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Forecast of Iran's Electricity Consumption Using a Combined Approach of Neural Networks and Econometrics

Mohammad Hossein Pourkazemi *
Roya Aghaeifar **

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Abstract

Electricity cannot be stored and needs huge amount of capital so producers and consumers pay special attention to predict electricity consumption. Besides, time series data of the electricity market are chaotic and complicated. Nonlinear methods such as Neural Networks have shown better performance for predicting such kind of data. We also need to analyze other variables affecting electricity consumption so as to estimate their quantitative effects. This paper presents a new approach for forecasting: a combined method of Neural Networks (ANN) and econometrics methods which can also explain the effect of raising the electricity prices on consumption after Subsidies Reform Plan. Data is from 1988-2008, and the method is compared with Neural Network and ARIMA based on the RMSE performance function that shows the advantage of the combinned approach. The provident prediction is done for 2009- 2014 and indicated that after decreasing subsidy, electricity consumption would increase slightly until 2014.

Keywords: forecasting, electricity consumption, neural network, ARDL model, ARIMA method

1- Introduction

Energy has played a vital role in the man's life. All countries in the world are trying to access to reliable sources of energy. In fact, the exploration for new sources of energy is vital for the future of our planet because fossil fuels like oil and gas are not renewable and clean. The most prominent plan of many developed countries is to turn their attention to new forms of energy,

* Associate Professor, Shahid Beheshti University (Corresponding Author).
** M.A.in Economics

electricity is a good example. Besides, the characteristics of electricity market are completely different from other economic markets. First, it needs high amount of investment to increase capacity for new generations, transmissions and distributions which is sort of time-consuming. Secondly, unlike other source of energy storage such as wood or coal, electricity must be consumed in time of generation, or converted immediately into another form of energy such as potential, kinetic or chemical [Pino et al, 2008]. As a result, the system operator must hold units of production that can change in response to demand. In other words, predicting more than actual need may cause additional investment cost and ineffective installation, and inversely predicting less than community's need may cause production shortages, damage to equipment and increase extinction [Electricity Market Report, 2009]. In this situation, studying economic concept of the power industry and useing new methods for forecasting is particularly important for decision-makers.

Nowadays, many researches particularly those in the field of data-base processing, have a tendency for developing intelligent dynamic theory made on the basis of experimental data. One of these systems is Neural Networks learning from the data structure so as to forecast appropriately [Sohrabkhani, 2006]. But this approach per se is not efficient because in economics analyzing the variebles affecting dependant variable and estimating their quantitative effects on economic models is important for policy- makers. That is why in this study we offer a new approach based on neural networks and econometric to satisfy this goal. To predict the electricity consumption, we use ARDL model to stimate an econometric model. This model is useful for finite sample and allows for a mix of I(1) and I(0) variables in the same cointegration equation. We also benefit ANN as a nonlinear method to improve the performance of prediction model. Finally, this approach is compared with the results of Neural Networks and ARIMA base on RMSE[1] test.

1- Root Mean Square Error.

2- Iran's electricity market

Iran's power market was established on October 23, 2003in order to comply with the general policy of the electric power industry of Iran in the field of providing just and fair competition atmosphere and providing indiscriminate access of market participants to transmission network Iran Grid Management Co (IGMC) which was formed in 2004 as an Independent System Operator (ISO) for Iran's power grid. System Operate (SO) that evaluates and acquires required ancillary services, conducts transmission girds, integrates schedule and manages network in real time along with Market Operator (MO) that administrates financial transactions and organizes information of transactions are two separate entities that operate under the supervision of IGMC. To provide a close and effective supervision on the power market of the country, Electricity Market Regulatory Board has been established which is independent of TAVANIR Co, private power stations and any other entities of Iran's electricity industry. The main responsibilities of Iran's Electricity Market Regulatory Board are determining and approving market rules, ensuring fair and efficient operation of the electricity, developing new markets, market monitoring and investigating suspected cases of abuse of market power. The power market in Iran is a purchasing agency and all participants are mandated to take part in the power pool. The most significant features of Iran's electricity market are:

- It is a day-ahead market.
- Unilateral auction (distribution companies and Regional Electric Companies (RECs) are just entitled to forecast their hourly demand, namely, the demand curve in a certain hour is a vertical line whose value is equal to the aggregated demand in that hour and the price elasticity of demand is zero).
- The discriminatory pricing in supply side (the method of payment is Pay-as-bid).
- Wholesale market.
- The uniform pricing in demand side (the price of energy for distribution companies and RECs is determined through a market clearing price (MCP)).

- A hybrid market model (direct access and bilateral contracts are allowed in Iran's power market between RECs and consumers. All information, except prices, must be submitted to the ISO)
- Availability based payments for transmission services [Electricity Market Report, 2009].

Ancillary service markets in Iran's power market are evolving gradually. The first presented ancillary service in Iran's electricity market was the regulation service (primary frequency control), launched on 22 May 2007. At present, voltage support services (reactive power market) and black start services are two other ancillary services in it. RECs and Regional Water Companies (RWCs) together with some private power stations are supply side participants of Iran's electricity market, which take part in the market individually. It is noteworthy that the private power stations are entered to a long term Energy Conversion Agreement (ECA) not to supply the part of electricity that is previously sold to TAVANIR, to the market. In fact, this part is sold by TAVANIR in the wholesale market. Thus, TAVANIR is considered as another supply side participant of Iranian power market. Most of private power plants sell their output with the guaranteed price to TAVANIR or IGMC so they normally do not directly participate in power pool. RWCs own generation facilities of hydro power plants and dams and work under the supervision of the Deputy of Water and Waste Water of the MOE. Hydro electricity consists 14.7% of the total installed power generation capacity of the country. Khuzestan Water & Power Authority possesses most of this capacity. Most of the thermal generation capacity of the country belongs to RECs. While RECs are affiliated to the Expert Holding Company of TAVANIR, they are acting the same as the holding company within the border of their managerial territory and are responsible for coordination of their affiliated companies, generation, transmission and sell and supply of electricity to all consuming sectors in their region. The whole bounds of these companies belong to government and administrate by TAVANIR Company. The generation, transmission and distribution facilities in each region are under the ownership of relative REC. Generation Management Companies (GMCs), which are established as private companies, are responsible for the operation of one or several power plants in the related region. At present, each of these companies acts as a contractor for operation of power plant under one agreement with the relative REC [IGMC & TAVANIR Website].

Distribution companies and RECs are demand side participants of Iranian electricity market. At present, 42 distribution companies are working as non-governmental companies in Iran. According to the articles of association of distribution companies, private sector possesses 60% of the share and the remaining share belongs to government sector. The governmental share of these companies is in the possession of the Expert Holding Company of TAVANIR and from the point of view of operation that they are under the supervision of the RECs. The activities of power distribution companies are carried out in less than five agreements with the RECs such as agreement for customer's service, agreement for planning design and supervision, agreement for improvement and optimization and agreement for development of services. RECs, as the other demand side participant, on behalf of large industries and consumers submit their hourly demand forecasts and take part in power market.

Payments to supply side participants in Iran's power market consist of two components: capacity payment and energy payment. All the available generators in the market receive a certain hourly fixed payment. The availability rate is set annually by the minister of energythat is equal for the all types of generators. All accepted generators in the market receive energy payment, too. The price of energy is calculated through the market clearing price from a submitted bid curve and pay-as-bid method is selected for this payment. In order to mitigate market power and prevent price spikes, a hard price cap is designed for Iran's power market. The value of price cap is determined annually by Iran's minister of energy. Market designers of Iranian electricity market confirm the capacity payment mechanism and claim this payment increases the investment security, prevents price spikes and avoids unnecessary stress in the market, especially at market start-up. Although the establishment of power market in Iran has had positive and undeniable consequences such as clarification and separation of costs of different sectors, reduction of losses and other excessive costs, provision of incentives for attracting private sector's investments and paving the way for privatization and industry liberalization [TAVANIR Website], Iranian electricity market is still in its initial steps to attain a fully competitive market. Regardless of the technical problems of Iran's power system such as lack of appropriate measuring, communication and telecommunication infrastructures, some problems in operation of power stations, transmission network constraints generation shortage and market power problems, there are some other significant factors that have unfavorable impacts on efficiency of Iran's power market. Long term governmental background about electricity supply, traditional thought in some managerial levels of the industry, some limitations in liberalization of energy prices, adverse budgeting system in the power industry, lack of proper education for market participants about restructuring and bidding strategies are other problems of Iran's electricity market in transition to a fully competitive market [Electricity Market Report, 2009].

3- Literature review

Before the early 1970s, forecasts were simply calculated based on the stable rate or even the growth of previous time series. However, severe change in energy prices in 1970 along with decreasing economic growth of development countries cuesed to put less trust in these kind of method and to increase energy studies [Sohrabkhani, 2006]. The purpose of these studies was to analyze the effected oeconomic activity on energy consumption or demand. Thus, two kinds of model introduced: "solved- form model" and "structural- formed model." The earlier one is the two times logarithm of the linear model in which energy prices and real income formed the direct factores. The later model is a kind of derived demand which means the customers would demand energy because they need other services such as lighting and warming. In this model, the demand of energy is devided into several demand equation and likewise considered as an indirect factor of energy prices and real income. Although the structural model has the more advantage, it is not welcomed due to a variety amount of variables and data. Another model for estimating the energy demand is introduced by Wolffram (1971) and is developed by Traill et all (1978) which is an immutable approach of prices clarifing the response to decrease prices is lower than the response to increase prices. After a while, this method is improved by Dargay and Gately [Dargay & Gately, 1992] in a way tht they broke up the prices into three ways and analysing the effect of fluctuating prices on the demand. Despite the widespread use of these modes, many discustions took place on the validity of hypothesis of coefficients. The hypothesis for two-time logarithm function easily clarifys the constant elasticities for the entire sample period.

But long-term developments in economics and consequently changes in electricity consumption caused that this hypothesis became unjustified and likewise there was the probability of instability of the regression parameters. In adition, the conventional method of estimating energy demand did hardly pay attention to trait of data and implicity assumed that the data are stabele meaning that the mean and variance of data do not change over times. That is why ARDL approach became the basic parts of energy model's study [Samady, 2008] since this method justified the widespread use of unstable data when there is a long-term relationship among them [Tashkini, 2005]. So we used the ARDL approach for estimating the long-term relationship among variables.

Samadi et al (2008) used co-integration analysis as well as ARIMA model to stimate and forecast electricity demand in Iran. The study concluded that consumers' respond to price and income changes is quite limited and therefore there is a need for economic regulation in Iran electricity market. Furthermore, forecasting future demand indicate that demand of electricity per capita increases with annual growth rate of 4.4 percent. Azarbayejani et all (2006) tried to analyze power consumption for industrial section by ARDL approach. They used electricity consumption, electricity price, national gas price and dummy variable, indicating the quality of the electrical energy supply as an influential variable of the model. Furthermore, they emphasized that consumption in long-term is not a function of electricity price. Indeed, power energy is inelastic in this section, additionally continuing subsidy policy has a tiny effect on the management of consumption. Pino et all (2008), Conjeo et al (2005), Zhang G (2003), Sohrabkhani (2006) and Sadeghi et all (2010) used time series approach to compared ANN with ARIMA. The results of all studies show that Neural Networks has better performance than ARIMA models for forecasting. Zhang (2003) in his paper claimed that combining two methods of ANN and ARIMA had better performance than the prediction with one of ANN or ARIMA on its own.

4- Methodology

Before the early 1920, forecasts were calculated by simply extrapolating time series. What might be dubbed as "modern forecasting" launched in 1927, when Yule presented auto-regressive techniques to forecast the annual number of sun spots which calculated forecasts as a weighted sum of previous data. If good performance achieved from this linear system, an external factor called noise had to be catered for, and affects the linear system. This linear system with noise research culminated in the ARIMA methodology proposed by Box and Jenkins. From this time, strongly theory-based studies focused on non-stationary and/or non-linear series [Pino, 2007]. During the 1980s, on the one hand, ever-increasing capacity and enhanced features of personal computers meant that much longer time series could be handled and more sophisticated algorithms could be used which supports the development of machine learning techniques, such as ANNs [Vashaghani, 2009].

4-1- Artificial Neural Networks

ANNs are information processing technique based upon the functioning of the human brain. The literature illustrates certain specification of ANNs that make them particularly useful for forecasting time series. ANNs behave as a non-linear function, which means they can not only correct estimate non-linear functions, but also extract non-linear elements from the data [Aggarwal, 2009]. In a simple word, every neuron includes some input which multiples by weights to identify the signal power. Finally, a mathematical operator decides whether neurons are active or not, and if the answer is positive, the output will be determined [Faost, 2009].

A number of neurons are properly connected to each other to make the structure of the Neural Networks and solve complex problems. One of these structures is Feed-forward Neural Networks that Multilayer Perceptron or MLP is the most important of them. However, we will discuss only one type of network called the multi-layer perceptron (MLP). In this network, the data flows forward to the output continuously without any feedback [Bill, 2007]. A three-layer feed forward model shows in Fig.1 which is appropriate for forecasting purposes.

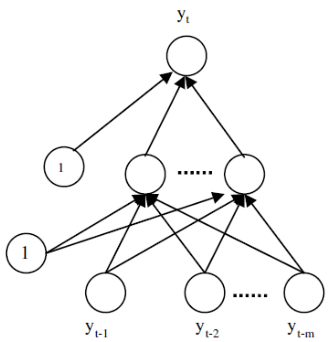

Figure1: Athree layer MLP network

Learning ability is one of the unique characteristics of Neural Network that will define the relationship between inputs and outputs. At first, the network learns the pattern of data received from input (training set). Then, the test set is located in the network to calculate accurately and predict [Gudarzvande Ghegini, 2009]. Learning depends on the degree of completeness of the previous information and divides into two categories: the supervised and the unsupervised. The earlier one or supervised networks uses known outputs for training. To carry out the training, known outputs are compared with those generated by the network. Then errors are computed and minimized in the minimum squared sense [Shalkof, 2003]. The architecture of the network is one of the most important steps, if the structure is appropriately selected, a good prediction can obtain. The standard method for designing a suitable network is trial and error, base on which we examined different Neural Networks to find the best network's architector [bill, 2009]. Error prediction is a criterion for evaluating network performance which is calculated by the diffrence between the real output and the output measured by Neural Networks. The most common criterion for evaluating the neural network is the Root Mean Square Error [Bishop, 1995].

4-2- ARIMA

ARIMA approach, introduced by Box and Jenkins, has the form of the following:

$$\phi(B)DEM_t = c + \theta(B)\varepsilon_t \qquad (1)$$

In which DEM_t is electricity consumption at time t, ε_t is the error term, $\phi(B)$ and $\theta(B)$ are polynomial functions of the backshift operator B (observe that $B^s DEM_t = DEM_{t-s}$). That is:

$$\phi(B) = 1 - \Sigma_{k=1}^{nF} \phi_k B^k \qquad (2)$$

In which

$$\phi(B)DEM_t = 1 - \phi_1 DEM_{t-1} - \phi_2 DEM_{t-2} - ... - \phi_{n_F} DEM_{t-n_F}$$

and $\phi_k (k = 1,..., n_F)$ are polynomial coefficients, and

$$\theta(B) = 1 - \Sigma_{k=1}^{nT} \theta_k B^k \qquad (3)$$

In which $\theta(B) = 1 - \theta_1\varepsilon_{t-1} - \theta_2\varepsilon_{t-2} - ... - \theta_{n_F}\varepsilon_{t-n_F}$ and $\theta_k (k = 1,..., n_T)$ are polynomial coefficients. The number of polynomial functions' terms $\phi(B), \theta(B), n_F$ and n_T respectively, depends on the time series under analysis. It is important that including in the left hand side of equation (1) factors of the form $(1 - B_s)$ allows appropriately taking into account for the annuality effects. Besides, equation (1) relates consumption to past consumption through function $\phi(B)$, and actual errors to past errors through function $\theta(B)$. Finally, certain hypotheses on the error terms are needed to ensure the effectiveness of the predictions. If the model is selected, these errors should behave as white noise [j. Conjeo, et al, 2005].

4-3- Combined approach of Neural Networks and Econometrics

Many reaserchers usually use variety of methods to predict historical data such as econometrics, ANN, and so forth, to name a few, each of which has some advantage. Although Neural Network models have shown better performance in prediction, historical data which use in this, does not significantly improve prediction because the model would only emphasize on previous data. In order to forecast as accurately as possible, we need to analyze other variables affecting economics models. Nowadays, some research such as Zhang (2003) and Rajabzadeh (2003) used some kinds of combine method for predicting time series data so as to enjoy not only from the pattern which may continue in the future but also from using the relationship between specific variables. In the literature of electricity consumption, various factors would consider as independent variables such as electricity price, income, alternative energy prices and other factors such as availability and temperature. The general agreement in this literature especially in long-run is to predict base on effective factors. In this section, by combining econometric and ANN we attempt to gain benefit from both aproach and offer a more accurate and efficient forecost for consumption.

In applying the combined technique, first we need to estimate an appropriate econometric function. AS noted in the literature, we employ ARDL approach which is the single equation procedure advanced by Pesaran (1996) and Shin (1998) and allows for a mix of I(1) and I(0) variables in the same cointegration equation. In adition, it is more efficient for small or finite sample [Azarbayejani, 2006]. In this method each equation is specified as follows:

$$\begin{aligned} &\alpha(L,P)DEM_t = \Sigma_{i=1}^{k}\beta_i(L,q_i)x_{it} + \lambda' w_t + \varepsilon_t \\ &\alpha(L,P) = 1 - \alpha_1 LD - \alpha_2 L^2 - \ldots - \alpha_p L^p \\ &\beta_i(L,s) = \beta_{io} + \beta_{i1}L + \beta_{i2}L^2 + \ldots + \beta_{is}L^s \end{aligned} \quad (4)$$

In which DEM_t reflects the electricity consumption and x_{it} the determinant factors of consumption including prices and income, w_t is a deterministic variables vector like constant term, time trend and exogenous variables with fixed lags. In the ARDL method the model (4) is estimated for different values p = 0, 1, 2, …, m and q_i = 0, 1, 2, …, m, i = 1, 2, ..., k namely a total of $(m+1)^{k+1}$ different ARDL models. The user chose the maximum lag or m. In order to identify the true lag (p, q) for each variable one of the criteria of model selection like adjusted R^2, the Akaike information criterion(AIC), Schwarz Bayesian criterion(SBC), or the hannan-quinn criterion (HHQ) can be used. This study has used the SBC criterion, which gives the highest priority to parsimony of the model with respect to the fitness. The long run coefficients for the response of y_t to a unit change in x_{it} are estimated by [Tashkini, 2005]:

$$\Pi = \frac{\hat{\lambda}(\hat{p}, \hat{q}_1, \hat{q}_2, ..., \hat{q}_k)}{1 - \hat{\alpha}_1 - \hat{\alpha}_2 - ... - \hat{\alpha}_p} \qquad (5)$$

In which $\hat{\lambda}(\hat{p}, \hat{q}_1, \hat{q}_2, ..., \hat{q}_{k)}$ is the selected (estimated) values of λ in equation 4. To confirm long-term equation, F test introduced by Pesaran et al (1996) is used. The null hypothesis that indicates all the coffecients of the lags of the variables are equal to zero and its opposite hypothesis are defined as follows:

$$H_0 : \delta_1 = \delta_2 = \delta_3 = \delta_4 = 0$$
$$H_1 : \delta_1 \neq \delta_2 \neq \delta_3 \neq \delta_4 \neq 0$$

Two acute value of F, when independent variables are I(d) in which 0≤d≤1, indicate cointegration test: the lower value supposes that regressors are I(0) and the upper value assumes that regressors are I(1). If calculated F is beyond the upper limit of the critical value of F, the null hypothesis is refuted, and if it is smaller than lower limite, the null hypothesis is accepted. Finally, if it is between both of critical value, the result is uncertain [Azarbayejani, 2006]. To forecast the model, first of all we should forecast each of independent variable for which different kinds of method can be used. ANN is more preferable for this study because of its better performance. It should be noted that the Nerual Network structure we will use here is the same as structure used in the section 4-1 which is the multi-layer perceptron (MLP). The results achived from this section positioned to ARDL model and consumption are forecasted.

5- Data

This paper uses alternative energy prices, electricity price and GDP (gross domestic product) as an independent variable and electricity consumption as a dependent variable. Power consumption is an indicator of the demand for electricity based on million kWh. In fact, it is electricity sold to electricity consumers including residential, industrial, commercial, public, agriculture, and street lighting sectors. The price of electricity is the average of nominal price (Rial/ kWh) of all consumer sections which is calculated by total expenditure on electricity consumption divided into the amount of kWh. Therefore, despite the fact that structure of electricity's tariff has multiple blocks, this method dependes on the quantity of consumption and likewise the quantity per se affectes the prices. In addition, according to some contries that the upper block of tariff rates are decreasing or increasing, this method considers the negative relationship between price and consumptions [Asgary, 2000]. Alternative energy price has been determined based on the average prices of kerosene, fuel oil and gas oil prices. Alternative energy price along with electricity price are realized by the price index of consumer goods and services of housing as well as fuel and lighting. The period of study is 1988-2008 and consumption is forecasted for 2009- 2014.

6- Analysis of Results

In this section, three models based on time series analysis are presented: ARIMA, Nureal Network, and combined approach.

6-1- Neural Networks Model

A multi-layer Perceptron Neural Network with fully connected is suitable for predicting electricity consumption, because non-linear relationship between consumption and its influencing factors is an important subject that MLP approximates it correctly. An algorithm is written in MATLAB by Moving Window Technique [Ridley D, 2003].

Time series of input data are given to the MATLAB software as a matrix. All of the MLP neural networks will be examined with maximum neurons in the hidden layer and maximum lags in the input variables. Data preprocessing plays an important role in convergence speed and the network accuracy. The input data are normalized by Premnmx function to the interval [-1 and 1], then Postmnmx function returns data to their actual ones [Matlab help]. The Levenberg – Marquardt Algorithm is used for Training algorithm, Hyperbolic Tangent transfer function and linear transfer function is used for hidden layer neurons and output layer respectively. All the Neural Networks are trained by 90 percent of data and network performance is compared by 10 percent remaining and finally the best network is selected based on the RMSE. After choosing the appropriate network, it is trained with all data so as to predict future values. Table 1 indicates these results:

Table 1: the retrospective forecasts of electricity consumption based on ANN approach

Time	Real data	Forecast data	RMSE
2005	134238	136450	2212.00
2006	147001	147070	1564.88
2007	155598	155760	1281.14
2008	169047	161480	3942.82

(Million kWh)

6-2- ARIMA

To apply ARIMA method we should identify appropriate parameters for the model which is based on the observation of the autocorrelation and partial autocorrelation plots; the DF-GLS test is used beside this one which is a simle modification of Dickey Fuller test. This test enrichs data if the data has a trend or an unknown mean. After that, a logarithmic transformation is usually applied to the data to attain a more stable variance, and a differential function can be used to attain a more stable mean. After different stimation, ARIMA (1,1,1) is identified as an appropriate model since its Akaike info criterion was less than others.

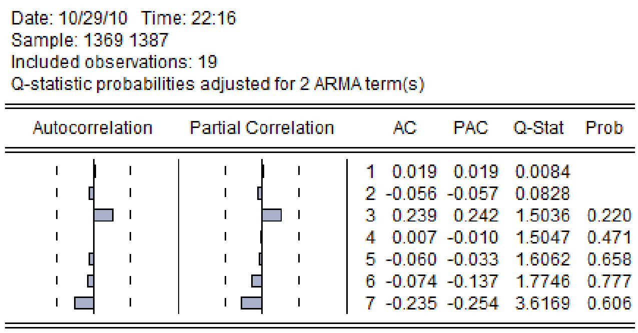

Figure 2: The Autocorrelation and Partial Autocorrelation Plots of Electricity Consumption

The plots indicated that neither autocorrelation nor partial autocorrelation are statistically acceptable and the residuals behave in a consistent manner with the model. Because the hypotheses on the residuals are validated, the corresponding model can be used to forecast consumption and this step is concluded successfully. In addition to compare with Noreal Network approach, retrospective forecasts dynamically done as below:

Table 2: The Retrospective Forecasts of Electricity Consumption Based on ARIM Approach

Time	Real data	Forecast data	RMSE
2005	134238	133435.4	802.56
2006	147001	143327.0	2659.20
2007	155598	153951.5	2370.21
2008	169047	165363.5	2757.80

(Million kWh)

6-3- Combined approach of Neural Networks and Econometrics

According to what mentioned points in the 4-3 section, we use ARDL approach as an econometric model. Before estimating the model, the reliability test shoud be performed for all variables in order to make sure that no variables are I(2) and avoid spurious regression. For this purpose, the DF-GLS test is also used which is a simple modification of the Dickey Fuller test. The results indicated that no variable is I(2). In the first stage of ARDL, F test is used to confirm the long term relationship [Azarbayejani, 2006]. Table 3 indicates the results of the F statistic:

Table 3: The result of F test

Dependent Variable	F	Prob	Result
$F_{Dldem}(Dldem \mid D\lg dp, Dlrp, Dlrps)$	4.8	0.009	Co integrated
$F_{d\lg dp}(D\lg dp \mid Dldem, Dlrp, Dlrps)$	2.63	0.067	None Co integrated
$F_{Dlrp}(Dlrp \mid D\lg dp, Dldem, Dlrps)$	2.34	0.093	None Co integrated
$F_{Dlrps}(Dlrps \mid D\lg dp, Dlrp, Dldem)$	2.66	0.065	None Co integrated

Upper limit of the critical value of $F_{0.05}$: 4.278
Lower limit of the critical value of $F_{0.05}$:3.219

Table 1 indicates that the critical value of F_{Dldem} is higher than upper limition of the critical value; then, the null hypothesis cannot be signified by

95% confidence so the long-term relationship is confirmed. The ARDL model (2, 0, 0, 3) for the long-term is obtained as follows:

$$LDEM_t = -5.69 + 1.36\,LGDP_t - 0.08\,LRP_t + 0.18\,LPS_t \quad (1)$$
$$t: \quad (-9.0712) \quad (29.3112) \quad (-2.3742) \quad (2.7574)$$

Where LDEM is logarithm of electricity consumption, LGDP is logarithm of gross domestic product, LRP is logarithm of real price of electricity and LPS is logarithm of real price of alternative fuels. The results show that all coefficients were significant and matched by economics models. In addition, R^2 is 99%, which indicates the high explanatory power of this model and DW=2.17 indicate that the residuals of model are not auto correlated. The F statistic was obtained to confirm the significance of all coefficients. To predict the model, we need to predict the independent variables for the years of 2005- 2008. As mentioned before, this can be done by different scenarios, and in this paper, we use Neural Networks to predict each of them. Like section 6-1, a MLP Neural Network with fully connection is used for predicting each independent variable examined with maximum neurons in the hidden layer and maximum lags in the input variables. The input data are normalized by Premnmx function to the interval of [-1 and 1], then Postmnmx function returns data to their actual one. The Levenberg – Marquardt Algorithm is also used for Training algorithm, Hyperbolic Tangent transfer function and linear transfer function is used for hidden layer neurons and output layer respectively. Table 4 indicates the result of forecasting independent variables.

Table 4: The Retrospective Forecasts Result of Independent Variables of Consumption Electricity. Base on ANN

Data	Nominal price of alternative fuels (Rial per lit)		GDP (M.Rial)		Nominal price of electricity (Rial per kWh)	
	Forecast	**Real**	**Forecast**	**Real**	**Forecast**	Real
2005	179.3	168.7	455200	438900	153.4	152.1
2006	179.4	166.5	513930	467930	156.3	152.8
2007	191.2	172.1	540370	499071	170.8	165.0
2008	172.4	176.1	564830	501000	177.9	173.2

Finally, the independent variables forecasted in this section put in the ARDL model and electricity consumption's function is predicted. Table 5 indicates the result of the retrospective forecasts of electricity consumption by this method:

Table 5: The Retrospective Forecasts of Electricity Consumption Based on Combined Approach

Time	Real data	Forecast data	RMSE
2005	134238	134657.6	419.64
2006	147001	146926.0	301.44
2007	155598	156377.7	513.07
2008	169047	170061.4	674.32

(Million kWh)

7- Conclusions

According to the above-mentioned points, Power industry has been having a significant position in many scientific researchs. The most important researchs concentrate on demand and consumption. In a short-time, electricity consumption is under the influence of temperature and humidity but in the long- time, it is under the influence of social and economic factor, as well as population growth. Although other approaches based on time series such as ARIMA and ANN have shown acceptable performances, we need to use a new method to estimate the quantitative effects of other important variables which affect consumption. This study suggests a new combined method of Neural Network techniques and econometrics in order to forecast power consumptions more accurately and with less error. Table 6 compares the result of the retrospective forecasts of electricity consumption done by these three methods base on RMSE.

Table 6: the result of RMSE for three methods

Time	ARIMA	ANN	Combined method
2005	802.56	2212.00	419.64
2006	2659.20	1564.88	301.44
2007	2370.21	1281.14	513.07
2008	2757.80	3942.82	674.32

(Million kWh)

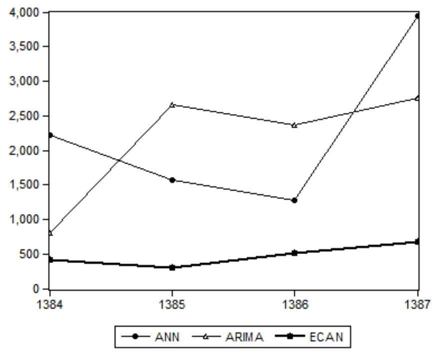

Figure 3: The Comparison of RMSE for Three Methods

According to table, in the second and thired steps of retrospective forecasts, nureal network has shown better performance than ARIMA, whereas ARIMA has shown beter performance in the firsth and forth steps, but our method is more capable than two others. Consequently, according to this paper the best method for forecasting is combined method used to peredict the power consumption for the future. Since Subsidies Reform Plan is implemented as a major policy in the country, we changed the prices base on the Plan for provident prediction; if the government wants to acquire net income equal to 150,000 Billion Rials from decreasing subsidy, electricity should be sold to consumers for 450 Rials. We inceased electricity price and alternative fuels price base on this scenario. Table 7 indicates the result of independent variables.

Table 7: The Provident Forecasts Result of Independent Variables Base on ANN

data	Nominal price of alternative fuels (Rial per lit)	GDP (M.Rial)	Nominal price of electricity (Rial per kWh)
2009	350.1	504100	441.5
2010	359.3	511670	453.9
2011	368.9	519080	481.2
2012	370.6	525210	506.0
2013	373.6	536800	533.6
2014	373.5	522290	575.6

Same as what we did in section 6-3 these arguments put into ARDL model and consumption function are predicted. Table 8 shows the result of the provident forecasts of electricity consumption by this method and indicates that after decreasing subsidy, electricity consumption will reasonably increase until 2014.

Table 8: The Provident Forecasts of Electricity Consumption Based on Combined Approach

Data	Consumption after Increasing	Change %
2009	172830	1.65
2010	176532	2.15
2011	179730.8	1.81
2012	181782.7	1.14
2013	186490.8	2.60
2014	178483.9	-4.20
The average		0.85

As a whole, according to results of this paper combining two methods of ANN and econometrics improve the performance of the prediction rather than predicting with ANN or econometrics per se. Consequently, we recommend using more innovative approach for modeling and forecasting so as to gain more accurate result in the future studies. To illustrate, one can use Neural Networks with other economic approaches like panel data.

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