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Research Paper

Investigating Asymmetry of Prices and Productivity of Energy Carriers in Iran's Agricultural Sector

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Abstract

Energy carriers are one of the most important inputs in the agricultural sector. These inputs have been the foundation of the development and transition of the agricultural sector from the traditional stage to the industrial stage. The energy per capita marginal consumption in Iran's agricultural sector is 3.2 times greater than its global average. Therefore, it is essential to save and optimally use energy carriers in this sector. Price liberalization is known as the most important pricing tool. The present study analyzes the effect of the prices of energy carriers on the productivity of their consumption in the agricultural sector by using the hidden cointegration method. The results show that the productivity of electricity and oil products display an asymmetric behavior in response to energy price variations so that electricity productivity decreases by 1145.04 units as the prices of electricity carriers rise and increases by 1254.32 units when the prices of electricity decrease. Also, when the price of oil products increases, productivity shows an increase of 22.18 units. In addition, the productivity of oil product carriers is improved by increasing their prices. Therefore, price correction is inevitable in the energy carrier sector. Given the asymmetric effect of the price of electricity on its productivity, the type of electricity price correction process should be considered along with non-price policies. The pricing tool only provides an incentive for productivity growth through the substitution of production factors. Given these conditions, if there is no economic structure and facilities to improve productivity, it cannot be expected that the pattern of energy consumption is corrected.

Keywords:
Agricultural sector, hidden cointegration, Iran, productivity of energy carriers

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INTRODUCTION

Energy carriers are one of the most important inputs in the agricultural sector. These inputs have been the foundation of the development and transition of the agricultural sector from the traditional stage to the industrial stage (Ahmadi Shadmehri et al., 2013; Fuglie et al., 2007). The electricity and oil products account for 86 percent of total energy consumption as the most important energy carriers in the agricultural sector. In 2013, the share of oil products (fuel oil, gas oil, petrol) and electricity was about 47 and 39 percent in total energy consumed by the agriculture sector, respectively (Iranian Ministry of Energy, 2009).

Given that energy per capita marginal consumption in Iran's agricultural sector is 3.2 times greater than the global average (Abrishami et al., 2010), it is essential to save and optimally use energy carriers in this sector. Productivity improvement as one of the most important sources of economic growth means more effective and efficient use of all production sources. Productivity is one of the factors that affect the economic condition of all nations because productivity enhancement will improve public welfare while boosting GDP and competitiveness of countries (Abrishami et al., 2010; Ahmadi Shadmehri et al., 2013; Bastanzadeh & Nilly, 2005; Miketa & Mulder, 2005; Roy et al., 1999).

Due to the growth of energy consumption in Iran, it has become a priority in the agenda of the country to attend to optimizing energy consumption in order to protect the environment, secure supplies and safeguard national resources and wealth, and this has led to designing and implementing various programs. However, in spite of many efforts, the relative stability of the energy productivity index indicates that the already taken actions have not always been successful (Figures 1 and 2) (Abrishami et al., 2010; Ahmadi Shadmehri et al., 2013; Bastanzadeh & Nilly, 2005; Iranian Ministry of Energy, 2009).

To explain the reasons for the failure of the programs to improve productivity and provide effective policy advice, solutions and methods should be distinguished for increasing productivity and the relationship should be recognized between them. The energy productivity optimization methods are typically divided into two categories: price and non-price. Reforming the structures and laws, promoting technology, and modifying the behavior of consumers and producers are presented as three major non-price strategies, and tax policies (subsidies) and price liberalization are known as the most important price tools (Karkacier et al., 2006). The sensitivity of energy intensity to actual energy price variations is one of the most important determinants of pricing or the policy of price liberalization. To demonstrate the effect of energy prices on energy productivity, it can be assumed that markets are in a full competition so that producers use energy to the point where the value of energy' marginal product becomes equal to the price of energy. If the prices of production factors can reflect the actual costs of inputs, energy productivity can be expected to increase. In such a situation, manufacturers are more efficient in energy consumption and can even use different combinations of inputs to reduce production costs (Abrishami et al., 2010; Bastanzadeh & Nilly, 2005; Karkacier et al., 2006).

Some analyses already done on energy productivity, especially in the agricultural sector across the world, are reviewed below. Karkacier et al. (2006) examined the effect of energy on Turkish agricultural productivity during the period 1971-2003. In this study, agricultural productivity was considered a function of energy consumption and investment. The results showed that the effect of both variables was significant and there was a strong relationship between energy consumption and agricultural productivity. In addition, the positive elasticity of energy consumption indicated the intensity of energy consumption on agricultural productivity. Fuglie et al. (2007) examined the total factor productivity in the American agricultural sector. According to them, in the period from 1948 to 2004, productivity was a factor in the growth of the agricultural sector, and

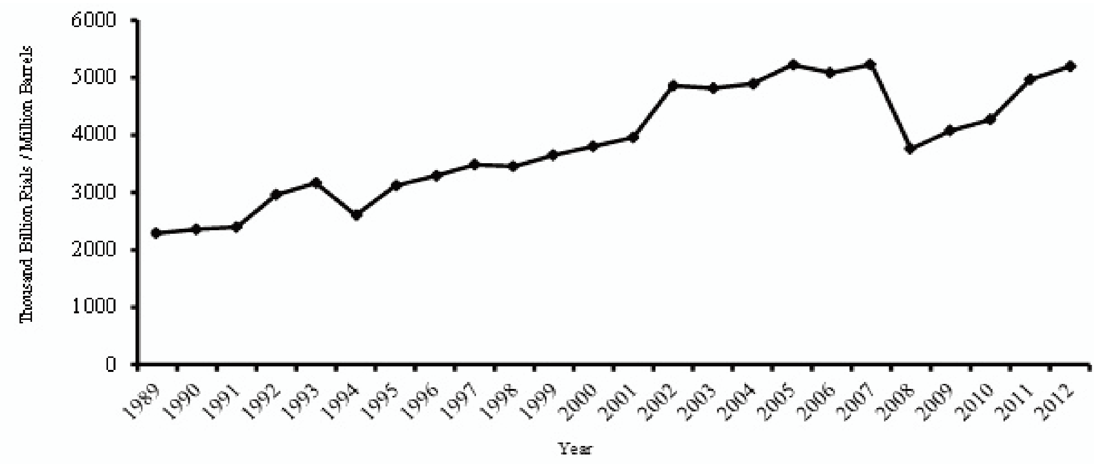

Figure 1. The trend of productivity of oil products in the agricultural sector

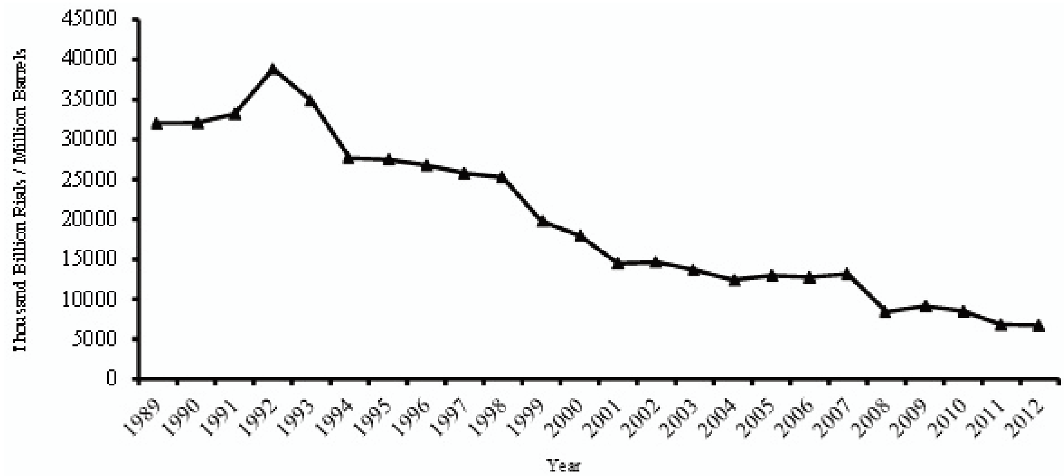

Figure 2. The trend of the process of electricity productivity in the agricultural sector

more than two-thirds of growth emanated from productivity growth. The development of new technologies has also contributed to this improvement, which is due to government investments in agricultural research. Ahmadi Shadmehri et al. (2013) studied the factors affecting energy productivity in the agricultural sector. According to the results, given the positive impact of technological progress (time trend variable) on energy productivity, new technologies should be considered in line with the country's conditions and the training of new methods. Given that energy prices have not had an impact on productivity, there should be more non-price solutions, such as technological changes in the production structure, training, and energy saving ways to increase productivity on the agenda.

Given that energy productivity in Iran' agricultural sector is very poor when compared to many countries, it can be seen that the increase in energy prices has led to an increase in energy productivity. Therefore, the main objective of the present study is to investigate the relationship between the relative price of energy carriers and their productivity in the Iranian agricultural sector during the period 1989-2012 by using the hidden cointegration method.

METHODOLOGY

If the components of a non-stationary time series are cointegrated, then the mentioned series may have hidden cointegration. In this case, the investigation of the existence of a long-run relationship is possible between non-stationary non-cointegrated time series. In other words, although the initial data series are not cointegrated, there may be a long-run relationship between the two time series after decomposition. Accordingly, each series is first-order integrated $I(1)$, consisting of a process *ARIMA (p, 1, q)* that involves a random walk. The two random walk series are considered as follows (Abrishami et al., 2010; Engle & Granger, 1987; Ramos et al., 2012):

$$X_t = X_{t-1} + \varepsilon_t = X_0 + \sum \varepsilon_t \qquad Y_t = Y_{t-1} + \eta_t = Y_0 + \sum \eta_t \tag{1}$$

where *t=1,2, ...,* X_0 and Y_0 are initial values, and ε_t and η_t are white noises with zero means. The new variables are then defined as:

$$\varepsilon_t^{\vee} = \max(\varepsilon_t, d) \qquad \varepsilon_t^{\wedge} = \min(\varepsilon_t, d) \tag{2}$$

where according to the term $\varepsilon_t = \varepsilon_t^{\vee} + \varepsilon_t^{\wedge} + d$ in Eq. (2), the term *d* indicates the threshold value. It is assumed that $\sum_1^t \varepsilon_t^{\wedge}$, $\sum_1^t \varepsilon_t^{\vee}$, $\sum_1^t \eta_t^{\vee}$ and $\sum_1^t \eta_t^{\wedge}$ are $I(1)$ and Eq. (1) is rephrased as below:

$$X_t = X_0 + \sum \varepsilon_t^{\wedge} + \sum \varepsilon_t^{\vee} \qquad Y_t = Y_0 + \sum \eta_t^{\wedge} + \sum \eta_t^{\vee} \tag{3}$$

The above equations are simplified based on symbols as follows:

$$X_t^- = \sum \varepsilon_t^{\wedge} \quad ; \quad X_t^+ = \sum \varepsilon_t^{\vee} \qquad Y_t^- = \sum \eta_t^{\wedge} \quad ; \quad Y_t^+ = \sum \eta_t^{\vee} \tag{4}$$

If components *X* and *Y* are cointegrated, then the mentioned series have hidden cointegration. There is a probability of a hidden cointegration investigation between all possible compounds of positive and negative components *X* and *Y*. The X^+ is a random walk acceleration process, and also this is true for X^-,Y^- and Y. Therefore, *X* and *Y* have hidden cointegration when their components are cointegrated to each other. In such a situation, the existence of hidden cointegration relationship between the components of these variables is tested by the Engle-Granger 2 step procedure (Engle & Granger, 1987). In this method, a regression relation is firstly estimated between non-stationary variables and then the residuals' stationary of the estimation equation will be considered. If these residuals are stationary, then there is a long-run relationship between the studied variables. The entire analyses were performed in Eviews 8.0.

The current research data are derived for the period 1989–2012 from the energy balance sheets and national accounts report of the Iranian Ministry of Energy (IME) (2009) and the National Bank of Iran (NBI) (2009), respectively. The research variables are described below:

The term *eprice* represents the relative price index of the electricity and *oprice* is the relative price index of oil products (fuel oil, gas oil, petrol) which are calculated by dividing the price of the intended energy carrier into Consumer Price Index (CPI).

The *eproductivity* indicates the variable of electricity productivity and *oproductivity* refers to the productivity variable of oil products, which are obtained by dividing the value added of the agricultural sector into the final consumption of the intended energy carrier.

The amount of energy (Electricity and Oil products) in this research was considered on the basis of the equivalent of crude oil (million barrels). The value added of the agricultural sector is based on the thousand billion IRR.

RESULTS

According to the research purpose, the relationship between relative price of energy carriers and their productivity in Iranian agricultural sector was investigated over the period 1989-2012. Due to the supply of 87 percent of energy by electricity and oil products, the two energy carriers were focused on in relation to the total final consumption of energy carriers in the agricultural sector.

Before the testing of the relationship between the relative price of energy carriers and their productivity, it is necessary to study the statistical characteristics of the studied variables in terms of stationarity and probability of the unit root. With respect to the confirmation of the existence of a unit root in the variables, the results of regression were spurious, and based on the estimated parameters, it was not possible to judge the relationship between the relative price of energy carriers and energy productivity. However, despite the non-stationarity of the variables, the cointegration models allowed extracting and analyzing the results from the estimated parameters.

The results of the investigation of the existence of unit root in the variables of electricity productivity, electricity relative price, productivity of oil products, and relative price of oil products were tested by using Augmented Dickey-Fuller (ADF) (Dickey & Fuller, 1979), Phillips-Perron (PP) (Phillips & Perron, 1988), and Kwiatkowski Phillips Schmidt Shin (KPSS) (Kwiatkowski et al., 1992) tests. The results presented in Table 1 show that not all examined variables were stationary at the data level, but they all were stationary in terms of the difference in data.

Because of the stationarity in difference of the variables, there may be a long-run relationship or, in other words, cointegration in variables. Therefore, the long-run relationship between the relative price of energy carriers and their productivity was analyzed using standard cointegration test and ADF, PP and KPSS tests. The results show that there was no long-run relationship between these variables (Table 2).

Due to the lack of standard cointegration between price and productivity, the existence of asymmetric cointegration was investigated. For this purpose, the asymmetric effects of increasing or decreasing the relative price of energy carriers were investigated on their productivity. In order to reduce the volume of the material, only the variables whose asymmetric cointegration has been proven were reported. The results of the long-run regression of electricity productivity are presented in Eq. 5. The numbers in parenthesis are t-student statistics, which is significant for all variables at the 1% level. As Eq. 5 shows, a decrease in the price of electricity leads to an increase in the electricity productivity by up to 1254.32 units while a one-unit increase in electricity price leads to a decrease in its productivity by 1145.04 units.

Table 1
The Results of Unit Root Tests at Level and the Difference in Data

Variables	Tests at level data			Tests at the difference in data		
	DF	PP	KPSS	DF	PP	KPSS
Eproductivity	-2.49	-2.59	0.66**	-4.32	-4.69	0.13
Oproductivity	-2.29	-2.31	0.12*	-5.14	-5.14	0.05
Eprice	-2.35	-2.21	0.155**	-5.68	-6.01	0.20
Oprice	-3.13	-1.82	0.13*	-5.03	-4.29	0.29

** $P<0.05$, *$P<0.1$

Table 2
The Results of Cointegration Tests

Variable	Df	PP	KPSS
Eproductivity	-2.60	-2.69	0.10*
Oproductivity	-1.81	-1.80	0.14*

* $P<0.1$

(5)

$$Eproductivity^{+} = 3090.97 + 1254.32Eprice^{-} + \varepsilon_{1t}$$
$$(4.20) \quad (5.41) \quad R^2 = 0.56$$
$$Eproductivity^{+} = 4821.1 - 1145.04Eprice^{+} + \varepsilon_{2t}$$
$$(8.30) \quad (-4.06) \quad R^2 = 0.44$$

The results of the asymmetric cointegration test for electricity productivity are presented in Table 3. They show a long-run relationship between *Eproductivity*$^{+}$ and *Eprice*$^{-}$ also between *Eproductivity*$^{+}$ and *Eprice*$^{+}$.

The results of long-run regression of oil products are presented in equation 6. The numbers in parenthesis indicate the value of t-student statistics, which is significant for all variables at the 1% level. As can be seen, increasing the prices of oil products will reduce the negative effects of productivity. In other words, higher prices for oil products will improve the productivity of this energy carrier.

(6)

$$Oproductivity^{-} = -427.39 - 22.18Oprice^{+} + \varepsilon_{3t}$$
$$(-5.87) \quad (-3.37) \quad R^2 = 0.62$$

The results of the asymmetric cointegration of oil products productivity are presented in Table 4. The results show a long-run relationship between *Eproductivity*$^{-}$ and *Eprice*$^{+}$.

Table 3
The Results of Electricity Cointegration Tests

Variable	Df	PP	KPSS
ε_{1t}	-3.78	-3.92	0.13*
ε_{2t}	-4.14	-6.28	0.12*

* *P*<0.1

Table 4
The Results of Energy Cointegration Tests of Oil Products

Variable	Df	PP	KPSS
ε_{3t}	-3.65*	-2.29	0.076**

** *P*<0.05

DISCUSSION

In this study, the effect of energy carrier prices on their productivity in the agricultural sector of Iran was investigated by using the hidden cointegration method. It was revealed that the productivity of electricity and oil products had asymmetric behaviors towards energy price variations. The long-run relationship was rejected between these two variables in the energy consumption of electricity and oil products. However, an asymmetric or hidden cointegration was observed between these variables. In this way, as electricity price decrease, the energy consumption of this carrier increases, and with its rise, its productivity decreases.

The results of analysis on the productivity of oil carriers show that with the increase in prices, their productivity will increase. Given that the price of oil products has a positive impact on their productivity in the agricultural sector, an increase in the actual price of oil products can motivate consumers to save this type of energy and optimize their use, resulting in the improvement of the productivity of oil products in this economic sector.

Our findings indicate that the current trend in relative prices of electricity impairs its productivity, so price correction will be inevitable in the energy carrier sector. Given the asymmetric effect of electricity prices on its productivity, attention should be paid to the type of electricity price correction process and the associated non-pricing policies. The important point is that it is necessary to pay attention to non-price methods. Considering that some agricultural products (e.g. greenhouses, poultry farms, and other agricultural industries) require electricity, reducing electricity price will motivate them to improve the mechanization of these units and to adopt modern technologies that improve water, soil and initial inputs productivity. But with increasing electricity prices, incentives will be reduced to use modern tools and technology, and hence, productivity will decline sharply. Therefore, in order to encourage the productivity of the agricultural sector of Iran, it is necessary to reduce electricity price through direct and indirect policies.

The price tool only provides an incentive for productivity growth through the substitution of the factors of production. Given these conditions, if there is no economic structure and facilities to improve productivity, then it cannot be expected that the pattern of energy consumption be corrected. Therefore, along with the reform of the energy pricing system, it is necessary to develop efficient technologies, train and develop manpower skills, reform management structure and ownership, develop infrastructure, and reduce the exchange costs of energy-saving services.

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