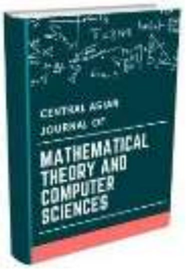

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Article

Utilizing the Time Series Model for Electricity Energy Consumption Prediction in Kirkuk Governorate, Iraq

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Abstract: A vector autoregression model is used to estimate electricity consumption in Kirkuk Province, Iraq. In order to manage their electricity grids, developing countries will need equipment that exactly measures how much electricity a customer consumes. This study proposes a time series analysis method using a VAR model to assess the volume of energy consumed in Kirkuk Province of Iraq. The temperature, population increase and electricity consumption would be studied. The data on temperature, humidity and electricity from 2001 to 2023 is collected and analyzed using Eviews12 software. The results of the VAR Model revealed that the electricity consumption of Kirkuk Province in Iraq is expected to increase with the rise in population of this region yearly. The considerable influence of temperature on overall electricity consumption in Kirkuk Province, Iraq. The expected results show that this VAR technique is a reliable way to measure electricity usage. The forecast method will help with more efficient power grid management and planning in light of the growing popularity of the region.

Keywords: Time series analysis (TSA) , Vector autoregression (VAR) , Electricity energy forecast , Kirkuk Governorate

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1. Introduction

If a prediction of electricity consumption is done at an excessively high level, it may lead to excess electricity, resulting in additional costs or higher operating costs to the energy supplier. Moreover, it can increase the risk of power outages. Thus, precise and precise forecast of electricity consumption is essential to escape fault errors, which can be harmful. The province of Kirkuk requires reliable methods to estimate the amount of electrical energy necessary to meet the load requirements of the present and future [1][2].

Earlier research often employed the time series model as a forecasting method for different objects. Sequentially collected time series data is useful for decision-making and uncovering hidden facts. The time series model proposed for the development of the electrical energy consumption of Kirkuk City [3]. This approach employs the use of Vector Autoregressive (VAR) model. Unlike methods that rely mainly on historical information about endogenous variables, the VAR model's promise has failed to materialise, even though it has been in use for a long time. The VAR model is a simple one because it spares researchers from having to rule out between endogenous variables and exogenous [4].

In conclusion, accurate energy consumption prediction is paramount for efficient resource planning. It also prevents unnecessary spending and power outages. The proposed VAR model is helpful for predicting energy consumption in Kirkuk governorates taking into account population growth and income level variables. Using reliable tools such as the VAR model, stakeholders might make educated decisions to effectively meet the energy needs of the Governorate [5].

2. Materials and Methods

2.1 Vector Autoregressive Model

Derived from previous univariate time series, a vector autoregression (VAR) model is a multiple variable statistical model. VAR models often look at how a random change to a system of variables affects the system. They are also often applied to forecasting systems of related time series. VAR models specifically study time-series data that does not have a trend. Moreover, the mean, variance and covariance of the time-series data must be constant. The VAR method computes each endogenous variable within the system as a function of past values of all endogenous system variables without structural modeling. Even when trends, dummies or constant components are included in the model, all of them are endogenous [6][7].

Let Y_t = (y_1t, y_2t,…, y_Kt) ' denote a (K × 1) vector of time series properties. The p-order VAR model is comprised of:

$$\boldsymbol{Y_t = \varphi_0 + \varphi_1 Y_{t-1} + \varphi_2 Y_{t-2} + \cdots + \varphi_p Y_{t-p} + \varepsilon_t}$$

where the coefficient matrix for each individual is estimated, i = 0, 1, 2,..., p, and the vector of random noise with a time-invariant, positive-definite covariance is considered, this is called an endogenous variable. One of the most significant attributes of a VAR model is its stability. Stability is measured by the characteristic polynomial det(I_k-A_1 z-A_2 z^2...-A_p z^p) = 0 (|z| ≤ 1). If the initial value of z = 1 in the solution to the inverse characteristic polynomial, then the VAR(p) process is considered nonstationary. In practice, the stability of a VAR(p) process can be assessed by calculating the eigenvalues of the coefficient matrix. If the magnitude of the eigenvalues of Ai is smaller than 1, then the process of VAR(p) is considered stable [8].

3. Results

This study looks at how temperature, population growth, and electricity usage in the Kirkuk area of Iraq are related, using a vector autoregression (VAR) model. The Eviews 12 program was used to apply the VAR method to temperature, population growth, and electricity consumption in the Kirkuk territory of Iraq. An important section of VAR will be recognizing whether or not the model is stationary and recognizing the nature of the data through the shape of the time series data plot and the probability values associated with it [9]. According to the study, the stationarity was determined through the station probability and first or second order differences. After the data processing, the probability of electric power usage, population growth, and temperature was found to be 0.0113, 0.0011, and 0.0259 respectively. P-value was lower than 0.05. The Augmented Dickey-Fuller ADF Test was used to check the temperature, Population growth and Electricity consumption stationarity, this test proved the null hypothesis was wrong. Study results demonstrate that none of the variables have constant magnitude or first-order difference However, all three series had a stationary second-order difference. This indicates that the order of integration of these series is 2 or I(2). This means that each series can only get stationary and have a single origin after differentiation of second order [10][11].

3.1 Optimal Lag

Before finding the optimal delay, the maximum delay (in this case, delay 12) must be entered to determine the delay at which the VAR model is steady. After observing the greatest delay associated with a stable VAR model, the model's stability is determined using the modulus values from the AR's root table in Table 1.

Table 1. Stability model

Root	Modulus	Conclusion
0.88276	0.88276	Stable
- 0.22037 – 0.42775	0.72229	Stable
- 0.22037 + 0.42775	0.43981	Stable
0.33762 – 0.53303	0.21194	Stable
0.33762 + 0.53303	0.20378	Stable
0.32774	0.20076	Stable

Table 1 shows the magnitude of each root modulus in inches. The values of AR for electricity consumption, population growth, and temperature are all less than 1, this indicates that the model is consistent. Next, we discuss the VAR model. The results are listed in Table 2 [12].

Table 2. Lag order selection

Lag	LR	AIC	SIC	H-Q
0	12.28	1.27339	1.72613	1.72201
1	159.37	-1.33074	-1.23463	-1.55630
2	176.39	-2.47728	-2.99836	-2.88854

Lag 2 was identified as the most appropriate lag from the output in Table 2 because the likelihood ratio test (LR), Hannan-Quinn information criterion (H-Q), Schwarz information criterion (SIC), and Akaike information criterion (AIC) typically choose the less complex model.

4. Estimation

Table 3 displays the findings of this study. Once this VAR model has been identified, we need to estimate using a mathematical equation model that was created using Ordinary Least Square (OLS) [13].

Table 3. The VAR model Estimates

Coefficient	Temperatures	Electricity Consumption	Population Growth
Constant	0.4773 (2.6731) [0.2880]	0.7660 (0.2919) [0.3220]	2.7641 (4.5419) [2.3218]
Temperatures (-1)	0.4664 (0.1540) [0.2988]	2.6261 (0.2919) [0.3220]	0.3603 (1.2993) [0.5237]
Temperatures (-2)	0.7530 (0.7391) [0.3908]	2.2964 (1.1540) [0.3903]	2.9604 (12.1943) [2.3208]
Electricity Consumption (-1)	3.8860 (2.1730) [3.2908]	- 0.3610 (0.1540) [0.7970]	10.2619 (- 0.0540) [0.0988]
Electricity Consumption (-2)	2.0692 (0.2282) [0.9081]	- 0.9619 (0.3540) [0.3083]	3.4664 (0.3527) [0.2900]
Population Growth (-1)	- 0.8682 (- 0.1540) [0.3184]	- 0.1630 (0.1343) [0.2988]	2.8604 (0.1291) [0.88990]
Population Growth (-2)	3.4664 (2.1043) [0.1089]	- 1.0681 (3.2041) [0.2988]	- 2.2633 (0.9349) [- 0.8917]

5. Forecasting

Assuming that the time series data is complete by time t, the predicted values are h periods prior. Table (4) illustrates the predictions of electricity consumption, population growth and temperature in the Kirkuk Province from 2001 to 2030 [14].

Table 4. The result of forecasts

Year	Energy Consumption	Temperatures	Population Growth
2001	706,563	32.3	878,824
2002	725,721	32.4	890,150
2003	784,552	32.7	871,301
2004	1,055,629	34.5	1,411,775
2005	1,278,305	37.2	1,421,296
2006	1,372,205	33.4	1,429,525
2007	1,577,542	29.8	1,436,772
2008	1,796,630	32.9	1,444,197
2009	1,799,948	34.6	1,453,390
2010	1,904,452	35.6	1,465,421
2011	1,988,325	36.2	1,480,808
2012	2,076,664	37.5	1,499,034
2013	2,292,004	34.7	1,518,862
2014	2,203,347	31.6	1,538,499
2015	2,377,328	36.8	1,556,657
2016	2,584,531	36.2	1,572,906
2017	2,695,795	36.3	1,587,649
2018	2,878,940	36.2	1,597,876
2019	2,898,202	37.4	1,615,144
2020	2,972,901	38.7	1,629,426
2021	3,292,203	28.7	1,726,409
2022	3,383,317	28.9	1,759,823
2023	3,504,553	31.2	1,875,563
2024	3,577,866	29.3	2,091,385
2025	3,593,329	31.8	2,107,118
2026	3,685,533	36.8	2,222,746
2027	3,689,223	29.9	2,238,349
2028	3,795,532	34.5	2,253,964
2029	3,804,491	35.7	2,269,654
2030	3,820,625	34.6	2,275,463

Table (4) shows that from 2004 to 2030, the Kirkuk Governorate's population growth and energy consumption trends continued to rise. In contrast, temperature tends to exhibit a tendency of fluctuation [15].

Figure 1. Prediction of Population Growth

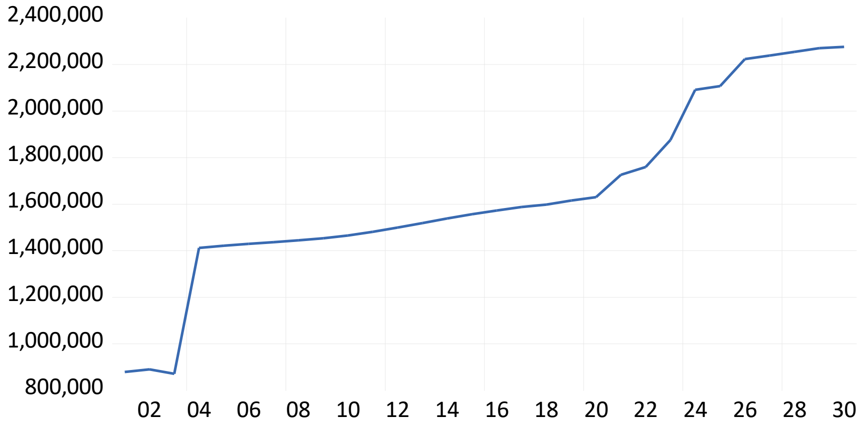


Figure 2.
Prediction of Temperature

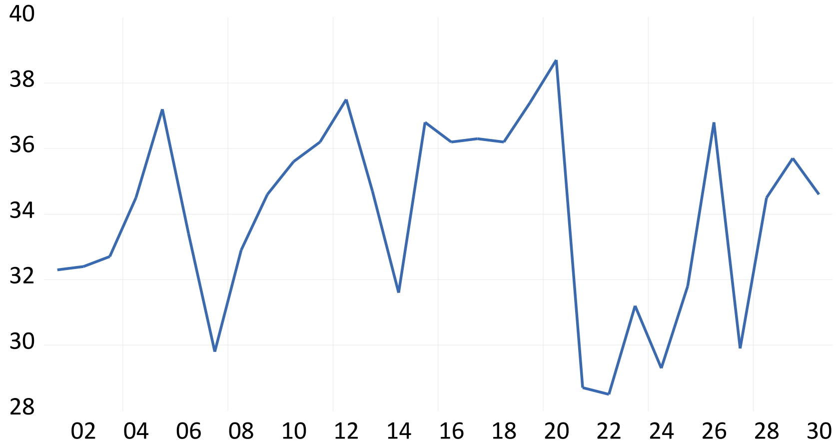
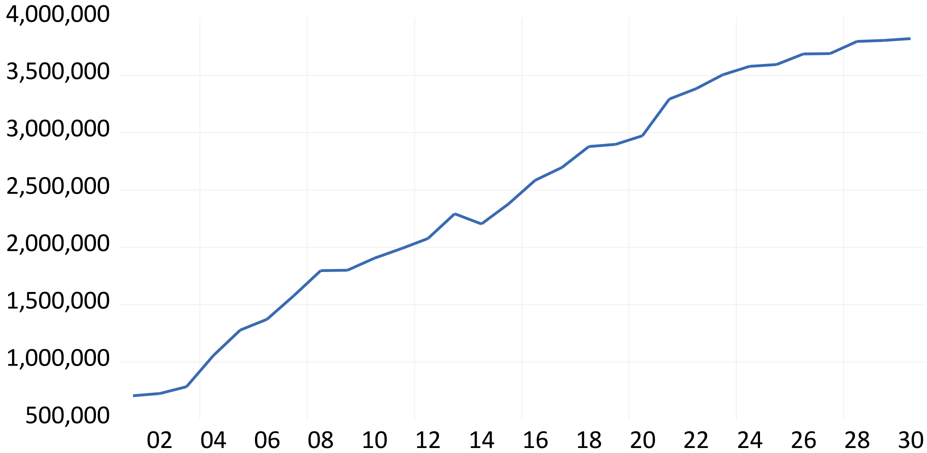


Figure 3.
Prediction of Energy Consumption



4. Conclusion

The VAR model implies that the time series is stationary at the second difference level, which is beneficial for the modeling of Kirkuk Province's consumption of electricity. In this study, the optimal duration of the VAR model is 2. The data from the VAR model indicate that the volume of electricity utilized in Kirkuk Province is increasing with every yearly increase in population. Additionally, the increase in the amount of electricity consumed in Kirkuk Province is primarily caused by temperature changes. As such, it is possible to deduce that temperature and population growth are the primary causes of the Kirkuk Province's increased reliance on electricity.

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