# Natural gas demand in Turkey

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## Abstract

On average, energy demand of Turkey is mounting by 8% annually, one of the highest rates in the world. Among primary energy sources, natural gas is the fastest growing one in Turkey. Gas consumption started at 0.5 bcm (billion cubic meters) in 1987 and reached approximately 35 bcm in 2007. Turkish natural gas usage is projected to further increase remarkably in coming years. The present paper focuses the characteristics of this demand and estimates short and long run price and income elasticities of sectoral

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natural gas demand in Turkey. The future growth in this demand is also forecasted using an ARIMA modelling and the results are compared with official projections. The paper reveals that natural gas demand elasticities are quite low, meaning that consumers do not respond possible abusive price increases by decreasing their demand or substituting natural gas with other energy sources. Since consumers are prone to monopoly abuse by incumbent, there is a need for market regulation in Turkish natural gas market. Based on forecasts obtained, it is clear that the current official projections do not over/under-estimate natural gas demand although past official projections highly overestimated it.

***Keywords:*** *Turkish natural gas demand, elasticity, ARIMA modelling*

## 1. Introduction

The Republic of Turkey, located in Southeastern Europe and Southwestern Asia (that portion of Turkey west of the Bosporus is geographically part of Europe[1]), has an area of about 780,580 sq km and a population of over 70 million [2]. With its young population, growing energy demand per person, fast growing urbanization and economic development, Turkey has been one of the fast growing power markets of the world for the last two decades. Turkey is an energy importing country; more than half of the energy requirement has been supplied by imports.

Turkey's primary energy sources include hydropower, geothermal, lignite, hard coal, oil, natural gas, wood, animal and plant wastes, solar and wind energy. In 2004, primary energy production and consumption has reached 24.1 million tonnes (Mt) of oil equivalent (Mtoe) and 81.9 Mtoe, respectively. Fossil fuels provided about 86.9% of the total energy consumption of the year 2004, with oil (31.5%) in first place, followed by coal (27.3%) and natural gas (22.8%). Turkey has not utilized nuclear energy yet[2]. The Turkish coal sector, which includes hard coal as well as lignite, accounts for nearly one half of the country's total primary energy production (%43.7). The renewables collectively provided 13.2% of the primary energy, mostly in the form of combustible renewables and wastes (6.8%), hydropower (about 4.8%) and other renewable energy resources (approximately 1.6%) [3].

Turkey has initiated a major reform program of her energy market. The reform program entails privatization, liberalization as well as a radical restructuring of the whole energy sector, especially electricity and natural gas industries. Also, an autonomous regulatory body, Energy Market Regulatory Authority (EMRA), was created to set up and maintain a financially strong, stable, transparent and competitive energy market.

The most controversial reason behind, or justification for, recent reforms has been the endeavor to avoid so-called “energy crisis”. Therefore, the present article focuses on the natural gas demand in Turkey by presenting a demand estimation and forecast. Besides, the econometric analysis here contributes to extremely limited literature in Turkish natural gas demand studies.

The article is organized as follows. The next section presents a literature review in energy demand studies. Section three concentrates on the scope of the study. Section four specifies the study methodology. Section five provides an overview of data used in the estimation and forecasting process. In section six, study results are presented; followed by evaluation of these results in section seven. The last section concludes.

## 2. Literature Review

The experiences of the 1970s and 1980s led to a blast in the number of energy demand studies, a trend that has been to some extent revitalized by the emergence of worries about the emissions of greenhouse gases from the combustion of fossil fuels. Therefore, since the early 1970s, various studies of energy demand have been undertaken using various estimation methods[3]. In most of these studies the purpose has been to measure the impact of economic activity and energy prices on energy demand, i.e. estimating income[4] and price[5] elasticities, which are of the utmost importance to forecasting energy demand. The evidence shows long-run income elasticities about unity, or slightly above, and the price elasticity is typically found to be rather small [4].

In most cases, energy demand studies have adopted two different types of modeling; namely, “reduced form model” and “structural form model”. The former is a double-log linear demand model under which energy demand is assumed to be a direct linear function of energy price and real income. Kouris [5], Drollas [6] and Stewart [7] have employed this model in their studies. Moreover, Dahl and Sterner [8] report that more than sixty published studies applied the reduced form model. On the other hand, the second model is a disaggregated demand model based on the idea that the demand for energy is derived demand; that is, energy is not demanded for its own sake rather for the services it provides such as lighting, heating and power. It separates energy demand into several numbers of demand equations and treats it as an indirect, rather than direct, function of energy price and real income. Pindyck [9] provides a detailed discussion of the structural form model. Although structural form model has various advantages over reduced form model from an economic point of view, its widespread utilization has been limited by the fact that it requires a large number of variables compared to the reduced form model.

Another model for energy demand estimation, namely "irreversibility and price decomposition model", was first proposed by Wolffram [10] and developed by Traill et al. [11]. Originally, it was based on the assumption that the response to price reductions would be less than that to price increases. This model was further improved by Dargay [12] and Gately [13], who introduced three-way price decomposition to isolate the effects on demand of price decrease, price increase below and above the historic maximum. Some of the work using this method includes that of Dargay and Gately [14], [15], Haas and Schipper [16], Ryan and Plourde [17], just to mention a few. However, it is important to note that most of the studies that applied this method could not find evidence of irreversibility.

Despite the relative popularity of the above methods, the long time span covered by these studies raises serious concerns about the validity of the fixed coefficients assumption in the energy demand equation employed by these methods. This assumption in a double-log functional form of demand simply implies constant elasticities for the entire sample period under study. This feature of the model is indeed questionable in light of the changes that could have taken place in the economy over such a long period of time affecting the demand for energy[6]. Therefore, it is argued that if data is collected over a relatively long time period to estimate an energy demand function, the possibility that the parameters in the regression may not be constant should be considered. Furthermore; previous methods, in general, utilize time series data to estimate energy demand but they do not analyze the data to establish its properties and therefore they implicitly assume the data to be stationary, meaning that their means and variances do not systematically vary over time. However, this attractive data feature is lacking in most cases. Engle and Granger [18] have developed a technique, popularly known as “cointegration and error correction method” (ECM), for analyzing time series properties and estimating elasticities based on this analysis, which enables full analysis of the properties of the relevant data before actual estimation. In their study, Engle and Granger have devised a model estimation procedure and recommended a number of tests, among which the most notable and commonly used is the Augmented Dickey-Fuller (ADF) test. Subsequent improvements related to this approach have been in the form of inclusion of more specific energy-related variables in the model and the development of new methods to identify cointegrating relationships, amongst which the Autoregressive Distributed Lag Model (ARDL) and the Johansen Maximum Likelihood Model (JML) – as outlined in Johansen [19] – are especially popular.

As for the history of energy demand projection in Turkey; although some efforts for the application of mathematical modeling to simulate the Turkish energy system were made during the late 1970s, the official use of such methods in energy planning and national policy making by the Ministry of Energy and Natural Resources (MENR) was realized only after 1984. The forecasts made before 1984 were simply based on various best fit curves developed by the State Planning Organization (SPO) and MENR. The year 1984 has been a milestone for energy planning and estimation of future energy demands in Turkey since, in that year, the World Bank recommended MENR use the simulation model MAED[7] (Model for Analysis of Energy Demand), which was originally developed by the IAEA (International Atomic Energy Agency) for determination of the general energy demand. Besides, the energy demand model called "EFOM-12 C Mark I" developed by the Commission of the European Communities in 1984 was applied to Turkey. Furthermore, Kouris' correlation models were also applied for forecasting the primary and secondary energy demands in Turkey. Moreover, the BALANCE and IMPACT models were used in the context of ENPEP (Energy and Power Evaluation Program) for the long term supply and demand projections. Finally, State Institute of Statistics (SIS) and SPO have developed some mathematical models [20].

Since 1984, the Ministry (MENR) prepares energy production and demand projections in accordance with the growth targets given by SPO. Projections are made taking into account various factors including development, industrialization, urbanization, technology, conservation and so on. The figures are revised each year in the light of the performance over the past year [21]. Unfortunately, the official forecasts have consistently predicted much higher values than the consumption actually occurred. There may be several reasons of these projection failures. Utgikar and Scott [22] conducted a research to identify and analyze the causes of failures in energy forecasting studies.

Several academic studies are presented to propose some models for energy demand policy management. Gilland [23] developed an energy demand projection of the world for the years 2000 and 2020. Gungor and Arikan [24] developed a method to compare natural gas, imported coal, and nuclear power plants in terms of long-term production economy. Demirbas [25] made a study about future developments and energy investments in Turkey. Isik [26] presented a study that shows supply and demand situation in Turkey and examines its background. Ediger and Camdali [27] made historical investigation from 1988 to 2004 to analyze energy and exergy efficiencies of Turkey. A summary of techniques used so far for Turkish energy demand forecasting is given in Table 1 [28].

[ Table 1 goes here ]

**3. Scope of Study**

One of the objectives of this article is to estimate a model of natural gas demand in Turkey with a view to obtaining short and long run estimates of price and income elasticities. Also, a natural gas demand forecast constitutes another aim of the paper.

The model to be employed in demand estimation is a dynamic version of reduced form model, namely "partial adjustment model". Also, a natural gas demand forecast is developed and presented based on autoregressive integrated moving average (ARIMA) modelling.

**4. Methodological Framework**

In line with economic theory and a priori knowledge, this study starts with a single equation demand model expressed in linear logarithmic form linking the quantity of per capita natural gas demand to real energy price and real income per capita.

The simplest model can be written as:

$$\ln E_t = \alpha + \beta_1 \ln P_t + \beta_2 \ln Y_t + u_t \qquad (1)$$

where $E_t$ is per capita demand for natural gas, $P_t$ is the real price of natural gas, $Y_t$ is real income per capita, $u_t$ is the error term, the subscript t represents time, $\alpha$ is intercept term; and finally $\beta_1$ and $\beta_2$ are the estimators of the price and income elasticities of demand respectively.

This simple "static" model (1) does not make a distinction between short and long run elasticities. Therefore, instead of this static one, a dynamic version of reduced form model, called "partial adjustment model", is used in this study to capture short-run and long run reactions separately. The partial adjustment model assumes that natural gas demand cannot immediately respond to the change in natural gas price and real income; but gradually converges toward the long run equilibrium. Suppose that $E'_t$ is the desired or equilibrium natural gas demand that is not observable directly but given by:

$$\ln E'_t = \alpha + \beta_1 \ln P_t + \beta_2 \ln Y_t + u_t \tag{2}$$

and the adjustment to the equilibrium demand level is assumed to be in the form of

$$\ln E_t - \ln E_{t-1} = \delta(\ln E'_t - \ln E_{t-1}) \tag{3}$$

where $\delta$ indicates the speed of adjustment ($\delta > 0$). Substituting equation (2) into equation (3) gives:

$$\ln E_t - \ln E_{t-1} = \delta(\alpha + \beta_1 \ln P_t + \beta_2 \ln Y_t + u_t - \ln E_{t-1})$$
$$\ln E_t = \delta\alpha + \delta\beta_1 \ln P_t + \delta\beta_2 \ln Y_t + \delta u_t - \delta \ln E_{t-1} + \ln E_{t-1}$$

$$\ln E_t = \delta\alpha + \delta\beta_1 \ln P_t + \delta\beta_2 \ln Y_t + (1-\delta)\ln E_{t-1} + \delta u_t \tag{4}$$

where $\delta\beta_1$ and $\delta\beta_2$ are the short-run price and income elasticities respectively. The long-run price and income elasticities are given by $\beta_1$ and $\beta_2$ correspondingly. Since the error term $\delta u_t$ is serially uncorrelated, consistent estimates of $\alpha$, $\beta_1$, $\beta_2$ and $\delta$ can be obtained by OLS (Ordinary Least Squares).

The publication authored by Box and Jenkins [29] ushered in a new generation of forecasting tools, technically known as the ARIMA methodology, which emphasizes on analyzing the probabilistic, or stochastic, properties of economic time series on their own rather than constructing single or simultaneous equation models. ARIMA models allow each variable to be explained by its own past, or lagged, values and stochastic error terms.

If we have to difference a time series *d* times to make it stationary and apply the ARMA(p,q) model to it, we say the original time series is ARIMA(*p,d,q*). The important point to note in ARIMA modelling is that we must have either a stationary time series or a time series that becomes stationary after one or more differencing to be able to use it.

ARIMA methodology consists of four steps; namely, identification, estimation, diagnostic checking and, of course, forecasting. First of all, in the first step, we need to identify appropriate values of our model; that is, *p*, *d* and *q*. The chief tools in identification are the autocorrelation function (ACF), the partial autocorrelation function (PACF), and the resulting correlogram, which is simply the plots of ACF and PACF against the lag length.

The ACF at lag *k*, denoted by $\rho_k$, is defined as

$$\rho_k = \frac{\gamma_k}{\gamma_0} \qquad (5)$$

where $\gamma_k$ is the covariance at lag k, $\gamma_0$ is the variance. Since both covariance and variance are measured in the same units, $\rho_k$ is a unitless, or pure, number; and lies between -1 and +1.

In time series data the main reason of correlation between $Y_t$ and $Y_{t-k}$ originates from the correlations they have with intervening lags; that is, $Y_{t-1}$, $Y_{t-2}$, … , $Y_{t-k+1}$. The partial correlation measures the correlation between observations that are *k* time periods apart after controlling for correlations at intermediate lags; that is, it removes the influence of these intervening variables. In other words, partial autocorrelation is the correlation between $Y_t$ and $Y_{t-k}$ after removing the effect of intermediate Y's.

If we find out, as a result of visual inspection of correlogram and/or formal unit root tests, that our data is nonstationary; we need to make it stationary by differencing until nonstationary fades away. Then, based on the stationary data after differencing and its correlogram, we identify the appropriate values of our model; that is, p, d and q.

In the second step; that is, estimation, the model based on the results from the first step is constructed and estimated, which is followed by diagnostic checking in the third step. To check whether the model is a reasonable fit to the data or not, we collect residuals from the estimation in previous step and check whether any of the autocorrelations and partial correlations of the residuals is individually statistically significant or not. If they are not statistically significant, then it means that the residuals are purely random and there is no need to look for another ARIMA model. In the final step, forecasting is carried out based on the constructed and checked ARIMA model.

## 5. Overview of Data

The data used in the estimation process is quarterly time series data on Turkish natural gas consumption by electricity generation sector (CE), by households (CH) and by industry sector (CI) in tonne of oil equivalent (toe); on natural gas real price in Turkey for electricity generation sector (PE), for households (PH) and for industry sector (PI) in Nat. Cur./toe (NCV); and finally on real GDP per capita in US$ at 2000 prices. The data covers the period 1988-2005, a total of 72 observations. The data is obtained from the "International Energy Agency" [30].

Since the data on consumption, price and real GDP per capita is not available quarterly, the annual series on these data are converted into quarterly data by linear interpolation so as to make use of them together with quarterly data on natural gas prices.

Since one of the main aims of this study is to get elasticities of natural gas demand, the series were transformed into natural logarithms so that direct estimates of elasticities can be obtained[8]. Figure 1 shows time series plots of natural logarithms of real natural gas prices (LNPE, LNPH, LNPI), real GDP per capita (RI) and real net natural gas consumption (LNCE, LNCH, LNCI).

[ Figure 1 goes here ]

A close look at the graphs reveals that there are trends in the variables LNCE, LNCH, LNCI and LNRI. On the other hand, the variables LNPE, LNPH and LNPI do not present trends and they fluctuate within an interval.

## 6. Presentation of Study Results

### 6.1. Partial Adjustment Model

Using quarterly data discussed in the previous section, partial adjustment model is estimated for electricity generation sector, households and industry sector separately[9]. Equation (4) is estimated as follows:

$$\ln CE_t = -1.58 + 0.11 * \ln PE_t + 0.31 * \ln RI_t + 0.94 * \ln CE_{t-1} \quad (6)$$

$$\ln CH_t = -5.55 - 7.82 * \ln PH_t + 1.70 * \ln RI_t + 0.75 * \ln CH_{t-1} \quad (7)$$

$$\ln CI_t = -2.30 - 0.78 * \ln PI_t + 0.47 * \ln RI_t + 0.90 * \ln CI_{t-1} \quad (8)$$

There is, however, a possibility that the OLS results may be misleading due to inappropriate standard errors because of the presence of heteroskedasticity. In order to test whether error terms are heteroskedastic or not, White heteroskedasticity test (without cross terms) is carried out. Table 2 provides the probability values of this test for each of the equations. Test results indicate that error terms are heteroskedastic in our model even at 1% significance level.

[ Table 2 goes here ]

Since we found evidence of heteroskedasticity, we have reapplied OLS with the robust standard errors option. We need also to test for serial correlation. Breusch-Godfrey Serial Correlation LM Test is applied. The probability values of 0.42, 0.26 and 0.41 in this test for Equations (6), (7) and (8) respectively strongly indicate the absence of serial correlation in the residuals.

In our three models, "R-squared" is between 0.95 and 0.97, meaning that our model may predict dependent variable with at least 95% accuracy with given sample, which is high enough for an appropriate model. As for "Adjusted R-squared", it is also between 0.95 and 0.97. Durbin-Watson statistic in our estimation outputs ranges between 1.98 and 2.17, indicating the absence of serial correlation in the residuals. Finally, as p-value of the F-statistics is zero in our model, we can reject the null hypothesis that all slope coefficients in the regression are zero.

Based on the Equations (6), (7) and (8), elasticities of demand for natural gas in Turkey are computed and presented in Table 3.

[ Table 3 goes here ]

When we look at the elasticities, following comments could be made:

- ✓ Apart from long run price elasticity of households, all elasticities range between 0 and 8. So, in Turkey, if real income or natural gas price level changes by 100%, natural gas demand changes by only 8% at most even in the long-run!

- ✓ The speed of adjustment to the long-run equilibrium demand level for households is much higher than those for electricity generation and industry sectors, meaning that households reach long run equilibrium level 4 and 2.5 times faster than electricity generation and industry sectors respectively.
- ✓ The most striking result is the positive price elasticity values for the electricity generation sector for both short and long run. Actually, the economic theory states that there is an inverse relationship between demand and price; and a positive relation exists between demand and income. Therefore, price elasticity values should be negative. However, in Turkey, electricity selling price of power plants producing electricity from natural gas does not depend on the cost of natural gas. They sell the electricity they produced based on a formula in which the cost of natural gas is treated as “cost-pass-through”, meaning that any increase in natural gas price is directly reflected in final tariffs. In short, natural gas fired power plants do not respond price changes so elasticities do not in conformity with economic theory.
- ✓ As expected, all long run demands are relatively elastic compared to short run demands. That is to say, the demand is most responsive to income and price changes in the long run.
- ✓ In electricity generation sector, the level of income has more effect on demand than that of prices. For households and industry sector, it is vice versa.

- ✓ In general, households have more elastic demand than all other sectors and demand of industry sector is more elastic than that of electricity generation sector.

### 6.2. Natural gas Demand Forecast for Turkey: 2008-2030

#### 6.2.1. Data and Methodology

Before starting the forecast, it is important to make some points clear. First of all, data used here is monthly Turkish natural gas consumption (NGC) data covering the period 1987-2007, a total of 252 observations. Also, unlike previous section, the data here is not converted into natural logarithms and, therefore, the unit is million $m^3$. The data for the period 1987-2004 is obtained from the "International Energy Agency" [30] and the rest is from Turkish Pipeline Corporation [31]. Since the data for 2005-7 is not available monthly, the annual series on these data are converted into monthly data by linear interpolation so as to make use of them together with other data.

In literature, there are five main approaches to economic forecasting based on time series data; namely, (1) exponential smoothing methods, (2) single-equation regression models, (3) simultaneous-equation regression models, (4) autoregressive integrated moving average models (ARIMA), and (5) vector autoregression. Although still used in some areas, the first group of models is now supplanted by the other four methods; therefore, we don't use them in this study. Taking into account rather low estimates of elasticities obtained in previous section[10], it seems better not to include price and income variables in the forecasting process and "let the demand data speak for itself", which is the main philosophy behind ARIMA modelling. Since the second, third and the fifth group of models require the inclusion of price, income and some other variables in the forecasting process; they are also not used here. In short, this section develops a natural gas demand forecast for Turkey based on ARIMA modelling.

### 6.2.2. Development of the Model

As mentioned before, ARIMA modelling consists of four steps. In the first step, namely identification step, we need to identify the appropriate parameters in our model, that is, ARIMA(*p,d,q*). Figure 2 provides us with the correlogram up to 40 lags, or the plots of ACF and PACF against the lag length of 40.

[ Figure 2 goes here ]

The column labeled AC and PAC are the sample autocorrelation function and the sample partial autocorrelation function respectively. Also the diagrams of AC and PAC are provided on the left. The solid and dashed vertical lines in the diagram represent the zero axis and 95% confidence interval respectively. From this figure, two facts stand out: First, the autocorrelation coefficient starts at a very high value at lag 1 (0.918) and declines very slowly. Second, after the second lag, the PACF drops dramatically, and all PACFs after lag 2 are statistically insignificant. These two facts strongly support the idea that the natural gas consumption time series is nonstationary. It may be nonstationary in mean or variance, or both.

Since the data is nonstationary, we have to make it stationary. Figure 3 shows the correlogram of the first differenced data up to 40 lags.

[ Figure 3 goes here ]

As can be seen in Figure3, the trend disappears in the first-differenced data, perhaps suggesting that the first-differenced data is stationary. A formal application of the ADF unit root test shows that that is indeed the case.

In Figure 3, we have a much different pattern of ACF and PACF. The ACFs at lags 3, 4, 5, 6, 7, 11, 12, 13, 18, 24, 35 and 36; and PACFs at 3, 6, 7, 8, 9, 12 and 24 seem statistically different from zero. But at all other lags, they are not statistically different from zero. If the partial correlation coefficient were significant only at lag 1, we could have identified this as an AR(1) model. Let us therefore assume that the process that generated the first-differenced consumption is at most an AR(36) process. Since from the partial correlogram we know that only the AR terms at lags 3, 4, 5, 6, 7, 8, 9, 11, 12, 13, 18, 24, 35 and 36 are significant, we only need to include these AR terms in our model. Therefore at the end of the first step we may conclude that the original time series is ARIMA(36,1,0); that is, the first differenced stationary data can be modeled as an ARMA(36,0) process.

The second step in ARIMA modelling is estimation. Let $E_t^*$ denote the second-differenced data. Then, in line with the conclusion in the first step, our model is:

$$\begin{aligned}E_t^* &= \delta + \alpha_1 E_{t-3}^* + \alpha_2 E_{t-4}^* + \alpha_3 E_{t-5}^* + \alpha_4 E_{t-6}^* + \alpha_5 E_{t-7}^* \\ &+ \alpha_6 E_{t-8}^* + \alpha_7 E_{t-9}^* + \alpha_8 E_{t-11}^* + \alpha_9 E_{t-12}^* + \alpha_{10} E_{t-13}^* \\ &+ \alpha_{11} E_{t-18}^* + \alpha_{12} E_{t-24}^* + \alpha_{13} E_{t-35}^* + \alpha_{14} E_{t-36}^* + u_t\end{aligned} \tag{9}$$

Using EViews, we obtained the following estimates:

$$\begin{aligned}E_t^* &= 24.96 - 0.29E_{t-3}^* - 0.11E_{t-4}^* - 0.09E_{t-5}^* - 0.31E_{t-6}^* - 0.23E_{t-7}^* \\ &- 0.14E_{t-8}^* - 0.16E_{t-9}^* + 0.02E_{t-11}^* + 0.24E_{t-12}^* - 0.02E_{t-13}^* \\ &+ 0.08E_{t-18}^* - 0.11E_{t-24}^* + 0.08E_{t-35}^* + 0.29E_{t-36}^* + u_t\end{aligned} \tag{10}$$

In the third step; that is, diagnostic checking, we obtain residuals from (10) and get the ACF and PACF of these residuals up to lag 40 in order to check that the model represented by equation (10) is a reasonable fit to the data. The estimated ACF and PACF are shown in Figure 4.

[ Figure 4 goes here ]

As can be seen in Figure 4, none of the autocorrelations and partial correlations (apart from first ones) is individually statistically significant. In other words, the correlograms of both autocorrelation and partial autocorrelation give the impression that the residuals estimated from regression (10) are purely random. Hence, there is not any need to look for another ARIMA model.

The final step is forecasting. However, we need to integrate the first-differenced series to obtain the forecast of consumption rather than its changes. We know that the following formula integrates data from first-differenced form into level form.

$$E_t^* = E_t - E_{t-1} \qquad (11)$$

Using equation (11), we easily obtain the forecast values for the period 2008-2030, which is given in Table 4.

[ Table 4 goes here ]

#### 6.2.3. Validation

It is useful to validate the present model with observed data. In order to do this, 5-year natural gas demand is calculated by ARIMA model supposing that present year is 1999; that is, five years observed data is used for validation. As can be seen in the Table 5, the results from ARIMA model deviates from the observed data 4% on average, which may definitely be regarded as within the acceptable range.

[ Table 5 goes here ]

### 6.2.4. Presentation of the Results

By using equation (10) and (11), natural gas demand forecasts are obtained for Turkey up to the year 2030. As given in Table 4, the results from ARIMA modelling clearly indicate that average annual percentage increase in natural gas consumption will be 4% during the following two decades.

## 7. Evaluation of Study Results

As a result of estimation and forecasting procedure outlined above, the results given in Table 3 and Table 4 are obtained. Having obtained both the elasticities of natural gas demand in Turkey and forecasted values for this demand, let me interpret the results and compare them with the official estimates that are available from BOTAS [31].

The estimated elasticities indicate that the price and income elasticities of natural gas demand in Turkey are quite low, meaning that there is definitely a need for economic regulation in Turkish natural gas market. Otherwise, since consumers do not react much especially to price increases, the firms with monopoly power (or those in oligopolistic market structure) may abuse their power to extract “monopoly rent”.

As to forecasted natural gas consumption values, it is obvious that there exists a natural gas demand growth in Turkey; and in the following two decades (i.e., 2008-2030), based on ARIMA modelling, we may argue that the demand will continue to increase at an annual average rate of 4% and will turn out to be 86.4 billion $m^3$ in 2030, corresponding to a 146.6% increase compared to 2007 demand level.

As for comparison of our results with official demand projections, the official projections are available from BOTAS [31]. Table 6 compares the results from ARIMA modelling with official projections.

[ Table 6 goes here ]

The key conclusion from the comparison is the fact that there is not a substantial difference between official projections and forecasts based on ARIMA modelling. If we suppose that ARIMA results are valid; for 2020, official demand projections deviates only 1.3%, which is perfectly acceptable. To put it in a different way, if we take natural gas demand in 2007 as 100 units; ARIMA modelling suggests that the demand will turn out to be 190 units in 2020, while official projections imply that it will turn out to be 187.6 units.

At this point, it is important to underline that official natural gas consumption projections have been substantially modified in the last years and previous projections had exceedingly overestimated demand, which resulted in a current risk of oversupply. It is estimated that the existing Turkish natural gas purchase contracts outstrip demand over the next 2 to 3 years by 9 to 13%, reaching 20% later in the decade due to the overestimated demand forecasts made in the early 2000s. [32]. Table 7 presents and compares current official forecasts, official forecasts in 2002 and the demand forecast results from

ARIMA modelling. Official forecasts in 2002 are obtained from MENR [33] and Kilic [34].

[ Table 7 goes here ]

The most outstanding outcome from the comparison is the fact that there is a substantial difference between current official projections and those made in 2002. As can clearly be seen in Table 7, official projections made in 2002 not only extremely overestimated demand but have also been extensively modified within just a few years. For instance, official projections in 2002 predicted 2007 natural gas demand as 47.31 bcm, but it turned out to be 35.06 bcm, meaning that official figures overestimated demand by 34.9% in that year, which is an absolutely unacceptable deviation within such a short period of time. Probably to correct for such intolerable variations, official projections have been reduced by 24.64% for the year 2008. Moreover, some argue that the official natural gas projections have overestimated natural gas demand to justify the construction of new power plants to use excess amount of natural gas [35]. Here, the reasons for why past forecasts were so wrong in Turkey could not be enquired as the method used to develop these forecasts has never been exposed to public.

There exist two important points to keep in mind while evaluating (and possibly using) these results. First of all, forecasting, especially in energy demand, is considered more an art than a science; therefore, some variations are to be expected depending on the model's underlying assumption(s). Like all other models, ARIMA modelling is based on some assumption(s) and, of course, there is a direct link between the accuracy of the forecast and the validity of the underlying assumption(s). The main assumption behind ARIMA modelling is that the already existing trends in natural gas consumption will more or less repeat themselves in the future. Despite the fact that this is a widely used, essential and reasonable assumption; some unanticipated events may also occur and it is always very difficult, if not impossible, to foresee such "unexpected" events that have a potential to completely change the natural gas demand trend in Turkey reducing the precision of the forecasts presented here. Second, due to nature of ARIMA modelling and the low elasticities obtained, present study has only employed net total consumption data for forecasting. There is an apparent need for further work with more variables, which is not only essential for policy formulation in Turkey but also will make more detailed and accurate understanding of the trends possible.

## 8. Conclusion

The natural gas supply and demand should be closely monitored and forecasts should be revised to take account of the progress of liberalization, energy efficiency improvements, structural changes in industry and other major factors. Medium and long-term forecasting of natural gas demand, based on realistic indicators, is a prerequisite to become an industrialized country and to have a healthy gas market. Energy planning is not possible without a reasonable knowledge of past and present natural gas consumption and likely future natural gas demand. Overestimating the natural gas demand may cause redundancy in resources, while underestimating may cause series energy crises.

The main objectives of this article have been, first, to estimate short and long run price and income elasticities of sectoral natural gas demand in Turkey; and, second, to forecast future growth in this demand using ARIMA modelling and compare the results with official projections.

In the course of study, elasticities are obtained and it is found out that they are quite low, meaning that consumers do not respond possible abusive price increases by decreasing their demand or substituting natural gas with other energy sources. Since consumers are prone to monopoly abuse by incumbent, there is a need for market regulation in Turkish natural gas market. Then, an ARIMA model is developed and used to forecast future natural gas consumption in Turkey. Based on forecasts obtained, it is clear that the current official projections do not over- or under-estimate natural gas demand in Turkey.

Developing countries like Turkey should plan very carefully about their energy demand for critical periods, such as economic crises that frequently hit them. For instance, economic crisis hit Turkey three times in the last decade, once in 1994 and the others in 2000 and 2001. During these periods, energy consumption shows fluctuations and presents a decreasing trend. After the economic crises, the energy consumption recovers and shows about the same trend as before the economic crises. Therefore, official energy projections should be formulated in such a way that possible crises are taken into account. Moreover, all related bodies in Turkey should take necessary steps to develop more accurate demand projections. In this context; the market regulator, EMRA, is especially responsible for development of healthy forecasts, which is one of the most important determinants in the success of recent energy market reforms in Turkey. In addition; while developing forecasts, the emphasis should be on the development and use of appropriate data and econometric techniques which are open to debate, rather than some computer packages for demand estimation provided by various international organizations or, even worse, the methods in which the demand is determined as a result of a bargaining process among various public bodies.

It is believed that the elasticities, forecasts and the comments presented in this paper would be helpful to policy makers in Turkey for future energy policy planning.

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## Footnotes

[1] In October 2005, European Union (EU) opened accession negotiations with Turkey, who has been an associate member of the EU since 1963 and an official candidate since 1999. For a more detailed discussion of EU-Turkey relations, see Erdogdu [36].

[2] For a more in depth discussion of nuclear energy in Turkey, see Erdogdu [37].

[3] Since economic theory and a priori knowledge indicates that the demand for energy in general depends on price and income, most of the studies in this area have been concentrated on these two variables as the major determinants of energy demand.

[4] The income elasticity of energy demand is defined as the percentage change in energy demand given a 1% change in income holding all else constant. This measure provides an indication of how demand will change as income changes.

[5] The price elasticity of energy demand is defined as the percentage change in energy demand given a 1% change in price holding all else constant. This measure calculates the influence of energy price on energy demand.

[6] See Hass and Schipper [16] for further discussion of the issue.

[7] The MAED is a detailed simulation model for evaluating the energy demand implications (in the medium and long term) of a scenario describing a hypothesized evolution of the economic activities and of the lifestyle of the population. It requires a number of data inputs from various sectors to simulate the energy demand for the desired years.

[8] The use of log-log specification only provides us with constant elasticities; however, elasticities may also be estimated from linear functions (or other specifications) that are not constant.

[9] All estimation throughout the study is carried out by EViews 5.1, the Windows-based forecasting and econometric analysis package.

[10] Low elasticities imply that responsiveness of demand to price and income changes is rather limited, meaning that a forecast linking price and income to consumption may not produce healthy results.

**Table Captions**

**Figure Captions**

**Table 1.** Academic studies on energy demand forecasting in Turkey

| **Method used** | **Reference** |
|---|---|
| Genetic algorithms (GA) | Ceylan and Ozturk (2004), Ozturk et al. (2005), Ceylan et al. (2005), Haldenbilen and Ceylan (2005) |
| Artificial neural networks (ANN) | Hobbs et al. (1998), Sozen et al. (2005), Sozen and Arcaklioğlu (2007) |
| Ant colony optimization (ACO) | Toksari (2007) |
| Autoregressive integrated moving average (ARIMA) | Ediger and Akar (2007), Erdogdu (2007a) |
| Grey prediction with rolling mechanism (GPRM) | Akay and Atak (2007) |
| Linear regression (LR) | Yumurtaci and Asmaz (2004) |

**Table 2.** The probability values of White heteroskedasticity test (without cross terms) for the equations (6), (7) and (8)

| **Equation** | **Probability of F-statistic** | **Result (at 1% significance level)** |
|---|---|---|
| Equation (6) | 0.000418 | Error terms are heteroskedastic! |
| Equation (7) | 0.000001 | Error terms are heteroskedastic! |
| Equation (8) | 0.000001 | Error terms are heteroskedastic! |

**Table 3.** Elasticities of demand for natural gas in Turkey, based on Partial Adjustment Model

| | Price Elasticity (%) | | Income Elasticity (%) | | The speed of adjustment to the long-run equilibrium demand level ($\delta$) |
|---|---|---|---|---|---|
| | Short-run | Long-run | Short-run | Long-run | |
| Electricity generation sector | 0.11 | 1.85 | 0.31 | 5.11 | 0.06 |
| Households | -7.82 | -31.90 | 1.70 | 6.92 | 0.25 |
| Industry sector | -0.78 | -7.81 | 0.47 | 4.73 | 0.10 |

**Table 4.** Forecasted Turkish natural gas consumption values for the period 2008-2030

| Year | million $m^3$ | Annual % Change[a] | Index (2007=100) |
|---|---|---|---|
| **2008** | 39,651 | 13.1 | 113.1 |
| **2009** | 41,992 | 5.9 | 119.8 |
| **2010** | 44,658 | 6.3 | 127.4 |
| **2011** | 46,887 | 5.0 | 133.7 |
| **2012** | 48,860 | 4.2 | 139.4 |
| **2013** | 51,155 | 4.7 | 145.9 |
| **2014** | 53,330 | 4.3 | 152.1 |
| **2015** | 55,330 | 3.7 | 157.8 |
| **2016** | 57,396 | 3.7 | 163.7 |
| **2017** | 59,529 | 3.7 | 169.8 |
| **2018** | 61,635 | 3.5 | 175.8 |
| **2019** | 63,699 | 3.3 | 181.7 |
| **2020** | 65,775 | 3.3 | 187.6 |
| **2021** | 67,876 | 3.2 | 193.6 |
| **2022** | 69,968 | 3.1 | 199.6 |
| **2023** | 72,043 | 3.0 | 205.5 |
| **2024** | 74,119 | 2.9 | 211.4 |
| **2025** | 76,199 | 2.8 | 217.4 |
| **2026** | 78,268 | 2.7 | 223.3 |
| **2027** | 80,326 | 2.6 | 229.1 |
| **2028** | 82,378 | 2.6 | 235.0 |
| **2029** | 84,419 | 2.5 | 240.8 |
| **2030** | 86,444 | 2.4 | 246.6 |

[a]***Note:*** *Average annual change is 4%.*

**Table 5.** Validation of ARIMA modelling

| | Forecasted Natural Gas Consumption (million $m^3$) | Annual % Change | Index (1999=100) | Actual Natural Gas Consumption (million $m^3$) | Annual % Change | Index (1999=100) | Absolute Value of Deviation (million $m^3$) | Annual Deviation as a Percentage of Actual Consumption[a] |
|---|---|---|---|---|---|---|---|---|
| **2000** | 14,302 | 12.9 | 112.9 | 15,092 | 19.1 | 119.1 | 790 | 5.2 |
| **2001** | 16,099 | 12.6 | 127.1 | 15,944 | 5.6 | 125.9 | 155 | 1.0 |
| **2002** | 19,004 | 18.0 | 150.0 | 17,588 | 10.3 | 138.8 | 1,416 | 8.1 |
| **2003** | 20,454 | 7.6 | 161.4 | 21,175 | 20.4 | 167.1 | 721 | 3.4 |
| **2004** | 22,407 | 9.5 | 176.9 | 21,938 | 3.6 | 173.2 | 469 | 2.1 |

[a]***Note:*** *Average deviation as a % of actual consumption is 4.0*

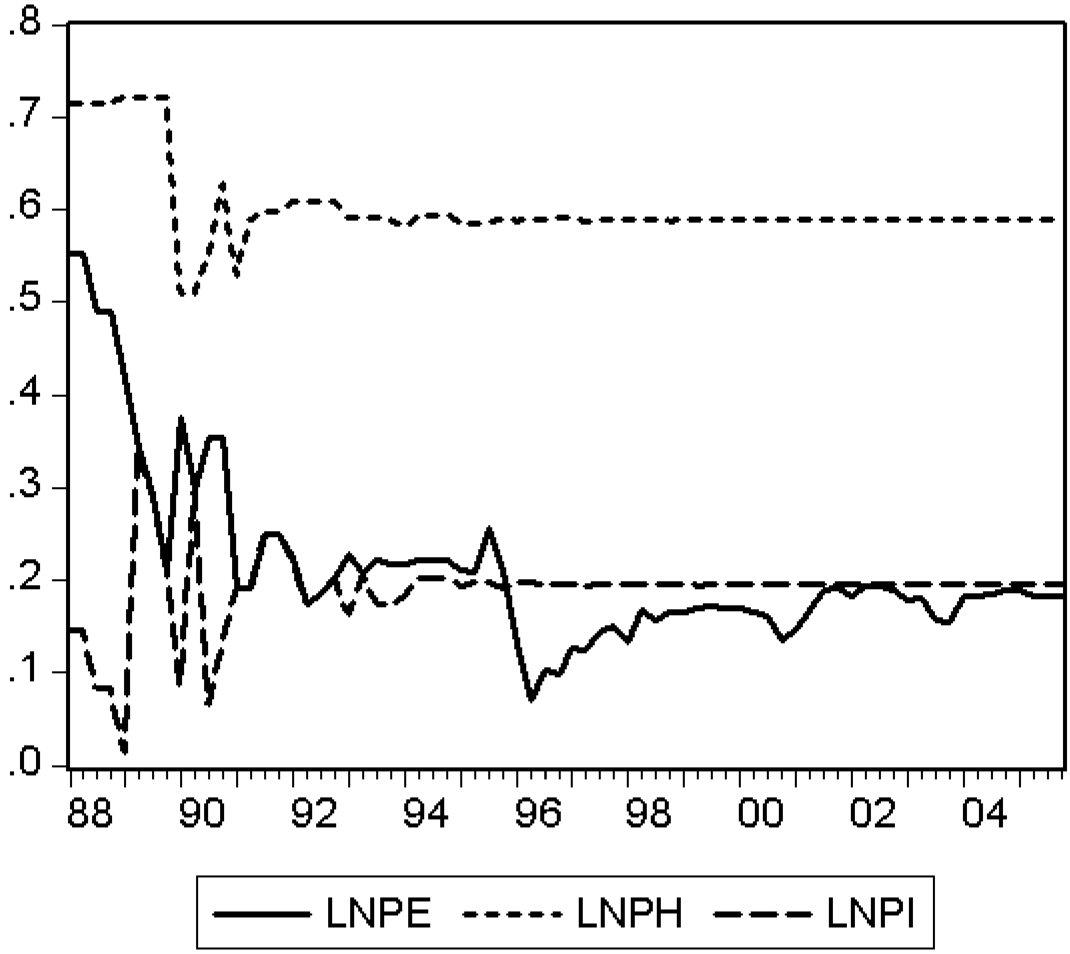
**Table 6.** The comparison of ARIMA results with official projections

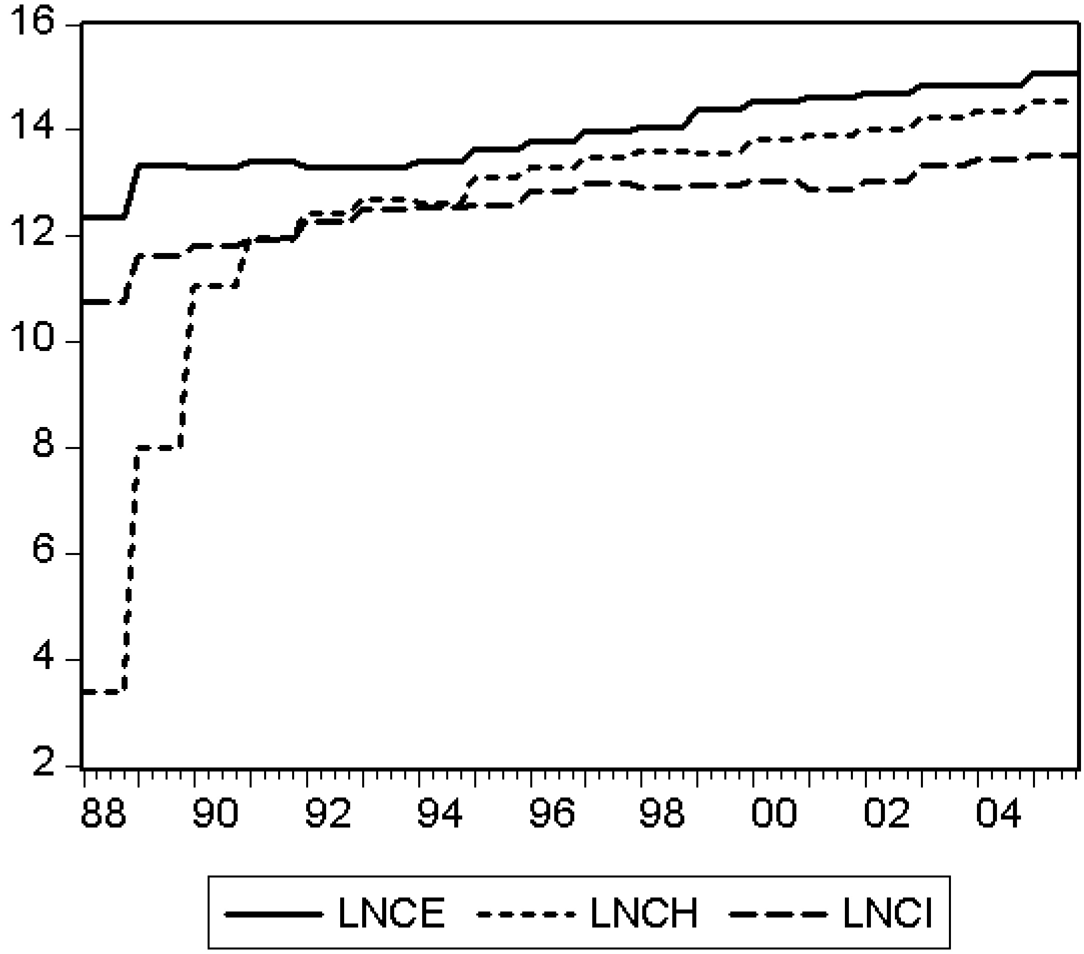
| **Year** | Official Projections for Natural Gas Consumption (million $m^3$) (a) | Forecasted Natural Gas Consumption based on ARIMA Modelling (million $m^3$) (b) | Difference (a-b) | Absolute Value of Difference as a % of Forecasts based on ARIMA Modelling |
|---|---|---|---|---|
| **2008** | 36,458 | 39,651 | -3,193 | 8.1 |
| **2009** | 40,517 | 41,992 | -1,475 | 3.5 |
| **2010** | 44,543 | 44,658 | -115 | 0.3 |
| **2015** | 56,920 | 55,330 | 1,590 | 2.9 |
| **2020** | 66,604 | 65,775 | 829 | 1.3 |
| **2025** | 70,546 | 76,199 | -5,653 | 7.4 |
| **2030** | 76,378 | 86,444 | -10,066 | 11.6 |

**Table 7.** Comparison of current official forecasts, official forecasts in 2002 and demand forecast results from ARIMA modelling

| | Official Natural Gas Consumption Projection in 2002 (MENR, 2002) (billion $m^3$) | Index (2001=100) | Current Official Natural Gas Consumption Projection (BOTAS, 2008) (billion $m^3$) | Index (2001=100) | Forecasted Natural Gas Consumption Based On ARIMA Modelling (billion $m^3$) | Index (2001=100) | Actual Natural Gas Consumption (billion $m^3$) | Modification of Official Projections as a % of 2002 Official Projections |
|---|---|---|---|---|---|---|---|---|
| **2001** | - | 100.0 | - | 100.0 | - | 100.0 | 15.94 | - |
| **2002** | 17.38 | 109.0 | - | - | - | - | 17.59 | - |
| **2003** | 22.93 | 143.8 | - | - | - | - | 21.18 | - |
| **2004** | 29.99 | 188.1 | - | - | - | - | 21.94 | - |
| **2005** | 31.41 | 197.0 | - | - | - | - | 26.87 | - |
| **2006** | 45.48 | 285.2 | - | - | - | - | 30.49 | - |
| **2007** | 47.31 | 296.7 | - | - | - | - | 35.06 | - |
| **2008** | 48.38 | 303.4 | 36.46 | 228.7 | 39.65 | 248.7 | - | **24.64** |
| **2009** | 51.21 | 321.2 | 40.52 | 254.1 | 41.99 | 263.4 | - | **20.88** |
| **2010** | 54.32 | 340.7 | 44.54 | 279.4 | 44.66 | 280.1 | - | **18.00** |
| **2015** | 66.56 | 417.5 | 56.92 | 357.0 | 55.33 | 347.0 | - | **14.48** |
| **2020** | 82.00 | 514.3 | 66.60 | 417.7 | 65.77 | 412.5 | - | **18.78** |

**Figure 1.** Time series plots of natural logarithms of LNPE, LNPH, LNPI, RI, LNCE, LNCH and LNCI

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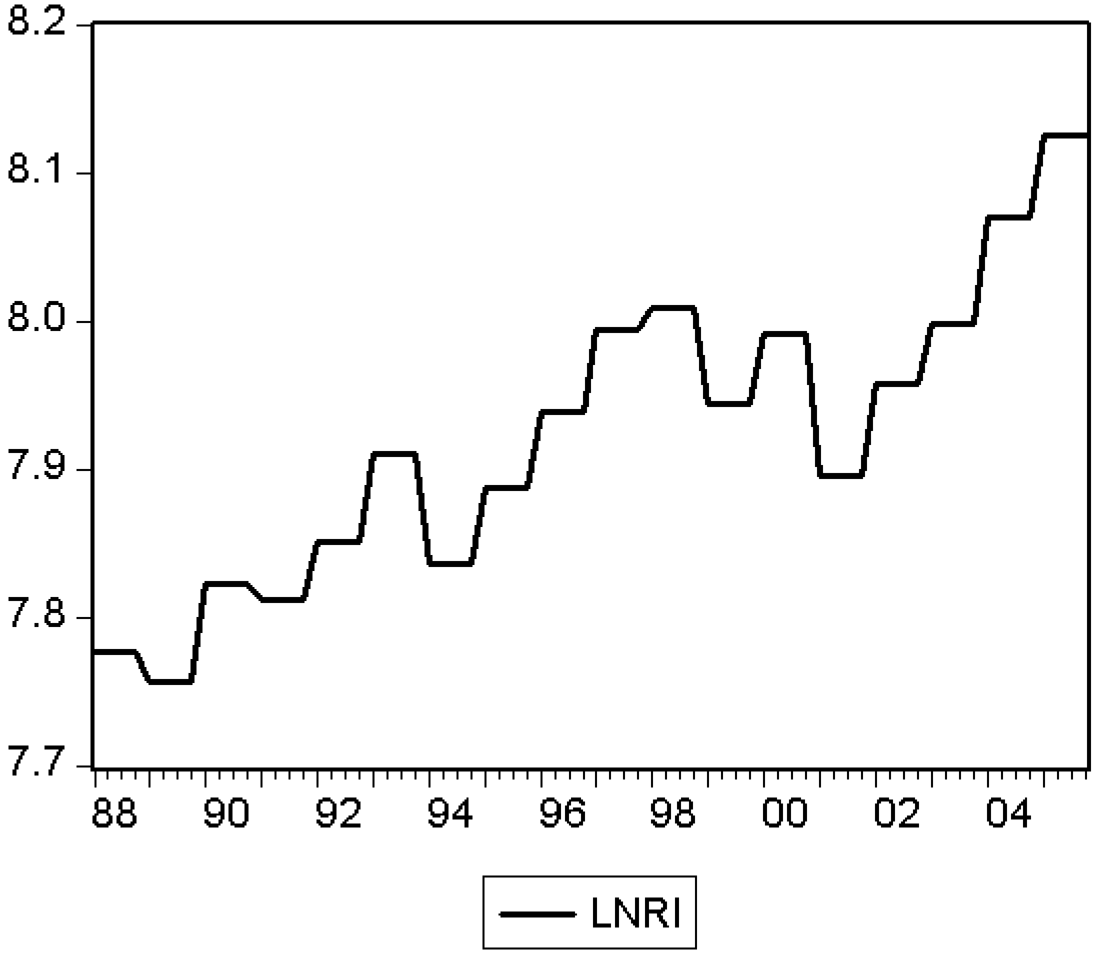
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LNRI

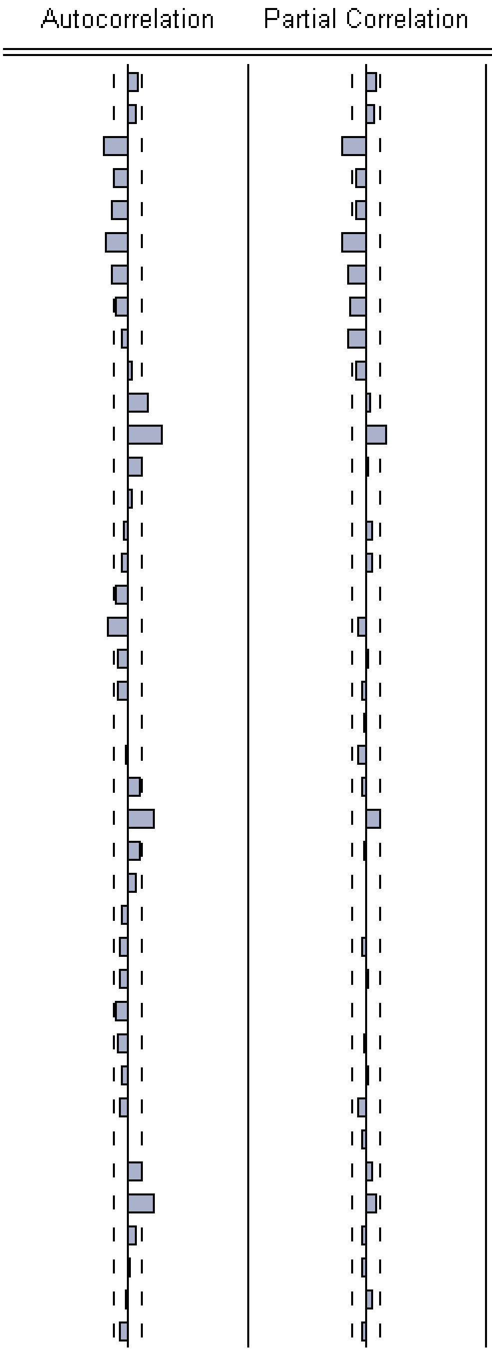
**Figure 2.** The correlogram of NGC

Date: 03/17/08 Time: 17:39
Sample: 1987M01 2007M12
Included observations: 252

| Autocorrelation | Partial Correlation | | AC | PAC | Q-Stat | Prob |
|---|---|---|---|---|---|---|
| | | 1 | 0.918 | 0.918 | 214.79 | 0.000 |
| | | 2 | 0.871 | 0.182 | 408.98 | 0.000 |
| | | 3 | 0.830 | 0.060 | 586.07 | 0.000 |
| | | 4 | 0.798 | 0.062 | 750.33 | 0.000 |
| | | 5 | 0.757 | -0.040 | 898.83 | 0.000 |
| | | 6 | 0.719 | -0.013 | 1033.3 | 0.000 |
| | | 7 | 0.699 | 0.099 | 1160.8 | 0.000 |
| | | 8 | 0.682 | 0.060 | 1282.7 | 0.000 |
| | | 9 | 0.664 | 0.026 | 1398.9 | 0.000 |
| | | 10 | 0.644 | -0.002 | 1508.6 | 0.000 |
| | | 11 | 0.624 | -0.015 | 1611.9 | 0.000 |
| | | 12 | 0.597 | -0.054 | 1706.9 | 0.000 |
| | | 13 | 0.573 | -0.003 | 1794.8 | 0.000 |
| | | 14 | 0.544 | -0.030 | 1874.5 | 0.000 |
| | | 15 | 0.515 | -0.034 | 1946.0 | 0.000 |
| | | 16 | 0.486 | -0.019 | 2010.0 | 0.000 |
| | | 17 | 0.459 | -0.019 | 2067.3 | 0.000 |
| | | 18 | 0.434 | -0.005 | 2118.9 | 0.000 |
| | | 19 | 0.417 | 0.035 | 2166.7 | 0.000 |
| | | 20 | 0.412 | 0.093 | 2213.6 | 0.000 |
| | | 21 | 0.410 | 0.059 | 2260.2 | 0.000 |
| | | 22 | 0.411 | 0.054 | 2307.2 | 0.000 |
| | | 23 | 0.406 | -0.005 | 2353.2 | 0.000 |
| | | 24 | 0.389 | -0.085 | 2395.7 | 0.000 |
| | | 25 | 0.369 | -0.052 | 2434.1 | 0.000 |
| | | 26 | 0.355 | 0.023 | 2469.7 | 0.000 |
| | | 27 | 0.338 | 0.004 | 2502.3 | 0.000 |
| | | 28 | 0.325 | 0.029 | 2532.5 | 0.000 |
| | | 29 | 0.307 | -0.038 | 2559.5 | 0.000 |
| | | 30 | 0.289 | -0.055 | 2583.5 | 0.000 |
| | | 31 | 0.278 | 0.001 | 2606.0 | 0.000 |
| | | 32 | 0.277 | 0.062 | 2628.3 | 0.000 |
| | | 33 | 0.277 | 0.050 | 2650.8 | 0.000 |
| | | 34 | 0.280 | 0.055 | 2673.8 | 0.000 |
| | | 35 | 0.279 | 0.000 | 2696.8 | 0.000 |
| | | 36 | 0.271 | -0.061 | 2718.6 | 0.000 |
| | | 37 | 0.257 | -0.065 | 2738.3 | 0.000 |
| | | 38 | 0.247 | 0.022 | 2756.5 | 0.000 |
| | | 39 | 0.237 | 0.038 | 2773.4 | 0.000 |
| | | 40 | 0.229 | 0.041 | 2789.2 | 0.000 |

**Figure 3.** The correlogram of D(NGC)

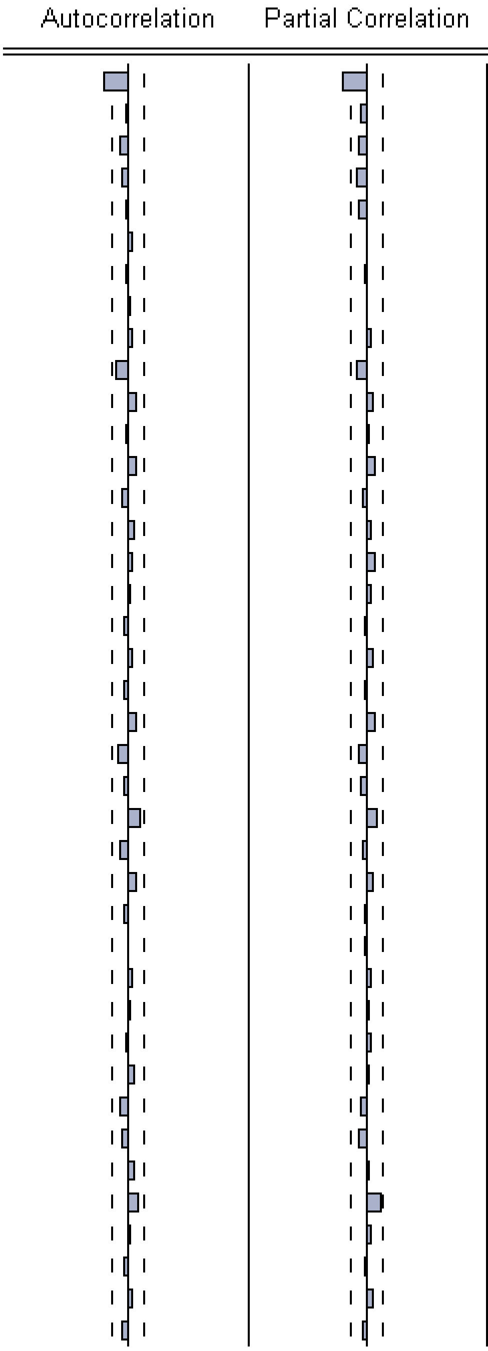
Date: 03/17/08 Time: 17:38
Sample: 1987M01 2007M12
Included observations: 251




| Lag | AC | PAC | Q-Stat | Prob |
|---|---|---|---|---|
| 1 | 0.090 | 0.090 | 2.0461 | 0.153 |
| 2 | 0.081 | 0.074 | 3.7292 | 0.155 |
| 3 | -0.199 | -0.215 | 13.867 | 0.003 |
| 4 | -0.124 | -0.098 | 17.801 | 0.001 |
| 5 | -0.138 | -0.089 | 22.718 | 0.000 |
| 6 | -0.184 | -0.203 | 31.477 | 0.000 |
| 7 | -0.142 | -0.162 | 36.709 | 0.000 |
| 8 | -0.099 | -0.137 | 39.297 | 0.000 |
| 9 | -0.043 | -0.152 | 39.776 | 0.000 |
| 10 | 0.039 | -0.096 | 40.179 | 0.000 |
| 11 | 0.168 | 0.037 | 47.647 | 0.000 |
| 12 | 0.296 | 0.180 | 70.970 | 0.000 |
| 13 | 0.130 | 0.021 | 75.508 | 0.000 |
| 14 | 0.038 | -0.003 | 75.905 | 0.000 |
| 15 | -0.034 | 0.055 | 76.223 | 0.000 |
| 16 | -0.048 | 0.044 | 76.857 | 0.000 |
| 17 | -0.104 | -0.007 | 79.815 | 0.000 |
| 18 | -0.177 | -0.061 | 88.373 | 0.000 |
| 19 | -0.093 | 0.022 | 90.748 | 0.000 |
| 20 | -0.092 | -0.034 | 93.078 | 0.000 |
| 21 | 0.007 | -0.009 | 93.091 | 0.000 |
| 22 | -0.019 | -0.071 | 93.187 | 0.000 |
| 23 | 0.099 | -0.029 | 95.908 | 0.000 |
| 24 | 0.232 | 0.119 | 110.96 | 0.000 |
| 25 | 0.105 | -0.009 | 114.09 | 0.000 |
| 26 | 0.071 | 0.004 | 115.49 | 0.000 |
| 27 | -0.044 | -0.006 | 116.03 | 0.000 |
| 28 | -0.063 | -0.035 | 117.17 | 0.000 |
| 29 | -0.075 | 0.014 | 118.77 | 0.000 |
| 30 | -0.106 | 0.006 | 121.98 | 0.000 |
| 31 | -0.088 | -0.024 | 124.20 | 0.000 |
| 32 | -0.045 | 0.010 | 124.78 | 0.000 |
| 33 | -0.067 | -0.068 | 126.09 | 0.000 |
| 34 | -0.003 | -0.030 | 126.09 | 0.000 |
| 35 | 0.118 | 0.053 | 130.16 | 0.000 |
| 36 | 0.224 | 0.096 | 144.99 | 0.000 |
| 37 | 0.077 | -0.033 | 146.76 | 0.000 |
| 38 | 0.010 | -0.034 | 146.79 | 0.000 |
| 39 | -0.016 | 0.054 | 146.86 | 0.000 |
| 40 | -0.063 | -0.037 | 148.04 | 0.000 |

**Figure 4.** The correlogram of the residuals from Equation (10)

Date: 03/24/08 Time: 11:21
Sample: 1987M01 2007M12
Included observations: 215




| | AC | PAC | Q-Stat | Prob |
|---|---|---|---|---|
| 1 | -0.199 | -0.199 | 8.6208 | 0.003 |
| 2 | -0.015 | -0.056 | 8.6670 | 0.013 |
| 3 | -0.063 | -0.081 | 9.5478 | 0.023 |
| 4 | -0.051 | -0.086 | 10.124 | 0.038 |
| 5 | -0.024 | -0.063 | 10.254 | 0.068 |
| 6 | 0.032 | 0.002 | 10.489 | 0.106 |
| 7 | -0.011 | -0.019 | 10.516 | 0.161 |
| 8 | 0.013 | -0.002 | 10.556 | 0.228 |
| 9 | 0.035 | 0.036 | 10.835 | 0.287 |
| 10 | -0.101 | -0.091 | 13.168 | 0.214 |
| 11 | 0.081 | 0.047 | 14.650 | 0.199 |
| 12 | -0.012 | 0.012 | 14.682 | 0.259 |
| 13 | 0.067 | 0.070 | 15.731 | 0.264 |
| 14 | -0.057 | -0.031 | 16.484 | 0.285 |
| 15 | 0.045 | 0.038 | 16.947 | 0.322 |
| 16 | 0.035 | 0.073 | 17.232 | 0.371 |
| 17 | 0.012 | 0.040 | 17.266 | 0.436 |
| 18 | -0.038 | -0.014 | 17.603 | 0.482 |
| 19 | 0.034 | 0.042 | 17.881 | 0.530 |
| 20 | -0.027 | -0.009 | 18.059 | 0.584 |
| 21 | 0.066 | 0.078 | 19.093 | 0.579 |
| 22 | -0.088 | -0.071 | 20.974 | 0.522 |
| 23 | -0.026 | -0.043 | 21.140 | 0.573 |
| 24 | 0.106 | 0.082 | 23.891 | 0.468 |
| 25 | -0.059 | -0.026 | 24.752 | 0.476 |
| 26 | 0.060 | 0.045 | 25.642 | 0.483 |
| 27 | -0.028 | -0.011 | 25.832 | 0.528 |
| 28 | 0.001 | -0.009 | 25.832 | 0.582 |
| 29 | 0.025 | 0.040 | 25.995 | 0.626 |
| 30 | 0.019 | 0.020 | 26.085 | 0.671 |
| 31 | -0.010 | 0.027 | 26.109 | 0.716 |
| 32 | 0.046 | 0.022 | 26.650 | 0.734 |
| 33 | -0.074 | -0.052 | 28.063 | 0.711 |
| 34 | -0.053 | -0.059 | 28.790 | 0.721 |
| 35 | 0.047 | 0.016 | 29.360 | 0.737 |
| 36 | 0.097 | 0.116 | 31.806 | 0.668 |
| 37 | 0.017 | 0.031 | 31.880 | 0.708 |
| 38 | -0.041 | -0.016 | 32.318 | 0.729 |
| 39 | 0.031 | 0.049 | 32.572 | 0.757 |
| 40 | -0.052 | -0.032 | 33.292 | 0.764 |

## Supplementary Material

*(This document is not a part of the paper and is intended just to provide referees with details of actual steps in the estimation and forecasting process.)*

**1) The original data used in the article**

| | CE | CH | CI | PE | PH | PI | RI |
|---|---|---|---|---|---|---|---|
| | Turkey Natural Gas Consumption Electricity Generation toe | Turkey Natural Gas Consumption Households toe | Turkey Natural Gas Consumption Industry toe | Turkey Natural Gas Real Price Electricity Generation Nat. Cur./toe (NCV) | Turkey Natural Gas Real Price Households Nat. Cur./toe (NCV) | Turkey Natural Gas Real Price Industry Nat. Cur./toe (NCV) | Real GDP per capita billion US$ 2000 prices and ex. rates |
| 1988Q1 | 232624.0 | 29.90000 | 47291.50 | 1.735747 | 2.043413 | 1.157164 | 2382.947 |
| 1988Q2 | 232624.0 | 29.90000 | 47291.50 | 1.735747 | 2.043413 | 1.157164 | 2382.947 |
| 1988Q3 | 232624.0 | 29.90000 | 47291.50 | 1.631177 | 2.043413 | 1.087451 | 2382.947 |
| 1988Q4 | 232624.0 | 29.90000 | 47291.50 | 1.631177 | 2.043413 | 1.087451 | 2382.947 |
| 1989Q1 | 620342.5 | 2985.600 | 112902.5 | 1.519734 | 2.055768 | 1.013156 | 2337.274 |
| 1989Q2 | 620342.5 | 2985.600 | 112902.5 | 1.407320 | 2.055768 | 1.407320 | 2337.274 |
| 1989Q3 | 620342.5 | 2985.600 | 112902.5 | 1.337241 | 2.055768 | 1.337241 | 2337.274 |
| 1989Q4 | 620342.5 | 2985.600 | 112902.5 | 1.233487 | 2.055768 | 1.233487 | 2337.274 |
| 1990Q1 | 591173.4 | 64781.00 | 137205.0 | 1.456338 | 1.662750 | 1.092254 | 2494.529 |
| 1990Q2 | 591173.4 | 64781.00 | 137205.0 | 1.346164 | 1.662750 | 1.346164 | 2494.529 |
| 1990Q3 | 591173.4 | 64781.00 | 137205.0 | 1.423731 | 1.730619 | 1.067798 | 2494.529 |
| 1990Q4 | 591173.4 | 64781.00 | 137205.0 | 1.425531 | 1.873130 | 1.140425 | 2494.529 |
| 1991Q1 | 657829.4 | 156521.7 | 154634.8 | 1.209861 | 1.696471 | 1.209861 | 2469.244 |
| 1991Q2 | 657829.4 | 156521.7 | 154634.8 | 1.209861 | 1.802908 | 1.209861 | 2469.244 |
| 1991Q3 | 657829.4 | 156521.7 | 154634.8 | 1.282813 | 1.820007 | 1.282813 | 2469.244 |
| 1991Q4 | 657829.4 | 156521.7 | 154634.8 | 1.282813 | 1.820007 | 1.282813 | 2469.244 |
| 1992Q1 | 598135.8 | 244202.0 | 217427.4 | 1.249777 | 1.837506 | 1.249777 | 2568.449 |
| 1992Q2 | 598135.8 | 244202.0 | 217427.4 | 1.190268 | 1.837506 | 1.190268 | 2568.449 |
| 1992Q3 | 598135.8 | 244202.0 | 217427.4 | 1.202285 | 1.837506 | 1.202285 | 2568.449 |
| 1992Q4 | 598135.8 | 244202.0 | 217427.4 | 1.224466 | 1.837506 | 1.224466 | 2568.449 |
| 1993Q1 | 590839.1 | 319844.5 | 267095.4 | 1.256320 | 1.808339 | 1.177800 | 2723.101 |
| 1993Q2 | 590839.1 | 319844.5 | 267095.4 | 1.230652 | 1.808339 | 1.230652 | 2723.101 |
| 1993Q3 | 590839.1 | 319844.5 | 267095.4 | 1.248485 | 1.808339 | 1.189033 | 2723.101 |
| 1993Q4 | 590839.1 | 319844.5 | 267095.4 | 1.243081 | 1.798795 | 1.189034 | 2723.101 |
| 1994Q1 | 674697.9 | 303961.3 | 277109.0 | 1.243232 | 1.786303 | 1.200361 | 2529.180 |
| 1994Q2 | 674697.9 | 303961.3 | 277109.0 | 1.247132 | 1.809204 | 1.224037 | 2529.180 |
| 1994Q3 | 674697.9 | 303961.3 | 277109.0 | 1.247132 | 1.809204 | 1.224037 | 2529.180 |
| 1994Q4 | 674697.9 | 303961.3 | 277109.0 | 1.247132 | 1.809204 | 1.224037 | 2529.180 |
| 1995Q1 | 823307.8 | 495026.0 | 289164.8 | 1.234299 | 1.795194 | 1.214391 | 2663.595 |
| 1995Q2 | 823307.8 | 495026.0 | 289164.8 | 1.233019 | 1.794090 | 1.217796 | 2663.595 |
| 1995Q3 | 823307.8 | 495026.0 | 289164.8 | 1.293422 | 1.795653 | 1.219932 | 2663.595 |
| 1995Q4 | 823307.8 | 495026.0 | 289164.8 | 1.235504 | 1.804377 | 1.210290 | 2663.595 |
| 1996Q1 | 985215.4 | 583333.3 | 372115.9 | 1.139777 | 1.800509 | 1.217050 | 2802.456 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1996Q2 | 985215.4 | 583333.3 | 372115.9 | 1.072313 | 1.800783 | 1.218206 | 2802.456 |
| 1996Q3 | 985215.4 | 583333.3 | 372115.9 | 1.107777 | 1.802384 | 1.214551 | 2802.456 |
| 1996Q4 | 985215.4 | 583333.3 | 372115.9 | 1.102895 | 1.804704 | 1.216165 | 2802.456 |
| 1997Q1 | 1161549. | 718185.7 | 437219.4 | 1.136007 | 1.801010 | 1.216141 | 2963.370 |
| 1997Q2 | 1161549. | 718185.7 | 437219.4 | 1.132100 | 1.800527 | 1.214363 | 2963.370 |
| 1997Q3 | 1161549. | 718185.7 | 437219.4 | 1.154818 | 1.800228 | 1.215955 | 2963.370 |
| 1997Q4 | 1161549. | 718185.7 | 437219.4 | 1.161470 | 1.801578 | 1.216918 | 2963.370 |
| 1998Q1 | 1283761. | 797345.2 | 403870.5 | 1.141141 | 1.802095 | 1.216868 | 3006.683 |
| 1998Q2 | 1283761. | 797345.2 | 403870.5 | 1.183299 | 1.801471 | 1.215148 | 3006.683 |
| 1998Q3 | 1283761. | 797345.2 | 403870.5 | 1.170279 | 1.801927 | 1.216411 | 3006.683 |
| 1998Q4 | 1283761. | 797345.2 | 403870.5 | 1.180751 | 1.800392 | 1.215009 | 3006.683 |
| 1999Q1 | 1758957. | 760831.7 | 422184.0 | 1.181056 | 1.801027 | 1.215377 | 2819.854 |
| 1999Q2 | 1758957. | 760831.7 | 422184.0 | 1.184691 | 1.801051 | 1.214750 | 2819.854 |
| 1999Q3 | 1758957. | 760831.7 | 422184.0 | 1.186536 | 1.801493 | 1.216238 | 2819.854 |
| 1999Q4 | 1758957. | 760831.7 | 422184.0 | 1.185497 | 1.801145 | 1.216025 | 2819.854 |
| 2000Q1 | 2057210. | 990267.0 | 463002.8 | 1.185161 | 1.800586 | 1.215746 | 2954.300 |
| 2000Q2 | 2057210. | 990267.0 | 463002.8 | 1.180590 | 1.800991 | 1.215832 | 2954.300 |
| 2000Q3 | 2057210. | 990267.0 | 463002.8 | 1.174546 | 1.800877 | 1.215484 | 2954.300 |
| 2000Q4 | 2057210. | 990267.0 | 463002.8 | 1.145534 | 1.801483 | 1.215930 | 2954.300 |
| 2001Q1 | 2229447. | 1087233. | 397714.2 | 1.157618 | 1.801003 | 1.215910 | 2685.884 |
| 2001Q2 | 2229447. | 1087233. | 397714.2 | 1.182901 | 1.801130 | 1.215637 | 2685.884 |
| 2001Q3 | 2229447. | 1087233. | 397714.2 | 1.209437 | 1.801233 | 1.215526 | 2685.884 |
| 2001Q4 | 2229447. | 1087233. | 397714.2 | 1.210533 | 1.801146 | 1.215479 | 2685.884 |
| 2002Q1 | 2404533. | 1224270. | 464370.2 | 1.200496 | 1.800971 | 1.215628 | 2858.128 |
| 2002Q2 | 2404533. | 1224270. | 464370.2 | 1.212304 | 1.801247 | 1.215577 | 2858.128 |
| 2002Q3 | 2404533. | 1224270. | 464370.2 | 1.214247 | 1.801006 | 1.215479 | 2858.128 |
| 2002Q4 | 2404533. | 1224270. | 464370.2 | 1.209303 | 1.800919 | 1.215668 | 2858.128 |
| 2003Q1 | 2766576. | 1529886. | 625961.4 | 1.195223 | 1.801159 | 1.215580 | 2976.864 |
| 2003Q2 | 2766576. | 1529886. | 625961.4 | 1.198599 | 1.801092 | 1.215489 | 2976.864 |
| 2003Q3 | 2766576. | 1529886. | 625961.4 | 1.170952 | 1.801173 | 1.215667 | 2976.864 |
| 2003Q4 | 2766576. | 1529886. | 625961.4 | 1.167485 | 1.801020 | 1.215502 | 2976.864 |
| 2004Q1 | 2815796. | 1701317. | 679946.5 | 1.199463 | 1.801020 | 1.215681 | 3194.083 |
| 2004Q2 | 2815796. | 1701317. | 679946.5 | 1.200491 | 1.801244 | 1.215641 | 3194.083 |
| 2004Q3 | 2815796. | 1701317. | 679946.5 | 1.204217 | 1.801137 | 1.215711 | 3194.083 |
| 2004Q4 | 2815796. | 1701317. | 679946.5 | 1.207210 | 1.800910 | 1.215699 | 3194.083 |
| 2005Q1 | 3505935. | 2072764. | 752352.6 | 1.207712 | 1.801079 | 1.215603 | 3379.083 |
| 2005Q2 | 3505935. | 2072764. | 752352.6 | 1.201381 | 1.800953 | 1.215646 | 3379.083 |
| 2005Q3 | 3505935. | 2072764. | 752352.6 | 1.200970 | 1.801190 | 1.215484 | 3379.083 |
| 2005Q4 | 3505935. | 2072764. | 752352.6 | 1.200499 | 1.801130 | 1.215664 | 3379.083 |

## 2) Estimation outputs of Equations (6), (7) and (8)

Dependent Variable: LNCE
Method: Least Squares
Date: 03/12/08 Time: 16:49
Sample (adjusted): 1988Q2 2005Q4
Included observations: 71 after adjustments

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | -1.581029 | 1.980741 | -0.798201 | 0.4276 |
| LNPE | 0.111535 | 0.235649 | 0.473310 | 0.6375 |
| LNRI | 0.307071 | 0.297138 | 1.033428 | 0.3051 |
| LNCE(-1) | 0.939857 | 0.042182 | 22.28083 | 0.0000 |

| | | | |
|---|---|---|---|
| R-squared | 0.966816 | Mean dependent var | 13.95711 |
| Adjusted R-squared | 0.965330 | S.D. dependent var | 0.703879 |
| S.E. of regression | 0.131061 | Akaike info criterion | -1.171623 |
| Sum squared resid | 1.150853 | Schwarz criterion | -1.044148 |
| Log likelihood | 45.59263 | F-statistic | 650.6868 |
| Durbin-Watson stat | 2.168747 | Prob(F-statistic) | 0.000000 |

Dependent Variable: LNCH
Method: Least Squares
Date: 03/12/08 Time: 16:52
Sample (adjusted): 1988Q2 2005Q4
Included observations: 71 after adjustments

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | -5.550087 | 7.423121 | -0.747676 | 0.4573 |
| LNPH | -7.820948 | 2.256152 | -3.466499 | 0.0009 |
| LNRI | 1.696497 | 0.992740 | 1.708903 | 0.0921 |
| LNCH(-1) | 0.754813 | 0.047458 | 15.90473 | 0.0000 |

| | | | |
|---|---|---|---|
| R-squared | 0.951401 | Mean dependent var | 12.57211 |
| Adjusted R-squared | 0.949225 | S.D. dependent var | 2.454763 |
| S.E. of regression | 0.553142 | Akaike info criterion | 1.708283 |
| Sum squared resid | 20.49969 | Schwarz criterion | 1.835758 |
| Log likelihood | -56.64405 | F-statistic | 437.2067 |
| Durbin-Watson stat | 2.078343 | Prob(F-statistic) | 0.000000 |

Dependent Variable: LNCI
Method: Least Squares
Date: 03/12/08 Time: 16:53
Sample (adjusted): 1988Q2 2005Q4
Included observations: 71 after adjustments

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | -2.302215 | 2.070085 | -1.112135 | 0.2701 |
| LNPI | -0.782223 | 0.346407 | -2.258102 | 0.0272 |
| LNRI | 0.473582 | 0.326555 | 1.450236 | 0.1517 |
| LNCI(-1) | 0.899846 | 0.048995 | 18.36608 | 0.0000 |

| | | | |
|---|---|---|---|
| R-squared | 0.971366 | Mean dependent var | 12.63942 |
| Adjusted R-squared | 0.970083 | S.D. dependent var | 0.658350 |
| S.E. of regression | 0.113871 | Akaike info criterion | -1.452816 |
| Sum squared resid | 0.868759 | Schwarz criterion | -1.325341 |
| Log likelihood | 55.57497 | F-statistic | 757.6138 |
| Durbin-Watson stat | 1.984341 | Prob(F-statistic) | 0.000000 |

### 3) White heteroskedasticity-consistent standard errors & covariance

Dependent Variable: LNCE
Method: Least Squares
Date: 03/12/08 Time: 17:10
Sample (adjusted): 1988Q2 2005Q4
Included observations: 71 after adjustments
White Heteroskedasticity-Consistent Standard Errors & Covariance

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | -1.581029 | 1.183283 | -1.336137 | 0.1860 |
| LNPE | 0.111535 | 0.298912 | 0.373136 | 0.7102 |
| LNRI | 0.307071 | 0.194211 | 1.581119 | 0.1186 |
| LNCE(-1) | 0.939857 | 0.038065 | 24.69081 | 0.0000 |

| | | | |
|---|---|---|---|
| R-squared | 0.966816 | Mean dependent var | 13.95711 |
| Adjusted R-squared | 0.965330 | S.D. dependent var | 0.703879 |
| S.E. of regression | 0.131061 | Akaike info criterion | -1.171623 |
| Sum squared resid | 1.150853 | Schwarz criterion | -1.044148 |
| Log likelihood | 45.59263 | F-statistic | 650.6868 |
| Durbin-Watson stat | 2.168747 | Prob(F-statistic) | 0.000000 |

Dependent Variable: LNCH
Method: Least Squares
Date: 03/12/08 Time: 17:12
Sample (adjusted): 1988Q2 2005Q4
Included observations: 71 after adjustments
White Heteroskedasticity-Consistent Standard Errors & Covariance

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | -5.550087 | 7.360427 | -0.754044 | 0.4535 |
| LNPH | -7.820948 | 3.785544 | -2.066004 | 0.0427 |
| LNRI | 1.696497 | 1.057151 | 1.604782 | 0.1132 |
| LNCH(-1) | 0.754813 | 0.113712 | 6.637930 | 0.0000 |

| | | | |
|---|---|---|---|
| R-squared | 0.951401 | Mean dependent var | 12.57211 |
| Adjusted R-squared | 0.949225 | S.D. dependent var | 2.454763 |
| S.E. of regression | 0.553142 | Akaike info criterion | 1.708283 |
| Sum squared resid | 20.49969 | Schwarz criterion | 1.835758 |
| Log likelihood | -56.64405 | F-statistic | 437.2067 |
| Durbin-Watson stat | 2.078343 | Prob(F-statistic) | 0.000000 |

Dependent Variable: LNCI
Method: Least Squares
Date: 03/12/08 Time: 17:12
Sample (adjusted): 1988Q2 2005Q4
Included observations: 71 after adjustments
White Heteroskedasticity-Consistent Standard Errors & Covariance

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | -2.302215 | 1.564898 | -1.471160 | 0.1459 |
| LNPI | -0.782223 | 0.697869 | -1.120875 | 0.2663 |
| LNRI | 0.473582 | 0.283518 | 1.670377 | 0.0995 |
| LNCI(-1) | 0.899846 | 0.061426 | 14.64930 | 0.0000 |

| | | | |
|---|---|---|---|
| R-squared | 0.971366 | Mean dependent var | 12.63942 |
| Adjusted R-squared | 0.970083 | S.D. dependent var | 0.658350 |
| S.E. of regression | 0.113871 | Akaike info criterion | -1.452816 |
| Sum squared resid | 0.868759 | Schwarz criterion | -1.325341 |
| Log likelihood | 55.57497 | F-statistic | 757.6138 |
| Durbin-Watson stat | 1.984341 | Prob(F-statistic) | 0.000000 |

## 4) The original data used in ARIMA modelling

| Time | Consumption | Time | Consumption | Time | Consumption |
|---|---|---|---|---|---|
| 1987M01 | 40,000 | 1994M01 | 458,000 | 2001M01 | 1680,000 |
| 1987M02 | 37,000 | 1994M02 | 422,000 | 2001M02 | 1535,000 |
| 1987M03 | 40,000 | 1994M03 | 427,000 | 2001M03 | 1326,000 |
| 1987M04 | 37,000 | 1994M04 | 459,000 | 2001M04 | 1225,000 |
| 1987M05 | 27,000 | 1994M05 | 451,000 | 2001M05 | 1069,000 |
| 1987M06 | 60,000 | 1994M06 | 377,000 | 2001M06 | 1110,000 |
| 1987M07 | 57,000 | 1994M07 | 479,000 | 2001M07 | 1126,000 |
| 1987M08 | 96,000 | 1994M08 | 451,000 | 2001M08 | 1142,000 |
| 1987M09 | 73,000 | 1994M09 | 471,000 | 2001M09 | 1143,000 |
| 1987M10 | 81,000 | 1994M10 | 507,000 | 2001M10 | 1286,000 |
| 1987M11 | 80,000 | 1994M11 | 504,000 | 2001M11 | 1603,000 |
| 1987M12 | 64,000 | 1994M12 | 553,000 | 2001M12 | 1699,000 |
| 1988M01 | 69,000 | 1995M01 | 434,000 | 2002M01 | 1962,000 |
| 1988M02 | 58,000 | 1995M02 | 504,000 | 2002M02 | 1427,000 |
| 1988M03 | 49,000 | 1995M03 | 588,000 | 2002M03 | 1550,000 |
| 1988M04 | 45,000 | 1995M04 | 540,000 | 2002M04 | 1431,000 |
| 1988M05 | 47,000 | 1995M05 | 547,000 | 2002M05 | 1339,000 |
| 1988M06 | 76,000 | 1995M06 | 482,000 | 2002M06 | 1175,000 |
| 1988M07 | 125,000 | 1995M07 | 538,000 | 2002M07 | 1327,000 |
| 1988M08 | 154,000 | 1995M08 | 587,000 | 2002M08 | 1244,000 |
| 1988M09 | 159,000 | 1995M09 | 541,000 | 2002M09 | 1296,000 |
| 1988M10 | 146,000 | 1995M10 | 646,000 | 2002M10 | 1321,000 |
| 1988M11 | 125,000 | 1995M11 | 696,000 | 2002M11 | 1605,000 |
| 1988M12 | 111,000 | 1995M12 | 926,000 | 2002M12 | 1911,000 |
| 1989M01 | 226,000 | 1996M01 | 724,000 | 2003M01 | 2042,000 |
| 1989M02 | 209,000 | 1996M02 | 670,000 | 2003M02 | 2051,000 |
| 1989M03 | 195,000 | 1996M03 | 742,000 | 2003M03 | 2162,000 |
| 1989M04 | 211,000 | 1996M04 | 731,000 | 2003M04 | 1679,000 |
| 1989M05 | 245,000 | 1996M05 | 611,000 | 2003M05 | 1464,000 |
| 1989M06 | 301,000 | 1996M06 | 667,000 | 2003M06 | 1317,000 |
| 1989M07 | 309,000 | 1996M07 | 617,000 | 2003M07 | 1457,000 |
| 1989M08 | 322,000 | 1996M08 | 661,000 | 2003M08 | 1549,000 |
| 1989M09 | 335,000 | 1996M09 | 612,000 | 2003M09 | 1454,000 |
| 1989M10 | 333,000 | 1996M10 | 685,000 | 2003M10 | 1638,000 |
| 1989M11 | 293,000 | 1996M11 | 772,000 | 2003M11 | 1913,000 |
| 1989M12 | 193,000 | 1996M12 | 722,000 | 2003M12 | 2449,000 |
| 1990M01 | 209,000 | 1997M01 | 926,000 | 2004M01 | 2421,000 |
| 1990M02 | 205,000 | 1997M02 | 811,000 | 2004M02 | 2169,000 |
| 1990M03 | 261,000 | 1997M03 | 963,000 | 2004M03 | 1943,000 |
| 1990M04 | 257,000 | 1997M04 | 882,000 | 2004M04 | 1658,000 |
| 1990M05 | 249,000 | 1997M05 | 743,000 | 2004M05 | 1430,000 |
| 1990M06 | 254,000 | 1997M06 | 684,000 | 2004M06 | 1461,000 |
| 1990M07 | 281,000 | 1997M07 | 694,000 | 2004M07 | 1623,000 |
| 1990M08 | 351,000 | 1997M08 | 685,000 | 2004M08 | 1646,000 |
| 1990M09 | 342,000 | 1997M09 | 756,000 | 2004M09 | 1587,000 |

| | | | | | |
|---|---|---|---|---|---|
| 1990M10 | 357,000 | 1997M10 | 884,000 | 2004M10 | 1638,000 |
| 1990M11 | 357,000 | 1997M11 | 895,000 | 2004M11 | 1913,000 |
| 1990M12 | 344,000 | 1997M12 | 877,000 | 2004M12 | 2449,000 |
| 1991M01 | 347,000 | 1998M01 | 997,000 | 2005M01 | 2238,750 |
| 1991M02 | 301,000 | 1998M02 | 907,000 | 2005M02 | 2238,750 |
| 1991M03 | 376,000 | 1998M03 | 1095,000 | 2005M03 | 2238,750 |
| 1991M04 | 332,000 | 1998M04 | 752,000 | 2005M04 | 2238,750 |
| 1991M05 | 336,000 | 1998M05 | 789,000 | 2005M05 | 2238,750 |
| 1991M06 | 334,000 | 1998M06 | 707,000 | 2005M06 | 2238,750 |
| 1991M07 | 385,000 | 1998M07 | 775,000 | 2005M07 | 2238,750 |
| 1991M08 | 343,000 | 1998M08 | 818,000 | 2005M08 | 2238,750 |
| 1991M09 | 349,000 | 1998M09 | 634,000 | 2005M09 | 2238,750 |
| 1991M10 | 370,000 | 1998M10 | 828,000 | 2005M10 | 2238,750 |
| 1991M11 | 391,000 | 1998M11 | 999,000 | 2005M11 | 2238,750 |
| 1991M12 | 375,000 | 1998M12 | 1181,000 | 2005M12 | 2238,750 |
| 1992M01 | 405,000 | 1999M01 | 1147,000 | 2006M01 | 2541,083 |
| 1992M02 | 362,000 | 1999M02 | 1058,000 | 2006M02 | 2541,083 |
| 1992M03 | 378,000 | 1999M03 | 1108,000 | 2006M03 | 2541,083 |
| 1992M04 | 345,000 | 1999M04 | 992,000 | 2006M04 | 2541,083 |
| 1992M05 | 378,000 | 1999M05 | 949,000 | 2006M05 | 2541,083 |
| 1992M06 | 357,000 | 1999M06 | 1021,000 | 2006M06 | 2541,083 |
| 1992M07 | 358,000 | 1999M07 | 1082,000 | 2006M07 | 2541,083 |
| 1992M08 | 390,000 | 1999M08 | 944,000 | 2006M08 | 2541,083 |
| 1992M09 | 368,000 | 1999M09 | 898,000 | 2006M09 | 2541,083 |
| 1992M10 | 416,000 | 1999M10 | 1006,000 | 2006M10 | 2541,083 |
| 1992M11 | 426,000 | 1999M11 | 1227,000 | 2006M11 | 2541,083 |
| 1992M12 | 451,000 | 1999M12 | 1237,000 | 2006M12 | 2541,083 |
| 1993M01 | 471,000 | 2000M01 | 1440,000 | 2007M01 | 3295,000 |
| 1993M02 | 411,000 | 2000M02 | 1325,000 | 2007M02 | 3179,000 |
| 1993M03 | 434,000 | 2000M03 | 1362,000 | 2007M03 | 3325,000 |
| 1993M04 | 422,000 | 2000M04 | 1128,000 | 2007M04 | 2881,000 |
| 1993M05 | 397,000 | 2000M05 | 1004,000 | 2007M05 | 2487,000 |
| 1993M06 | 404,000 | 2000M06 | 966,000 | 2007M06 | 2381,000 |
| 1993M07 | 459,000 | 2000M07 | 1142,000 | 2007M07 | 2480,000 |
| 1993M08 | 459,000 | 2000M08 | 1182,000 | 2007M08 | 2548,000 |
| 1993M09 | 376,000 | 2000M09 | 1208,000 | 2007M09 | 2489,000 |
| 1993M10 | 429,000 | 2000M10 | 1356,000 | 2007M10 | 2643,000 |
| 1993M11 | 450,000 | 2000M11 | 1393,000 | 2007M11 | 3453,000 |
| 1993M12 | 447,000 | 2000M12 | 1586,000 | 2007M12 | 3895,000 |

**5) Estimation output of Equation (9)**

Dependent Variable: DNGC
Method: Least Squares
Date: 03/18/08 Time: 09:48
Sample (adjusted): 1990M02 2007M12
Included observations: 215 after adjustments

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | 24.96243 | 9.830097 | 2.539388 | 0.0119 |
| DNGC(-3) | -0.294861 | 0.072754 | -4.052868 | 0.0001 |
| DNGC(-4) | -0.113829 | 0.068361 | -1.665100 | 0.0975 |
| DNGC(-5) | -0.090102 | 0.069056 | -1.304772 | 0.1935 |
| DNGC(-6) | -0.312657 | 0.077564 | -4.030955 | 0.0001 |
| DNGC(-7) | -0.227019 | 0.070017 | -3.242328 | 0.0014 |
| DNGC(-8) | -0.136385 | 0.073636 | -1.852157 | 0.0655 |
| DNGC(-9) | -0.157935 | 0.075410 | -2.094348 | 0.0375 |
| DNGC(-11) | 0.020004 | 0.076328 | 0.262073 | 0.7935 |
| DNGC(-12) | 0.235124 | 0.087417 | 2.689671 | 0.0078 |
| DNGC(-13) | -0.017501 | 0.077860 | -0.224773 | 0.8224 |
| DNGC(-18) | 0.078353 | 0.080541 | 0.972834 | 0.3318 |
| DNGC(-24) | -0.111355 | 0.089430 | -1.245163 | 0.2145 |
| DNGC(-35) | 0.080594 | 0.076564 | 1.052642 | 0.2938 |
| DNGC(-36) | 0.293845 | 0.087554 | 3.356144 | 0.0009 |

| | | | |
|---|---|---|---|
| R-squared | 0.400387 | Mean dependent var | 17.14419 |
| Adjusted R-squared | 0.358414 | S.D. dependent var | 156.9921 |
| S.E. of regression | 125.7492 | Akaike info criterion | 12.57367 |
| Sum squared resid | 3162573. | Schwarz criterion | 12.80883 |
| Log likelihood | -1336.670 | F-statistic | 9.539181 |
| Durbin-Watson stat | 2.365125 | Prob(F-statistic) | 0.000000 |