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Application of Panel Data Seemingly Unrelated Regression in Consumption of Hydrocarbon Energy Carriers

Parastoo Boroomandfar[1], Alireza Daghighi Asli[2*], Azadeh Mehrabian[3], and Marjan Daman Keshideh[3]

[1]Ph.D. Student, Department of Economics, Central Tehran Branch, Islamic Azad University, Tehran, Iran
[2]Assistant Professor, Department of Economics, Central Tehran Branch, Islamic Azad University, Tehran, Iran
[3]Assistant Professor, Department of Economics, Central Tehran Branch, Islamic Azad University, Tehran, Iran

Highlights

- This work examines seemingly unrelated regression (SUR) model in economic sectors in Iran.
- Four sectors of economic in Iran are residential–commercial, industry, agriculture, and transportation.
- An increase in weighted average price can lead to the optimal use of energy consumption in four sectors.

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Abstract

This study collected consumption data of hydrocarbon energy carriers in Iran from 1982 to 2017. A seemingly unrelated regression (SUR) model in a balanced panel data approach was proposed. It can be beneficial to control energy demand. The results revealed that in the residential-commercial sector, the consumption of hydrocarbon energy carriers with lag has a positive effect. The weighted average price of petroleum energy carriers negatively impacts the consumption of hydrocarbon energy carriers. In the industry sector, the consumption of hydrocarbon energy carriers with lag has a positive effect on the usage of hydrocarbon energy carriers, and the weighted average price of petroleum energy carriers negatively impacts the consumption of hydrocarbon energy carriers. In the agriculture sector, the variables of energy intensity, the added value of the agriculture sector, population, and consumption of hydrocarbon energy carriers with lag positively impact the usage of hydrocarbon energy carriers in this sector. In the transportation sector, gross domestic product, the extremity of energy usage in the transportation part, and the consumption of hydrocarbon energy carriers with lag have a positive impact on the use of hydrocarbon energy carriers in this sector and a negative effect on the consumption of hydrocarbon.

Keywords: Seemingly Unrelated Regression, Panel Data, Hydrocarbon Energy Carriers Consumption, Iran

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1. Introduction

The seemingly unrelated regression (SUR) model has recently gained popularity in different phenomena like energy, finance, and health. It is simply a generalization of a linear regression model involving more than one equation, and each equation has its own dependent variable and different sets of explanatory variables. Still, all the errors in the model are contemporaneously correlated. Many

* Corresponding author:
Email: daghighiasli@gmail.com

estimation methods in the SUR model have been proposed in classical inference. Zellner described a method of estimating the parameters of the SUR model. This method entails the application of generalized least squares (GLS) to the entire system of equations. It was revealed that regression coefficients using the estimators are at least asymptotically more efficient than the equation-by-equation OLS method (Oluwadare, 2020).

Iran has a privileged position compared to other countries regarding rich and extensive oil and gas resources. Iran is one of the seven leading countries in in-site oil reserves and the second country having natural gas resources; its current geographical situation has an extraordinary and unique place that could make Iran one of the best actors of the world economic future (Salimian and Shahbazi, 2017). These vast resources and ease of access have led to the country's desired energy supply and have caused foreign exchange earnings. Unfortunately, our irrational behavior with power over the past several decades has led to excessive consumption in unproductive and polluted environmental sectors. Moreover, the currency generated from exporting these resources has made the government budget heavily dependent on oil revenues. Further, the dual function of oil resources in terms of energy supply and foreign exchange earnings has resulted in the neglect of serious attention to these two issues over the past century. Excessive resource usage is impossible in the long run because the Earth's natural resources are finite. Thus, it is easy to imagine that we will exhaust all of the country's non-renewable resources at a point in the future (Hadian and Ostadzad, 2021).

The purpose of this research is to know the consumption framework of hydrocarbon energy carriers in Iran to provide a sufficient amount of energy at an acceptable cost to meet the country's demand and, at the same time, protect the environment from pollution.

There is no way to achieve sustainable economic growth and development without recognizing mutual relationships among economic sectors and formulating appropriate policies. Due to the significant importance of this issue, it has been proposed in the Sixth Five-Year Development Plan as one of the policies for accelerated, sustainable, and job-creating economic growth.

A review of studies shows that research on the consumption of hydrocarbon products has been done in only one sector or in general and without considering the economic sectors. In the present study, the consumption of these products is simultaneously investigated in four sectors in Iran: residential–commercial, agriculture, industry, and transportation.

Thus, the procedure of this study is to apply panel data SUR model to analyze the consumption of hydrocarbon energy carriers in Iran by sectors. In the following, the theoretical foundations and background of the research are examined, and then the equations of consumption of hydrocarbon products are explained. After that, the data analysis method and research method, including second-generation unit root test and seemingly unrelated regression, are reviewed; finally, the research results are reviewed and analyzed.

2. Theoretical background and literature review

2.1. Seemingly unrelated regression model

Consider the seemingly unrelated regression (SUR) model is given as follows:

$$\begin{aligned} y_1 &= X_1\beta_1 + \varepsilon_1 \\ y_2 &= X_2\beta_2 + \varepsilon_2 \\ y_M &= X_M\beta_M + \varepsilon_M. \end{aligned} \quad (1)$$

M equations and *T* observations are in the sample of data used to estimate them. The second and third examples embody different types of constraints across equations and other structures of the disturbances. A basic set of principles will apply to them all, however. The seemingly unrelated regressions model in Equation 1 is given by:

$y_i = X_i\beta_i + \varepsilon_i. \quad i = 1, \ldots, M.$

Define the MT × 1 vector of disturbances

$\varepsilon = [\acute{\varepsilon}_1 . \acute{\varepsilon}_2 . \ldots . \acute{\varepsilon}_M]\acute{}$

We assume strict exogeneity of X_i, (2)

$\mathrm{E}[\varepsilon | \mathrm{X}_1 . \mathrm{X}_2 . \ldots . \mathrm{X}_\mathrm{M}] = 0$

and homoscedasticity

$\mathrm{E}[\varepsilon_\mathrm{m} \acute{\varepsilon}_\mathrm{m} | \mathrm{X}_1 . \mathrm{X}_2 . \ldots . \mathrm{X}_\mathrm{M}] = \sigma_{mm} I_T$

We assume that a total of *T* observations is used in estimating the parameters of the *M* equations. Each equation involves K_i regressors, for a total of $K = \sum_{i=1}^{M} \mathrm{K}_i$. We will require $T > \mathrm{K}_i$. The data are assumed to be well-behaved, and we shall not treat the issue separately here. For the present, we also believe that disturbances are uncorrelated across observations but correlated across equations. Therefore, we may have:

$\mathrm{E}\left[\varepsilon_{\mathrm{it}} \varepsilon_{\mathrm{js}} \middle| \mathrm{X}_1 . \mathrm{X}_2 . \ldots . \mathrm{X}_\mathrm{M}\right] = \sigma_{ij}.$ if $t=s$ and 0 otherwise.

The disturbance formulation is, therefore

$\mathrm{E}\left[\varepsilon_\mathrm{i} \acute{\varepsilon}_\mathrm{j} \middle| \mathrm{X}_1 . \mathrm{X}_2 . \ldots . \mathrm{X}_\mathrm{M}\right] = \sigma_{\mathrm{ig}} I_T$

or (3)

$$\mathrm{E}[\varepsilon\acute{\varepsilon} | X_1 . X_2 . \ldots . X_M] = \Omega = \begin{bmatrix} \sigma_{11} I & \sigma_{12} I & \ldots & \sigma_{1M} I \\ \sigma_{21} I & \sigma_{22} I & \ldots & \sigma_{2M} I \\ & \vdots & & \\ \sigma_{M1} I & \sigma_{M2} I & \ldots & \sigma_{MM} I \end{bmatrix}$$

2.2. Generalized least squares

Each equation is, by itself, a classical regression. Therefore, the parameters could be estimated consistently, if not efficiently, by ordinary least squares one equation at a time. The generalized regression model applies to the stacked model:

$$\begin{bmatrix} y_1 \\ y_2 \\ \vdots \\ y_M \end{bmatrix} = \begin{bmatrix} X_1 & 0 & \ldots & 0 \\ 0 & X_2 & \ldots & 0 \\ & & \vdots & \\ 0 & 0 & \ldots & X_M \end{bmatrix} \begin{bmatrix} \beta_1 \\ \beta_2 \\ \vdots \\ \beta_M \end{bmatrix} + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \vdots \\ \varepsilon_M \end{bmatrix} = \quad (4)$$

$X\beta + \varepsilon$

Therefore, the efficient estimator is generalized least squares. The model has an exceptionally convenient form. For the *t*th observation, the *M* × *M* covariance matrix of the disturbances is given by:

$$\sum = \begin{bmatrix} \sigma_{11} & \sigma_{12} & \cdots & \sigma_{1M} \\ \sigma_{21} & \sigma_{22} & \cdots & \sigma_{2M} \\ & \vdots & & \\ \sigma_{M1} & \sigma_{M2} & \cdots & \sigma_{MM} \end{bmatrix} \tag{5}$$

So, in Equation 3:

$$\Omega = \sum \otimes I \tag{6}$$

Denoting the *ij*th element of $\sum^{-1}$ by σ_{ij}, we find that the GLS estimator is defined as:

$$\hat{\beta} = [\acute{X}\Omega^{-1}X]^{-1}\acute{X}\Omega^{-1}y = [\acute{X}(\sum^{-1} \otimes I)X]^{-1}\acute{X}(\sum^{-1} \otimes I)y \tag{7}$$

The likelihood ratio statistics requires the unrestricted MLE to compute the residual covariance matrix under the alternative so that it can be cumbersome. A simpler alternative is the Lagrange multiplier statistic developed by Breusch and Pagan (1980), which is defined as:

$$\lambda_{LM} = T\sum_{i=2}^{M}\sum_{j=1}^{i-1} r_{ij}^2 = (T/2)[\text{trace}\,(\acute{R}R) - M] \tag{8}$$

where R is the sample correlation matrix of the M sets of T's OLS residuals. This has the same large sample distribution under the null hypothesis as the likelihood ratio statistics but is more accessible to compute as it only requires the OLS residuals (Greene, 335–338).

3. Previous studies

Sadrzadeh Moghadam et al. (2013) estimated the function of energy demand, price elasticity, and substitution of inputs in the industry sector with a seemingly unrelated regression model. The variables used in this research are energy consumption, industrial added value, and energy price index (weighted average price of gasoline, gas oil, kerosene, and fuel oil considering their small share in energy consumption). The results of this study showed that energy demand in Iran is low elasticity, the income of the industrial part in the previous time will not affect the energy consumption amount in the current period, changes in energy carrier prices have little effect on energy usage in industrial part, and increasing the amount of energy consumption in previous period will increase the amount of consumption in the current period. Kim et al. (2015) analyzed the impact of a household head's telecommuting on household travel while controlling for the interdependence within a household and across travel purposes by applying seemingly unrelated censored regression models in the Seoul Metropolitan Area. The analysis showed that telecommuters' non-commute and non-work trips and their household members' non-work trips were greater than those of non-telecommuters and their household members, whereas telecommuting partially reduced commuting trips.

With seemingly unrelated regression, Mao (2016) evaluated the relationship between capital income, economic growth, and income inequality. The empirical results showed that capital income taxes negatively influenced economic growth and income inequality. Ozturk (2017) explored the impact of alternative and nuclear energy consumption, fossil fuel energy consumption, carbon dioxide emissions (CO_2), and oil rent on economic growth and foreign direct investment in the panel of nine Latin American countries from 1975 to 2013. The result of pooled seemingly unrelated regression indicated fossil fuel energy consumption increased along with GDP per capita in Bolivia, Chile, Colombia, and Venezuela.

To address the correlation and heterogeneity, Xu et al. (2018) proposed a seemingly unrelated regression model in an unbalanced panel data approach, in which the seemingly unrelated model addressed the correlation of residuals, while the panel data model accommodated the heterogeneity due to unobserved factors. By comparing the pooled, fixed-effects, and random-effects SUR models, the random-effects SUR model showed priority to the two others. The results revealed that (1) low visibility and the number of invalid traffic signs per kilometer increased the accident rate of material damage, death, or injuries; (2) average speed limit exhibited a high accident rate of death or injuries; (3) the number of mandatory signs was more likely to reduce the accident rate of material damage, while the number of warning signs was significant for an accident rate of death or injured.

Amiri and Fakhari (2020) investigated financial reporting in Iran from 2011–2018. They used the seemingly unrelated regression method to examine financial reporting and auditor comment data. Their findings showed a two-way inverse relationship between financial reporting and auditor comment. Varahrami and Kolivand (2020) used the PANEL-SUR model to survey the effects of human health on economic growth for oil countries from 1995 to 2017. The innovation of this paper was estimating an endogenous economic growth model with a survey of the effect of human health on economic growth and the effect of environmental pollution on human health. Their results revealed that environmental pollution had a negative effect on the health index and human development index. There was a negative relation between pollution and economic growth because of a positive relation between the health index and human development index and a positive relation between the human development index and economic growth; more pollution decreased the positive effect of the human development index on economic growth.

Abdul Mottaleb and Rahut (2021) examined the factors influencing fuel choice and investigated the fuel consumption behavior of urban households in India. The SUR estimation procedure's result explained the factors influencing the dependency on three broad fuel categories over the sampled years. Their findings presented regional heterogeneity in the dependence on a specific energy source among urban households. Compared to West Indian states, households from Northeast India, Central India, East India, and North India tended to rely more on biomass, kerosene, and coal and less on gas and electricity. Anik and Rahman (2021) used the OLS and SURE model estimates to forecast energy demand in Bangladesh for two decades (2019–2038). The strategies they followed can be classified into two broad categories. First, to forecast demand, they need to know the future values of the independent variables. Afterward, using the estimated coefficients of the OLS and SURE models, they forecasted the aggregate coal, gas, and oil demands using the forecast and forecast-solve command. In addition, they did an in-sample forecast using the estimates and forecast-solve commands. They calculated the 95% upper and lower bounds of the confidence interval to check the accuracy of their forecasts.

Fadaee and Veisi (2021) used a seemingly unrelated regression estimator to estimate factors affecting energy intensity in manufacturing industries with 10 or more employees in Iran. They compared energy-based industries and non-energy-based industries. Their results showed that while energy prices were inversely related to energy intensity in both sectors, the effect of rising energy prices on reducing energy intensity in energy-intensive industries was much more significant. The ownership structure and industrial concentration were also inversely related to the energy intensity of the industry. More privatization and increased industrial concentration would reduce energy intensity, especially in energy-based industries. The effect of research and development costs on energy intensity was either insignificant or, contrary to expectations, directly related to energy intensity. Royal et al. (2022) investigated the sustaining connection of renewable energy consumption with trade openness, oil rent, oil prices, and carbon dioxide emissions of the G7 (Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States besides the European Union) nations over the period 1971–2019 using FMOLS and DOLS approach to panel data for analyzing the long-run elasticity and SUR for estimating the short-run elasticities. In this research, higher oil rent was desired to further strengthen renewable energy generation and consumption, as the findings implied.

The current paper develops an SUR model, a model not used in other studies that have estimated models for the consumption of hydrocarbon energy carriers in Iran.

4. Research model and estimation method

This research uses panel data from four sectors of the Iranian economy: residential–commercial, industry, agriculture, and transportation. The system of equations used in this research includes the consumption of hydrocarbon products in the mentioned sectors, based on the experimental studies of Kialashaki-Reisel (2013, 2014) and Ghader et al. (2006). These models include:

$$Ckh_t = \alpha_1 + \beta_{11}POP_t + \beta_{12}GDP_t + \beta_{13}Income_t + \beta_{14}P_{it} + u_{1t} \quad (9)$$

$$Cs_t = \alpha_2 + \beta_{21}vas + \beta_{22}POP_t + \beta_{23}P_{it} + \beta_{24}eis_t + \beta_{25}\,Cs_{t-1} + u_{2t} \quad (10)$$

$$Ck_t = \alpha_3 + \beta_{31}vak_t + \beta_{32}POP_t + \beta_{33}P_{it} + \beta_{34}eik + \beta_{35}Ck_{t-1} + u_{3t} \quad (11)$$

$$Ch_t = \alpha_4 + \beta_{41}POP_t + \beta_{42}GDP_t + \beta_{43}P_{it} + \beta_{44}CAR_t + u_{4t} \quad (12)$$

In this research Cs_{t-1} and Ck_{t-1} variables (the consumption of hydrocarbon energy carriers in industry and agriculture sectors with lag) have been added to the model.

Table 1

Definition of variables

Variable	Definition	Unit of measurement	Research model
ckh	Consumption of hydrocarbon energy carriers in the residential–commercial sector	Million barrels of oil equivalent	Kialashaki-Reisel (2013)
cs	Consumption of hydrocarbon energy carriers in the industry sector	Million barrels of oil equivalent	Ghader et al. (2006)
ck	Consumption of hydrocarbon energy carriers in the agriculture sector	Million barrels of oil equivalent	Ghader et al. (2006)
ch	Consumption of hydrocarbon energy carriers in the transportation sector	Million barrels of oil equivalent	Kialashaki-Reisel (2014)

Variable	Definition	Unit of measurement	Research model
cs_{t-1}	Consumption of hydrocarbon energy carriers in the industry sector with lag	Million barrels of oil equivalent	Ghader et al. (2006)
ck_{t-1}	Consumption of hydrocarbon energy carriers in the agriculture sector with lag	Million barrels of oil equivalent	Ghader et al. (2006)
car	Number of cars	Devise	Kialashaki-Reisel (2014)
pop	Population	Thousand	Kialashaki-Reisel (2013)
gdp	Gross domestic product	Billion Rials	Kialashaki-Reisel (2013), Kialashaki-Reisel (2014)
Income	Average annual household income	Thousand Rials	Kialashaki-Reisel (2013)
vas	Value added to the industry sector	Billion Rials	Ghader et al. (2006)
vak	Value added to the agriculture sector	Billion Rials	Ghader et al. (2006)
eis	Energy intensity of the industry sector	Million barrels of oil equivalent\Billion Rials	Ghader et al. (2006)
eik	Energy intensity of the agriculture sector	Million barrels of oil equivalent\Billion Rials	Ghader et al. (2006)
pb	Price of petrol	Liter\Rials	Kialashaki-Reisel (2013), Kialashaki-Reisel (2014), and Ghader et al. (2006)
Pg	Price of natural gas	Liter\Rials	Kialashaki-Reisel (2013), Kialashaki-Reisel (2014), and Ghader et al. (2006)
pns	Price of kerosene	Liter\Rials	Kialashaki-Reisel (2013), Kialashaki-Reisel (2014), and Ghader et al. (2006)
pnk	Price of fuel oil	Liter\Rials	Kialashaki-Reisel (2013), Kialashaki-Reisel (2014), and Ghader et al. (2006)
png	Price of gasoline	Liter\Rials	Kialashaki-Reisel (2013), Kialashaki-Reisel (2014), and Ghader et al. (2006)

The data used in this study is at a fixed price in 2011, and the source of this data is the time series data of the Central Bank of Iran and the energy balance sheet. Because panel data have been used in this research, the correlation between sections is first investigated. After determining the result, the unit root test is performed.

According to Phillips and Sol, the results obtained from the unit root test will not be accurate and reliable when there is a correlation between the sections. Pesaran (2005) proposed a solution to this problem. The cross-section augmented Dickey-Fuller (CADF) test was used in this method. The CADF regression is as follows (Haghighat,2015):

$$\Delta Y_{it} = \alpha_i + \gamma_i^* Y_{it-1} + c_i \bar{Y}_{t-1} + \sum_{j=1}^{P} \rho_{ij}\, \Delta Y_{it-j} + \sum_{j=1}^{P} d_{ij}\, \Delta \bar{Y}_{t-j} + \varepsilon_{it} \tag{13}$$

After estimating this equation for each section, the trace statistic for γ_i^* (CADF$_i$) is obtained as follows:

$$CIPS = \frac{1}{N}\sum_{i=1}^{N} CADF_i \tag{14}$$

The results of the cross-sectional dependence test show that except for the consumption variables of hydrocarbon products, other variables are nonstationary, so the growth values of the variables are examined with the second-generation unit root test. This test shows that the growth values of all variables are nonstationary.

Table 2

Second generation unit root test, Pesaran (2007) (CIPS)

Variables	Critical value			Stationarity
	1%	5%	10%	
gcar	–2.3	–2.1	–2	*
gckh	–2.4	–2.1	–2	*
gcs	–2.4	–2.1	–2	*
gck	–2.4	–2.1	–2	*
gch	–2.4	–2.1	–2	*
geis	–2.3	–2.1	–2	*
geik	–2.3	–2.1	–2	*
ggdp	–2.4	–2.1	–2	*
gincome	–2.4	–2.1	–2	*
gpop	–2.4	–2.1	–2	*
gvas	–2.4	–2.1	–2	*
gvak	–2.4	–2.1	–2	*
gpg	–2.4	–2.1	–2	*
gpb	–2.4	–2.1	–2	*
gpns	–2.4	–2.1	–2	*
gpnk	–2.4	–2.1	–2	*
gpng	–2.4	–2.1	–2	*

In this study, four equations are examined. Two methods of single equations and a system of equations can be used to estimate the consumption equations of hydrocarbon products. Still, since the four equations are four parts of one *Economy* (Iran's economy), a simultaneous correlation between disruption sentences is not unexpected; therefore, this research examines the possibility of using a seemingly unrelated regression method first. If the possibility of using this method is confirmed, the estimation of panel data in seemingly unrelated regression will be the criterion.

Seemingly unrelated equations allow the coefficients of the equations and the variance of the coefficients to change, as well as residuals in the system of equations, to be correlated simultaneously.

Before estimating the equations in the mentioned method, it is necessary to check the correlation coefficients between residuals in the four equations. The LM test statistics is used to test for correlation coefficients between residuals. The result of the LM test is presented in Table 3.

Table 3

The correlation matrix of residuals (the LM test)

Distribution of χ^2	f-Statistic	Degree of freedom	p-Value
Breusch-Pagan test	98	6	0.000

Table 4

The correlation matrix of residuals

Sector	Residential-commercial	Industry	Agriculture	Transportation
Residential–commercial	1.000	0.548	0.204	0.097
Industry	0.548	1.000	0.376	0.869
Agriculture	0.204	0.376	1.000	0.356
Transportation	0.097	0.869	0.356	1.000

Table 4 lists the matrix of correlation coefficients between residuals. According to Tables 3 and 4, the correlation coefficients between residuals of the four equations of the household–commercial, industry, agriculture, and transportation sectors are confirmed. Therefore, the seemingly unrelated regression method can be used to estimate the system of equations.

According to the χ^2 table, the critical value is 12.6 for a degree of freedom of 6; thus, according to the results of LM and *Pval*, there is a correlation coefficient between residuals of the four sections, and the seemingly unrelated regression model is appropriate.

In this research, the basic model was first examined. Due to the insignificance of the coefficients in some equations, several variables were added or removed. The final model is selected as follows.

$$ckh_t=gpop_t+ggdp_t+mwp_t+gincome_t+gpg_t+ckh_{t-1}+gcpi_t \quad (15)$$

$$cs_t=gvas_t+gpop_t+mwp_t+gpg_t+geis_t+cs_{t-1} \quad (16)$$

$$ck_t=gvak_t+gpop_t+mwp_t+gpg_t+geik_t+ck_{t-1} \quad (17)$$

$$ch_t=gpop_t+ggdp_t+mwp_t+gpg_t+gcar_t+ch_{t-1}+gEih_t \quad (18)$$

Table 5
The results of estimating equations by the method of seemingly unrelated regression

Variables	Transportation	Agriculture	Industry	Residential–commercial
gpop	–0.372*	0.024	–0.053*	–0.056*
ggdp	0.271			0.309*
mwp	–0.050	–0.001*	–0.023	–0.031
gincome				–0.068*
gpg	0.028*	–0.002*	0.012*	0.024*
Ckh_{t-1}				1.043
gcpi				–0.027*
gvas			0.000*	
geis			–0.019*	
Cs_{t-1}			1.028	
gvak		0.067		
geik		0.073		
Ck_{t-1}		1.027		
gcar	0.006*			
Ch_{t-1}	1.039			
geih	0.246			
R_2	98%	99%	98%	98%
RMSE	0.499	0.344	0.045	0.519

5. Conclusions

The primary purpose of this article was to use a seemingly unrelated regression method to estimate the consumption of hydrocarbon energy carriers in Iran. The seemingly unrelated regressions model Zellner (1962) developed is perhaps the most widely used econometric model after linear regressions. The reason is that it provides a simple and helpful representation of systems of demand equations that arise in neoclassical static theories of producer and consumer behavior. In addition, by joint analysis of the set of regression equations rather than equation by equation analysis, more precise estimates and predictions are obtained, leading to better solutions to many applied problems.

The results of this research showed that:

- The residential–commercial sector showed that the consumption of hydrocarbon energy carriers with lag positively impacted current usage, and the weighted average price of petroleum energy carriers had a negative effect on the use of hydrocarbon energy carriers. These results were not consistent with Lim's findings (2019) but were consistent with the findings of Asadi et al. (2019), Hashemi et al. (2019), Ashouri et al. (2019), Li and Just (2018), He et al. (2016), and Zhao et al. (2012).
- In the industry sector, the consumption of hydrocarbon energy carriers with lag positively impacted the usage of hydrocarbon energy carriers. This outcome was consistent with the findings of Sadrzadeh Moghadam et al. (2013). The weighted average price of petroleum energy carriers negatively impacted the usage of hydrocarbon energy carriers.

- In the agriculture sector, the variables of energy intensity, the value added to the agricultural part, population, and consumption of hydrocarbon energy carriers with lag positively impacted the usage of hydrocarbon energy carriers in this sector. These conclusions aligned with the findings of Ziaabadi and Zare Mehrjerdi (2019).
- In the transportation sector, GDP, the intensity of energy consumption, and the consumption of hydrocarbon energy carriers with lag positively impacted the usage of hydrocarbon energy carriers. The weighted average price of petroleum energy carriers had a negative effect on the consumption of hydrocarbon product carriers. These results did not match the findings of Tianxiang and Xu (2019) and Kialashaki and Reisel (2014).

6. Recommendations

It is possible to control the consumption of hydrocarbon energy carriers by tax incentives to improve the consumption of hydrocarbon energy carriers in the residential, commercial, and industrial sectors.

If the policy for increasing energy prices continues in the industry sector, pricing policies will effectively manage hydrocarbon energy demand. Therefore, the price mechanism can create an incentive to save energy consumption in the long run. Whenever the growth in the price of energy carriers causes an increase in the cost of industrial products in the market, it may reduce the competitiveness of goods in the local and foreign markets, negatively affecting industrial production.

Therefore, several goals should be considered in the pricing policy of energy carriers. First, the pricing of energy carriers should lead to their optimal use in industry units and prevent excessive energy consumption. Second, in the long run, by reducing or eliminating energy subsidies, the cost of industry products will be affordable and competitive with similar products in domestic and foreign markets.

In the agriculture sector, we can reduce the cost of using hydrocarbon energy carriers and increase the added value of this sector by replacing traditional agricultural methods with modern methods and adopting appropriate policies to properly implement energy efficiency strategies.

We can reduce the energy consumption of the transportation sector by examining the fuel consumption of all types of vehicles, both domestic and imported, examining the status of production fuels, examining the traffic situation, and planning for the optimal use of different transportation methods.

The increase in weighted average price can lead to the optimal use of energy consumption in four sectors. Hence, it is suggested that in energy consumption research, the weighted average cost of all hydrocarbon energy carriers should be utilized instead of using the price of only one type of energy.

Nomenclature

CADF	Cross section augmented Dickey-Fuller
car	Number of cars
ch	Consumption of hydrocarbon energy carriers in the transportation sector
cips	Cross section augmented IPS
ck	Consumption of hydrocarbon energy carriers in the agriculture sector
ckt–1	Consumption of hydrocarbon energy carriers in the agriculture sector with lag
ckh	Consumption of hydrocarbon energy carriers in the residential–commercial sector
cs	Consumption of hydrocarbon energy carriers in the industry sector
cst–1	Consumption of hydrocarbon energy carriers in the industry sector with lag

eik	Energy intensity of the agriculture sector
eis	Energy intensity of the industry sector
gcar	Growth value of the number of cars
gch	Growth value of the consumption of hydrocarbon energy carriers in the transportation sector
gck	Growth value of the consumption of hydrocarbon energy carriers in the agriculture sector
gckh	Growth value of the consumption of hydrocarbon energy carriers in the residential–commercial sector
gcs	Growth value of the consumption of hydrocarbon energy carriers in the industry sector
geik	Growth value of the energy intensity of the agriculture sector
geis	Growth value of the energy intensity of the industry sector
gdp	Gross domestic product
gls	Generalized least squares
ggdp	Growth value of the gross domestic product
gincome	Growth value of the average annual household income
gpb	Growth value of the price of petrol
gpg	Growth value of the price of natural gas
gpng	Growth value of the price of gasoline
gpnk	Growth value of the price of fuel oil
gpop	Growth value of the population
gpns	Growth value of the price of kerosene
gvak	Growth value of the value added to the agriculture sector
gvas	Growth value of the value added to the industry sector
Income	Average annual household income
lm	Lagrange multiplier
pb	Price of petrol
Pg	Price of natural gas
png	Price of gasoline
pnk	Price of fuel oil
pop	Population
pns	Price of kerosene
Pval	P-value
SUR	Seemingly unrelated regression
vak	Value added to the agriculture sector
vas	Value added to the industry sector

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