

Predicting Consumption Rate of Natural Gas and Evaluating its Future Export Facilities

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ABSTRACT

Being aware of demand and consumption rate of natural gas in every period as well as its prediction for future is of the most important issues for Iran National Gas Company; since it is really important to consider future export plans, in addition to necessity of responding to the consumers and clients of the gas company. During recent decades, economists and management scientists have used econometric methods to determine demand and consumption rate. In this research, simultaneous equations system has been used to determine its production, consumption, and export rate obtained from difference between production and consumption. Additionally, the variable rates have been predicted in horizon 2021 using Excel program. Outputs, resulted from these studies and estimations, make it possible for Iran National Gas Company, engineers, planners and involving peoples to plan effectively for the volume of production, extent of consumption, and the most important, the exporting power and quantity of Iran gas that will have a remarkable effect on the exporting incomes. Results of the research indicate that export during the previous years and future predicted years is fluctuating and almost increasing process. But, the important point is that we will not be able to meet new export plans in case of lasting the current conditions. Changing domestic consumption pattern will provide export conditions for the new plans; otherwise, export capacity will not meet the conditions required to use the new plans and export.

KEYWORDS: Simultaneous equations system, Prediction of consumption rate, Demand and offer of natural gas, Natural gas, Resources of natural gas, Export

JEL CLASSIFICATION : C32, Q47, Q41

1. INTRODUCTION

Before high-rise in oil price in 1973, it was generally understood that there were opulent energy resources and there was no special concern regarding its offer insufficiency. Oil price shock attracted the attention of policy makers and economists toward planning in energy consumption so that energy became one of the determinant factors in directing interaction of the countries all over the world during initial years of the third millennium. Natural gas- one of the energy carries which has main advantages to other carriers considering environmental indexes, has attracted special attentions such that it has been used at higher scales in the countries producing natural gas including Russia, America and Middle East countries since oil crisis of 1970s. Also, other countries increasingly used natural gas as an alternative fuel considering its cleanness, easy application, high heat value, and availability. Of course, Iran was not excluded. Gaining benefit from more than 15% of the world natural gas resources, Islamic republic of Iran is the second country (after Russia) in this regard. We will notice the important role and position of natural gas as one of the main providers of energy required by different consumption sectors of the country at present and especially in future considering abundance and dispersion of gas resources in Iran; less extraction, refinement, process and transfer costs in comparison with oil; its durability and application capability to the next three centuries; its relative low and competitive price considering its high heat value in comparison with other fossil fuels and continuity of its availability; less pollution of the environment in comparison with other fuels; high foreign currency saving due to replacing other fuels by natural gas including, kerosene, gas oil, fuel oil (Mazout), and gasoline; non-energy applications in oil and petrochemical industries through its injection to oil tanks or changing it to different goods; and other advantages. Several factors including atmospheric variations, economic conditions and fuel replacement affect short-term and factors such as renovation of gas and electricity industry structures, demographic variations and population centers of a country, energy efficiency rule and technology advancement

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affect long-term demand of gas at home and commercial sectors. Demand volume for natural gas is always periodic. Gas is more demanded in cold seasons than warm ones. Most seasonal fluctuations of energy carrier demand of natural gas at home and commercial sector is related to temperature variations. Replacing oil products by the inexpensive and environment-friendly energies through developing gas-supplying networks, changing fuel of power stations and great industries to natural gas, using compressed natural gas (CNG) and liquid petroleum gas (LPG) as vehicles fuel, performing offer management in distribution of oil products which are regarded as the most important executed or in progress plans of energy offer management in Iran. A comprehensive planning is required in energy demand and consumption considering actions taken in offer management. Evaluating energy demand behavior as complementary of the country energy-planning sector may lead to modification of energy consumption pattern as well as great saving in energy consumption through correct performing of demand management.

Energy production and consumption behavior can be evaluated for different consumption sectors and different forms of energy carriers. For this purpose, the present research has evaluated production and consumption rate of natural gas during 1967-2007. Considering that export of natural gas is regarded as one of the most important ways of foreign currency income, its export capacity was calculated for natural gas using the differences found between production and consumption. On the other hand, production, consumption, and export rate were predicted to 2021.

2. LITERATURE REVIEW

Experiences of 1970s and 1980s resulted in high increase of studies regarding demand of kinds of energy including fossil and non-fossil fuels. It was the process restored due to increasing concerns about diffusion of greenhouse gases resulted from fossil fuels combustion. Therefore, several studies have been conducted on determining energy needs using different estimative models since beginning of 1970s. Most of these studies aimed at measuring effects of economic activities and energy prices on energy demand. In other words, the studies evaluated estimation of price elasticity and energy income, which are very important in predicting energy demand. In their study, Lotfalipour & Bagheri (2003) estimated total demand function of natural gas for families residing in Tehran and referred to less elasticity of natural gas demand at home sector of Tehran and necessity of this energy carrier among Tehranian families. In a study, Heidari (2004) predicted demand rate or final consumption of three energy carriers at productive sectors of Iran economy including industry, agriculture, and transportation services using an analysis pattern for a 15-years period. Results of the predictions indicate the increase of consumption rate during this period. In an article, Moshiri & Shahmoradi (2005) analyzed gas and electricity consumption structures of families of Tehran and Isfahan and the resulted outcomes indicated inelasticity of natural gas in the families' consumption bin. Delavari & Baghbazadeh (2007) estimated oil demand function in those countries importing oil from Iran. The results indicated inelasticity of oil demand in these countries. Keshavarz Haddad & Mirbagheri (2007) used STSM model to estimate energy demand function and indicated less income elasticity of gas in consumption bin of Iranian families. It referred to necessity of natural gas in fuel bin of an Iranian consumer. Samadi et al (2007) estimated consumed electricity demand in Iran using ARIMA model and suggested that the obtained results refer to significant growth of electricity demand in Iran. Fetri et al (2009) predicted the consumed electricity in Iran using Harodi logistic model. In a research, Sadeghi & Zolfaghari (2009) predicted daily demand of natural gas at home sector based on ARIMA and neural network models. The research points out the exact accuracy of linear and non-linear integration method compared with other ones in predicting daily demand of natural gas. In another study, Sadeghi et al (2009) estimated gasoline demand function at transportation sector using genetic algorithm. The results demonstrated that 2nd class model offers better results in estimating gasoline demand function in comparison with linear and exponential models. In their study, Menhaj et al (2009) predicted demand rate of energy used at transportation sector of Iran using artificial neural network. The results of the research demonstrated that errors of the artificial neural network model are fewer than the regression model. Pourkazemi et al (2009) studied application for urban gas royalty at home sector of Tehran using ARMA and phase neural network method. The research aimed at focusing on developing more exact and valid prediction methods. The results of the study indicated successful formation of phase neural network through combining artificial neural network and phase logic models and significant decrease of prediction errors. Using artificial neural network model, Kermanshahi & Aiwamia (2000) predicted consumption rate of electricity in Japan to 2020. J. W. Sun predicted energy demand in 15 European countries and suggested that intensified variation in energy consumption rate was negative during 1960-97. Aras, N. and Aras, H. predicted consumption rate of natural gas at home sector of Eskişehir city of Turkey. They used their models separately for two heating and non-heating periods and concluded that consumption of natural gas during heating period is affected by atmospheric variations. While, it is less affected by atmospheric variations factor during non-heating period when gas is used to cook and heat water. Nouredine Kirichene (2005) tested simultaneous model for demand and offer of global market of petroleum and natural gas during 1998-99.

They divided the period into two pre- and post-oil shocks of 1973. The results demonstrated that price elasticity of offer for petroleum encountered significantly long-term decrease after oil shock. It manifests changing of competitive structure to market structure for the producers. The elasticity was increased for natural gas and therefore a flexible offer and demand transfer toward natural gas. Canyurt & Ozturk (2006) used three application models in their article and determined search techniques of genetic algorithm of energy demand function in order to estimate energy and oil demand using genetic algorithm optimization method. They used it to reach future value of oil demand. In an article, Taksari (2007) determined energy demand function using ant colonial optimization method (ACO) and predicted future value of energy in Turkey to 2025. Zebrivanderska et al (2007) used non-linear regression model to estimate consumption of natural gas in Czech Republic. Adiker & Akar (2007) used ARIMA model as well as seasonal model of SARIMA to predict demand of energy carriers in Turkey for 2005-2035. Finally, they concluded that mean annual growth rate of energy resources and total energy will decrease and growth coefficient will be negative. Anler predicted energy demand using artificial intelligent model in Turkey to 2025.

3. METHODOLOGY AND MATERIALS

A simultaneous equations System

Simultaneous equations system models are defined as models with more than one dependent variable and, as a result, more than one equation. The models are different from single equation ones. As know, it is supposed that descriptive variables are non-stochastic in single equation models. Even if they are stochastic, they distribute independently from disordering elements of stochastic. One unique characteristic of simultaneous equations models is that dependent variable of one equation is regarded as descriptive one in another equation of the same system. Therefore, this kind of descriptive variables are stochastic-dependent and are usually correlated to disordering element of the equation entered it as a descriptive equation. In these cases, classic least squares method cannot be used due to inconsistency of the resulted estimations. In other words, the above-mentioned estimators will never tend toward real quantities irrespective of sample volume and as big as possible. Therefore, effects of extrovert variables on natural gas price as well as interactions of these endogenous variables with each other were studied in this research based on a pattern and using simultaneous equations system. In this study that was conducted in a time interval of 1981-2007, time structure was based on annual data and three stage least squares method (3SLS) was used as the estimation method. Mathematical structure was based on linear equations (parameters and variables) and EViews 6. In this pattern, three equations and one identity were used where endogenous variables equaled to number of equations, i.e. four. Initially, there were nine parameters in this pattern but we had to omit some variables because the first model was not meaningful. Finally, we continued our research with eight parameters. Considering internal relation of the pattern, two equations are used to calculate production and consumption of natural gas. The third equation evaluates price of natural gas. The mentioned identity calculates offer surplus of natural gas, which is the same as exportable volume of gas (which is obtained via difference found between production and consumption). The variable has been identified as the main variable in the equation of natural gas price. The above-mentioned cases describe those equations and identities used in the pattern.

System Definition, Estimation & Simulation

Equation of natural gas production:

In this equation, natural gas production is defined as extraction of sour gas from gas wells. In this pattern, the mentioned equation is based on million barrels of petroleum and a function of natural gas price during the last round and gross domestic product (GDP) with following mathematical formula:

$$PRO=C (12)*PGAS (-1) +C (13)*GDP$$

Equation of natural gas consumption:

In this equation, natural gas consumption has been defined as total consumption of natural gas at home, industry, transportation, public, power station, and commercial sectors. In this pattern, the mentioned equation is based on million barrels of petroleum and a function of natural gas price, GDP, and delayed consumption of natural gas with following mathematical formula:

$$CO=C (31)*PGAS+C (32)*GDP (-1) + C (33)*AR (1)$$

Equation of natural gas price:

In this equation, natural gas price has been defined as mean weight of natural gas price at home, industry, transportation, public, power station, and commercial sectors which has been calculated according to consumption rate at every sector and is based on Rials/m³. The relationship is a function of delayed price of natural gas, price of petroleum as the complementary item for natural gas offer surplus which in fact indicates export capacity of the country with following mathematical formula:

$$\begin{aligned} \text{PGAS} &= C(22) * \text{AR}(1) + C(23) * \text{POIL} + C(24) * \text{EXC} \\ \text{EXC} &= \text{PRO} - \text{CO} \end{aligned}$$

As mentioned, the study aims at evaluating those factors affecting production, consumption, export, and price of natural gas as well as estimating these relations using dynamic simulation method. The method can be used to determine variation effects of some extrovert variables on endogenous ones. Relation of natural gas price suggests that the most important factors affecting natural gas price is nothing other than its production and consumption and other factors directly and indirectly affect global price of natural gas through influencing the mentioned indexes. Generally, there are so many factors in natural gas market that affect natural gas surplus found in the market and natural gas price through production. Consumption rate of the previous round affects formation of future consumption of natural gas. Considering production or consumption surplus in market, production and consumption rate of natural gas during every round will lead to changes in natural gas price during the next round. On the other hand, events of other markets related to alternative energies of natural gas such as petroleum influences natural gas price such that increasing the petroleum price during every round, provided that natural gas price is fixed, will cause kinds of industries (which can alternate gas and oil) take actions to change their application from oil to gas. It will result in increasing gas price during the next round. Price variations will encourage natural gas providers to increase their production and therefore, benefit rate, on one hand, and price increases will provide conditions for entering marginal gas producers to the market and increasing natural gas offer in the market, on the other hand. Additionally, reverse effects of the event will affect demand. In these conditions, applicants delay some of their future or unnecessary demands. As mentioned, this equation system cannot be estimated using TSLS and OLS methods because they are single equation estimation methods, every equation is separately estimated in these methods, and possible relation between terms of equations errors are ignored. Therefore, the method is not asymptotically efficient and we have to use 3SLS estimation method. In this method, structural equations simultaneously consider and estimate one simultaneous pattern. Two first stages of the method are the same as TSLS which simultaneously considers and estimates the pattern. In the third stage, variance matrix and covariance of error terms are also involved in the calculation. To estimate equations system using 3SLS method, select the related option and click. The following process is the same as the previous methods. Results obtained from estimating the system are as follows:

$$\begin{aligned} \text{PRO} &= 7.06 * \text{PGAS}(-1) + 0.00044 * \text{GDP} \\ \text{t-statistic} &= 9.79 \qquad \qquad \qquad 5.43 \\ \text{CO} &= 1.86 * \text{PGAS} + 0.00065 * \text{GDP}(-1) + 0.92 * \text{AR}(1) \\ \text{t-statistic} &= 2.13 \qquad \qquad 2.96 \qquad \qquad 16.35 \\ \text{PGAS} &= 0.88 * \text{AR}(1) + 0.000042 * \text{POIL} + 0.16 * \text{EXC} \\ \text{t-statistic} &= 12.90 \qquad \qquad 3.30 \qquad \qquad 3.59 \\ \text{R-squared} &= \qquad \qquad \qquad 0.97 \end{aligned}$$

The estimates indicate that there are acceptable T-statistics and signs in all parameters. Simple and adjusted determination coefficient statistics indicate describing power of the equations. Theoretically, all coefficients are confirmed and in accordance with theoretic patterns. Also, interpretations of pattern coefficients are as follows:

Equation 1: as observed, natural gas production is in direct relationship with gross domestic product. Additionally, there is a direct relation between production and price of natural gas during the last year, i.e. natural gas production will increase during the next year in order to benefit the income opportunity following annual increase of the prices. Of course, this increase may also be attributed to the factor of entering the marginal groups of producers to the market because increasing the prices will provide required conditions for their economical saving, exploitation and production.

Equation 2: natural gas consumption is in direct relationship with its consumption rate during the last year. It is in complete correspondence with development of application of gas and its by-products in all economical activities and ascending process of demand. Additionally, there is a direct relation between demand and world gross domestic product during the last year.

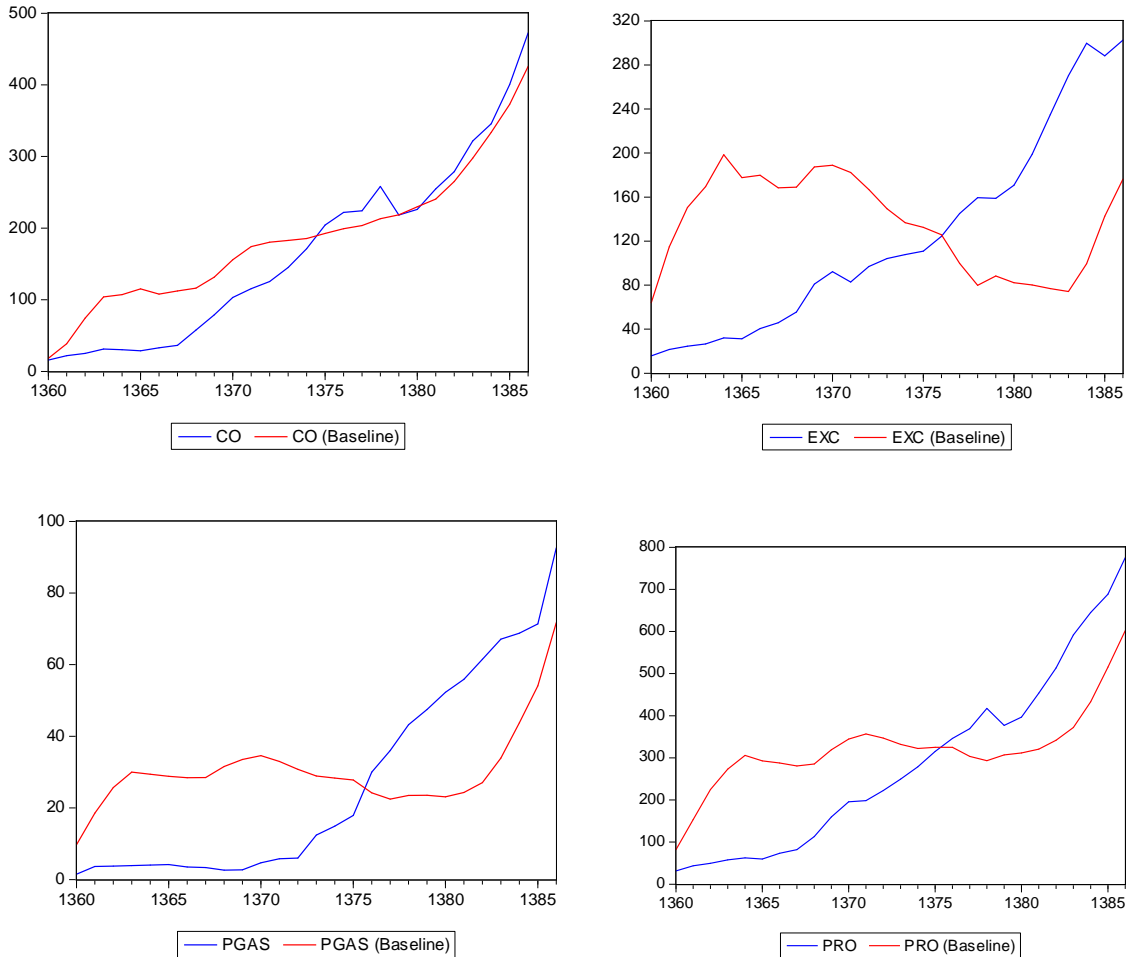
Equation 3: natural gas price has a direct relation with its price within the last year resulting from existence of petroleum as the closet alternative of natural gas. Therefore, the higher the price of petroleum, the higher the demand rate of natural gas. It will lead to demand increase in the same year and demand surplus in the market and increase of natural gas price in the next year. Evidently, it can be expected that natural gas price decreases due to increase of offer surplus of gas market in the last year.

Also, there is a direct relation between natural gas price at every time and the same price in the last year. It indicates annual continuation of natural gas shift process for the next years. The pattern should be made after estimating the related equations. Contrary to system with estimated unknown coefficients, there is no non-estimated coefficient in the pattern. Solving the pattern determines the value of its endogenous solved variables. The pattern is defined as follows:

$$\begin{aligned} \text{PRO} &= 7.06 * \text{PGAS} (-1) + 0.00044 * \text{GDP} \\ \text{CO} &= 1.86 * \text{PGAS} + 0.00065 * \text{GDP} (-1) + 0.92 * \text{AR} (1) \\ \text{PGAS} &= 0.88 * \text{AR} (1) + 0.000042 * \text{POIL} + 0.16 * \text{EXC} \\ \text{EXC} &= \text{PRO} - \text{CO} \end{aligned}$$

Here, output of the solved value of endogenous variables of the model including EXC, PGAS, CO, PRO have been demonstrated as diagrams:

Figure 1: Solved values of endogenous variables



System Simulation

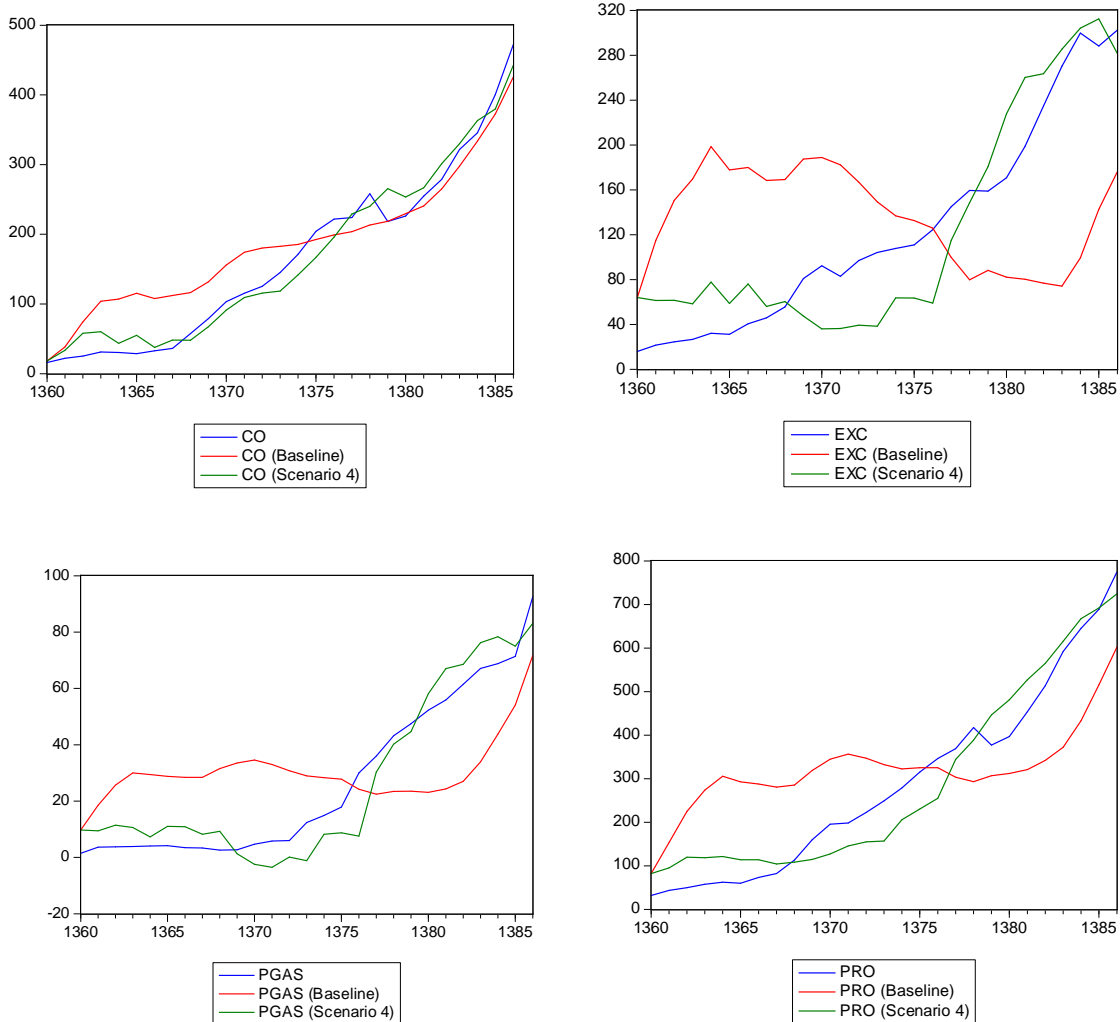
Following estimation operation of the regression equations in the pattern, different scenarios can be simulated using the estimated pattern. In other words, the numerical pattern is the estimation of the pattern structural form, which should be solved for the endogenous variables in order to find the summarized form. If the pattern solved in the sample period, simulation of the sample period or Ex-post simulation will be obtained for 1981-2007. It is possible to compare values of the solved endogenous variables with the real ones to evaluate pattern function in the past. If value of the endogenous variables is changed during the sample period and the pattern is solved for the endogenous variables, value of endogenous variables will be obtained based on extrovert political variable known as "shock analysis". In these conditions, we defined a scenario where an effect of 10% change of oil price on endogenous variables of the system was regarded as the best alternative for natural gas.

Scenarios

Evaluating effects of 10% increase of petroleum price:

The scenario suppose that 10% increase of petroleum price for 1981-2007 will affect simulation of shift effects of the descriptive variable on the endogenous variables such that 10% increase of petroleum price will lead to decrease of petroleum demand in energy market and increase of natural gas demand as its closet alternative. Therefore, increase of natural gas price will be followed by increase of natural gas demand in the market and increase of production rate of natural gas by the producer countries. Effects of oil price increase on the endogenous variables will be demonstrated in the following diagrams:

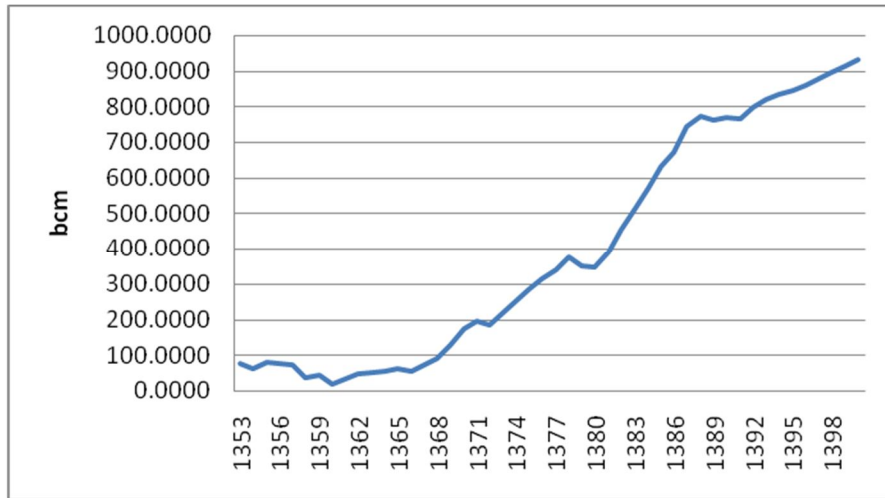
Figure 2: Solved values of the endogenous variables



Prediction of natural gas production, consumption, and export

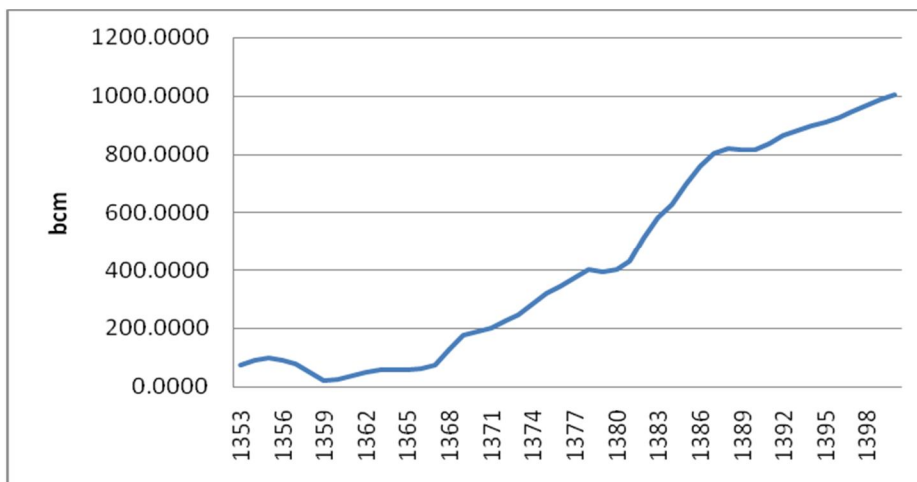
After estimating natural gas production, consumption, and export functions, production, consumption and export rate was predicted to 2021 using simultaneous equations system and Excel software.

Figure 3: Prediction of natural gas consumption



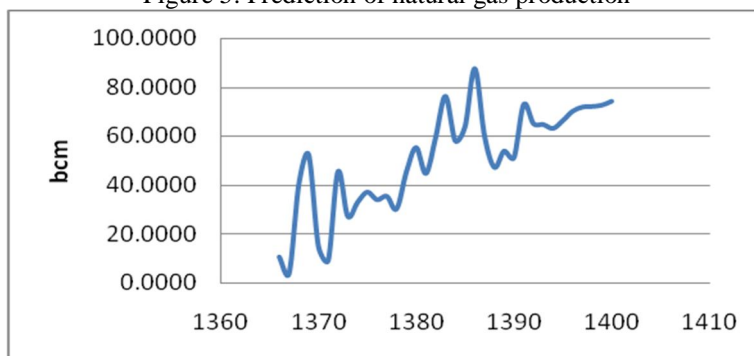
The above diagram indicated increase of natural gas consumption during 1981-2007 and it will continue its ascending shift during 2008-2021, according to the predictions.

Figure 4: Prediction of natural gas production



The above diagram indicated increase of natural gas production during 1981-2007 and it will continue its ascending shift during 2008-2021, according to the predictions.

Figure 5: Prediction of natural gas production



The above diagram indicated fluctuating and average increase of natural gas export during 1981-2007 and the fluctuations will continue to 2021, according to the predictions.

4. Conclusions and Comments

The present research evaluated factors affecting natural gas production, consumption and export and estimating their relations using simultaneous equations system. After studying the theoretical and experimental literature as well as reviewing the previous studies, the model was chosen to estimate the mentioned relations. Considering natural gas production, its price and gross domestic product were regarded as the main variables affecting its production. Gas price, gross domestic product, and price of natural gas during the last round were introduced as main factors affecting natural gas consumption. Factors affecting natural gas price were consisted of oil price as a complementary item for gas, gas price during the last round, and offer surplus of natural gas. Results of the study indicate a logical and meaningful relationship between all endogenous variables and extrovert variable of the pattern. Then, the scenario definition was used to evaluate effects of oil price variation as complementary of natural gas on extrovert variable of the model, i.e. natural gas production, consumption, price, and offer surplus. Evaluating outcomes resulted from the scenario demonstrated that production rate of natural gas is influenced by several factors including oil price as the closet alternative for natural gas because production rate of natural gas significantly depends on oil price. Analyzing oil price and its effective factors manifested that increase of oil price lead to changes in production rate of natural gas. If the government directs its policies using special approaches toward investment on discoveries and increasing production and export capacity of petroleum, fluctuations of natural gas price will result in more incomes to the government through more sale and more appropriate price of petroleum. Then, production, consumption, and export rate of natural gas was predicted in horizon of 2021. The obtained results indicate ever-increasing rate of gas consumption during the understudy period, i.e. 1981-2007 as well as those years when research prediction has been conducted. Production rate also grew in the mentioned period which could be mainly attributed to exploitation from phases of South Pars Gas Project since 1997 and continuing establishment of other phases of the plan. Additionally, export rate fluctuation was observed during 1981-2007 as well as the period predicted in this research. Export is defined as difference between production and consumption; therefore, the conducted studies demonstrated that we have gas export capacity for future years. But, new economic conditions and executive plans along with economic revolution including subsidies planning rule indicate that, at the best conditions, the available rate of gas capacity was responsive only to previous plans and undertakings with exporting objectives while new plans with the same objectives encounter high risks considering economic justifications and supplying gas required by home applications. Recent economic decisions may provide conditions to encourage export and increase of export capacity. For example, subsidies planning rule and prices specified for energy may modify the culture of using energy and result in reduction of consumption rate in long time. It is hoped that exchange devaluation introduced by most economists as a policy to increase exports and decrease imports (adjusting budget deficit) can provide appropriate conditions to pay attention to the subject and focus on by-products market and replacement the raw materials by products lead to increase of the export capacity.

Comments

- The understudy model was only dedicated to Iran and conducting the research at international level is recommended. Also, it is suggested that the global research divide production pattern of natural gas to two production equations by OPEC and non-OPEC countries and use an identity to calculate total offer. It is better to reuse the model for more data.
- Considering that the research relies on natural gas, petroleum price was regarded and used as the main alternative and an extrovert variable in the pattern. In this regard, it is recommended that future researches design a pattern similar to the one used in this study and petroleum is determined as an endogenous variable in the pattern. Therefore, a bilateral pattern will be created from which petroleum price is estimated in its market and then enters petroleum market and estimation pattern of gas price.
- The pattern can be used to predict gas price considering that the designed pattern is completely capable of prediction.
- As know, annual average of air temperature does not meaningfully affect natural gas demand. Considering that air temperature is one of the most important variables in natural gas consumption, it is recommended that further studies conducted as seasonal ones so that effects of temperature variable can be entered the model.
- Generally, there are few studies regarding production and consumption of natural gas. More exact projects should be conducted considering factors affecting its production and consumption in Iran as well as importance of this divine resource.

REFERENCES

- 1-Canyurt, O.E., Ozturk, H.K., 2006. Three different applications of geneticAlgorithm (GA) search techniques on oil demand estimation. *Energy Conversion and Management* 47, 3138–3148
- 2-Fotros,M,Zolfaghari,M(2009),”estimating gasoline demand function in transportation sector using Genetic Algorithms”,pp1-27
- 3-J.W.Sun ,(2001), “Energy demand in fifteen European union countries by zolo –A forecasting model based on decomposition approach “ , *energy* , 26 pp . 549-560
- 4-keshavarz hadad,gh,mirbagheri jam,m(2007) study on natural gas (domestic and commercial in Iran,pp 137-160
- 5-Lotfipour,M,bagheri,A(2003),” Estimating the residential demand function for natural gas in Tehran” *The economic researches journal*,pp133-151
- 6-Monhaj,M,kazemi,A(2009),” forecasting demand of energy for transportation sector using Neural Networks case study on Iran”, *Iran management researches* pp203-220
- 7-Noureddine krichene(2005)”a simultaneous equation model for world crude oil and natural gas market,*international monetary fund*
- 8-Pourkazemi,M”(2008) comparative study of arima linear methods and Neural Networks nonlinear methods on forecasting of urban subscription demand of natural gas”pp133-146
- 9-Samadi,S ,Shahidi,A,mohammadi,F(2008),estimating electricite demand in iran with ARIMA model ,pp 113-136
- 10-Sadeghi,H, ,Zolfaghari,M,Heidarzade,M(2009), “estimating gasoline demand function in transportation sector using Genetic Algorithms,*Energy studies journal*”pp 1-27
- 11-Toksari, M.D., 2007. Ant colony optimization approach to estimate energy Demand in Turkey. *Energy Policy* 35, 3984–3990
- 12-Unler, A, 2008. Improvement of energy demand forecasts using swarm intelligence: The case of Turkey with projections to 2025. *Energy Policy* 36, 1937–1944