manufacturing sectors in the total energy consumption of the economy, improving the efficiency of energy carriers by 5% led to a rebound effect of the total economy equal to 34, 30, 26, 23 and 18 percent for coal, gasoline, diesel, electric power, and natural gas. Therefore, it can be conclude that following improved energy efficiency, the amount of saved energy is not necessarily as much as expected.

The results are separately presented based on energy carriers:

- Coal: From the 34% rebound effect of coal, 98.8% was related to the "basic metals production" sector, followed by "mines" with a share of 61.1 percent. The very high share of "production of basic metals" is due to the high dependence of the products in this sector on coal consumption compared to other sectors.

- Gasoline: Out of the rebound effect of 30% for gasoline, 80.95% was for the transportation sector, followed by the 'household' with a share of 82.8%.
- Gasoil: Out of the rebound effect of 26% for gasoil, 68.88% belonged to the transportation sector, followed by the agricultural sector with a share of 19.23%.
- Electricity: Out of the rebound effect of 23% for electricity, 31.93% was related to the trade and all kinds of repair services, and then 'Other Services' with a share of 26.06%.
- Natural gas: Out of the rebound effect of 18% for natural gas, 28.31% belonged to the 'household' entity, and then the 'production of basic metals' section with a share of 21.41%.

It should be noted that the major consumers of energy carriers are the major contributors to the rebound effect of each of the energy carriers.

The results related to the decomposition of the rebound effect into substitution and output effects indicate that a major part of the rebound effect of the production sectors is related to the substitution effect and the output effect plays a minor role. This means that, in the short run, in order for firms make the best of improved efficiency of energy carriers, the substitution approach between energy carriers and other inputs is used, and development of production capacity approach is transferred to the long term.

4. Conclusion:

First of all, governments need to pay attention to non-price policies, in addition to price policies, for energy demand management, because they also have a great ability to manage and reduce energy demand. Second, policy makers need to pay attention to the rebound effect as well as the effects of substitution and output resulting from the programmed achievement of their intended goals prior to planning to improve energy efficiency.

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