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## Article

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## Research paper

## How energy consumption is related to agricultural growth and export: An econometric analysis on Iranian data

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## ABSTRACT

Iranian agriculture has been supported by cheap energy for decades. So the question of whether this policy had brought any real outcome in terms of sector growth and export is of high importance for policy making. This paper tries to empirically identify such relation by using time series econometrics techniques including causality and cointegration tests for the period 1967–2015. Main results confirm existence of a unidirectional causality from energy consumption to agricultural growth while no relation is found between energy consumption and export. Other findings revealed that one percent increase in energy use results in 1.29 percent rise in agricultural growth in the long-run. In order to avoid detrimental impacts on sector growth, gradual liberalization of energy price for agricultural uses is recommended.

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## 1. Introduction

Energy is known as a prerequisite for economic growth and development (Makun, 2015; Sultan, 2012). Some ecological economists believe that in the biophysical growth model, energy acts as the most influential factor (Stern, 1993). Also many studies have reported the impact of economic growth on export (growth-driven export) (Mishra, 2011; Abbas, 2012). So, one may think of an association between energy use and export. In other words, trade is an important driver of economic growth and export enhancement promotes the economic activities and, thus, the energy demand (Sadorsky, 2012).

As many other developing nations, agriculture plays an important role in the Iranian economy. Based on recent data, it accounts for about 10% of gross domestic product, 20% of employment and more than 20% of non-oil exports (CBI,<sup>1</sup> 2017). Also as a member of OPEC,<sup>2</sup> Iran is an example of oil-dominant economies that has provided cheap energy to different sectors, including agriculture, for decades. It has been seeking non-oil export promotion and low dependency on oil export for three decades. So from policy making point of view it would be very informative to know how energy use has affected major economic variables (growth and export) of the sector.

By examination of the relevant literature one may find that study on the relationship between energy consumption (EC) and

economic growth (EG) (energy-growth nexus) has got huge attention in the scientific literature after 1970s energy price boom. Some of them have reported a one-way causality from EC to EG or *growth hypothesis* (Destek, 2016; Streimikiene and Kasperowicz, 2016; Altinay and Karagol, 2005; Lee and Chang, 2008; Adebola, 2011; Apergis and Payne, 2010). Some others found reverse relationship from EG to EC which is known as *conservation hypothesis* (Paul and Bhattacharya, 2004; Alper and Oguz, 2016 in the case of Czech Republic; Ahmed and Azam, 2016 for 40 countries; Mutascu, 2016 in the case of France and Germany; Narayan, 2016 for 90 developing countries; Shahbaz et al., 2018). Third group of studies including Ahmed and Azam (2016) for 18 countries; Mutascu (2016) in the case of Canada, Japan and the U.S.; Yang (2000) and Chandran et al. (2010) indicated a two-way causality between EC and EG which is called *feedback hypothesis* in the literature. Finally, some studies have supported *neutrality hypothesis* implying no causality relationship between EC and EG (Ouedraogo, 2013; Alper and Oguz, 2016 in the case of Cyprus, Estonia, Hungary, Poland, and Slovenia; Chontanawat et al., 2008 in the case of Ecuador). Also, Doytch and Narayan (2017) studied the linkage between energy consumption and economic growth, both in per capita, for two different sources of energy, renewable and non-renewable, for a panel of 89 countries. They found some evidence of *neutrality hypothesis* for renewables for most of countries under study, while feedback, growth and conservative hypotheses are supported for non-renewables.

On the other hand, the type of association between EG and export (EX) has been a matter of debate among economists, though the majority of previous studies have shown a positive relationship. To be specific some believe that export promotes growth

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**Table 1**  
Descriptive statistics.

Variable	Description	Unit	Mean	Min	Max	Standard deviation	Growth (%)
EC	agricultural energy consumption	million barrel OE	25.8	2.8	51.3	14.1	35.8
VA	agricultural real value added	billion Rial	75560.2	21930.8	142000.0	37598.6	11.4
EX	agricultural real export value	million USD	1343.8	92.2	6740.0	1708.7	133.9

Note: OE stands for Oil Equivalent; Rial is Iranian national currency which roughly equals 0.00003 USD by August 2016.

**Table 2**  
Unit root test results.

Variable	KPSS		Phillips–Perron		Augmented Dickey Fuller	
	Level	First difference	Level	First difference	Level	First difference
EC	0.22*	0.15	−2.40	−6.71**	−1.67	−6.61**
EG(LVA)	0.92*	0.22	−1.59	−6.06**	−1.66	−8.10**
EX	0.12*	0.05	−2.67	−8.36**	−2.71	−8.27**

Note: Variables are in natural logarithm; Change in LVA represents growth.

**Table 3**  
The results of JJ test.

Null hypothesis	Alternative hypothesis	Trace statistic		Maximum eigenvalue statistic	
		Value	Critical value 5%	Value	Critical value 5%
$r = 0^*$	$r \geq 1$	20.58	15.49	14.55	14.26
$r = 1$	$r \geq 2$	4.02	6.02	3.02	3.84

meaning a unidirectional causality from EX to EG (Dritsaki, 2013; Ee, 2016; Lee, 2011; Trost and Bojnec, 2015; Vamvoukas, 2007; Jung and Marshall, 1985; Krisna et al., 2003). Another view expressed and validated in some studies states that EX follows EG (Mishra, 2011; Abbas, 2012; Tekin, 2012; Gokmenoglu et al., 2015).

Empirical findings on the relationship between EC and EX are diverse as well. Sadorsky used a panel data set of eight Middle Eastern countries and found evidence of unidirectional Granger causality running from exports to energy consumption in the short run. Adewuyi and Adeniyi (2015) reported insignificant linkage between EC and EX in the three West African countries (Benin, Ivory Coast and Togo) while EC was found to be Granger cause of EX in Ghana and Nigeria. Moreover, the case of Senegal has revealed two-way causality between variables.

The Iranian literature on the type and size of association between EC, EG and EX is not so rich. Although, some studies have focused on the EC–EG linkage (Moghaddasi and Pour, 2016; Zibaei and Tarazkar, 2004) but there is no empirical evidence on EC–EX relationship especially in agriculture. Hence, the main motivation of this study relates to the lack of empirical works on EC–EG and EC–EX nexus at sector level (agriculture) in general and for Iran in particular. Therefore, the main objective of this research is to find reliable answer to the question of whether heavily subsidized energy has contributed in more growth and export in agriculture. The rest of the paper is organized as follows. Section 2 provides materials and methods used. Section 3 is dedicated to presentation of obtained results and their discussion, and finally Section 4 concludes.

## 2. Materials and methods

### 2.1. Econometric techniques

In order to touch our objectives, Granger causality test has been employed to find the type of causality relation (if any) among EC, EG and EX. This test is expressed by two separate regression

equations as follows:

$$Y_t = \sum_{i=1}^p \alpha_i X_{t-i} + \sum_{j=1}^q \beta_j Y_{t-j} + \varepsilon_{1t} \quad (1)$$

$$X_t = \sum_{i=1}^m \gamma_i Y_{t-i} + \sum_{j=1}^n \delta_j X_{t-j} + \varepsilon_{2t} \quad (2)$$

where p, q, m, and n are lags (to be determined by lag selection criteria), Y and X are three variables of interest (EC, EG, and EX) and  $\varepsilon_i$ 's are white noise residuals. Four possible outcomes after estimation are:

$\sum_{i=1}^p \alpha_i \neq 0 \rightarrow$  one-way causality from X to Y

$\sum_{i=1}^m \gamma_i \neq 0 \rightarrow$  one-way causality from Y to X

$\sum_{i=1}^p \alpha_i \neq 0$  and  $\sum_{i=1}^m \gamma_i \neq 0 \rightarrow$  two-way causality between X and Y

$\sum_{i=1}^p \alpha_i = 0$  and  $\sum_{i=1}^m \gamma_i = 0 \rightarrow$  no causality relation between X and Y

After checking for possible causal effects, the Johansen–Juselius (JJ) cointegration test is applied to explore both the size of effect and existence of long-run equilibrium relationship. According to JJ test, if  $Y_t$  is a vector of non-stationary time series like:  $Y_t = (EC_t, EG_t, EX_t)$  then Y can be specified as a vector autoregressive process of order k:

$$Y_t = \Delta_1 Y_{t-1} + \dots + \Delta_k Y_{t-k} + U_t \quad (3)$$

Eq. (3) can be equivalently expressed as a vector error correction model (VECM):

$$\Delta Y_t = \varnothing_1 \Delta Y_{t-1} + \dots + \varnothing_k \Delta Y_{t-k+1} - \mathbb{C} Y_{t-k} + V_t \quad (4)$$

where  $\Delta$  is the first difference operator. Here  $\mathbb{C}$  is a square matrix containing information about long-run relations among variables of interest. To be specific, rank of  $\mathbb{C}$  suggests the number of cointegrating relationships among variables.

The JJ strategy uses the maximum likelihood method in determination of the cointegrating rank ( $\mathbb{C}$ ). The existence of a cointegrating relation is considered as a necessary condition for specification of the vector-error-correction model (VECM) for three

**Table 4**  
Granger causality test results.

Null hypothesis	No of observations	F-statistic	probability
EC doesn't Granger cause EG	48	4.28	0.04
EG doesn't Granger cause EC		0.15	0.70
EG doesn't Granger cause EX	48	6.93	0.01
EX doesn't Granger cause EG		0.62	0.43
EC doesn't Granger cause EX	48	0.94	0.34
EX doesn't Granger cause EG		0.03	0.86

Note: EC and EX are in natural logarithm; EG represents LVA.

variables of interest. The ECM represents the change in one variable as a linear function of its own past changes as well as past changes in the other variables, and an error-correction term. The last one is very important for policy making as it shows how the effect of a deviational shock would be corrected through time. Thus, an ECM provides two alternative channels of the interaction among variables: short-run causality through past changes in the variable, and long-run causality through adjustments in equilibrium error (Sultan, 2012).

## 2.2. Data

The data used in this research is taken from different national sources including Ministry of Energy, Ministry of Agriculture and CBI. All data are annual for the period spanning from 1967 to 2015.

## 3. Results and discussion

Table 1 presents some descriptive statistics of the variables.

As it is clear from the last column, all variables followed increasing trend though by different rates. Moreover, VA was more instable than other two variables as its standard deviation is far from similar figure for others. Table 2 portrays the result of the unit root tests. It is obvious that all three variables are non-stationary, so we should check for possible cointegration relationship. Table 3 shows the output of JJ test that revealed existence of one cointegrating relationship.

In order to examine presence of causality association, common Granger test is applied. Based on Table 4 existence of unidirectional causality running from EC to EG (growth hypothesis) and, EG to EX cannot be rejected while our findings do not support any causality relation between EC and EX. In other words, EC was a growth creating factor in Iranian agriculture and it has contributed in promotion of Iranian agricultural export and, thus, non-oil revenues. These are in line with some previous works (Destek, 2016; Streimikiene and Kasperowicz, 2016; Altinay and Karagol, 2005; Lee and Chang, 2008; Adebola, 2011; Apergis and Payne, 2010; Mishra, 2011; Abbas, 2012; Tekin, 2012; Gokmenoglu et al., 2015; Adewuyi and Adeniyi, 2015).

By application of canonical cointegrating regression (CCR) method, it is found that, on average, one percent increase in energy consumption leads to 1.29 percent rise in agricultural growth in the long-run. This finding is supported by some previous works (Altinay and Karagol, 2005; Lee and Chang, 2008; Adebola, 2011; Apergis and Payne, 2010). Furthermore, the error correction coefficient for the growth equation is estimated at  $-0.06$  implying that the effect of any shock imposed (resulting from policies like energy price liberalization) on the system will be slowly corrected. In fact, this is a valuable finding from policy making point of view suggesting that government should prevent imposing any great shock in energy consumption in the agriculture.

## 4. Conclusion

This study is an attempt for examination of causal impacts of energy consumption on growth and export in the Iranian agriculture. Different time series econometric techniques are applied on annual data for three variables of interest (EC, EG and EX) for the period from 1967 to 2015. Main results confirmed existence of a one-way causality from EC to EG. In other words, our findings show consistency of Iranian data with *growth hypothesis*. This is in line with the findings of Zibaei and Tarazkar (2004). Further examinations revealed existence of a long-run association between variables as one percent increase in EC results in 1.29 rise in EG. Besides, we could not be able to find any causal relation between EC and EX. Due to positive and strong impact of energy consumption on agricultural growth at one hand and critical role of agricultural activities in Iranian economy at the other hand, gradual liberalization of energy price for agricultural applications is highly recommended in order to avoid considerable adverse impact on sector growth.

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