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Investigating the Long-Run Relationship between Energy Losses and Energy Supply Surplus

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Abstract: *Energy is an important input in agricultural production and economics growth. This paper attempts to investigate the long-run relationship between energy losses and supply surplus. A Vector Error Correction Model (VECM) was used to examine the long run relationship between energy losses and supply surplus. According to the study results, energy supply surplus is among the major reason of energy losses in Iran. The results indicate that an increase in the energy supply surplus would increase the energy losses by 0.0275 units. However, estimation of error correction term shows that without an energy supply management program, after 1.2 periods the energy losses will revert to its previous mode. Therefore, political solutions are needed to be included in the long-run planning such as implementation of economics development plans with adequate management in order to reduce the energy losses.*

Keywords: *Energy losses, Energy supply surplus, Vectors error correction model*

1. Introduction

Energy is an input of significant importance in production, and a leading factor in the economic growth of a country (Warr and Ayres, 2010). Energy and its efficient use have long been among the chief issues discussed by the developing and developed countries. Great efforts have been made to save energy and reduce energy consumption (Mazarrati, 2008). Sustainable development can meet the current needs of societies without sacrificing future generations' potentials in energy supplying and damage to the environment (world commission on environment and development, 1987). Sustainable and comprehensive development calls for an exclusive and optimal program in energy use and proper energy convertibility to different conventional forms. Abundance of energy resources in Iran has caused the per capita energy consumption and intensity to be far greater than the countries with similar structures and fewer resources (Arman and Zare, 2005). Accordingly, in spite of the existence of multitude of potential problems resulting from adverse energy use in Iran's economy, Iranian government has paid special attention to issues and aspects of energy in the form of a principled policy that has led to many serious actions to be taken in the recent years. One of the measures taken to prevent energy losses, in line with economic development initiatives and targeted subsidies plan, has been the elimination of subsidies regarding energy and raising prices of these resources to reach their real prices (Government information center, 2010). It is also possible to increase energy efficiency and reduce energy intensity by adopting appropriate energy supply and demand policies, replacing old machinery, motors, and equipment, especially in energy consuming units that is at homes, business, transportation, industries, and power generation (energy balance, 2002). Research suggests that in the period under investigation, particularly after the 1978 Iranian revolution, the growth rate of energy consumption has been far beyond the economic growth rate. The average efficiency of power plants in the country has been 37 percent in the recent years, while losses in electricity transmission and distribution network have been far beyond 20 percent. Energy losses in the country have reached well thousand million barrels of cued oil a year, with 400 thousand barrels in the domestic energy consumption sector. Iranian oil, gas, and coal resources will finish in 60, 40, and 105 years respectively, and over the next 25 years, with the increase in the energy consumption, Iran will be excluded from the petroleum exporting countries list (EPOI, 2009). Before the economic development plan implementation, Iranian government paid 600 dollars annually for the energy subsidies per capita. However, energy losses in domestic sector, transportation, industry, and agriculture sectors have been 40, 27, 20, and 4 percent respectively. Based on the Iranian energy productivity organization report, Iran's energy consumption intensity index is 13 times higher than Japan's (EPIO, 2009). Despite these losses, it is obvious that Iran does not try well enough to maintain and preserve the God-given oil and gas resources. Current paper examines the relationship between energy losses rates with energy supply surplus. In fact, exceeded energy supply can compound the energy losses issue from adverse management and heterogeneous and inappropriate energy distribution to different parts of the country and economic sectors and energy losses in the production, distribution, and transportation of energy carriers' network. In this study, for the first time, the long-run causality relationship between energy supply and energy losses is characterized with the importance of the appropriate energy supply and distribution.

2. Data, Methodology And Empirical Results

The required data were gathered from the annual energy balance sheets released by Iranian ministry of energy for the period 1968 to 20013. Figure 1 shows Trend of energy losses and supply surplus during 1960-2013 (Unit: Million barrels of crude oil equivalent).

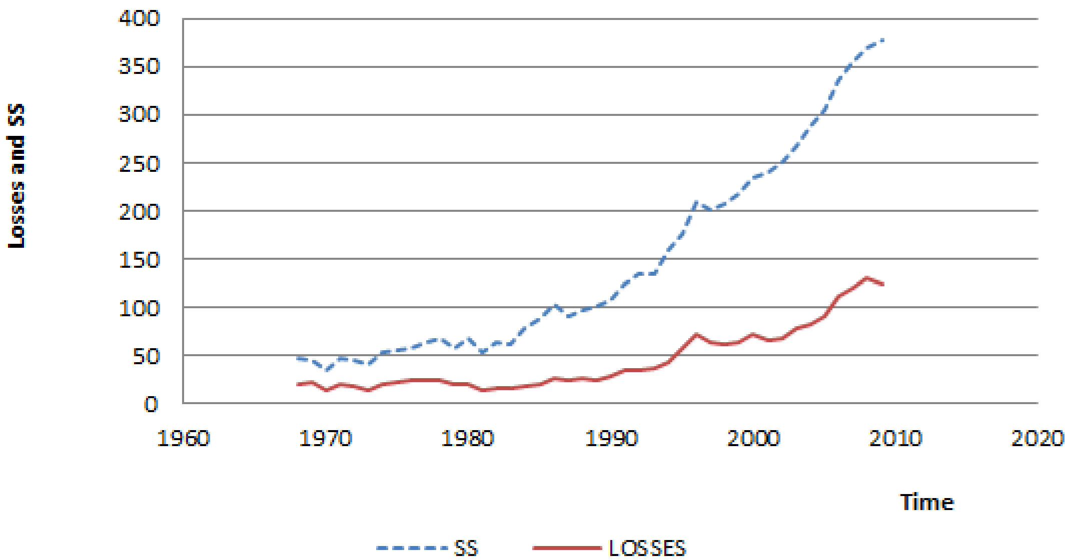

Fig. 1: trend of losses and energy supply surplus

According to the above figure a positive trend for energy consumption and supply surplus exist during 1960 to 2013.

In order to examine the long-run equilibrium relationship between two variables a Vector Auto-regression Model (VAR) was used to choose the optimum number of lag and investigate the relationship between energy losses and energy supply surplus. The general form of Vector error correction model is:

$$\Delta L_t = \sum_{i=1}^{n-1} \delta_i \Delta L_{t-i} + \sum_{j=1}^{n-1} \mu_j \Delta SS_{t-j} + \varphi_1 ECT_{t-n} + \lambda_2 d_2 + \lambda_3 d_3 + \lambda_4 d_4 \quad (1)$$

Where Δ is differences of order 1, i and j is the number of optimum lag, ECT is error correction term andδ_i,μ_j, $\varphi$and $\lambda$are estimated model parameters. The significance of ECT coefficient shows the long-run causal relationship from energy supply surplus (independent variable) to energy losses (dependent variable). Indeed, error correction term (ECT), shows the speed of error correction and the tendency toward long-run equilibrium.

2.1. Empirical results and Discussion

As it was mentioned earlier, stationary of the time series should be examined prior to the investigation of the relationship between them. Results of augmented Dickey-Fuller test are presented in table 1. These results indicate that neither of the two variables L and SS is reliable, and t statistics of the two variables are greater than the critical amount of Dickey-Fuller test at %5 level. Results of the differences of order 1 of the variables indicate that the statistics regarding the two variables is less than the critical amount of Dickey-Fuller test at %5 level. Thus, both variables have turned into collective variables of I(1) value after a subtraction. Therefore, we can conclude that a long-run relationship might exist between the two variables.

TABLE I: Results of unit root tests

Variable	Level		1 difference	
	Constant	Constant and Trend	Constant	Constant and Trend
L	-1.615	-2.306	-3.732	-5.271
SS	-1.714	-2.910	-4.012	-4.822
Critical Value (5%)	-2.941	-3.533	-2.941	-3.553

Ref: research findings

In order to investigate the long-run relationship between the variables, number of optimal lags of the co-integration model needs to be determined through a vector auto regression model. Having designed a vector auto regression model, number of the lags should be extracted. As the results of table 2 indicate, and according to the criterion presented in the model, optimal lag would equal 2. As a result, co-integration models are to be designed with a lower interruption.

TABLE II: VAR Lag Order Selection Criteria

Lag	LR	AIC	SBC	HQC
0	NA	14.320	14.838	14.504
1	68.581	12.245	12.934	12.490
2	18.870*	11.781*	12.643*	12.088*
3	1.789	11.923	12.957	12.291
4	3.341	11.994	13.201	12.424

Note: * indicates lag order selected by the criterion, LR: sequential modified LR test statistic (each test at 5% level)

Table 3 and 4 contain the results of Johansen-Juselin co-integration tests (1992) that have been used to determine the long-run co-integration vectors. Based on the results of Eigen value test and Trance test existence of a co-integration vector in long-run is confirmed at %5.1 level.

TABLE III: Results of Johansen's cointegration tests: (Unrestricted Cointegration Rank λtrace Test)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.
None *	0.6896	50.0114	25.872	0.0000
At most 1	0.0771	3.20941	12.518	0.8507

Trace test indicates 1 cointegrating (s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

TABLE IV: Results of Johansen's cointegration tests: (Unrestricted Cointegration Rank λmax test)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.6896	46.8020	19.387	0.0000
At most 1	0.0771	3.20941	12.518	0.8507

Max-eigenvalue test indicates 1 cointegrating eqn(s)at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

In the next stage, long-run and short-run regression between variables under investigation is estimated using VECM. The model is designed as follows: given the existence of a long-run relationship, in VECM, between energy losses and energy supply surplus, a significant positive relationship exists in long-run. Based on the estimated coefficients and significance of ECT coefficient, a long-run relationship exists from energy supply surplus to energy losses. The value of this coefficient is negative and lower than 1 that tends to reach equilibrium in long-run. Regarding the obtained coefficient, short-term error adjustment rate tends to reach equilibrium at 0.83 that indicates speed of adjustment runs towards long-run equilibrium. So, after a period of about 83 percent of disequilibrium in prior periods, energy losses become adjusted. These results indicate that if the energy losses experience a reduction due to an impulse such as economic development plan, the energy losses will reoccur after 1/2 course in case of inadequate energy management.

TABLE V: Vector Error Correction Estimates

Variables	ECT	ΔL_{t-1}	ΔSS_{t-1}	C	d_2	d_3	d_4
$L_t\Delta$	-0.835	0.543	-0.212	-0.413	6.299	3.980	18.917
t-Student	-4.491	1.775	-1.365	-0.368	2.343	1.562	4.394
Log likelihood = -116.0715				F-statistic = 4.573074			

According to the long-run VECM estimation, energy supply surplus is proved to affect the energy losses rate in long-run; as with other conditions kept constant, a one-unit increase (one million barrels of oil) in energy supply surplus leads to 0.275 unit (0.275 million barrels of oil) increase in energy losses. These results are significant at %1 level (statistics of t equals 661/7). The second and fourth development plans, however, had a significant effect on energy losses in short-term; with the coefficients of 6.3 and 18.91 respectively. Fourth development plan proved to have the most significant effect on the energy losses in the short-run. This suggests that energy efficiency and effective use of energy have been of hardly any interest in this program, or at least the program has not been effective in the energy sector which calls for doubled attention on the part of politicians.

$$\Delta L_t = -0.834982(L_{t-1} - 4.811951 - 0.275296\, SS_{t-1}) + 0.543211\, \Delta L_{t-1} - 0.211867\, \Delta SS_{t-1} - 0.834982\, ECT_{t-1} + 6.298958\, d_2 + 3.980123 d_3 + 18.91703\, d_4$$

In order to ensure the suitability of the model, cointegration and normality tests are applied to examine the components under discussion. Auto correlation between the error terms was evaluated through the LM test and the results are presented in the following table. According to the statistics, at probability level, the null hypothesis regarding the non-existence of an autocorrelation between the error terms cannot be rejected; therefore, there is no autocorrelation between disruption terms.

3. Conclusions and policy implications

According to the study results, energy supply surplus is among the major reason of energy losses in Iran. Energy supply surplus results from the abundance of the energy resources, especially oil and gas that has led to the improper use of these valuable resources. The energy supply surplus in Iran stems from lack of proper cooperation in timely energy distribution, high consumption rate in domestic, business, and industrial sectors due to the low energy price and low technologies in distribution, transportation, and conversion of energy. Therefore, careful planning to timely supply the required amount of energy to the proper extent, and to prevent the inadequate management resulting in energy losses will prove essential. Considering the high energy use in Iran, policy-makers and planners have paid great deal of attention to the improvement of the energy efficiency, especially in development plans, and the increasing need to improve energy productivity and decrease energy losses in the coming programs along with exploiting the private sector potentials in energy production, distribution, transportation, and conversion as means of reducing energy losses. Also, modifying energy prices in order to approximate the real value of energy carriers, reforming the energy transmission and distribution networks, improving the power plants technology, and optimizing consumption patterns through training and promoting the proper-use culture, will contribute significantly to proper utilization of energy and less energy losses in the country. As the error correction results revealed, short-run solution that work like a shock effect on energy consumption and losses, will be adjusted in a short period of time and lose its effect whatsoever. Therefore, political solutions are needed to be included in the long-run planning and plans such as economic development plans, be implemented with adequate management in all developmental plans with the aim of energy losses reduction.

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