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Research Article

Changes in Production Structure and Natural Gas Consumption in Iran's Provinces: Spatial Econometric Approach

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Abstract
Change in structure of production in an economy is one of the factors affecting energy consumption in different economic activities. Therefore, the purpose of this study is to investigate the direct and spillover effects of structural changes in production on natural gas consumption in different provinces of Iran during 2007-2018 using spatial econometrics approach. In this study, two indices of production structure changes including industry share in total output and the structural change index (NAV) were used to measure structural changes in the production of the economy. The results indicate that the direct effects of all variables except natural gas price are positive and significant. The direct effect of natural gas price (LGP) on the consumption of this energy is negative and significant. The direct effect of GDP, industrialization, production structure change and urbanization were positive and significant. Spillover effect of the industrialization and change in production structure were positive and significant on natural gas consumption.
Keywords: Energy Consumption, Change of Production Structure, Spatial Econometrics.

Introduction

Along with capital and labor, energy is one of the important inputs of production and plays an essential role in the production of goods and services (Shahbazi et al., 2011). Therefore, with economic growth in a country or region, energy demand will also increase. In addition to the positive effect of energy consumption on economic growth, it has negative effects on environmental pollution. Also, energy consumption is considered as one of the main factors of pollution emission and climate change. Therefore, one of the main concerns of policymakers and decision-makers in the field of energy economics is to find a balance between economic growth and energy consumption and environmental protection. In other words, achieving sustainable growth and development is one of the main concerns of policy makers (Jahangard et al., 2016). According to this, one of the ways to plan in line with sustainable growth is to identify the factors affecting energy consumption and pollutant emission and determine the importance of each of them.

Based on theoretical foundations, several factors affect energy consumption including the economic growth, urbanization, energy prices (Xie, 2014, Wang et al. 2017). Another factor that can affect the energy demand and its consumption is the structure of production in a country or region. In a simple definition, the structure of production in an economy can be considered as the relative share of each economic sector in the total production. Therefore, the change in

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the share of each economic sector in the production of the whole economy will indicate the change in the production structure. Different economic sectors differ from each other in terms of energy consumption per unit of production (energy intensity). Therefore, changing the economic structure (changes the share of sectors) can changes the energy consumption in one country or region (Iqbali et al., 2014). For example, increasing the share of high energy intensive sectors will increase energy consumption in the economy. On the contrary, if the share of sectors with low energy intensity in the total production increases, the amount of energy consumption in that country will decrease.

The experience of developed countries has shown that during the process of economic growth, the structure of production has also changed. In the industrialization stage, the amount of energy consumption (due to the high dependence of this sector on energy) has increased greatly (Del Angizan et al., 2015). Based on this, it can be argued that if the production structure of countries and regions moves towards industrial production and the share of the industrial sector in the economy of the country (region) increases, the total energy consumption of the country (region) will also increase.

Another factor that can affect energy consumption in one region is interregional linkages. According to the literature of regional economy, different regions can influence each other's economic variables through interregional relationships (trade of goods and services between regions) (Sharify and Hosseinzadeh, 2016). Therefore, following the changes in the production structure in one region and the change in energy consumption in that region, the production and also energy consumption in other neighboring regions will also be affected. For example, if the demand increases in one region, the spillover of this demand to the surrounding regions will increase the production and then increase the energy consumption in the neighboring regions.

Based on the above, the main question is what factors affect the consumption of different energies, including natural gas, in the country and in different provinces? Another question in this case is whether the change of production structure in different regions can affect the consumption of natural gas. To answer these questions, this study has examined the effect of changing production structure on natural gas consumption. In other words, the purpose of this study is to investigate the impact of changes in the production structure on energy consumption in the provinces of Iran in the period of 2007-2018 using the spatial econometric approach.

This study is organized in five sections. After the introduction, the theoretical foundations and literature review are stated in the next section. The third part is devoted to the introduction of methodology. In the fourth section, the empirical findings are presented and discussed, and in the final section, the conclusions and policy suggestions are presented.

Literature Review

In economic growth theories, energy is included as one of the main factors of production. Therefore, the increase in the level of production in countries leads to an increase in energy demand. In other words, the amount of energy consumption in one country or region depends strongly on the level of economic activities and growth of economic activity. The high economic growth rate, by creating new needs, puts increasing pressure on energy consumption (Salim et al. 2014). In addition to the level of production, the structure of production also affects energy consumption. Chenery (1986) introduces the changes in the production structure as the transition from the traditional economy to the developed economy (Moshiri and Eltajaei, 2007).

Changes in the production structure are one of the main factors affecting energy consumption (Jones, 2004). For this reason, according to the different economic structure in different countries and regions, their energy consumption is also different. In other words, the amount of energy consumption differs according to the economic structure of each country or region (Abounuri and Roudbari, 2016). For example, the growth of the service sector compared to

other sectors in a country can reduce energy consumption and reduce the emission of environmental pollutants (Adebayo et al. 2022). During the changes in the production structure, on the one hand, the share of different sectors changes, and on the other hand, the dependence of different sectors (agriculture, industry and services) on energy is different from each other. For this reason, if the share of energy-intensive sectors or the sectors with high energy-intensity (energy consumption per unit of production) increases, the amount of energy consumption in the economy will also increase (Salimi et al., 2019). For example, the manufacturing sector, as one of the most important economic sectors, is highly dependent on the consumption of various types of energy. For this reason, this sector has a high share in the amount of energy consumption in both developing and developed countries. Based on this, if the production structure of regions or countries moves more towards manufacturing production, it is expected that the total energy consumption of the region or country will increase (Abounuri and Roudbari, 2016). Also, the agricultural sector needs less energy consumption compared to other economic sectors. So that the share of final energy consumption in this sector in the country has always been less than 10% (Ghasemi, 2013). Therefore, if the share of the agricultural sector in the total production of an economy is high, the amount of energy consumption in that economy will be less.

Changing the production structure of a region's economy, in addition to direct effects on energy consumption in that region, has indirect and spillover effects on other regions as well. Tobler (1970) states, the production level of each geographical area is dependent on another place or other geographical areas. So that the areas that are closer to each other have a greater impact on each other than the areas and places that are further away. Based on this, the energy consumption in a province depends not only on the performance of the province itself, but also on the economic variables and energy consumption of neighboring provinces (Seif and Hamidi-Rozi, 2016). In other words, different regions can influence each other's economic variables through inter-regional relationship (trade of goods and services between regions). Therefore, following the changes in the production structure in one region and the change in energy consumption in it, the production and energy consumption in other neighboring regions will also be affected. On the other hand, if the economy is growing in a certain region, the neighboring regions may imitate the patterns of development and growth and structure of that region. Therefore, energy consumption and environmental quality in nearby areas are affected. When a province accelerates its economic growth by introducing and encouraging industries with high energy consumption, its neighboring provinces can have strong incentives to follow this way of economic growth. In this way, neighboring provinces may influence each other in terms of demand for energy (Hao and Peng, 2017). In other words, the changing the production structure in a region can affect the amount of energy consumption in that region and even the amount of energy consumption in the surrounding regions.

Several empirical studies have been conducted regarding energy consumption. Tsani (2010) has investigated the causal relationship between economic growth and energy consumption in Greece during the period of 1960-2006 using Toda Yamamoto's Granger causality method. The results show a one-way causal relationship between energy consumption and GDP. Pomani and Kanko (2010) have investigated the effect of urbanization on energy consumption for 99 selected countries during the period of 1975-2005. The results show the negative effect of urbanization in the low-income group and the positive effect in the middle and high-income groups on energy consumption.

Aghaei et al. (2011) have investigated the relationship between economic growth and energy consumption during 2001-2009 using panel causality test. The results of this study show a two-way relationship between energy consumption and economic growth in developed, less developed and undeveloped provinces in Iran. Eggoh et al. (2011) have investigated the relationship between economic growth and energy consumption for 21 African countries during

1970-2006. The results show that there is a long-term relationship between real GDP and energy consumption. Zhang and Lin (2012) investigated the impact of urbanization on energy consumption and CO_2 emissions in China during the 1995-2010. The results show that the positive effect of urbanization on energy consumption and the effects of urbanization are different in different regions and have decreased from the western region to the central and eastern regions.

Gairuzazmi (2012) has investigated the effect of trade liberalization and economic growth on energy consumption during 1970-1990. The results have shown that trade liberalization does not affect the increase in energy consumption in developing countries, and economic growth has caused an increase in energy consumption.

Issazadeh and Mehranfar (2012) investigated the relationship between urbanization and energy consumption using the Granger causality test during the years 1973-2006 in Iran. The results indicate that the level of technology, economic growth, and urbanization have contributed the most to the total energy consumption. Mohammadi et al. (2012) investigated the relationship between economic growth and natural gas consumption in the period of 1974-2007 using the Granger causality method. The results showed that there is the two-way causality between GDP and gas consumption. Adeli and Ghanbari (2013) have investigated the relationship between GDP and energy consumption during 1980 to 2010 using cointegration and Granger causality methods. The results showed that there is the one-way causality in the short term from gross domestic product to energy consumption. Baranzini et al. (2013) investigated the causal relationships between economic growth and energy consumption in Switzerland during the 1950-2010. The results have shown that there is a two-way causal relationship between GDP and oil consumption.

Wandji (2013) has investigated the relationship between economic growth and energy consumption in Cameron using Granger causality test and panel cointegration test during the period of 1971-2009. The results showed a one-way causality relationship from energy consumption to GDP. Jiang et al. (2014) investigated energy intensity in Chinese provinces during the period of 2003-2011 using the spatial Durbin model. The results show an inverted U-shaped relationship between income and energy consumption in 10 provinces. Bahmani et al. (2014) investigated the factors affecting the energy consumption of the household sector in different provinces during the years 2011-2018 using a spatial econometric approach. The results show that energy consumption is less elastic compared to the price, and it is elastic compared to the per-capita income of the household and the population.

Lee and Lin (2015) investigated the effects of urbanization and industrialization on energy consumption data of 73 countries during 1971- 2010 and the method of panel regression models. The results show that urbanization has a negative effect on energy consumption in the low-income group and does not affect the middle and high-income groups. Salatin and Mohammadi (2016) investigated the impact of urbanization on energy consumption in selected oil exporting countries using the generalized moment method (GMM) in the period of 2010-2018. Wang et al. (2016) investigated the impact of urbanization on energy consumption in China during the 1990-2012. The results have shown that the increase in urbanization has increased energy consumption. The results show a positive and significant effect of urbanization on energy consumption.

Behboodi et al. (2017) investigated the interrelationship between development, renewable and non-renewable energies and environment by using (BVAR) in Iran during 1980-2013. The results of this study showed that there is a positive between sustainable development and renewable energy consumption.

Shahnazi et al. (2017) investigated the causality relationship between economic growth, consumption of energy in the period of 1977-2012 and the causality method of Toda and Yamamoto. The results have shown that economic growth in transportation a commercial sector

has a two-way causality relationship with energy consumption and a one-way causality relationship in the industry sector. Saif and Hamidi-Rozi (2017) analyzed the factors affecting the energy consumption intensity index of the provinces using the spatial dynamic econometric approach during the period of 2000-2013. The results show that the increase in per capita income has had a negative and significant effect on the intensity of energy consumption. Golkhandan et al. (2017) investigated the relationship between the added-value of economic sectors and energy consumption during the period of 2013-2015 using the Granger causality test. The results show a two-way causality relationship between the added value in the service sector and all sectors with electricity consumption.

Karimi and Heydarian (2017) studied the relationship between urbanization and energy consumption in the provinces of Iran using the ARDL method during the 2004-2015. The results show a positive two-way relationship between urbanization and energy consumption. Chen et al. (2018) investigated the impact of urbanization on energy consumption in 188 cities in Chinese provinces in the period of 2005-2013 and the STIRPAT model. The results have shown that the increase in the rate of urbanization has caused an increase in the consumption of natural gas in the eastern region. Yang et al. (2018) studied the effect of urbanization on residential energy consumption in Chinese provinces from 1996 to 2014 and the random effects model. The results have shown that a higher urbanization rate has led to an increase in urban and rural electricity consumption. Wang et al. (2019), investigated the effect of energy price and economic growth on per capita energy consumption in 186 countries during the period of 1980-2015 and the Granger causality method.

The results indicate a two-way causality between urbanization and energy consumption. Eghbali et al. (2020) investigated the causality relationship between the total energy consumption and the value- added of Iran's industrial sub-sectors in the period of 1996-2016 using the panel Granger causality test and bootstrap approach. The results show that there is no Granger causality relationship from the total energy consumption to the growth of value- added in the studied sub-sectors of the industry except for one sub-sector. Kamali Dehkordi et al. (2021) investigated the spatial effect of urbanization on energy consumption in selected OPEC member countries using the STIRPAT spatial approach. Based on the findings, in the long-term direct effects of the variables of industrialization, trade and economic growth has a positive effect on energy consumption.

Vafaei et al. (2022) investigated the indirect effect of financial development on energy consumption in Iran using GMM method. The results of the study showed that financial depth and GDP have a positive effect on energy consumption. Tan and Uprasen (2022) investigate the effect of FDI on renewable energy consumption in the BRICS countries from 1990 to 2015. In this study the environmental regulation is considered as a moderating variable and a threshold variable simultaneously to capture the nonlinear association between FDI and renewable energy consumption. The empirical results indicate that FDI reduces renewable energy consumption when the degree of regulatory stringency is lower than a threshold level.

Fatemi et al. (2022) introduced a model based on sustainable development indicators to forecast energy consumption in Iran in which the relevant indicators are specified by the determination phase. The experiment result of the model using the GA-Based feature selection indicates that the hybrid model has had better results and GA-SVM and GA-MLP have the best result respectively. Xu and Zhong (2023) investigate the impact of income inequality on energy consumption in 108 countries from 2000 to 2019. The empirical results indicate that income inequality causes a surge in energy consumption.

One of the characteristics of this research compared to previous ones, is that in this study we investigate the effect of changes in the production structure of the provinces on energy consumption .This has been neglected in the previous study.

Methodology and data

Spatial correlation test

The first step in spatial econometric models is to investigate the presence of spatial effects in the data used in the model. There are different statistics to perform this test. One of these statistics is Moran's I statistic. The null hypothesis of this test is the absence of spatial correlation. Moran's statistic for variable *x* in different regions can be calculated as equation (1).

$$\mathrm{I} = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij} c_{ij}}{s^2 . \sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij}} = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij}(x_i - \bar{x})(x_j - \bar{x})}{s^2 . \sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij}} \qquad (1)$$

$$s^2 = \frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n}$$

In the above relationship, *xi* and *xj* are the values of *x* for different regions and the S^2 is variance of the sample. W_{ij} is the contiguity of *i* and *j* to each other and called as weight matrix (Lesage, 2014).

Different models in spatial econometrics

There are different models in the spatial data channel. Therefore, one of the problems in estimating these models is the choice of the type of spatial model. In general, in spatial panel data, there are spatial effects through three kind of the relationships including spatial lag on dependent, independent variables spatial effect and finally and error sentences (Anselin, 1988). The general specification of panel data includes all spatial effects. This specification for spatial panel data is as follows:

$$Y = PWY + \alpha I_n + X\beta + \lambda WX + \alpha_t + \gamma_t + v_{it}$$
$$v_{it} = \theta w v_{it} + u_{it} \qquad (2)$$

In equation (2) *i* and *t* are cross section and time respectively, *Y* is a vector of dependent variables and *X* represents the matrix of explanatory variables and *W* is the spatial weight matrix in dimensions and the first order matrix of all the numbers on the main diameter is zero. And the rows of this matrix are zero for non-adjacent observations and one for neighboring observations.

Spatial autoregressive (SAR) model:

The general form of the SAR model is as equation (3).

$$Y = \rho . W . Y + X . \beta + \varepsilon \qquad \varepsilon \approx N(0, \sigma^2 . I_n) \qquad (3)$$

Based on the general model of relation (2), the spatial autocorrelation coefficient of the explanatory variables and the spatial autocorrelation coefficient of the disturbance sentences are considered zero, so the mutual effects of the error sentences in different units and the

exogenous mutual effects among the independent variables are removed to obtain the SAR model. Also, ρ is the spatial autoregressive coefficient that indicates that how much the dependent variable in one country is affected by the dependent variable of other neighboring countries.

Spatial error model (SEM):

$$Y = X.\beta + u \qquad u = \gamma.Wu + \varepsilon \tag{4}$$

This model includes the spatial relationship in the error sentences with the assumption that there are spatial effects but their influencing variable has not been identified.

Spatial Durbin model (SDM):

$$y_i = PWy_{it} + \alpha I_n + X\beta + WX\beta_2 + \alpha_i + \gamma_t + v_{it} \tag{5}$$

Based on the equation (2), if the spatial autocorrelation coefficient of the explanatory variables is zero, it will eliminate the exogenous interactions among the independent variables to obtain the SDM model (Elhorst, 2014)

Selecting the best spatial models

In this study, Elmhurst's method (2014) is used to select among different spatial modes. In this method, after estimating the spatial model, the Lagrange coefficient (LM) tests is used to test the spatial patterns, which causes the four possible states:

A- Only the spatial lag pattern (SAR) is significant.

B- Only the spatial error pattern (SEM) is significant.

C- Both the spatial lag pattern (SAR) and the spatial error pattern (SEM) are significant.

D- None of the patterns of interruption and spatial error are significant. In this case, the spatial lag pattern and the spatial error pattern are estimated separately to see if the spatial lag parameter and the spatial error parameter are significant or not. The results can reproduce one of the states A, B, C or D.

If the fourth state occurs, the model is estimated with spatial effects in the explanatory variables (WX), which are two possible states:

A- If the hypothesis is not rejected, the OLS model is the best model.

B- If the hypothesis is rejected, the spatial Durbin model (SDM) is estimated.

Spatial Hausman test

After choosing the type of spatial model, the type of effect should be specified in the spatial panel data. One of the necessary tests in panel data models is the choice of effect type (fixed effects or random effects). Spatial Hausman test is used to choose between fixed effects and random effects model in spatial econometrics (Elhurst, 2011).

Model specification

In this research, spatial econometrics is used to investigate factors affecting natural gas consumption. The model used in this study is as follows:

$$\ln \mathrm{E}_{it} = \beta_o + \beta_1 UR_{it} + \beta_2 S\mathrm{T}_{it} + \beta_3 SP_{it} + \beta_4 p_{it} + \beta_5 GD\mathrm{P}_{it} \tag{6}$$

In this regard, E_{it} is the natural gas consumption of province i at time t, UR_{it} is the urbanization rate of province i at time period t, ST_{it} changes in the production structure of province i at time t, SP_{it} the share of the industry sector from the production of province i at time t, p_{it} the price of natural gas at province i at time t, GDP_{it} is the gross domestic product of province i at time t.

Data

In this study, the information of 30 provinces of the country is used for the period of 2007-2019. The data of Tehran and Alborz provinces are collected together from 2010 to 2019. The data of GDP, the population, the urban population and the production (output) of economic activities were extracted from Statistics Center of Iran. The data of natural gas consumption extracted from hydrocarbon energy balance sheet and natural gas price extracted from Iran energy balance sheet. The index of changes in production structure is calculated according to Cortuk and Singh (2011) as follows:

$$NAV = 0/5\sum_{i=1}^{n}\left|x_{it} - x_{is}\right| \tag{7}$$

In this index, x_{it}, is the share of the sector i of the total production in the time t, and x_{is}, is the share of the sector i of the total production in the time s. The value of this index is between zero and one, if the structure of production in the economy has not changed, the value of this index is zero, and if the whole economy has changed, then the value is one.

Results

Changes in production structure in provinces

The index of structural changes (Eq. 7) was calculated for each province for the 11 years (2007-2018) under study, and then its average was obtained for each province. The average of this index for each province is shown in Fig. 1. Based on Fig. the highest coefficient of change in production structure belongs to Tehran, Khorasan Razavi and Hormozgan provinces. The least change in the production structure belongs to the provinces of Azerbaijan Gharbi, Qazvin and Khorasan Jonoobi.

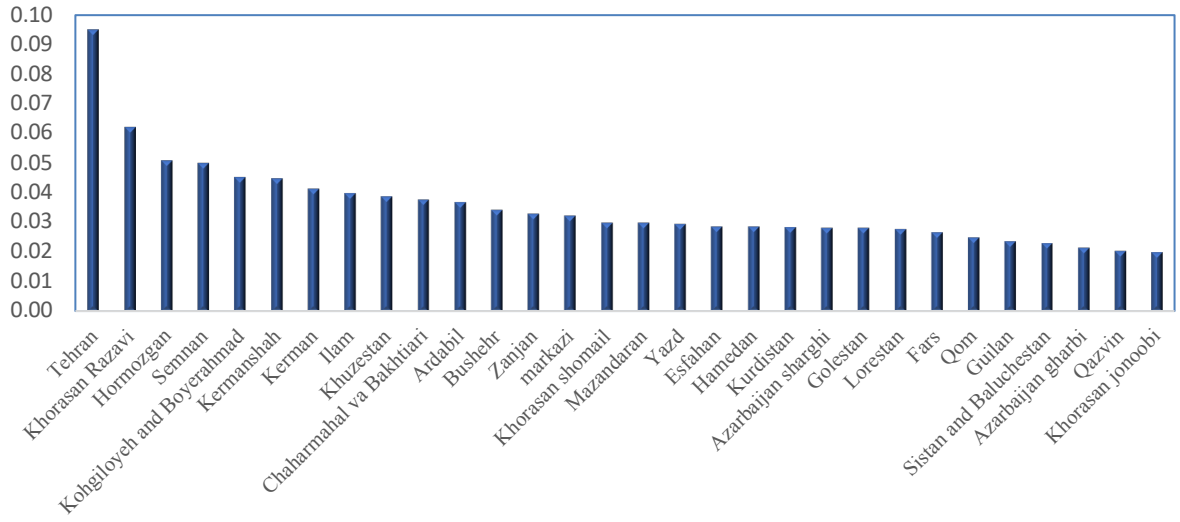

Figure 1. Average structural changes in production during 2007-2018.

Unit root test of variables

Using non-stationary data in econometric models leads to spurious regression. Therefore, in the first step, stationary of the data used in the model should be ensured. Table 1 shows the result of unit root test for research variables.

Table 1. Unit Root test (LLC test for stationary)

Variables		Level		First difference	
		Probe	Result	Probe	Result
Log of Gas Consumption	LGC	0.00	stationary	-	-
Log of Gas Price	LGP	0.00	stationary	-	-
Log of GDP	LGDP	0.00	stationary	-	-
Share of the industry	SII	0.04	stationary	-	-
Production Structure Change	PSC	0.00	stationary	-	-
Urbanization Rate	UR	0.34	Non-stationary	0.00	Stationary

The unit root test for the LOG of natural gas consumption (LGC), LOG of natural gas price (LGP), LOG of GDP (LGDP) and the share of the industry sector (SII), the change in the structure of production (PSC) shows that these variables have not unit root at level (I(0)) and the urbanization rate is stationary with one difference (I(1)).

Cointegration test:

Since all research variables were not stationary, it is necessary to check the existence of Cointegration between the data of the model. In this study, Pederoni's test was used to check the Cointegration test. The results of this test are shown in table 2.

Table 2. Pederoni co-integration test

Pederoni statistics	Probe	Result
-28.23	0.000	There is co-integration between data

The results of the model indicate that there is the Cointegration between data and the data can be used to estimate the model.

Spatial Hausman test:

One of the necessary tests in panel models is the choice of effect type (fixed effects or random effects). Spatial Hausman test is used to choose between fixed effects and random effects model in spatial econometrics. The result of the Hausman test is shown in Table 3. According to Table 3, the fixed effects model is better than the random effects model and the model should be estimated based on the fixed effects.

Table 3. Spatial Hausman test

Hausman statistics	Probe	Result
12.07	0.001	Fixed effect

Diagnosis test for spatial econometrics models:

After determining the type of effects (fixed or random), the type of spatial model can be determined in the next step. As mentioned, in this study, the Elhurst (2014) method is used to

detect the type of spatial model. The result of Wald's tests to identify the type of spatial model according to the Elhurst method is shown in the table below.

Table 4. Wald tests

Test	Stat.	Probe	Result
Wald test for selection between SDM and SAR	6.14	0.0004	SDM
Wald test for selection between SDM and SEM	7.21	0.0002	SDM

According to the test of selecting between two SDM and SAR models for the natural gas consumption function, since the value of the probability level is less than five percent, the SDM model is more suitable. Also, according to the test of distinguishing between SDM and SEM models, since the calculated probability statistic is less than 5 percent, then the more appropriate model is the SDM model. Finally, the model should be estimated based on the SDM model with fixed effects.

Estimation results

The result of estimation is shown in Table 5. As shown in the table, the direct effects of all variables are significant. The direct effect of natural gas price (LGP) on the consumption of this energy is negative and significant. The direct effect coefficient of this variable shows that if the price of natural gas in the region increases by one percent, the amount of energy consumption will decrease by 0.63 percent. The indirect/ spillover effect of this variable is not significant. In other words, the change in the price of natural gas in one region does not have a significant effect on the consumption of this energy in other regions.

Table 5. Result of estimation

Variables		Direct effect		Indirect (spillover) effect	
		Coeff.	Prob	Coeff.	Prob
Log of Gas Price	LGP	-0.63	0.000	-0.207	0.12
Log of GDP	LGDP	0.2	0.001	0.85	0.37
Share of the industry	SI	0.26	0.02	0.09	0.06
Production Structure Change	PSC	0.14	0.02	0.103	0.02
Urbanization Rate	UR	0.81	0.03	0.06	0.87

The direct effect of GDP on natural gas consumption is significant. The direct coefficient of this variable shows that for every one percent increase in the region's GDP, the amount of natural gas consumption will increase by 0.2 percent. The indirect (spillover) effect of GDP on natural gas consumption is not significant.

The direct effect of industrialization (Share of the industry) on natural gas consumption is positive and significant. The direct coefficient of this variable shows that for one percent increase in the industrialization index, the amount of natural gas consumption in the region will increase by 0.26 percent. The spillover effect of this variable is also positive and significant on natural gas consumption. The indirect coefficient of this variable (0.09) shows that for one percent in the industrialization index in a region, natural gas consumption in other nearby regions will increase by 0.09 percent. One of the reasons for the increase in energy consumption in neighboring regions due to the increase in the share of industry (industrialization) in one region can be in the dependence between the industry sectors of neighboring provinces. In this way, following the increase in the production of the industrial sector of one province, the industrial production of the neighboring provinces will increase (due to the linkages between

the industrial sectors in the two provinces) and as a result, the consumption of natural gas will also increase.

The index of production structure change has had a direct and significant effect on the amount of natural gas consumption. The direct coefficient of this variable shows that for every one percent change in the production structure within the region, natural gas consumption increases by 0.14 percent. The indirect coefficient of this variable shows that for every one percent change in the production structure within the region, the amount of natural gas consumption in other nearby regions will increase by 0.1 percent.

The direct effect of urbanization on natural gas consumption has been positive and significant. The direct coefficient of this variable shows that for a one percent increase in the urbanization rate, the amount of natural gas consumption will increase by 0.81 percent. The indirect effect of this variable on natural gas consumption was not significant.

Comparing the direct coefficients of the variable shows that the rate of urbanization has the most direct effect on energy consumption. After this variable, industrialization has had the greatest effect on energy consumption in different provinces. The effect of changes in production structure has had the least direct effect on natural gas consumption. Investigating the spillover effects of variables shows that only two factors of industrialization and change in production structure have had positive and significant spillover effects on natural gas consumption. Among these two variables, industrialization has had a greater effect than changing the structure of production on natural gas consumption.

Conclusion

The volume and structure of production in an economy are of the basic factors in the amount of energy consumption in that economy. Therefore, changing the volume of production and changing the structure of production in that country can lead to changes in the consumption of all types of energy. Therefore, the purpose of this study is to investigate the effect of changes in the production structure on natural gas consumption in 30 provinces of Iran during 2007-2018. To achieve this goal, a spatial econometric approach has been used. The reason for using this model was to investigate the spillover effects of variables (such as changes in structure of production) on natural gas consumption.

The results of the model indicate, the direct effect of natural gas price (LGP) on the consumption of this energy is negative and significant. The direct effect coefficient of this variable shows that if the price of natural gas in the region increases by one percent, the amount of energy consumption in that region will decrease by 0.63 percent. The indirect/ spillover effect of this variable is not significant. In other words, the change in the price of natural gas in one region does not have a significant effect on the consumption of this energy in other regions. This result is consistent with the results of Wang et al. (2019).

The direct effect coefficients of variables have shown that the urbanization rate has the highest coefficient of direct effect. This result is consistent with the results of Pomani and Kanko (2010), Zhang and Lin (2012), Issazadeh and Mehranfar (2012), Salatin and Mohammadi (2016), Wang et al. (2016), Karimi and Heydarian (2017) and Chen et al. (2018). Based on this result, national and regional policy makers should adopt appropriate policies for optimal natural gas consumption in urban areas. Encouraging urban consumers to modify the pattern of natural gas consumption through different pricing for consumers can be one of the ways to adjust natural gas consumption due to the increase in the rate of urbanization. Improving the culture of natural gas consumption in urban households and promoting optimal consumption among these households is another way to reduce natural gas consumption. Investigating the direct effect of industrialization had positive and significant effects on natural gas consumption. This result is consistent with Kamali Dehkordi et al. (2021). Investigating the

spillover effects of variables shows that two factors industrialization and change in production structure have had positive and significant spillover effects on natural gas consumption. Based on this result, the interregional linkages should be considered in regional modeling and studies in different areas such as economic growth or energy consumption and environment. Also, energy consumption (Natural gas) in the production process should be more efficient, especially in sectors with high energy consumption. In this regard, it will be very helpful to identify sectors with high production in the economy and high energy consumption, as well as to examine the trend of changes in the intensity of energy consumption in these sectors.

Among industrialization and change in production structure, industrialization has had a greater spillover effect than changing the structure of production on natural gas consumption. This shows that the process of industrialization will cause more demand for natural gas consumption. Therefore, in order to achieve economic growth and development through industrialization, the first step should be to supply natural gas to industries. On the other hand, to save natural gas consumption, industries with high natural gas consumption intensity should be identified and appropriate policies should be implemented to increase the efficiency of natural gas consumption in these industries. Also, the dependence between industries in different regions has intensified energy consumption. Based on this, it is suggested that in the first stage, the industries with high energy intensity in the region should be studied and investigated so that a suitable plan can be made to reduce the intensity of energy consumption in these industries. Also, the relationship between industries in different regions (the backward and forward linkages of industries in the regions) should also be investigated so that energy consumption planning can be done at the inter-regional and national level.

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