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A Change in Energy Intensity: Test of Relationship between Energy Intensity and Income in Iran

Abdolnaser Hemmati*

Abstract

In this paper we study the long- term trend of energy intensity for Iran. We use a quadratic function of the logarithm of income to take account of the change in trend of energy intensity and test the non-monotonic relationship between energy intensity and income during 1967- 2002. We find that the long-run coefficient on squared income is negative and significant, indicating a change in trend of energy intensity.

Keywords: Energy demand, income elasticity, Energy intensity in Iran.

1- Introduction

Energy intensity provides a general idea of the energy performance of an economy and is usually defined as the ratio of energy consumption to GDP. Across countries, the ratio of energy consumption to income does not appear to be constant.

Countries, which rely on their abundant energy resources, may have relatively higher energy intensities. Lower and distorted energy prices, in general, are positively correlated to higher levels of energy intensity. Limited

*- Assistant professor, Faculty of Economics, Tehran University.
Hemmati @ cent- IR.com.

resource endowments, on the other hand, might act as an incentive for many countries to have relatively lower energy intensities.

Income levels, which are a major determinant of the lifestyle people can afford, affect the use of energy, particularly for non-production purposes in the residential or transportation sectors. The levels of efficiency and economic development also have an impact on energy intensity, usually with an inverse relationship.

Developed Economies with higher levels of efficiency mostly demonstrate lower energy intensities. The movement of aggregate energy intensities reflects the different stages of economic development, while low-income countries would still be passing through a substitution process of commercial fuels for traditional biomass energy, thus having a temporary downward trend in aggregate energy intensity, others would have steadily rising intensities due to rapid economic growth and modernization.

Urbanization associated with an energy-intensive, socio-economic lifestyle, an increasing level of transportation along with industrialization and commercialization, and accelerated consumer and basic material demand all impose major changes in energy use. In other words, the upward intensity trend in higher-income developing countries is a function of primary industrialization (e.g. the growing percentage share of industry in GDP) and private energy consumption (e.g. rising personal income levels). On the other hand, in industrialized countries, there is a distinctive down-ward trend in overall energy intensity, reflecting the impact of technological innovation, conservation efforts, changing consumption habits, declines in the material intensity of economies, changes in the composition of industrial output away from energy-intensive industries (e.g. due to relative factor prices and competitive pressures) and the growing contribution of services to GDP. The changes in these trends of aggregate intensities over time can therefore, as described above, be due not only to efficiency improvements but also to changes in: The structure of economy, the composition of trade with other countries, the primary energy mix, real income and consumer behavior and preference.

Across countries, energy intensity tends to increase with income, as income rises from low levels, and then to fall with income, as income increases beyond a critical level. The evidence for a trend change in energy intensity has been ignored by most models of energy demand, typically assuming a monotonic

relationship between energy consumption and the level of economic activity as well as a constant elasticity of energy demand to income. Some studies acknowledge the instability of the estimate of income elasticity through time, by using moving window regressions over a period of six to twelve years, this instability is interpreted as the effect of omitted variables, such as changes in the efficiency of capital, in the industrial mix, or in the energy price regimes, rather than a non-monotonicity in the fundamental relationship with income (Galli, 1998).

We use a non- monotonic (a quadratic), rather than a monotonic (a log-linear) function of income to better approximate energy demand in IRAN, as Galli (1998) used for estimating energy demand of ten Asian countries. So, we estimate energy demand for IRAN by using a quadratic function of the logarithm of income, to take account of the change in trend of energy intensity.

Energy Intensity: Definition and Data Overview

The variable we are interested in explaining is energy intensity. For evaluating the energy intensity trend, two ways can be used: one is the ratio of final energy demand to GDP and second is the ratio of energy demand of sectors to GDP. Energy demand of sectors includes all energy lost in the transformation of primary to secondary energy, and the energy used with in the transformation industries. In this paper we use second definition. So, the energy demand is energy demand of sectors that measured in tons of oil equivalent (toe) per-capita. Our measure of GDP is real per-capita GDP on 1376 (1997) basis. Our measure of price is the weighted average price of commercial fuels for a ton of oil equivalent (toe) in Million Rials deflated by the CPI (consumer Price Index) on 1376 (1997) basis.

Table 1, shows the growth rate of energy demand, per capita real GDP, and energy intensity of IRAN in our definition. As table shows, the energy intensity was decreasing till beginning of 1350 (1970)'s decade and started to rise from 1351 (1972). Increasing the oil world prices in the beginning of 1350's decade caused by gradually disappearing of Excess supply at the end of 1960's (demand was increasing and excess production capacity was decreasing) and increasing the role of organization of petroleum exporting countries (OPEC) in the early 1970's, affected the Iran's income. The increase of per capita income transferred

to huge imported goods and commodities that in turn caused growth in energy consumption.

Table 1: the Average Growth Rate of GDP Per Capita, Energy Demand Per Capita and Energy Intensity

Years / Variables	1346-1350 (1967-1971) Growth %	1351-1360 (1972-1981) Growth %	1361-1370 (1982-1991) Growth %	1371-1381 (1992-2002) Growth %
GDP Per Capita	9.12	-2.76	-.32	1.94
Energy Demand Per Capita	5.65	6.15	3.92	4.21
Energy Intensity	-3.18	9.16	4.26	2.23

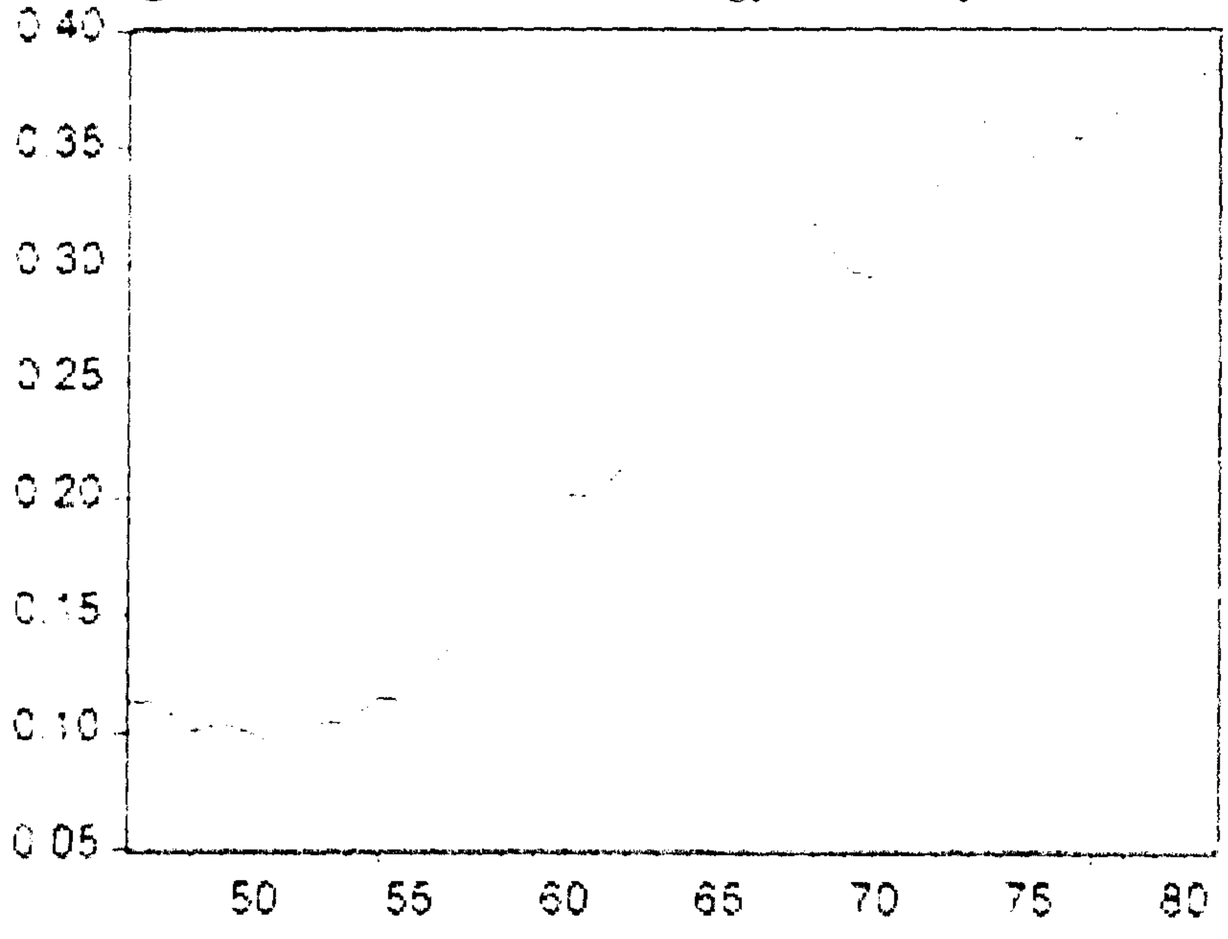
Source: Energy Balance of I.R. IRAN, Ministry of Energy, Energy Planning Department.

As national income increases, the structure of energy demand changes and this changes the intensity of energy and material use. As explained by Bernardini and Ricardo Galli (1993), in the pre-industrial phase based on agriculture, energy demand is shaped by basic needs, the energy and material intensity of economic activity is low and much of energy and material needs can be made from biomass. In the subsequent stage of development, increased industrialization is associated with extensive infrastructure development such as railroads, highways, factories, cities and related water supply, sewerage facilities and other distribution net works. All these activities require high and sustained energy and materials consumption.

As table-1 present's, the average growth rates of energy demand over the periods 1346-1350 (1967-1971) and 1351-1360 (1972-1981) are the same. But, the average growth rate of Real GDP per capita during period 1351-1360 (1972-1981) is negative in compare with period 1346-1350 that shows very high and positive. So, the decline in energy intensity over period 1346-1350 caused by high growth rate of real GDP per capita that mainly caused by Agricultural and

other sectors that are less dependent to energy consumption. The trend of energy intensity in table-1 and Figure-1 indicates that IRAN has passed the plateau of the bell-shape and approaching the top of curve. So, the energy intensity still is increasing but the marginal rate of growth is decreasing.

Figure 1: The Trend of Energy Intensity in Iran



Model

As we discussed in page 4 we use non-monotonic function of income to better approximate energy demand in Iran. So, we use a quadratic function of the logarithm of income, to take account of the change in trend of energy intensity. The specific function that we have used is similar the model have been used by Galli for estimating energy intensity of ten Asian countries (1998), namely, a quadratic logarithmic model, for long-run energy demand q_t and energy intensity $(q_t - y_t)$, in income y_t and energy price p_t, with a quadratic term in the logarithm of income[1]

1- q_t, y_t, p_t are logarithms of Q_t (energy demand), Y_t (income) and P_t (Price).

$$q_t = \alpha_1 y_t + \alpha_2 y_t^2 + \alpha_3 p_t \quad (1)$$

$$(q_t - y_t) = (\alpha_1 - 1) y_t + \alpha_2 y_t^2 + \alpha_3 p_t \quad (2)$$

The non-monotonicity of the relationship between energy demand (energy intensity) and income implies that income elasticity of energy demand (energy intensity) depends on income levels. In terms of equation (1) the long-run income elasticity of energy demand is "$\alpha_1 + 2\alpha_2 y$" and the long-run income elasticity of energy intensity is "$(\alpha_1 - 1) + 2\alpha_2 y_2$"and the long-run price elasticity of energy demand is α_3. We expect $\alpha_3 < 0$ and $\alpha_1 > 0$, $\alpha_2 < 0$, i.e., the long-run income elasticity raises and then falls with income.

Estimation Results

Table-2 presents the estimates of the long-run coefficients in regressions (1) using the ARDL approach based on Schwarz Bayesion Criterion The fact that the long-run coefficient of income is greater one and the long-run coefficient of squared in come is negative is consistent whit the hypothesis that energy demand (and also energy intensity) is a non-monotonic function of income.

table2: Estimated Long-Run Coefficients of Energy Demand Using the ARDL Approach.

Regressor	Coefficient	t-Ratio
y	11.9261	3.8050
y^2	-3.0471	-3.094
p	-.88427	-3.9036

$\bar{R}^2 = 0.99$ Durbin's h: -1.4728 (.141)

The long-run income elasticity of energy demand from equation (1) and table2 is $\alpha_1 + 2\alpha_2 y_t = 11.93 - 6.09 y_t$ and the long-run income elasticity of energy intensity is $(\alpha_1 - 1) + 2\alpha_2 y_t = 10.93 - 6.09 y_t$. The long-run price elasticity of energy demand from equation (1) and table (2) is $\alpha_3 = -.88 < 1$ and is consistent with the hypothesis. The long-run income elasticity of energy demand shows that, by 1381 (2002), income elasticity is above unity. The level of the logarithm of per capita income which maximizes energy intensity is $y' = (1 - \alpha_1)/2\alpha_2$ at this point the long-run income elasticity of energy demand equals unity. So, the estimated level of the logarithm of per capita income which maximizes energy intensity by using estimated long-run coefficients of table (2) is $\hat{y}' = (1 - 11.93)/2(-3.0470) = 1.794$. It means that the estimated level of real per capita GDP which maximize energy intensity is 6.02 million Rials. So, this level of real per capita GDP will be the turning point of energy intensity and we expect to be the beginning point of energy intensity reduction.

Conclusion

This paper investigated the relationship between energy demand, and income in Iran. Our analysis showed that the relationship is non-monotonic. We used a quadratic function of the logarithm of income to take account of the change in trend of Energy intensity and tested the non-monotonic relationship between energy demand (and energy intensity) and income during 1346-1381 (1967-2002). Our model of aggregate energy demand was logarithmic in income and energy price, with a quadratic term in the logarithm of income.

Using the ARDL Approach, we found that the long-run coefficient on squared income is negative and significant. It confirmed that the relationship between energy demand and income is non-monotonic. We also found that the income elasticity of energy demand, in Iran by 1381 (2002), was above unity, but is going to reduce with increasing the real GDP per capita. And the estimated real GDP per capita which maximizes energy intensity showed that trend of energy intensity is going to change. This phenomenon could progress fast if the policy makers in Iran focus on efficient use of energy especially, in transportation and increasing the contribution of services such as banking and

insurance to GDP and also concentrate on industries such as software and biotechnology.

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