Energy Intensity of GDP: A Nonlinear Estimation of Determinants in Iran

Hassan Heidari[1] **Saharnaz Babaei Balderlou**[2] **Mahyar Ebrahimi Torki**[3]

Abstract

Energy intensity is a measure of the energy efficiency of a nation's economy. Many factors influence a country's energy intensity. In this paper, however, we note the effective factors of energy intensity and decompose it by applying Logistic Smooth Transition Regression (LSTR) in Iran during the period 1980- 2013. The main factors are the ratio of the added value of services to GDP (explaining both linear and nonlinear part of the energy intensity), the percentage of internet users, income per capita and Human Development Index (explaining nonlinear part of the energy intensity). The results indicated that the lifestyle and structural changes had a significant and considerable effect on decreasing energy intensity and that the ratio of services value-added to GDP as a transition variable caused an asymmetric behavior of energy intensity affected from explanatory variables. The most effective factor on energy intensity was Human Development Index.

Keywords: Energy Intensity, Energy Efficiency, LSTR Model, Iran

1. Introduction

Energy conservation is determined as reducing the use of energy without changing the amount of work or raising the work with constant energy use. Therefore, quantifying the energy conservation is often defined as a technological energy efficiency term. Hense, it is quantified by the energy intensity which is often used interchangeably with the energy efficiency (Suehiro, 2007; Nanduri 1998). On the one hand, energy conservation is based on energy saving behavior of consumers,and changes in the lifestyle and in industrial structure. On the other hand, GDP based energy intensity includes all such technological, behavioral, and structural factors (Suehiro, 2007; Nanduri 1998). Therefore, energy intensity of GDP is measured as an index for energy conservation of a country.

Decreasing energy intensity is essential for concerning about energy conservation and energy security. Therefore, historic trends of energy intensity and the determinants of it should be considered as an academic research and policy making requirements. There is a vast body of literature which studies energy intensity trends, its determinants and the relationship between economic variables and energy intensity. Wing (2008) showed that increasing energy prices was an effective factor in decreasing energy intensity in the U.S., but the effect of technology on it was less important. Al-Ghandoor et al. (2009) revealed that in the Jordanian industrial sector, the

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[1] *Associate Professor of Economics, Urmia University (h.heidari@urmia.ac.ir)*
[2] *MA. in Economics, Urmia University (saharnaz.babaei@yahoo.com)*
[3] *MA. in Financial Management, Allame Tabatabaei University (mahyar_ebrahimi_torki@yahoo.com)*

most important determinants of decreasing energy intensity were the structural changes and increase of efficiency. Narayanan and Sahu (2010) showed that the changes in the sectorial energy intensity played a greater role in changes of the total energy intensity of the Indian Manufacturing in comparison to the changes in the production structure of the Industries. Mulder and de Groot (2011) analysed energy intensity trends explained by shifts in underlying sectorial structures and efficiency improvements within individual sectors. They showed that energy intensity decreased at the aggregate economy level and at the manufacturing sector level, but it increased at the services sector. They also showed a convergence of energy intensity levels across OECD countries. They revealed that reduction in the energy intensity has been affected more by energy efficiency improvements than by changes in composition of activities. Shahiduzzaman and Alam (2012) estimated energy efficiency and approximated factors which explain the energy intensity in Australia. The results showed that efficiency effect and sectorial composition effect caused the reduction of the energy intensity. Wu (2012) found that the structural transformation of the Chinese economy caused the reduction of energy intensity. Li and Lin (2014) assessed the nonlinear impact of industrial structure on China’s energy intensity and showed that the industrial structure had different effects on the energy intensity when industrial structure was greater or smaller than 40.435%.

As stated above, there are numerous studies of energy intensity determinants but most papers have used linear regression methods. In this paper, we extend the literature with a nonlinear smooth transition regression to explore the effects of the lifestyle and structural changes on the energy intensity in Iran. Thus, this study aimed at clarifying the possible effects of structural changes and the level of lifestyle on energy intensity and at providing evidence for determining the possible factors explaining the energy intensity. Following the investigation, we found that it was the first time that a nonlinear method has been used to explore the determinants of the energy intensity.

The structure of the remainder of the paper is as follows: Following the introduction, objectives of the research is explained and a brief review of the literature is provided in the Section 1.Section 2 focuses on the methodology of the study and some data are provided on the energy intensity of GDP , the factors affecting it, and the model specification. Section 3explains the empirical results and discusses the estimated function of energy intensity. And finally, section 4 consists of the conclusions which are derived from the results of the estimated model.

2. Methodology and Data

2.1 *Energy Intensity of GDP and Determinants*

Energy intensity is the quantity of energy consumption per output unit and is calculated by dividing the total energy consumed to the total amount of output produced. Physical energy intensity is obtained by measuring output in physical units and economic energy intensity is calculated using the dollar value of output. Energy intensity is used for assessing trends in energy efficiency and is inversely related to efficiency. A logical conclusion is that energy intensity is calculated as energy consumption per unit of GDP while high energy intensity points out a high cost of converting energy into GDP, and vice versa. Also, reducing energy intensity over time may indicate enhancement in energy efficiencies (Nanduri, 1998; Jamshidi, 2008; Baumann, 2008).

GDP is a common index revealing a country's economy and is easy to obtain. As a result, GDP per unit of energy is regarded as the quantity of production to interpret the amount of work gained by using the energy quantity. On the other hand, the amount of energy is used as an input factor for the production in the economics. GDP per unit of energy is called energy productivity and energy intensity is its reciprocal number. Then, according to the definition of energy efficiency and energy intensity of GDP, we can show how efficiently production can be enhanced from the energy point of view (Suehiro, 2007). Generally, energy intensity of GDP estimates energy intensity for total production of a country.

We use machinery and consume energy in order to enhance utility which in total represents the living standard in a country. The level of income is often used as a proxy to quantify the living standard. GDP is a country's total value of production as well as its total value of income. Considering this aspect, energy intensity of GDP can interpret the efficient enhancement of living standard from the energy point of view. (Suehiro, 2007)

There are many factors influencing an economy's energy intensity. As stated above, energy intensity of GDP includes two concepts: advanced standard of a lifestyle, which causes an increase in energy intensity, and technologically developed economies, which causes a decrease in energy intensity) (Jamshidi, 2008). We expect the energy intensity of a country to decrease while the technological developments lead to an increase in energy-efficiency. However, energy intensity in countries with high speed of industrializing may first increase as economic activities shift from lower energy-intensive activities to higher ones. But when the industrialization is achieved, high incomes lead to high demand of professional services and a decrease of the energy intensity is expected with a shift to less energy-intensive activities. Therefore, both the energy efficiency improvements and sectorial shifts in economic activities will determine the direction and quantity of change in energy intensity (Baksi and Green, 2007).

As expressed, low energy intensity in a country does not only mean high energy efficiency and high energy conservation, but also may be the result of less advanced standard of lifestyle, natural conditions, mild weather, geographical extent or the volume of using telecommunication networks and internet which causes less distance of commutes and so on. Also, developed countries encounter a high percentage of services sector in GDP in comparison to the agriculture and industry sectors. Since services sector is a less energy-intensive compared to the agriculture and industry sectors, we expect the energy intensity to decrease, as the economy develops and the structure of the country changes.

The above background makes these questions: do the lifestyle and the structural and technological changes produce different and time-varying effects on the energy intensity? What proxies of the lifestyle and structural changes determine the energy intensity trend the best? To answer these questions and to determine the trend of the energy intensity, we initially define the proxies affecting the energy intensity.

To achieve the motivation stated in this paper, the energy intensity time series is achieved from "yearbook 2014: key world energy market data" of Enerdara. According to Enerdata (Global Energy Intelligence), dividing the total energy consumption of the country by its Gross Domestic Product (GDP) results in the energy intensity of a country. It measures the total amount of energy necessary to generate one unit of GDP. As stated in research and consulting firm of Enerdata: "total energy consumption includes coal, gas, oil, electricity, heat and biomass. GDP is expressed at constant exchange rate and purchasing power parity to remove the impact of inflation and relate energy consumption to the real level of economic activity. Using purchasing power parity rates for GDP instead of exchange rates increases the value of GDP in regions with a low cost of living, and therefore decreases their energy intensities" (Global Energy Statistical Yearbook 2014). As shown in Fig. 1, energy intensity is increasing in 1980-2013, but there are nonlinear upward and downward fluctuations in different period, which may imply that the changes in the lifestyle and structure had different effects on the energy intensity in different periods. The fluctuations are clear in the rate of declining energy intensity in Fig. 1, which is defined as following:

$$EIR_t = -((EI_t/EI_{t-1}) - 1) \times 100\% \qquad (1)$$

Lower EI means higher energy intensity. Hence, EIR > 0 shows improving energy efficiency and EIR < 0 indicates decreasing energy efficiency.

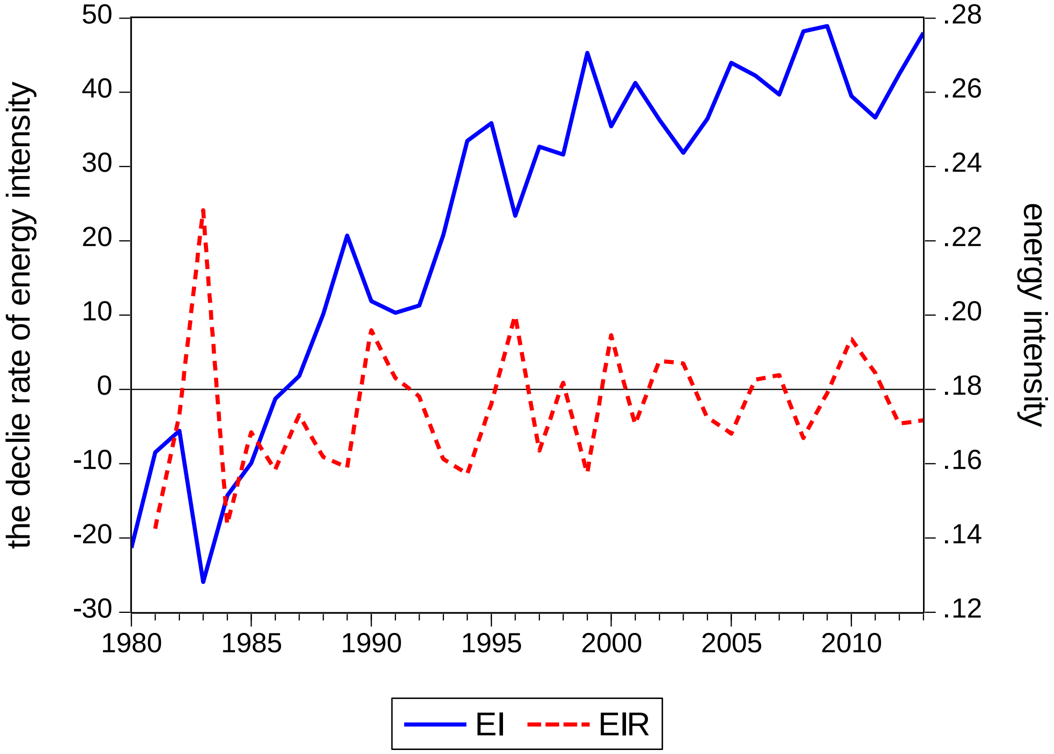

Figure 1. Energy intensity (EI) and the rate of declining energy intensity (EIR). Data Source: "yearbook 2014: key world energy market data" of Enerdara (Global Energy Intelligence).

Human Development Index and national income per capita are utilized as the lifestyle proxies in this paper and are illustrated in Figure 2. Human Development Index (HDI) data is achieved from Human Development Reports of United Nations Development Programme (UNDP) for the period 1980-2013. The HDI measures the key dimensions of human development including a long and healthy life, being knowledgeable and having acceptable standard of living. As stated in the UNDP, the HDI is the geometric mean of normalized indices for each of the three dimensions. It is expected that the higher human development index (HDI), the further energy intensity.

National income per capita is calculated by dividing national income of a country by its population. National income is used to make economic decisions and to decide on economic policies. It is a criterion for measuring economic activities and the welfare level of a country. The national income (constant 1997 prices) and population time series are retrieved from the archive of the central bank of Iran for the period 1980-2013. The coefficient of the national income per capita as an income proxy (YP) can be positive or negative since income per capita has a positive effect on the standard of lifestyle. On the other hand, income per capita has a positive effect on energy efficiency, which is inversely related to energy intensity.

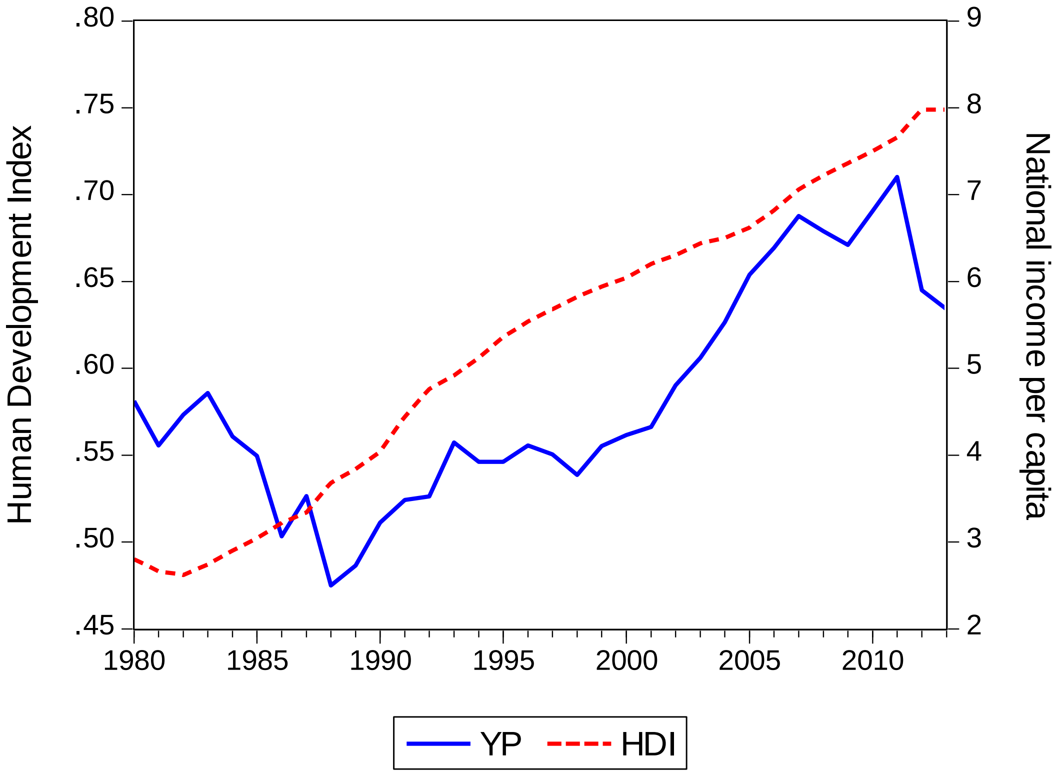

Figure 2.The proxies of Lifestyle: Human Development index (HDI) and National Income per capita (YP). Data source: UNDP and Central Bank of Iran.

The second concept of energy intensity is explained by the percentage of internet users and the ratio of services value-added to GDP as the proxies of structural and technological changes. The ratio of services value-added to GDP is calculated with the following equation:

$$SER = (\text{Services value-added} / GDP) \times 100 \qquad (2)$$

In which the time series of the added value of services and Gross Domestic Product (GDP) (constant 1997 prices) are obtained from central bank of Iran. It is expected that the energy intensity of a country will decrease while the ratio of services value-added to GDP (SER) increases. The calculated data is illustrated in Figure 3.

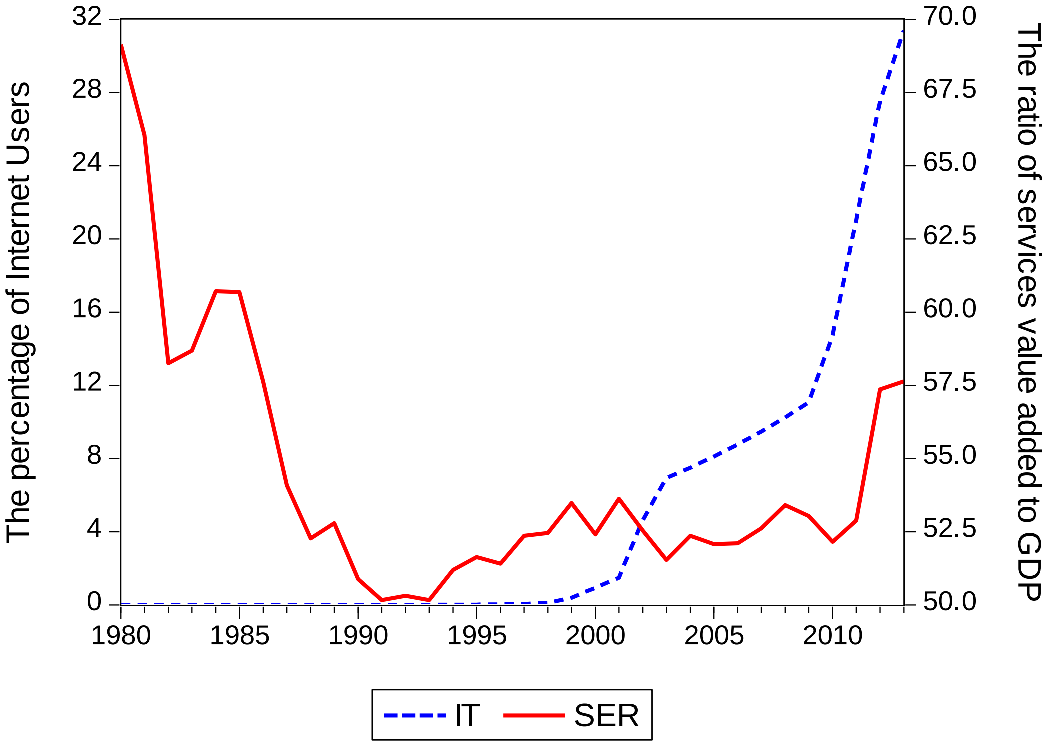

Figure 3. The proxies of structural changes: the percentage of internet users (IT) and the ratio of services value added to GDP. Data source: WDI and Central Bank of Iran.

Utilizing Internet prepares easier communication and less transportation. Accordingly, when the percentage of internet users of a country (IT) increases the amount of energy intensity decreases. The time series of internet users' percentage is gained from World Development Indicators (WDI) of the World Bank for the period 1980-2013 and is drawn in Figure 3.

2.2 *Model Specification*

In the recent years, the methods of energy intensity decomposition, which separates structural changes and gross changes of energy intensity, have been extended. In these methods, it is possible to study changes in the pattern of energy consumption, energy demand forecasts, and identification of factors influencing changes in total energy consumption and energy intensity. Changes in energy consumption during a period of time can be divided into productive effects (the overall level of economic activity), structural effects (changes in energy consumption because of structural changes) and energy intensity effects (real changes in energy efficiency).

According to the literature review and explanation of the effective factors of energy intensity in the previous section, we suggest the following function which includes effective factors of energy intensity (EI):

$$EI_t = f(SER_t, IT_t, HDI_t, YP_t) \qquad (3)$$

Where EI is energy intensity, and SER, IT, HDI, and YP show the ratio of the services value added to GDP, the percentage of internet users, human development index and the national income per capita respectively. The data employed are annually time series over the period 1980-2013 and are retrieved from the archives of the central bank of Iran, Enerdata, UNDP, and WDI.

The methods used in the literature review are mostly linear in the parameters. On the other hand, nonlinear models have been fitted to many macroeconomic theories. In this paper, we first test the linearity and then choose a sufficient nonlinear model to estimate the energy intensity in Iran from 1980 to 2013.

The smooth transition autoregressive (STAR) model was first introduced to the time series by Chan and Tong (1986).They used the cumulative distribution function of the standard normal variable as the transition function. Using logistic instead of this function results in the logistic smooth transition regression (LSTR). The LSTR model has been applied to macroeconomic series with asymmetric behaviour. In this paper, we use the STR model to specify the nonlinear function of the energy intensity. It is defined as:

$$y_t = \Phi' z_t + \theta' z_t G(\gamma, y_{t-1}) + \varepsilon_t = \{\Phi + \theta G(\gamma, y_{t-1})\}' z_t + \varepsilon_t \tag{4}$$

Where $z_t = (1, y'_{t-1})'$ with $y_t = (y_t, \ldots, y_{t-p+1})'$,and $\Phi = (\Phi_0, \Phi_1, \ldots, \Phi_p)'$ and $\theta = (\theta_0, \theta_1, \ldots, \theta_p)'$ are parameter vectors, and $\varepsilon_t \sim iid(0,\sigma^2)$. The transition function is defined as follows:

$$G(\gamma, c, y_{t-d}) = (1 + \exp\left\{-\gamma \prod_{k=1}^{K} (y_{t-d} - c_k)\right\})^{-1}, \gamma > 0 \tag{5}$$

In (5), parameter γ is the slope parameter and $c = (c_1, \ldots, c_k)'$ is a vector of location parameters, $c_1 \leq \ldots \leq c_k$. the transition function is a bounded function of y_{t-d}, continuous everywhere in the parameter space for any value of y_{t-d}. The most common choices for K are $K = 1$ and $K = 2$. When $K = 1$, we get the standard logistic function and the parameters $\Phi + \theta G(\gamma, c, y_{t-1})$ change monotonically from Φ to $\Phi + \theta$. When K = 2, the parameters change symmetrically around the mid-point $(c_1 + c_2) / 2$ where the logistic function reaches the minimum value that is between zero and $1 / 2$. When $\gamma \to \infty$, the logistic function reaches zero and when $c_1 = c_2$ and $\gamma \to \infty$, it reaches $1 / 2$. When $\gamma = 0$, the LSTR model becomes a linear model and when $\gamma \to \infty$, it becomes a Self-Exciting Threshold Autoregressive (SETAR) model.

Maringer and Meyer (2008) studied the STR models introduced by Terasvirta (1998) and expanded a model applying exogenous variables as explanatory variables. In this paper, we estimate the following model, in which energy intensity of GDP (EI) is the dependent variable, and SER, IT, HDI and YP are independent variables:

$$\begin{aligned} EI_t = \alpha + \{\phi + \theta F(q_t)\} Z(&\textstyle\sum_{i=0}^{2} EI_{t-i}, \sum_{i=0}^{2} SER_{t-i}, \sum_{i=0}^{2} IT_{t-i}, \\ &\textstyle\sum_{i=0}^{2} HDI_{t-i}, \sum_{i=0}^{2} YP_{t-i}) + \varepsilon_t \end{aligned} \tag{6}$$

$$\text{LSTR} \quad F(q_t) = (1 + \exp\left\{-\gamma \prod_{k=1}^{2} (q_t - c_k)\right\})^{-1} \tag{7}$$

In (6) and (7), $F(q_t)$ is the transition function and q_t can be each of the variables in vector Z, their lags, or time trend. In (6), if k = 1, the model is called LSTR1 and if k = 2, it is called LSTR2.

First step to estimate this model is to test the nonlinearity. We test nonlinearity, diagnose the type of model and choose between Linear, LSTR1 and LSTR2 models by F statistics. The null hypothesis of nonlinearity test is defined as H_0: $\beta_1 = \beta_2 = \beta_3 = 0$, in which β_j is the coefficient of transition variable in an auxiliary regression defined as the following:

$$EI_t = \beta_0' z_t + \sum_{j=1}^{3} \beta_j' z_t s_t^j + \varepsilon_t \tag{8}$$

When the linearity hypothesis rejected, the second step is to determine the type of model. To choose between LSTR1 and LSTR2, the three null hypothesises are defined as the following:

H_{04}: $\beta_3 = 0$ (9)
H_{03}: $\beta_2 = 0 \mid \beta_3 = 0$ (10)
H_{02}: $\beta_1 = 0 \mid \beta_2 = \beta_3 = 0$ (11)

The test statistics used for the above hypothesises are F statistics, which are called F_4, F_3, and F_2 for every hypothesis, respectively, in this paper. If the H_{03} is rejected the LSTR2 model is estimated. If the H_{04} and the H_{02} are rejected the LSTR1 model is estimated.

3. Empirical results

The aim of this paper is to specify a nonlinear function of the energy intensity of GDP for Iran and to assess the affecting factors. Hence, we first test unit root by KPSS unit root test with the null hypothesis of stationary against the alternative of unit root, unlike other unit root tests. According to results, shown in table 1, all variables do not significantly reject the null hypothesis of stationary at 5% level. Next, we determine the optimized lag of variables based on the minimum value of AIC in a linear model over a range of lags from 0 to 2. The optimal lag lengths are 1 for HDI and IT and 0 for SER and YP in this paper. Then, we test the linearity and choose the transition variable by F statistic and significance of the estimated variables. We choose the number of regimes and the type of model regarding to the amount of F_4, F_3, and F_2 statistics. The p-values related to test statistics are reported in table 2.

Table 1. Unit root test results

Variable	Testing specification*	KPSS	Conclusion
EI	(c,0)	0.4424 (0.4630)	I(0)
SER	(c,0)	0.3581 (0.4630)	I(0)
IT	(c,0)	0.4362 (0.4630)	I(0)
HDI	(c,t)	0.1269 (0.1460)	I(0)
YP	(c,0)	0.4245 (0.4630)	I(0)

Note *: c indicates an intercept item; t indicates a time trend item. Critical values in parentheses.

Table 2. Choosing transition variable and suggested model**

Transition Variable	F	F_4	F_3	F_2	Suggested Model at 5%
SER(t)	1.3542e-08	7.3986e-01	1.4001e-01	3.8721e-13	LSTR1
IT(t)	2.0461e-03	2.0226e-01	6.5608e-02	5.6354e-04	LSTR1
HDI(t)	9.3596e-09	1.4099e-01	1.1894e-02	1.2626e-11	LSTR1
YP(t)	4.3749e-08	7.0377e-01	3.1385e-01	7.2877e-13	LSTR1
SER(t-1)*	2.7643e-09	4.4328e-02	2.9447e-02	4.6253e-12	LSTR1
IT(t-1)	9.9087e-03	5.1439e-01	4.1170e-01	1.7639e-04	LSTR1
HDI(t-1)	1.7487e-09	1.0705e-01	2.4573e-01	3.7653e-13	LSTR1
YP(t-1)	9.6010e-07	8.2984e-01	4.1703e-01	1.1587e-12	LSTR1
TREND(t)	4.5649e-09	2.3797e-03	2.6509e-01	6.8336e-11	LSTR1

Note: *: The transition variable regarding the p-values of F statistics and the significance of the estimated variables.

**: e-i = 10^{-i}, i = 0, 1, 2, ….

The transition variable is the first lag of the ratio of services value-added to GDP, according to the smallest amount of p-value of F statistic for testing nonlinearity and the significance of the estimated variables in the LSTR model. It is clear that linearity for dependant variable can be rejected at 5% significance level. Given that linearity is rejected for the series above at 95% of confidence level, we specify the appropriate STR model that catches the nonlinear dynamics of the variable. Reported results in table 2 are the p-value of F statistics with each hypothesis tests explained in previous section. According to F_4, F_3, and F_2, the selected model to be estimated is Logistic Smooth Transition model with 1 threshold in this paper. In other words, the estimated model would have a regime changes with initial values of 4.3762 and 50.8138 respectively for the transition coefficient γ and parameter c. Then, we select the linear or nonlinear relationship between the explanatory variables and the independent variable by the significance of the coefficients. The parameters are estimated by Newton-Raphson Algorithm. The results of the estimated LSTR model are reported in table 3.

Table 3. Estimated coefficients of LSTR1 model

Linear part	coefficients (θ)	S.D.	t-stat.	p-value
Constant	-0.8193***	0.2391	-3.4261	0.0022
SER(t)	0.0205***	0.0047	4.3972	0.0002
Nonlinear part	coefficients (Φ)	S.D.	t-stat.	p-value
Constant	0.7634***	0.2592	2.9447	0.0071
SER(t)	-0.0213***	0.0048	-4.4382	0.0002
YP(t)	-0.0071*	0.0038	-1.8850	0.0716
IT(t-1)	-0.0011	0.0007	-1.6043	0.1217
HDI(t-1)	0.5890***	0.0757	7.7784	0.0000
γ	16.3731	-	-	-
C	52.1092	-	-	-
adj. R^2	0.9436	-	-	-
AIC	-8.6773	-	-	-

***, **, * respectively show the significance level of 1%, 5%, 10%.

According to the estimation results of the LSTR for energy intensity, the transition coefficient, γ, which indicates the speed of transition between different regimes of energy intensity, is estimated 16.3731. The parameter *c*, which determines the halfway point between the expansion and contraction cyclical phases of the variables, is estimated 52.1092. Regarding γ suggests a rapid transition between regimes, but slower than Markov-Switching (MS) and Threshold Autoregressive (TAR) models. This implies that the LSTR model is more appropriate to explain energy intensity dynamics compared to other nonlinear models, as the MS and TAR models which sharply switch between two regimes.

According to standard interpretation of STR models, energy intensity of Iran smoothly changes its regime where the transition variable value stays around 52.1092 between expansion and contraction regimes. In other words, Effecting factors of energy intensity don't have constant impact on it and they are affected by the first lag of the ratio of services value-added to GDP. In other words, the choice of SER as the transition variable leads to the asymmetric behaviour of energy intensity in Iran. As reported in table 3, coefficients are significant at 10% level (except the coefficient of IT). The sign of coefficients are based on the expectations. The ratio of services value-added to GDP has a negative effect on the nonlinear part and a positive effect on the linear part of the energy intensity. In other words, aggregate effect of SER on energy intensity is negative (-0.0213 + 0.0205 = -0.0007) and an increase of the ratio of services value-added to GDP as a substitution for structural changes has a significant effect on the decrease of the energy intensity in Iran. Percentage of Internet users has negative, but not significant effect on energy intensity, because internet is known as luxury goods in the third world and developing countries and is more utilized for the entertainment than Electronic government. The human development index, as a substitution for the standard of lifestyle, affects the energy intensity considerably, directly and significantly.

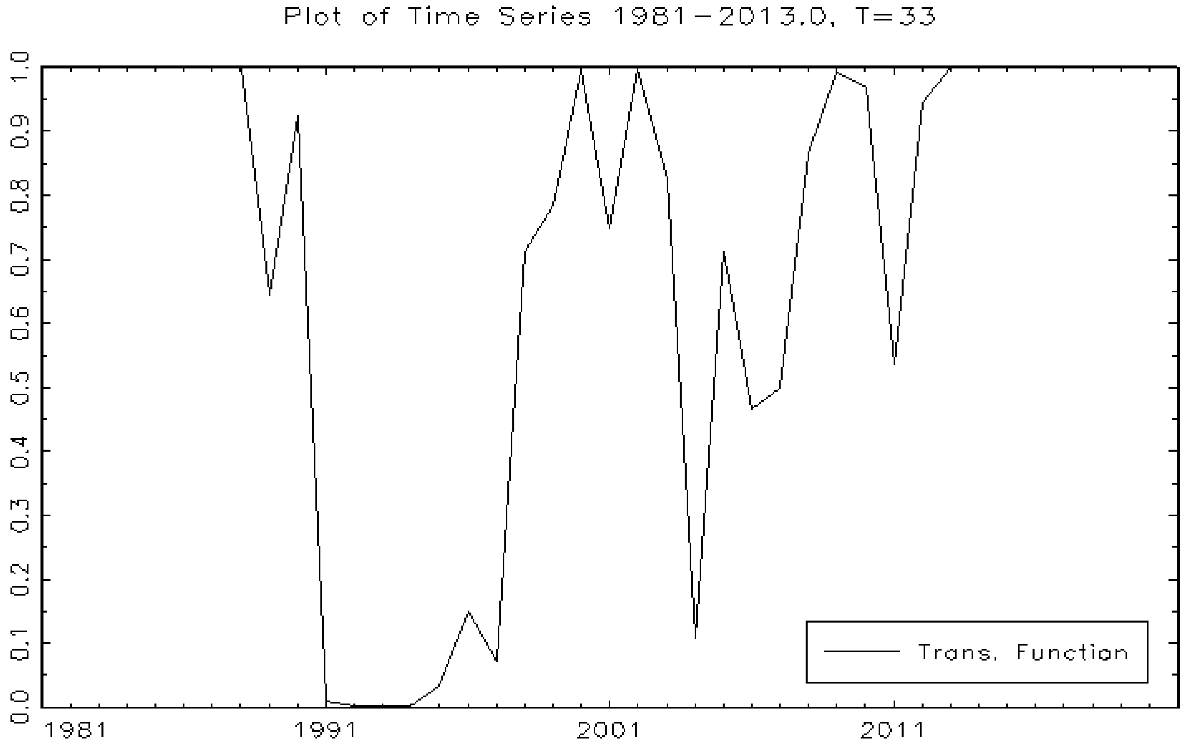

Figure 4. The transition function

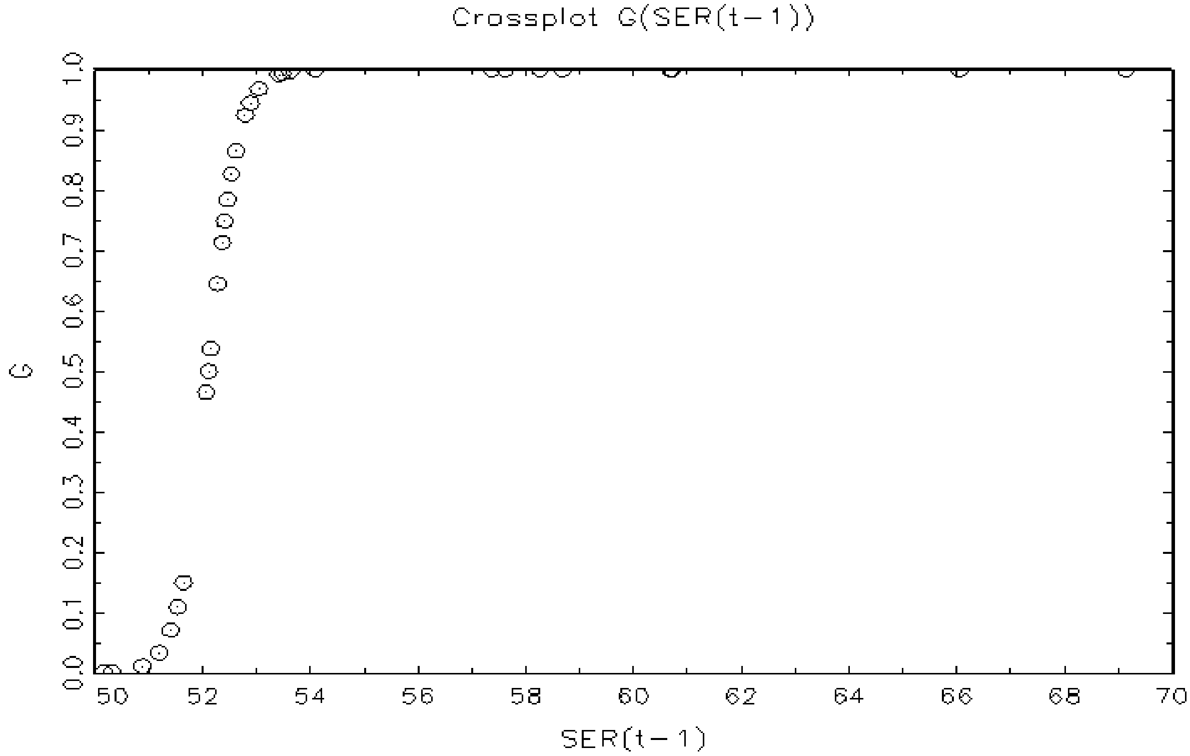

Figure 5. The transition function as function of transition variable

Figure 4 plots transition function during the period 1980-2013. Given the fig. 4 and the parameter c (where the changes between regimes start), higher regime of energy intensity happened during the periods 1980-1987, 1997-2003, 2007-2010 and 2013. The remaining period since 1987-1997, 2003-2007 and 2010-2013 is related to lower regime of energy intensity. The years indicated for higher regime may be expressed as a result of world turmoil or a domestic event. Iran-Iraq war from1980 to 1987, Asian economic crisis in 1997-98, September 11th attack in 2001 and the global crisis in 2007-2009 are the events affecting the energy consumption and production, and subsequently, the energy intensity of Iran. Fig. 5 plots the transition function as function of transition variable (SER(t-1)). Regarding fig. 5, transition speed is relatively fast but the regimes of energy intensity smoothly changes around the estimated threshold of 52.1092 in LSTR model.

We have employed misspecification tests to evaluate the adequacy of LSTR model. The results of misspecification tests are reported in tables 4, 5 and 6. The test of no error autocorrelation reported in table 4 exhibits no serial correlations of residuals at 1% significance level. The ARCH effect test reported in table 5 shows that nonlinearity is not aroused from the conditional variance of the error terms at 1% significance level. According to the results of no remaining nonlinearity test reported in table 6 it is clear that there is no other transition function and transition variables. In other words, there is no misspecification in estimated LSTR model.

Table 4. The test of no error autocorrelation

Lag	F-value	df1	df2	p-value
1	0.8549	1	22	0.3652
2	1.3614	2	20	0.2790
3	3.5121	3	18	0.0366
4	2.5359	4	16	0.0808
5	2.5350	5	14	0.0780
6	1.9246	6	12	0.1575
7	1.9464	7	10	0.1638
8	1.5557	8	8	0.2731

Table 5. The ARCH effect and the normality test

ARCH effect test				Jarque-Bera test	
Test statistic	p-value (ci^2)	F statistic	p-value (F)	Test statistic	p-value (chi^2)
11.3264	0.1839	2.5886	0.0502	1.1503	0.5626

Table 6. The results of no remaining nonlinearity test*

Transition variable	F	F_4	F_3	F_2
E(t-1)	4.5635e-01	1.9634e-01	7.2527e-01	1.8669e-01
SER(t)	2.2324e-01	1.3078e-01	6.8514e-01	9.1911e-02
IT(t)	4.0304e-01	4.7134e-01	4.0979e-01	4.4975e-02
HDI(t)	1.6021e-01	4.7532e-01	2.9496e-01	4.4171e-03
YP(t)	6.8258e-01	6.0690e-01	7.6495e-01	1.0774e-01
SER(t-1)	1.5242e-01	5.6285e-01	9.1343e-02	1.4294e-02
IT(t-1)	5.9062e-01	9.6168e-01	3.1283e-01	5.7059e-02
HDI(t-1)	2.7556e-01	1.2259e-01	9.4001e-01	8.3505e-02
YP(t-1)	7.9568e-01	7.6683e-01	9.8741e-01	3.1267e-02

Note: *: e-i = 10^{-i}, i = 0, 1, 2, ….

4. Conclusion

The aim of this paper is to decompose the energy intensity to the affecting factors. The main factors are the ratio of services value-added to GDP, the percentage of Internet users, human development index and income per capita. Using the nonlinear STR models, we first investigated nonlinearities of the energy intensity in Iran during the period 1980 - 2013. All coefficients are significant at 10% level (except the coefficient of the percentage of internet users). Therefore, tests and the estimation results confirm that a smooth transition relationship exists among variables. We conclude from the estimated results as follows:

(1) The first lag of the ratio of services value-added to GDP as transition variable has an effect on the factors of energy intensity and causes an asymmetric behaviour of energy intensity. In other words, nonlinear transition of energy intensity ,which is under the effect of lifestyle and structural changes, depends on the estimated threshold value of the ratio of services value-added to GDP (c = 52.1092).

(2) According to the reported coefficients, the most effective factor on energy intensity is the first lag of HDI that has a nonlinear relationship with the independent variable. SER is the variable which affects both linear and nonlinear manner. While IT, with one lag, and YP are the other variables explaining nonlinear part of the energy intensity.

(3) Changing the lifestyle has different effects on the energy intensity. Upgrading Human development index has a positive effect on the energy intensity by improving lifestyle. While income per capita has a positive effect on energy efficiency, which is inversely related to energy intensity. The aggregate effect of lifestyle proxies in Iran is positive (-0.0011+0.5890=0.5879).

(4) Structural changes have an effect on both linear and nonlinear parts of the energy intensity by the percentage of internet users and the ratio of services value-added to GDP. Increasing the ratio of services value-added to GDP as a proxy for structural changes totally has significant effect on decreasing the energy intensity in Iran. Increasing internet users has a negative effect on the energy intensity by decreasing the transportation and consequently decreasing energy consumption.

(5) Therefore, Iran should pay more attention to the factors of Human Development Index, as the most effective determinant of energy intensity.

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