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The Role of Energy in Iranian Agricultural Development

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***Abstract**: Energy plays an essential role in economy on both demand and supply sides. Energy management is an important issue in terms of efficient, sustainable, and economic use of energy. There are many factors at the present time that influence us to consider renewable energy options. This paper tries to examine the relationship between Energy consumption in agriculture and agricultural development in Iran. In this study VAR, VECM and Environmental Kuznets Curve models were used to achieve the study objectives. The Results indicate that energy consumption has a significant impact on Iran agricultural development. The granger causality test shows that during the study period, per capita energy consumption has increased by agricultural growth.*

***Keywords:** Energy, Agricultural Development, VAR, VECM, Kuznets Curve.*

1. Introduction

Energy requirements in agriculture can be categorized as direct or indirect and non-renewable and renewable energy (Beheshti Tabar et al., 2010). Energy plays an essential role in economy on both demand and supply sides. On the demand side, energy is one of the products that consumer decides to buy for maximize his / her utility (Soytas & Sarý 2003). On the supply side, energy is a key factor of product in addition to capital, labor and raw materials and is seen to play a vital role in the economic and social development of countries, being a key factor in increasing economic growth and living standards. Agriculture growth can cause to economic growth in Iran.
Agriculture is an energy conversion process in which solar radiation, fossil fuels, electricity and labor energy converts to food and other products for human consumption. Agricultural production consumes energy in its process of energy supply in the form of bioenergy(Alam et al., 2005).

Energy as an input has a lot of usage in agriculture. Stern (1993) believes that energy is the most important factor in biophysical growth model. Neo classic economists like Bernet (1978) believes that energy has impact on labor and capital stocks factors; therefore energy impacts on economic growth indirectly.
Efficient use of energies help to achieve increased production efficiency and therefore contribute to economy, profitability and competitiveness of agriculture sustainability in rural areas.
In addition to economic benefits, there are of course social and environmental advantages to reducing energy consumption, such as preserving fossil fuel supply and minimizing the impact of climate change (Boyle 2011).

It's attractive for policy makers and economist to find the relationship between agricultural energy consumption (AEC) and Agricultural growth (Arman et al.2005). If causality runs from energy consumption to agricultural growth, then it implies that an economy is energy dependent and hence energy is a stimulus to growth implying that a shortage of energy may negatively affect agricultural growth or may cause poor economic performance, leading to a fall in income and employment(Soytas, Sarı, & Özdemir, 2001). In other words, energy is a limiting factor in economic growth (Stern 2000). Whereas if causality only runs from agricultural growth to agricultural energy consumption this implies that an economy is not energy dependent, hence, energy conservation policies may be implemented with no adverse effect on growth and employment. If, on the other hand, there is no causality in either direction (referred to as the 'neutrality hypotheses), it implies that agricultural energy consumption is not correlated with agricultural growth, so that energy conservation policies may be pursued without adversely affecting the economy (Jumbe 2004). It is important therefore, to ascertain empirically whether there is a causal link between agricultural energy consumption and agricultural growth (Maleki 1999).

This paper therefore attempts to address this issue. In particular, a systematic and consistent methodology is adapted to test whether there is evidence of causality between agricultural energy consumption and agricultural growth for Iran between years 1976-2005. Furthermore, the application to energy Kuznets curve (EKC) is also refreshing, as the co-integration analysis, which is hardly used, is the only correct way to test the EKC hypothesis. For finding long run and short run relationship between agricultural energy consumption and agricultural growth using VAR(Vector Auto Regression) and VECM(Vector Error Correction) models.

2. Material and Methods

The required data were gathered from ministry of agriculture for years 1976-2012.

A VAR system contains a set of m variables, each of which is expressed as a linear func-tion of p lags of itself and of all of the other m – 1 variables, plus an error term. When the variables of a VAR are cointegrated, we use a vector error-correction Model (VECM).

$$\Delta yt = \beta 0 + \beta 1\ yt\text{-}1 + \ldots\ldots + \beta pyt\text{-}p + \alpha 1 \Delta xt\text{-}1 + \ldots. + \alpha pxt\text{-}p\text{-}\gamma y(yt\text{-}\ \delta 0\text{-}\delta 1xt\text{-}1) + vt \quad (1)$$

$$\Delta xt = \beta 0 + \beta 1\ yt\text{-}1 + \ldots\ldots + \beta pyt\text{-}p + \alpha 1 \Delta xt\text{-}1 + \ldots. + \alpha pxt\text{-}p\text{-}\gamma x(yt\text{-}\ \delta 0\text{-}\delta 1xt\text{-}1) + vt \quad (2)$$

where yt= δ0- δ1xt is the long-run cointegrating relationship between the two variables and λy and λx are the error-correction parameters that measure how y and x react to deviations from long-run equilibrium.

The standard Engle & Granger (1987) test has been employed to analysis the data. The test is based on the following regressions.

$$X_t = \gamma_0 + \sum_{k=1}^{M} \gamma_K Y_{t-k} + \sum_{l=1}^{N} \delta_t X_{t-1} + U_t \quad (3)$$

$$X_t = \gamma_0 + \sum_{k=1}^{M} \gamma_K Y_{t-k} + \sum_{l=1}^{N} \delta_t X_{t-1} + V_t \mathbf{Z} \quad (4)$$

3. Discussion and Results

The level of energy consumption in in Iran comparing to other countries is high. For example the amount of energy used in ran comparing to Italy has a increasing trend during 1980-2012 (figure 1).

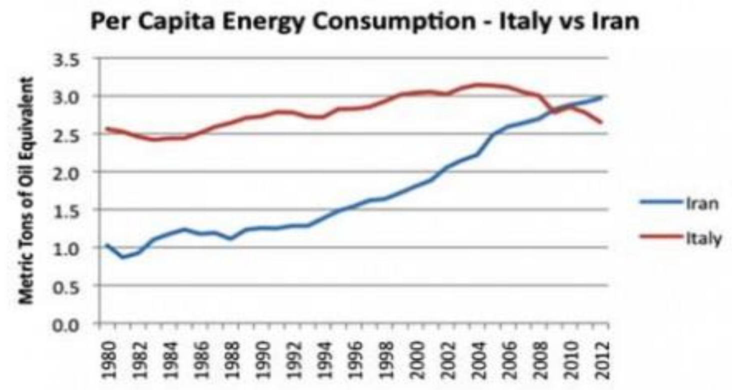

Fig. 1: Comparison of per capita consumption of energy.

Looking at the trend of GDP and energy consumption also shows that the slope of energy used curve is higher than GDP growth. This means that there is not a logical relationship between energy used and GDP trend in Iran.

First of all Augmented Dickey Fuller test was used to examine the stationary of time series data. Results show all variable to be non stationary, while the first order differences of the variables are stationary.

There are many factors at the present time that influence us to consider renewable energy options. Stern (1993) believe that in biophysical growth model, energy is the most important factor for growth.

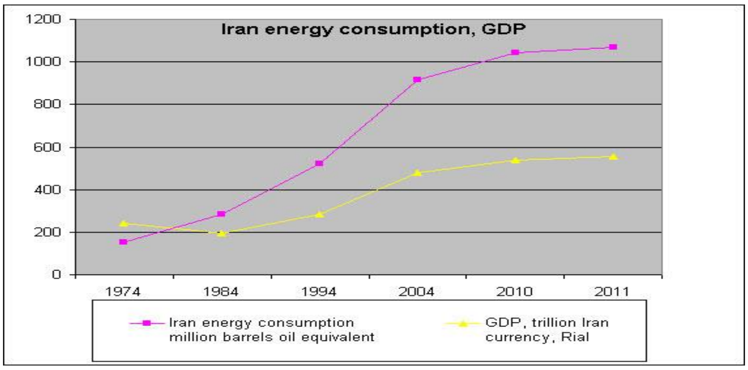

Fig. 2: Energy Consumption and GDP

Capital and labor are middle inputs that are needed to energy applying. Neo-classic economists like Berndth (1978), implied that energy has impact on capital and labor inputs there for, energy has an indirectly impact on economic growth. For this reason, as the second step, like Stern (1993), we enter capital stock and labor variables to Granger causality model.

Table 1 reports the results of Granger causality test.

TABLE I: Results Of Granger Causality Test Between Model Variables

Null Hypothesis	Obs	F- Value	Probability
L does not Granger Cause AEC	29	0.09	0.76
AEC does not Granger Cause L	29	2.82	0.1
TR does not Granger Cause AVA	29	2.5	0.12
AVA does not Granger Cause TR	29	0.95	0.34
AEC does not Granger Cause AVA	29	0.001	0.97
AVA does not Granger Cause AEC	29	0.004	0.94
AVA does not Granger Cause K	29	1.31	0.26
K does not Granger Cause AVA	29	1.51	0.23
AEC does not Granger Cause TR	29	9.7	0.004
TR does not Granger Cause AEC	29	6.3	0.02
L does not Granger Cause TR	29	2.1	0.15
TR does not Granger Cause L	29	3.51	0.07
L does not Granger Cause AVA	29	6.86	0.01
AVA does not Granger Cause L	29	2.31	0.14
K does not Granger Cause AEC	29	2.3	0.13
AEC does not Granger Cause K	29	0.11	0.74
L does not Granger Cause K	29	1.32	0.26
K does not Granger Cause L	29	0.04	0.84

Ref: Research finding

The results of Granger causality show that there is not a directly relationship between agricultural energy consumption (AEC) and agricultural value added (AVA). Despite of this result like Stern (1993), causality runs from AEC to labor and Capital (with probability 0.15). This implies that labor implementing depends on agricultural energy consumption. For clarified the relation between labor and agricultural energy consumption, we enter mechanization to model (Sarı & Soytas 2004). We get Tractor implemented in agricultural sector as a proxy of mechanization. Results show there is a mutual relation between agricultural energy consumption and Tractor and this relation is significant (with probability level 0.05) .On the other side, Granger causality show that there is a mutual relation between Tractor and labor, and this relationship is significant also (with probability level 0.01) .There for there is a relationship between labor and agricultural energy consumption, which is acceptable and expected. The Granger causality test between agricultural energy consumption and capital stock show a relation runs from capital stock to energy consumption and this relation is significant (with probability level 0.15). Results also show causality runs from capital stock (K) to AVA. For applying energy in agriculture it needs investment. Changing investment during production period cause capital formation, thus this relation is expected and acceptable too. From all of the above, we find that, there is an indirect relation between AEC and AVA.

Estimation of aggregate agriculture production function with OLS method shows that labor and capital stock have positive effect on agricultural value added.

$$LAVA=-62.47+0.16LAEC+4.81LL+8.5\times 10^{-4}LK \quad (3)$$

(0.04) (0.23) (0.03)

Where LAVA is logarithm of agricultural value added, LAEC is logarithm of agricultural energy consumption, LL is logarithm of agricultural labor and LK is logarithm of agricultural capital stock.

From all of the above discussion we find that there is a relation between agricultural energy consumption (AEC) and agricultural value added (AVA).

For co-integration test between all variables in model (all the variables come in logarithm form), we use Johansson co-integration test. (Standard deviation are in brackets).

$$AVA=11.22AEC+0.06K+0.05L \quad (4)$$
$$(104.91) \ (0.05) \ (0.004)$$

Johanson co-integration test, like Granger causality test, Shows, base on maximum Eigen value, one co integrate equation confirmed (with probability level 0.05). Normalize co-integration coefficients confirm a positive and significant relation between AEC and AVA (Glasure 2002).

For evaluating long-run relation between agricultural energy consumption and agricultural value added we use VAR model. First, optimum lag for VAR model by AIC modified criterion has been chosen. AIC modified criterion chooses one lag as optimum for VAR model. (Standard error in brackets).

Table 2 shows the results of VAR model.

TABLE II: Results of VAR model

	LAVA(-1)	LAEC(-1)	LK(-1)	LL(-1)	C
LAVA	0.32	0.11	0.018	3.46	-45.5
SE	(0.19)	(0.05)	(0.03)	(1.017)	(13.3902)
t-value	((1.69))	((1.93))	((0.48))	((3.41))	((-3.4))

Ref: research finding

In this model F statistic (F=646) shows the model is statistically significant.

All variables which are in this model have positive effect on logarithm of agricultural value added. From the above table it follows that LAVA in specific year is strongly influenced by logarithm of AEC and L.

The error correction model yields the following results (standard deviation between brackets).

$$(3): \ D(LVA) = -36.57 - 0.75\, LVA_{(-1)} - 0.16LE_{(-1)} + 0.25D*LVA_{(-1)} +$$
$$(12.5) \quad (0.26) \qquad (0.05) \qquad (0.25)$$
$$+ 0.26D*LVA_{(-2)}) + 0.15D*LE_{(-1)} + 0.08D*LE_{(-2)} + 0.026T$$
$$(0.2) \qquad (0.14) \qquad (0.12) \qquad (0.1)$$

Where the residuals are I(0) and R^2=0.4 .The above equation shows there is a long-run relation between AVA and AEC. The above equation also shows that, by the time passes (in 2 periods) the effects of error (residuals) on AVA will be balanced.

TABLE III: Variance decomposition of agricultural value added variable

Period	S.E	LAVA	LAEC	LK	LL
1	0.037	100	0	0	0
2	0.041	95.322	3.504	0.001	1.173
3	0.043	88.237	8.654	0.018	3.092
4	0.045	81.406	13.407	0.067	5.120
5	0.047	75.649	17.184	0.151	7.016
6	0.048	70.966	20.033	0.262	8.740
7	0.050	67.164	22.144	0.386	10.305
8	0.051	64.052	23.702	0.510	11.737
9	0.052	61.473	24.851	0.621	13.055
10	0.053	59.310	25.701	0.713	14.276

Ref: research finding

In respect to variance decomposition table 3, we can understand that while time passes, forecast Error increases. Table 3 shows that the share of changing in AEC on AVA is large, and while the time passes, this share is increasing.

It would be finding from variance decomposition of agricultural value added variable that forecast error in different periods would obtained from changing in present quantity and future impulses. Forecast error in the first period is 0.03% and from 4th period this share increase to 0.04% and this share increase by the time passes. The results of variance decomposition also show that, in the first period 100% changing in AVA is From Changing AVA itself. In the second period, this share decrease to 95% and AEC with Comparison to other variables like agricultural labor and capital stock explaining the maximum share of changing in AVA.

The results of impulse-response show that an unexpected changing or impulse to amount of one standard error(S.E) in AVA variable, Would changed AVA to 0.03% and this trend decrease during time and from 6^{th} period it takes reverse sign to itself. It means from sixth period if one E.S positive impulse from AVA come to AVA, this impulse decrease AVA. The results of table 2 show that between all of investigated variables in this model, one S.E impulse of AEC from second period has great effect in comparison to other variables to AVA, these impulse during this ten period are decreasing and finally at the end of period would balanced. It means that if one standard error impulse from AEC comes to AVA in the first period, this impulse doesn't have any impact on AVA but this impulse effect begins from second period and this impact is 0.007 in second period and by the time passes the effect of these impulse will balanced.

There is a large body of literature related to the so-called environmental Kuznets curve (EKC). If the EKC hypothesis is true, then environmental problems will be solved ultimately in time, as long as the economy keeps on growing. Stern (2004) gives an excellent survey of this body of literature and basically concludes that most of the existing studies on EKC suffer from serious weaknesses and the evidence for EKC is very weak. Moreover, even if an EKC relationship could be found, the models used are generally not suitable for forecasting and generalization of the results are not possible. Still then, it would be reaffirming to establish such a relationship for agriculture sector of Iran.

We try to test the EKC hypothesis for agriculture sector of Iran by using agricultural energy consumption as an indicator of the environment. Stern (2004) indicates that energy use can be a good indicator of overall impact different variables on environment. So actually we are testing an energy Kuznets curve hypothesis by establishing a link between agricultural energy consumption per capita (AECPC) and agricultural value added per capita (AVAPC).

In order to test the EKC hypothesis, it is a general practice to estimate the coefficients of the quadratic relationship between the dependent variable ln(AECPCt) and the independent variables ln (AVAPCt) and ln(AVAPCt)2 (e.g. see Stern (2004) for an overview) However, in this case this is not allowed because ln(AECPCt) , ln(AVAPCt) and (ln (AVAPCt))2 do have unit roots According to the augmented Dickey–Fuller test with two lags, there is no unit root for ΔAECPCt and Δ(AVAPCt) . Therefore, instead of the mentioned quadratic regression relation we estimate the following simple linear regression relation between ΔAECPCt and ΔAVAPCt (with the corresponding standard deviations between brackets):

$$\Delta AECPC_t = 1.23\times 10^{-5} + 2.9\times 10^{-4}\,\Delta AVAPC_t \qquad (1\text{-}5)$$

$$(1.71\times 10^{-5}) \qquad (1.5\times 10^{-4})$$

The regression coefficients in Eq. (4) have probability levels 0.07, and the R^2_{adj} is equal to 0.3. If the EKC hypothesis is true, the regression coefficient of ΔAVAPCt has to be smaller than 0. Nevertheless, this coefficient turns out to have a significantly positive sign. Fig. 1 presents a graphical plot of the data and the fitted quadratic curve corresponding to Eq. (1-5).

From figures 1 it follows that the the link between per capita AVA and per capita agricultural energy consumption in agriculture sector of Iran.

Consumption per capita follows the growth path AVA per capita. This result contradicts the EKC hypothesis. During the considered period, energy consumption per capita as an indicator of environment problem keeps on growing in time as long as the economy keeps on growing.

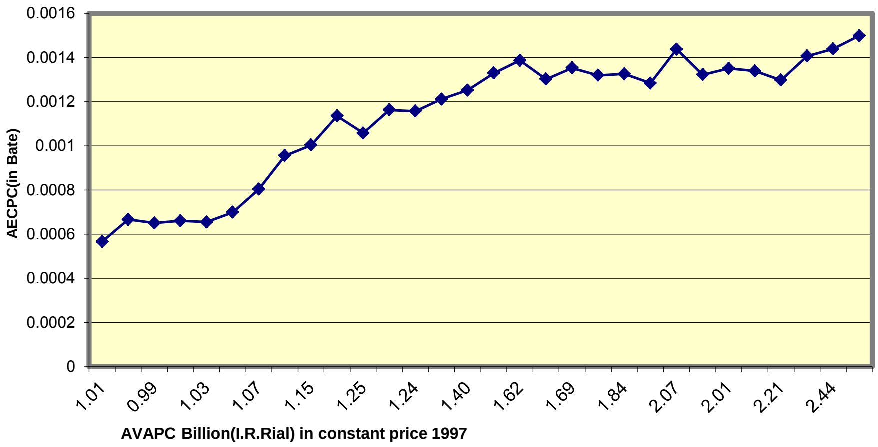

Fig. 3: Trend of Energy consumption and agricultural Growth

4. Conclusion

Based on these results the short-run and long run relation between AVA and AEC with using VAR and VECM model is analyzed. The results of Granger causality test show that AEC impacts on AVA indirectly. For purification the effect of AEC variable on AVA we use mechanization (the Number of tractors used in agriculture) as a middle factor. The analysis shows that AEC and AVA are co-integrated. This means that there is a causality relation between these two variables. We establish that causality runs indirectly from AEC to AVA. We find that the causality runs from AEC to TR (Number of tractor used in agriculture which as a proxy of mechanization) and also a causality runs from TR to AVA directly, so causality run from AEC to AVA indirectly. It means that increasing in AEC is a movement force for AVA growth. The results of VAR and VECM estimation show that there is a relation between AVA and AEC in short-run and long run respectively. The results also show that the role of AEC is relatively large in comparison with other variable (agricultural labor and capital stock) on AVA by the time passes.

The analyses in this paper also reject the EKC hypothesis for agricultural sector of Iran. Rejection of the EKC hypothesis has as a policy implication that agricultural growth will lead to higher energy consumption. There are two possibilities to reduce the environmental impacts. First, the energy mix can change over time and induce lower emissions. Second, an energy saving programmed can be followed as the co-integration analysis indicates that this does not harm economic growth.

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