

Social Capital and Energy Consumption: an Evidence for Iran

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Abstract

Determination of the factors affecting energy consumption has always been considered by planners, economists, and policymakers. Energy plays an essential role in ensuring the social welfare of societies. Considering the high intensity of energy in Iran, reforming the consumption pattern in the country is an inevitable necessity. The modification of energy consumption patterns, in addition to economic factors and price balancers, needs the recognition and application of social variables. The present paper aims to investigate the simultaneous effect of economic variables and social capital on energy consumption in Iran. In this regard, first, the social capital variable has been estimated by fuzzy logic. Then, using the GMM method, the effects of the social capital index and economic variables on energy consumption in Iran have been estimated in the time series and data of the period 1981-2019. The obtained results showed that social capital had a significant negative effect on energy consumption. Despite the government's focus on price policy and the targeting of subsidies to control consumption, social capital has had a constructive effect on reducing energy consumption without any kind of mechanism. Per capita income, urbanization, trade liberalization, and industrialization have a positive effect on energy consumption. The results also showed that the energy consumption of the previous period had the greatest effect on the energy consumption function.

Keywords: Energy Consumption, Social Capital, Iran, GMM, Time Series.

Introduction

To control energy consumption, the influential parameters should be considered. With the entry of societies into the modern era and the loosening of the traditional structure, consumption has gradually changed its traditional meaning, has moved away from a mainly economic concept, and is becoming a social phenomenon. Nowadays, social capital has been mentioned in the economic and social studies of modern societies. It can be claimed that social capital has a more important role than physical and human capital because, in its absence, other capitals will be ineffective. It is clear considering the key role of this capital in all fields and different attitudes towards it in all aspects of life (Zugravu-Soilita et al., 2021). Without social capital, no society can reach any capital, so many groups, organizations, and human societies have been able to achieve success with minimal economic capital and solely by relying on human and social capital. However, no society can take useful and purposeful measures without social capital. Social capital is a component of economic development. Several studies (Helliwell and Putnam,

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1995; Rupasingha et al., 2000; Woodhouse, 2006) have examined the relationship between social capital and economic performance and have proven the positive effect of social capital on production and economic growth. However, despite its important and influential role in the economy, it is often neglected. Social capital is the third circle of the evolutionary circles of capital (after physical capital and human capital) which has attracted the attention of many economists as a determining factor in the process of sustainable development.

Social capital is one of the hidden variables and, at the same time, a very influential factor in the economic situation. One of the most important effects of social capital is on the efficiency and productivity of production factors. Investing in social projects is one of the most important requirements of developing countries. In these countries, there are natural resources, but there are no suitable production methods and necessary skills for the effective and rational exploitation of these resources for sustainable development, so it causes non-optimal exploitation of these resources and sometimes leads to damage to the environment (McMichael, 2007).

The sense of cooperation and trust among society members, responsibility towards future generations, and satisfaction are among the components of social capital, that affect energy consumption. It is clear that production and technology affect energy consumption, and social capital can be considered to affect production and technology, and in this way, it can be considered effective on energy consumption. The most important source of emission of greenhouse gases such as carbon dioxide is energy consumption. In Iran, in the field of optimizing energy consumption, some policies such as targeting subsidies and liberalizing the price of energy carriers have been adopted. In the scientific studies conducted in the field of energy consumption, it is not mentioned to what extent these policies, which have been announced to the people by the government, have been welcomed by people and to what extent they have followed these policies and controlled energy consumption (relative to their peers and future generations in Iran) as a social duty. If there is a sense of cooperation and participation with the government in controlling energy consumption among the people of the society, the speed of effectiveness of policies to balance energy consumption will probably increase. Also, if the required trust and cooperation (important components of social capital) do not form in society, the aforementioned policies are likely to fail. Therefore, it is necessary to conduct a study to measure the effects of social capital on energy consumption in the economy of Iran. The present study investigates this issue in the period 1981-2019. This paper is organized as follows:

In Section 2, the literature is reviewed, and Section 3 includes the research model and methodology. In Section 4, the findings of the research are presented. Section 5 presents general conclusions and policy recommendations.

Literature Review

Theoretical Foundations

The most common function of social capital is that it is the source of benefits that accrue through networks that extend far beyond the family. As the third function, social capital strengthening, and in turn, strengthening social networks, can lead to benefits outside the family network. Among the effective consequences of social capital, its effect on energy consumption can be mentioned (Borozan et al., 2016). In this new approach, special attention is paid to human beings and their behaviors as one of the main elements and factors protecting the interests of future generations and the feeling of sympathy with their fellows. Social capital is one of the latent and hidden variables, and at the same time, it is very influential on energy consumption and environmental behaviors (Portes, 1998). Social capital can be used as a variable to optimize

energy consumption and protect the environment. Since every economic growth and increase in production results in energy consumption and more exploitation of resources, by using social capital and investing in it, it is possible to reduce the excessive consumption of energy and the negative consequences of economic growth and achieve sustainable development, along with growth. Since many energy inputs are common resources and properties, their sustainable use and protection require collective action. It is expected that societies with higher social capital promote better collective action in the field of energy management. Communication in society, in the sense that members of society communicate with each other, plays a vital role in preventing the destruction of resources and increasing the wealth of society (Safari et al., 2020).

Crime reflects people's non-compliance with society's laws and regulations, and the increase in the amount of crime indicates a decrease in social capital (Rosenfield et al., 2001). Social capital includes concepts such as trust, cooperation, and mutual relations among group members, leading the group toward achieving a positive goal based on common values and standards. Social capital is considered an important component in modern crime prevention, in other words, it is the creation of a tight social network that, by maintaining social order, creates a sense of social responsibility and collective commitment in people toward environmental issues (Deller and Deller, 2010). The research results of social researchers show that with a decrease in social capital, deviations will increase, and vice versa, with the increase in social capital, deviations and crimes will decrease. As mentioned, social capital denotes trust in others, the amount of dialogue between parents and children, self-sacrifice, reducing the feeling of relative deprivation, etc. (Akçomak & Ter Weel, 2012).

Awareness of society's issues and the living environment and knowledge of the needs and deficiencies of the living environment, the individual and collective rights, and responsibilities of the people living in the neighborhood, as well as the responsibility of government bodies towards these deficiencies and needs, can enhance people's awareness and strengthen the social capital (Pérez-Luño et al., 2011). Awareness can be created or strengthened in the first place by creating the spirit of knowledge in the individual and secondly by educating people about their rights and responsibilities towards the living environment. So, when a person is aware of his rights and responsibilities toward society and the environment, they can do the right behavior to improve the situation of the neighborhood (Lesser, 2000).

Cooperation is another important concept and one of the aspects of social capital. In the concept of partnership, there are two points from which the idea of equal value for human beings is the most basic of the two (Dekker and Uslaner, 2003). One of the reasons for the difficulty of measuring social capital is that this phenomenon does not appear at the individual level, nor the collective level, but is observed between the individual and collective levels and when the individual participates in the group. It is misleading to consider social capital as a metaphor for capital because, unlike financial capital that is under the control of individuals, the benefits of various types of social organizations are not formed by actors, but rather they result from people's participation in groups organized for a specific benefit (Hoenig et al., 2016).

Experimental Evidence

Social Capital and Energy Consumption

Ozkan et al (2022) investigate the impact of social capital on energy consumption in turkey from 1980 to 2017 by using the dynamic ARDL method. The results of this study illustrate that human capital has a long-term relationship with energy consumption; however, social capital has a dual impact on energy consumption in different years.

Safari et al. (2020) studied the sociological relationship between social capital and the pattern of electricity consumption in the city of Babol, Iran. For this purpose, they collected the data from 120 questionnaires using systematic random sampling. The results showed that the level of household awareness did not have much effect on the consumption pattern. There was a significant relationship between social capital (social trust and social interaction) and consumption patterns, but there was no significant relationship between social participation and consumption pattern.

Sechi et al. (2018) investigated the relationship between social capital and environmental protection and education in Latvia using the questionnaire tool and the method of path analysis and structural equations. The results showed a significant relationship between environmental education and social capital. Also, it was found that improving the level of social capital improved the environmental situation.

Wu (2017) evaluated the effect of human capital and life expectancy on the environment of developing countries in the period 1994-2015 using the GMM. The results showed that life expectancy and human capital had a negative effect on environmental degradation.

Borozan et al. (2016) investigated the effect of social capital on electricity consumption in Croatia. For this purpose, they used questionnaire data and regression analysis. The results showed the positive effect of social capital indices (trust, participation, empathy, and awareness) on reducing household electricity consumption.

Economic Growth and Energy Consumption

Rodríguez-Caballero (2022) investigate the impact of the gross domestic product on energy consumption by using a panel of 69 countries divided into four regions according to the geographic location to analyze the economic nexus. The results of this study indicate that economic growth significantly surges energy consumption.

Myszczyzyn and Supron (2021) in their study investigated the relationship between economic growth and energy consumption in V4 countries from 1992 to 2015 by using the vector auto-regression (VAR) method. This study illustrates the positive impact of economic growth on energy consumption.

Saidi & Hammami (2015), in a study using a dynamic panel model and relying on the generalized method of moments (GMM), investigated the effect of economic growth and carbon dioxide emissions on energy consumption for 58 countries in the period 1990-2012. The results indicate a significant positive effect of carbon dioxide emissions and economic growth on energy consumption.

Halicioglu (2008), in an econometric study, investigated the relationship between carbon emissions, energy consumption, income, and foreign trade in Turkey during 1960-2005. He investigated the interrelationship between these variables using the cointegration test and autoregressive distributed lag (ARDL) econometric model. The results obtained in this study confirmed two types of long-term relationships between variables which means energy consumption and income as critical social capital factors have a long-run relationship.

Trade Liberalization and Energy Consumption

Zhou and Li (2022) investigate the impact of trade liberalization on energy consumption in 69 countries from 1990 to 2015. Moreover, The pooled mean group (PMG) method was used to estimate long-term and short-term effects. The PMG results revealed the long and short-term positive effects of trade liberalization on energy use.

Akbar et al (2021) Unraveled the relationship between trade liberalization and energy consumption in Southeast Asian countries from 1991 to 2018 by using the structural equation

modeling (SEM) technique. The empirical results reveal a positive nexus between trade openness and energy consumption in Southeast Asian countries.

Nasreen & Anwar (2014) investigated the causal relationship between trade liberalization and energy consumption. This study was conducted using the Granger method for 15 selected Asian countries in the period 1980-2011. On the account of the obtained results, a two-way relationship between liberalization and energy consumption in the short and long term was observed.

Jebli and Youssef (2013) investigated the relationship between foreign trade and energy consumption. This study was conducted for 11 African countries in the period 1908-2008 using Granger methods and panel cointegration techniques with ordinary least squares (OLS) and fully modified ordinary least squares (FMOLS) approaches. The obtained results showed a two-way relationship between foreign trade and energy consumption in the short term, and also indicated the significant positive effect of foreign trade on energy consumption.

Urbanization and Energy Consumption

Anwar et al (2022) in their study investigated the nexus between urbanization and energy consumption in 15 Asian countries from 1990 to 2014. The empirical evidence demonstrates that urbanization surges energy consumption in the selected countries.

Abbasi et al (2020) investigate the impact of urbanization on energy consumption in 8 Asian countries from 1982 to 2017. The analyses are executed using panel co-integration and Granger causality techniques. Moreover, the results indicate an incremental and significant impact of urbanization on energy consumption.

Li and Zhou (2019), in a study using the cross-sectional spatial methodology, investigated the effect of population age structure on carbon dioxide emissions in Chinese provinces in 2017. The results showed that the age structures of the population in young and old age groups had positive and negative effects on the spread of air pollution in the provinces of China.

In a paper entitled "Investigation of the role of the financial market along with the variables of industrialization and urbanization on the increase in energy consumption in Tunisia in the period 1971-2008", Shahbaz and Lean (2012), using the auto-regression model and the Granger causality test, found that there was a long-term causal relationship between financial market development and energy consumption, between energy consumption and economic growth, and between industrialization and urbanization. Moreover, there is a two-way causal relationship between urbanization, industrialization, and energy consumption.

Research Model and Data

According to the theoretical foundations and background, it is obvious that one of the determining and effective factors in energy consumption is social capital. In Iran, few coherent studies have been conducted on the simultaneous effect of social capital and macroeconomic variables on energy consumption. The most important innovation of this study is the calculation of Iran's social capital time series, the investigation of the simultaneous effect of social capital and economic variables on energy consumption, and the use of the GMM in time series to estimate the energy demand function. After reviewing the related literature, variables affecting energy consumption in Iran were identified and selected. According to the conditions of Iran's economy, the econometric model of this research has been specified as follows.

$$LE_t = \beta_0 + \beta_1 LE_{t-1} + \beta_2 LGDP_t + \beta_3 LTR_t + \beta_4 LSC_t + \beta_5 LURB_t + \beta_6 LIND_t + \varepsilon_t \quad (1)$$

In equation (1), L at the beginning of the variables means the natural logarithm and in this model, the index t denotes the period. The description of the variables is as follows:

E : Energy consumption (in kilograms of oil), GDP : Real per capita income, TR : Trade liberalization, which in this research is the ratio of the total value of exports and imports to GDP and is calculated as follows:

$$OPEN_t = \left(\frac{EX+IM}{GDP} \right) \quad (2)$$

Where, EX : Export value, IM : Import value, GDP : Gross domestic product at constant prices (This GDP is different from the GDP used in equation 1 because it is used to calculate the degree of trade liberalization), URB : Urbanization rate (urban population over total population), IND : Industrialization level (industry sector's value-added share of GDP), SC : Social capital. β_0 is constant which indicates if the effect of all variables affecting energy consumption reaches zero, there will still be the amount of energy consumption equal to the constant. Furthermore, β_1 to β_6 indicate the coefficients of independent variables which illustrates the impact of each independent variable on the dependent variable (energy consumption).

It is worth noting that the necessary data for this study have been collected from the World Bank data, Iran's energy balance sheets for different years, the Central Bank's website, statistical yearbooks, and the Statistical Centre of Iran.

Various studies have been conducted on the methods of measuring social capital. However, a general method to measure this variable has not yet been introduced. This issue goes back to the literature and analysis of social capital. There are different proxies for the social capital index. Considering that the present study was conducted in Iran and since all the statistics and information are not collected and published coherently, the main limitation of the current research for calculating social capital is the lack of access to statistics and information including all aspects of social capital in the calculations. Thus, taking into account the limited availability of statistics in Iran, the following proxies and accompanying variables have been used:

A) The ratio of crime to population: In this regard, the crime index is calculated using the method of calculating the United Nations Human Development Index and macro indices, such as murder, embezzlement, theft, bad checks, assault, threats, coercion, drugs, fake stabbing, and committing suicide.

The desired information has been extracted from the statistical yearbook in different years. To obtain the mass index, first, all the raw indices become per capita, then, they are standardized through the following relationship, that is, by subtracting the average of each index from the observations related to that index and dividing it by the corresponding standard deviation.

$$X^+_{it} = \frac{X_{it} - \bar{X}_i}{Se(X_i)} \quad (3)$$

In this way, according to the characteristics of the "standard form of data", observations of different indices become unitless and can be compared with each other. After completing this step, the crime index is calculated using the human development index calculation method provided by the United Nations (Ghatak, 1995). In the first step, using equation (3) from the observations related to each of the indices, the minimum value recorded for that index is subtracted and the result is divided by the range of its changes (in this way, the numerical values of all the indices are placed in the range of 0 and 1).

$$X^*_{it} = \frac{X^+_{it} - Min(X^+_i)}{Max(X^+_i) - Min(X^+_i)} \quad (4)$$

After performing this calculation for all components, the mass index of that year is extracted from the arithmetic average of all indices for each year of the studied period. This index changes between 0 and 1, i.e., the closer its value is to 1, the greater the mass will be.

$$SC^T = \frac{1}{N} \sum_{i=1}^N X_{it}^* \quad t=1,2,\dots,T \quad (5)$$

B) Public awareness: The number of books borrowed from public libraries concerning the population.

C) Collective participation: The number of members of non-governmental organizations (NGOs), cultural centers, and charity centers concerning the population.

Considering the availability of these data for Iran, the variables mentioned above are among the most important factors affecting the formation and the main variables accompanying the variable of social capital. It is worth noting that the source of statistics and information related to variables determining social capital (crimes – number of borrowed books – number of members of NGOs, and charitable and cultural centers) is the Statistical Centre of Iran – statistical yearbooks of each province during different years. Therefore, it is possible to create a comprehensive index for social capital using fuzzy logic, which is influenced by the aforementioned variables. In other words, in this research, an index for social capital is estimated during different years using fuzzy logic.

After characterizing the variables determining social capital, the fuzzy inference system (FIS) for calculating this index is as follows:

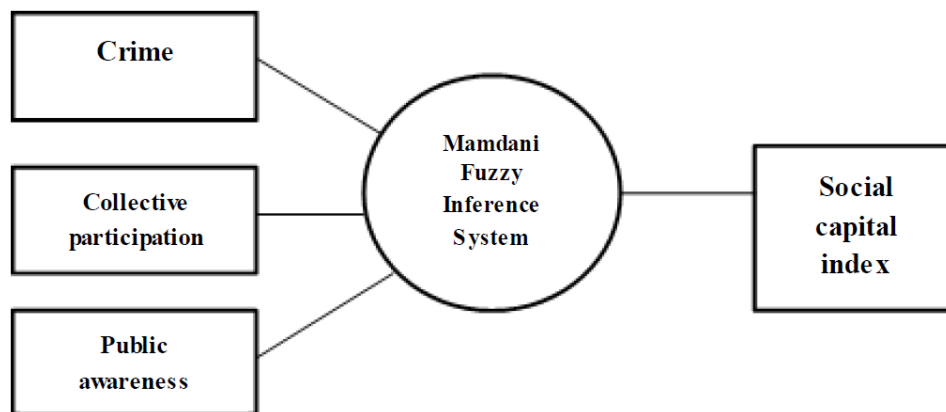


Figure 1. Fuzzy inference system (FIS) for social capital index

Using Mamdani fuzzy inference system and according to the associated variables mentioned in figure 1, the social capital index has been calculated. To obtain the mass index, We act exactly like equations (3), (4), and (5), therefore, this index changes between 0 and 1, i.e., the closer its value is to 1, the greater the crime and the lower the level of social capital will be.

Since the model of this research is dynamic and establishes the conditions of generalized moments, therefore, time series GMM has been used to estimate the model. The GMM is used in time series for dynamic models that firstly satisfy the conditions of moments and asymptotic properties and secondly are linear. Application of this method to estimate the model has many advantages. For example, Beck et al. (2000) consider the use of this estimator to be very suitable for solving the variance of time series data. The GMM estimator provides better control over the endogeneity of all explanatory variables of the model by calculating the unobserved individual special effects in the model (which is done by entering the dependent variable with an interval as an explanatory variable in the model).

Research Findings

Estimation of Social Capital Index

First, for each of the input and output variables, language expressions of low (L), medium (M), and high (H) have been mentioned. To create a base value, a moving average for each input variable is used. To account for possible cycles in the data, a 5-year moving average was taken from the data. The average shows the normal value of the components of the set of variables. Then, to determine the breaking points of the data, one or two standard deviations around the normal value are obtained in each period.

Table 1. Membership functions

LOW	MEDIUM	HIGH
-SD	Mean	+SD

After determining the breaking points of the data, depending on the opinion of the system designer, different functions can be selected in terms of shape or degree of complexity for each variable. Since triangular and trapezoidal membership functions are very simple and accurate, in this study, these two types of membership functions are used.

Figures 2 to 4 demonstrate the trend of the variables in Iran from 1981 to 2019. As is evident, the crime-to-population ratio in Iran is almost high and the level of collective participation and public awareness is low. Further, whenever the level of collective participation and public awareness is at its lowest (1981 and 2019), the crime rate against the population is at its lowest. On the other hand, while collective participation and public awareness are at their maximum (2002), the crime-to-population ratio started to decrease in 2004. From the above, it can be concluded that there is a close relationship between crime to population ratio, collective participation and public awareness.

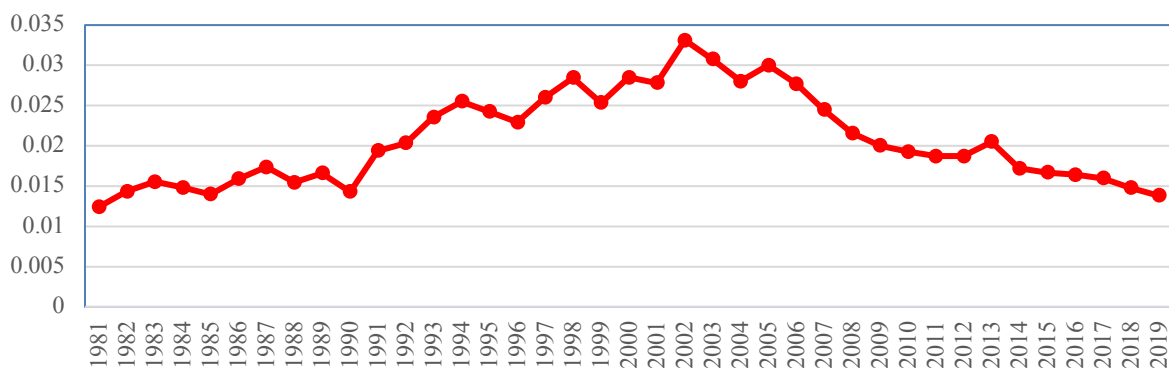


Figure 2. Collective Participation of Iran from 1981 to 2019.

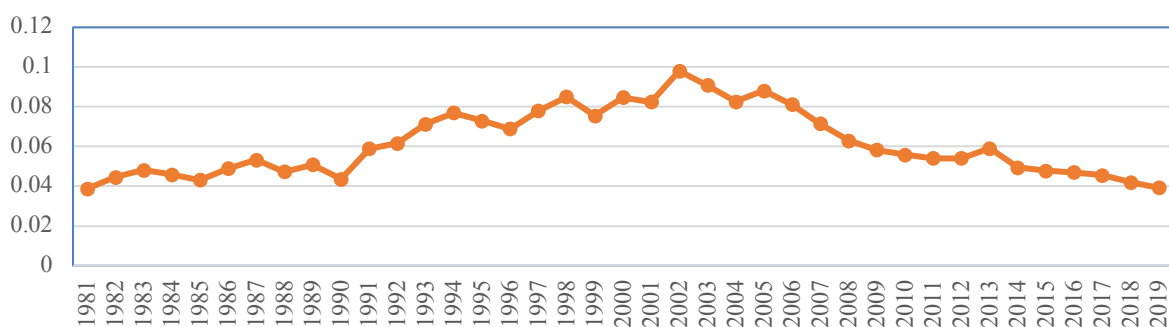


Figure 3. Public Awareness of Iran from 1981 to 2019.

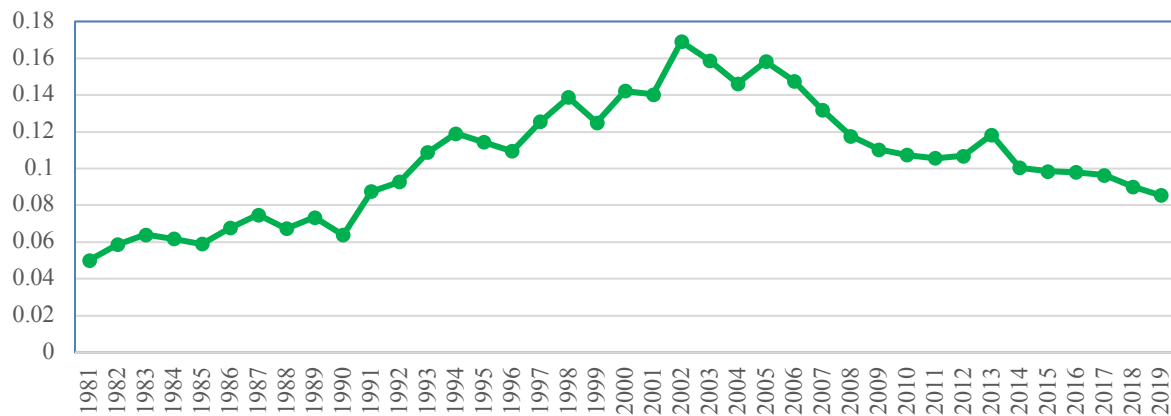


Figure 4. Crime-to-Population Ratio of Iran from 1981 to 2019.

Figure 5 shows the results of social capital index estimation as the average final index of Iran.

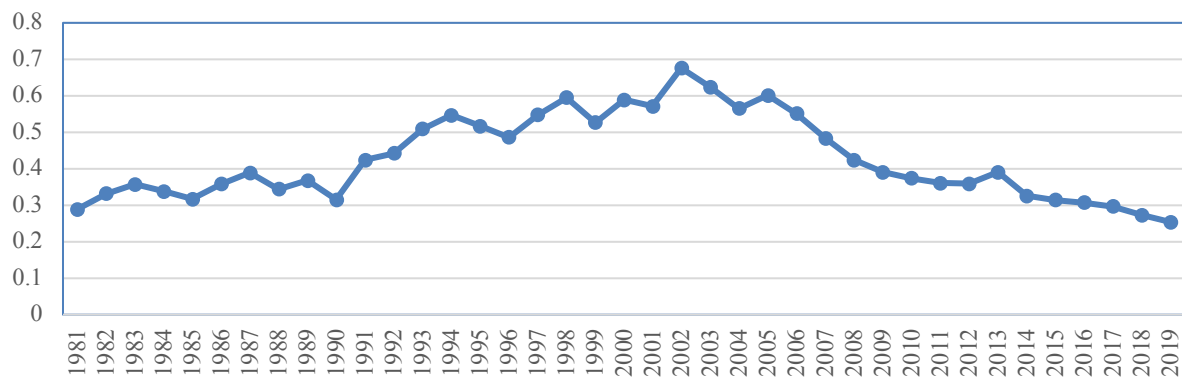


Figure 5. Social capital index in the period 1981-2019.

As shown in figure 5, the social capital index has experienced fluctuations during the years of research. The social capital index in Iran has a significant difference during the years under investigation. The social capital index illustrates the highest value in 2002 and the lowest value in 2019. In 2002, since public awareness and collective participation per capita had a high value compared to other years, the social capital index was high. Moreover, between 2005 to 2019 collective participation and public awareness started to plunge in Iran due to economic and political issues, after that the social capital followed the trend of collective participation and public awareness and decreased. Furthermore, In 2002, social capital was maximum and the crime-to-population ratio started to decrease from 2002.

Estimation of the Research Regression Model

To ensure the estimated coefficients of the model, durability tests should confirm the stationarity of the variables. In the present study, the durability test of the model variables is performed through the augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests. The results of the static test of variables are shown in Table 2.

Considering that the null hypothesis of the test indicates the existence of a single root for each variable, if the calculated P-Value is less than five percent, the hypothesis of the existence of a single root for that variable is rejected. Examining the stationarity of model variables based on the ADF and PP tests shows that all variables are at a stationary level. Thus, they are $I(0)$.

After checking the stationarity of the variables and making sure that the variables are static, the research model is estimated. Table 3 shows the research model's estimation results using the GMM.

Table 2. Unit root test based on the Augmented Dickey-Fuller (ADF) Phillips-Perron (PP) tests.

Augmented Dickey-Fuller (ADF)			
Variable	Type	Value	Stationarity result
LE	Statistic value	-7.85	Stationarity
	Critical value	-3.52	
LTR	Statistic value	-5.72	Stationarity
	Critical value	-3.52	
LSC	Statistic value	-3.58	Stationarity
	Critical value	-3.52	
LURB	Statistic value	-1.71	Stationarity
	Critical value	-1.61	
LGDP	Statistic value	-2.47	Stationarity
	Critical value	-1.94	
LIND	Statistic value	-5.58	Stationarity
	Critical value	-3.52	
Phillips-Perron (PP)			
Variable	Type	Value	Stationarity result
LE	Statistic value	-7.95	Stationarity
	Critical value	-3.52	
LTR	Statistic value	-3.56	Stationarity
	Critical value	-3.52	
LSC	Statistic value	-3.21	Stationarity
	Critical value	-2.93	
LURB	Statistic value	-7.35	Stationarity
	Critical value	-3.52	
LGDP	Statistic value	-2.24	Stationarity
	Critical value	-1.94	
LIND	Statistic value	-5.56	Stationarity
	Critical value	-3.52	

Table 3. The results of estimating the model with the dependent variable of energy consumption.

Explanatory variable	Coefficient	Standard deviation	T-statistic	Probability
LE(-1)	0.823	0.038	21.342	0.0000
LTR	0.117	0.032	3.672	0.0008
LSC	-0.173	0.032	-5.37	0.0000
LURB	0.038	0.005	7.114	0.0000
LGDP	0.345	0.095	3.602	0.0010
LIND	0.217	0.039	5.486	0.0000
C	1.015	0.015	66.17	0.0000
Sargan test		J-statistic: 6.987		0.136

The results of Table 3 show that the estimated model is in a good condition in terms of statistical indices. The null hypothesis of the Sargan test cannot be rejected, and thus, it can be concluded that the instrumental variables used in the estimation model are valid because the null hypothesis of the Sargan test indicates the validity of the instruments. The energy consumption of the previous period has had the most positive and significant effect on energy consumption in Iran, so, with a one percent increase in energy consumption in period t-1, energy

consumption in the current period increases by 0.82%. Social capital has a significant negative effect on energy consumption. So, the elasticity of energy consumption compared to social capital is equal to -0.173. That is, with a one percent increase in the social capital index, energy consumption will decrease by 0.17%.

The coefficient of the urbanization variable is estimated at 0.038. This coefficient is also statistically significant. The coefficient of real per capita income (economic growth index) and economic industrialization variables are estimated at 0.345 and 0.217, respectively. These coefficients are also evaluated according to the probability threshold corresponding to the significant t-statistic.

Conclusion and Policy Recommendations

The present research has investigated the effect of social capital on energy consumption in the period 1981-2019 in Iran. For this purpose, after examining the theoretical and empirical foundations of social capital, three main components accompanying social capital (crime, participation, and awareness) have been considered for the calculation of social capital. Then, the social capital index is estimated using the Mamdani fuzzy inference system. Moreover, using the time series GMM, the impact of social capital has been measured along with other variables in the regression model of energy consumption.

The obtained results indicate that increasing social capital has reduced energy consumption. Accordingly, adopting policies to increase social capital and, in turn, reduce energy consumption and achieve an optimal consumption pattern will be quite effective. It is suggested that special attention be paid to this important capital in the country's decision-making and macro-planning so that with the proper management of this great social capital, it can be used to its full potential and experience an upward trend. At the macro level, the government can increase the level of social capital in the society by involving as many people as possible in decision-making, strengthening and encouraging people's institutions, enacting strict laws and punishments for the agents of corruption and destruction of social capital in the society and especially in government institutions, paying special attention to education, avoiding government involvement in business or enterprises, creating public security and stabilizing it, creating effective and stable laws for property rights, creating solutions to reduce inflation and unemployment in society, providing transparent information, and increasing accountability to the people. To stimulate a sense of altruism and participation in the preservation of resources, one of the policies suggested to the government is to pay attention to the formation and development of local institutions and the expansion of non-governmental organizations (NGOs).

Trade liberalization has a significant positive effect on energy consumption. Specifically, trade includes the export and import of goods, and theoretically, there are several reasons why exports can affect energy consumption. To increase growth in exports, machines, and equipment for loading and transporting exported goods should be sent to ports, airports, or unloading stations. Machines and equipment in the process of production and transportation of goods for export require primary energy, and any increase in export indicates the growth of economic activities, and this growth causes an increase in energy demand. Therefore, exported goods require energy for transportation, i.e., without enough energy, export development will be weakened. Imports can also affect energy consumption. If the import includes machinery, equipment, and new technology, it will increase production and energy use. Furthermore, the import of goods is done through the transportation network, leading to the consumption of fuel energy by the transportation system.

Urbanization significantly surges energy consumption. The concentration of factories and production companies in urban centers causes the rural population to move toward urban areas

to find jobs, earn higher incomes, and use extensive public facilities. The phenomenon of urbanization has also affected the pattern of energy consumption, leading to its excessive use. The main reason for the increase in energy consumption due to the phenomenon of urbanization is the change in people's consumption patterns, the increase in the demand for goods and services, and as a result, the increase in the scale of production, as well as the increase in energy consumption in the transportation sector due to the production of private cars and the evolution of the public transportation system, including passenger and cargo transport systems. Therefore, It can be concluded that urbanization has destructive effects in terms of increasing energy consumption due to the increased use of goods and services.

As deduced from economic theories and empirical studies, economic growth has a positive effect on energy consumption. In the present study, this relationship has been evaluated as positive and significant. Industrialization and increasing the value-added share of the industrial sector in the GDP have had a significant positive effect on energy consumption. Industrialization is a process that occurs in various ways, including technological changes. Also, the use of advanced production technology through creating efficiency in production leads to the use of fewer inputs, including energy, to produce a unit of the product and increases energy efficiency. However, it seems that the structure of the Iranian industry sector is such that it uses old technology, which mainly has high energy consumption because the use of advanced technology requires more research and development expenses and the small share of these expenses may not lead to the creation of energy-efficient technologies.

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