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Forecasting Crude Oil Imports In India Through Time Series Analysis

Dr Smita Sharma[1],*N. K. Kamboj[2]

1.Associate professor, Department of Statistics, D. A. V(P. G.) College Dehradun

2. Assistant Professor, School of Physical Sciences, D.I.T University Dehradun

Abstract

The present research study was carried out on Crude oil imports in India on the data from April 2011 to March 2021 using Time series methods for identifying the appropriate models for the data. Autoregressive Integrated Moving Average (ARIMA) based on Box and Jenkins is used to identify the model also the forecasts of import pattern of crude oil is done till December 2022. The best model has been identified on the basis of highest R^2, BIC values also RMSE and MAPE is calculated for the models. Among the ARIMA models the most appropriate model for forecasting crude oil imports inside India is the one with p = 6, d=1 and q=7.

Key Words: Crude Oil, ARIMA Model, Forecasting.

Introduction

Crude oil is regarded as the most essential energy source globally. After processing crude oil generates various by products to name few as distillate fuel oil, gasoline, aviation, kerosene Jet fuel, Residue oil fuel Oil, LPG, lubricants, paraffin wax etc. Crude oil plays vital role in running Industries from automobiles to Pharmaceuticals. Crude oil is the key substance impacting economy and growth of the country. In India crude oil consumption is increasing and its production in India is not sufficient so India is dependent on imports of crude oil. India imports crude oil from its import partners as Nigeria, UAE, Iraq, Malaysia, Kuwait, Saudi Arabia, Iran, Mexico,Venezuela, Qatar Brazil etc. [12].

Researchers have been applying various methodologies in area of energy related matters. it's consumption in various sectors, energy imports, exports etc. in the nation. ARIMA modeling, regression models, exponential smoothing are some of the methodologies which can be applied for forecasting energy related matters. example consumption of energy, Import of energy especially crude oil, exports of crude oil etc.

Crude oil is important source of energy. Import patterns are mainly related to consumption of energy. Energy consumed by a nation is directly related to the economic rise of the nation. International Energy agency(IEA)is the agency that helps to decide about energy related policies globally for sustainable future. It is autonomous in nature and based in Paris, established in 1974 after 1973 oil crisis. The IEA served as a source of information on Statistics about oil markets and other energy sectors Internationally. The bifurcation of global supply percentage as per IEA records in the year 2020 are oil 52.6 %,coal 22.6 %, natural gas 13.9%, bio fuels and waste 2.3%,nuclear 1.3 % and hydro 2.1%[4,5]. IEA indicates highest energy supply sources as oil energy. In this paper our main focus is on oil energy that is crude oil imports in India. Crude oil import forecasting plays key role for Nation's progress, it will help policymakers in designing policies in the interest of national benefit.

Got fred 2013 used model of SARIMA (1, 1, 1)(0, 1) based on relation of energy consumption with respect to per capita increase in GDP for country Ghana, from 2000-2008. The results showed by him gives the relation that if yearly consumption is increased by 1.1% then yearly per capita GDP will be increased by 5.5%, for the time interval considered.

Yuan et al (2016) created hybrid model using ARIMA model and GM(1,1) model. Forecasting result shows increased rate of energy consumption from 2014 till 2020 for the country China.

Narendra N. Dalei. et al (2017) in his paper findings, he showed the most preferred import partners as UAE amongst Saudi, Iraq, Iran and Malaysia. He also suggested that the findings are very helpful for macroeconomic planners and companies that import crude oil to take prudent decisions in dealing with import of oil for India from its major import partners.

Chaido Dritsakii et al (2021) studied consumption of oil in designing strategies of energy for policy maker in Greece by using yearly data of 60 years from 1960 to 2020.He made an attempt to develop ARIMA model also forecasts for the time period of 2021 till 2023 has been done.

In this paper the study is carried out for crude oil imports in India on past data through ARIMA model and best model is suggested also the forecast is made till the month December 2022.

Materials and methods

The data of the paper have been collected from the website of Petroleum planning and analysis cell (PPAC) Ministry of petroleum and natural gas, Government of India, for the period of April 2011 to March 2021on a monthly basis, ARIMA models are worked out using SPSS in order to examine the pattern of crude oil imports in India. Autoregressive Integrated Moving Average (ARIMA) model describes the current behavior of variables as linearly related with their past values, this is called as Box-Jenkins (1976) models. An ARIMA model consist of two segments. The break off the model segments is (1) Integrated (I) component and (2) **ARMA** component. The first segment is the differencing amount on the series to change into stationary. Another second segment is **ARMA** model (for the series rendered stationary through differentiation) has further break off into components **AR** and **MA**. The correlation between the present value of the time series and some of the previous values of the series is the **autoregressive (AR)** component. For example, **AR *(1)*** indicates that the present observation is correlated with its immediate previous observation at time t-1.

The general form of a $\mathbf{p}^{th}$ order autoregressive model ***AR(p)*** is given as :

$$Y_t = \varphi_o + \varphi_1 Y_{t-1} + \varphi_2 Y_{t-2} + \ldots + \varphi_p Y_{t-p} + \varepsilon_t$$

Where,

Y_t = Response(dependent) variable at time t

$Y_{t-1}\ Y_{t-2} \ldots\ Y_{t-p}$ = Response variables at time t-1, t-2,...t-p respectively

$\varphi_o\ \varphi_1 \ldots\ \varphi_p$ = Coefficients to be estimated

ε_t = Error term at time t

In a similar way **MA** is the component known as moving average component which shows the duration of the effect of a random shock. For example; a shock on the value of the series at time t is correlated with the shock at t-1s is represented by **MA *(1).***

$$Y_t = \mu + \varepsilon_t - \theta_1 \varepsilon_{t-t} - \theta_2 \varepsilon_{t-2} \text{ -...- } \theta_q \varepsilon_{t-q}$$

Where,

Y_t= Response (dependent) variable at time t

μ = Constant mean of the process

$\theta_o\ \theta_1 \ldots\ \theta_q$= Coefficients to be estimated

ε_t = Error term at time t

$\varepsilon_{t-1}\ \varepsilon_{t-2} \ldots\ \varepsilon_{t-p}$ = Errors in previous periods that are incorporated in the response Y_t

Auto Regressive Moving Average Model ARMA (p,q) has the general form

$$Y_t = \varphi_o + \varphi_1 Y_{t-1} + \varphi_2 Y_{t-2} + \ldots + \varphi_p Y_{t-p} + \varepsilon_t - \theta_1 \varepsilon_{t-t} - \theta_2 \varepsilon_{t-2} \text{ -...- } \theta_q \varepsilon_{t-q}$$

Important calculations for Model identification:

Differencing: The stationarity in the series must be insured before building of the AR, MA and ARMA models. Most of the economic and business series are non stationary due to presence of trends or random shifts on level. Thus transformation into stationary series is must before fitting an ARMA model. Differencing continues till a plot of the data depicts that the series varies about a fixed level.

Lag: By 'lagging' a value of the time series by ***k*** time units is known as the function lag let us suppose the values of a time series are as below:

Y_1	Y_2	Y_3	...	Y_r

If lagging is done once, the series becomes

*	Y_1	Y_2	...	Y_{r-1}

If lagging is done once again, the series becomes

*	*	Y_1	Y_2	Y_3	...	Y_{r-2}

and this is continued further.

Here, `***k***' is the number of lags indicates, the number of times, time series has been lagged.

Auto Correlation Function (ACF): ***ACF(k)*** denotes the autocorrelation where ***k*** is lag. It is the linear Pearson's correlation between values k time periods apart. The **plot ACF** is a bar graph of the coefficients of correlations between a time series and lags by itself.

Partial Auto Correlation Function (PACF): Similarly partial autocorrelation by lag ***k***, ***PACF (k)*** measures the correlation among observations k time periods apart., It eliminates or 'partials' out all intervening lags.
The **plot PACF** is the plot of the partial coefficients of correlations between a time series and lags by itself.

Fitting of Trend: The Box-L jung Q statistics was used to change the non-stationary data in to stationary data also to check the adequacy for the residuals. For assessing the validity of AR, MA and ARIMA approach, several reliability statistics as R^2, Stationary R^2, Root Mean Square Error (RMSE), Mean Absolute Percentage Error (MAPE), and Bayesian-Information Criterion (BIC) [as suggested by Schwartz, 1978] were used.

Analysis was performed based on ARIMA models given in Table 1.

Table 1. Model Statistics

Model	Model Fit statistics		
	Stationary R-squared	Normalized BIC	Sig. (L jung- Box)
ARIMA (1, 1, 1)	0.342	14.677	0.054
ARIMA (1, 1, 6)	0.436	14.769	0.134
ARIMA (1, 1, 7)	0.478	14.738	0.414
ARIMA (2, 1, 1)	0.351	14.712	0.047
ARIMA (2, 1, 6)	0.476	14.744	0.547
ARIMA (2, 1, 7)	0.480	14.786	0.401
ARIMA (3, 1, 1)	0.319	14.809	0.008
ARIMA (3, 1, 6)	0.477	14.790	0.402
ARIMA (3, 1, 7)	0.486	14.823	0.415
ARIMA (6, 1, 1)	0.435	14.770	0.349
ARIMA (6, 1, 6)	0.484	14.925	0.395
ARIMA (6, 1, 7)	0.473	14.996	0.016

Further using ARIMA (6, 1, 7) model forecast is done. Model summary with fit statistics is given in the Table 2. Model Fit Summary.

Table 2. Model Fit Summary

Fit Statistic	Mean	SE	Minimum	Maximum
Stationary R-squared	.473	.	.473	.473
R-squared	.573	.	.573	.573
RMSE	1362.104	.	1362.104	1362.104
MAPE	5.971	.	5.971	5.971
MaxAPE	28.215	.	28.215	28.215
MAE	972.160	.	972.160	972.160
MaxAE	4121.415	.	4121.415	4121.415
Normalized BIC	14.996	.	14.996	14.996

Table 3. Model Statistics

Model	Ljung-Box Q(18)			Number of Outliers
	Statistics	DF	Sig.	
CrudeOil-Model_1	13.961	5	.016	0

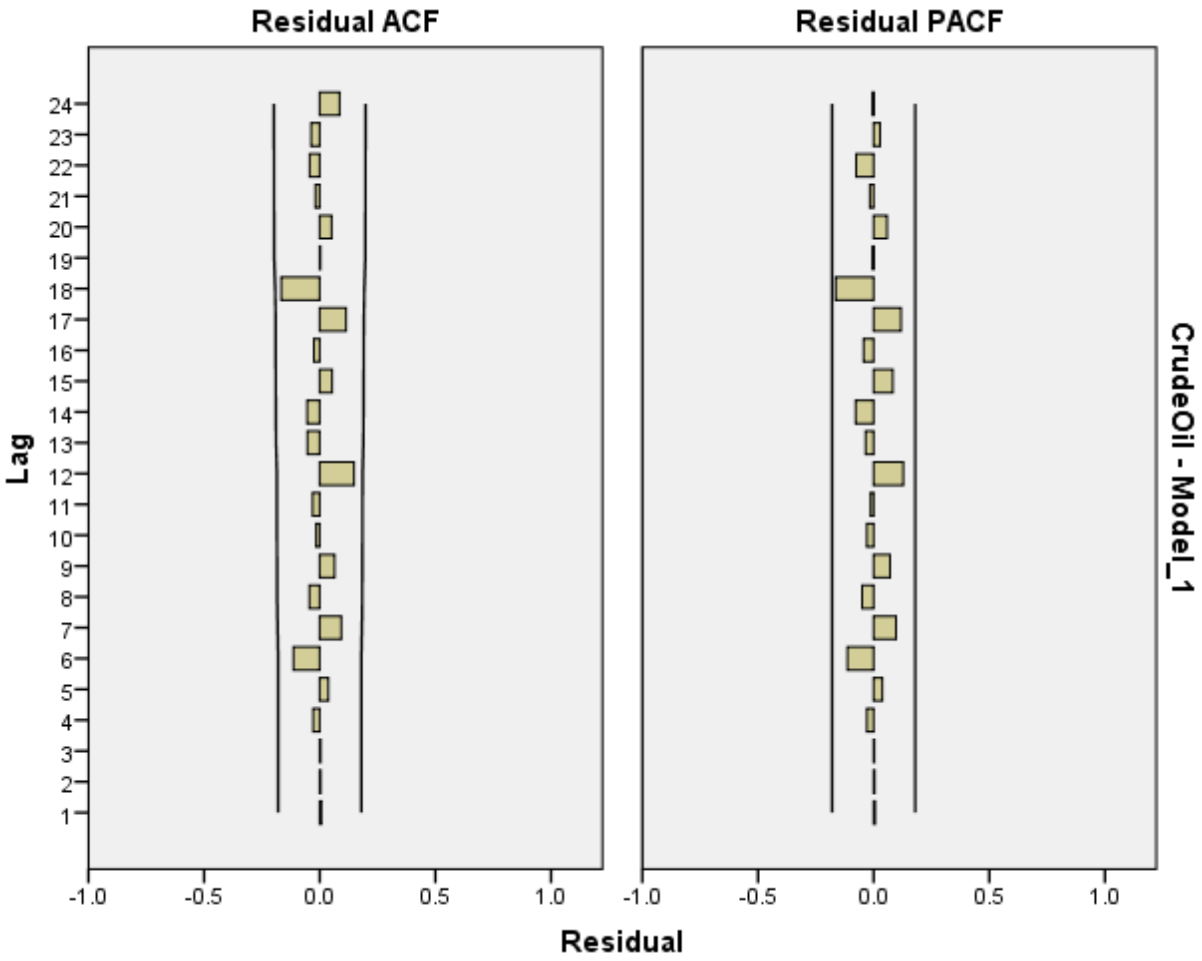

Fig. 1 Residual Plots for ACF and PACF

For every model, forecast starts after the last non-missing in the span of the requested estimation period, and end at the last period for which non-missing values of all the predictors are accessible or at the end date of the requested forecast period, whichever is earlier. Using the ARIMA (6,1,7) model the month-wise forecast is given below in Table No. 4.

Table 4. Crude Oil Import Forecast

ARIMA-Model		Apr-2021	May-2021	Jun-2021	Jul-2021	Aug-2021	Sep-2021
Model (6,1,7)	Forecast	17723.95	16572.50	17035.40	17702.95	17621.63	17590.67
	UCL	20376.58	19355.46	19991.96	20723.48	20901.97	20877.18
	LCL	15071.32	13789.53	14078.85	14682.43	14341.29	14304.17

ARIMA-Model		Oct-2021	Nov-2021	Dec-2021	Jan-2022	Feb-2022	Mar-2022
	Forecast	18027.98	17720.22	17230.08	17874.10	17972.65	17386.80
Model (6,1,7)	UCL	21314.49	21066.78	20593.25	21276.05	21436.41	20877.66
	LCL	14741.47	14373.67	13866.92	14472.15	14508.88	13895.94

ARIMA-Model		Apr-2022	May-2022	Jun-2022	Jul-2022	Aug-2022	Sep-2022
	Forecast	17907.26	18161.18	17504.51	17799.84	18252.44	17725.17
Model (6,1,7)	UCL	21433.74	21709.68	21083.71	21423.83	21894.16	21404.61
	LCL	14380.77	14612.69	13925.32	14175.84	14610.72	14045.73

ARIMA-Model		Oct-2022	Nov-2022	Dec-2022
	Forecast	17758.77	18300.32	17965.02
Model (6,1,7)	UCL	21483.54	22039.28	21738.67
	LCL	14034.00	14561.35	14191.36

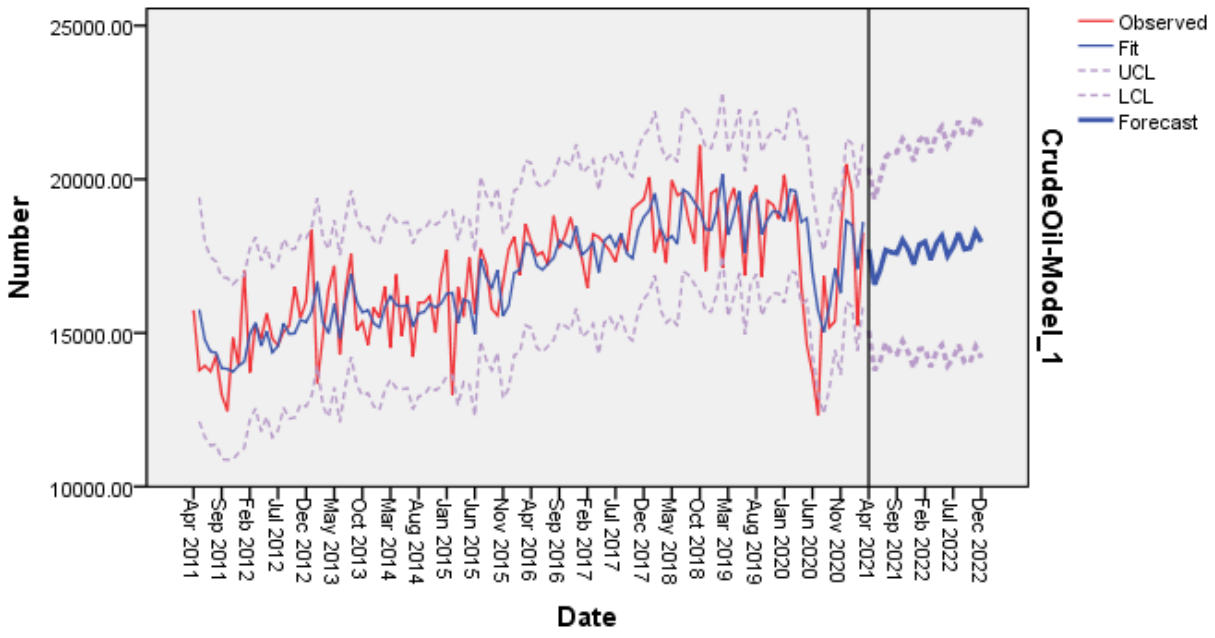

Fig. 2 Forecast Plot

Conclusion

India is fast developing country and has a high global presence. India has good associations with its import partners. Crude oil influences the economy of the country as crude oil is the key factor for country's industrial and business growth. India is not the largest producer of crude oil so crude oil imports and the assessment of its import patterns plays significant role for policymakers to plan effective policies for the benefiting the country and its further growth. The application of Box-Jenkins ARIMA model has been carried out in our study under the normal assumptions. In the present study the best model that can be used for forecasting crude oil imports in India have been found ARIMA(6,1,7) that is ARIMA with p = 6, d=1 and q = 7. With this model the forecast is done till December 2022 (Table No. 4), which can further be forecast using the same model. Also, during pandemic covid-19 situation the import was affected for the year 2020, less imports has been realized in the plot (Fig.2).

References

1. Box, G.E.P. & Jenkins, J.M. (1970): "Time Series Analysis Forecasting & Control Holden – Day Inc. San Francisco.
2. Brockweel, Peter, J. & Davis, Richard, A. (1987). Time Series: Theory and Method, Springer Vielag.
3. Hannon, E.J. & Quinn B.G. (1979) : "The Determination of the sides of an autoregression". Journal of Royal Statistical Society, B(41). PP 190-195.
4. Box. GEP Source Problem of Statistics and everyday life. J.Ann. Stat Assoc. 1979 (Google Scholar). (Cross Ref.)
5. DasDaba, D. & Mishra, D. K. (2014) Tax reforms & tax revenues performance in Ethiopia. Journal of Economics & Sustainable Development. (Google Scholar)
6. , Gupta A., 2011. An assessment of the revenue impact of the state level VAT in India Goa Institute of Management, India. doi:10.2139/ssrn.1953165(google scholar)
7. Forecasting tax revenue using time series techniques – a case of Pakistan. DahiaStreimikiene, Rizwan Raheem Ahmed, JolitaVeinhardt, SaghirLervaizGhauri Sarwar Zahid, Journal Economic Research – EkonomskaIstraziranja> Vol. 31, 2018, issue 1. (google scholar)
8. Godfred ,A.k (2013), Modeling and Forecasting Energy Consumption in GhanaJournal of Energy Technologies and Policy volume 3 ,(12) ISSN 2224 _ 3232
   Https :// www. academia.edu
9. Narendra N. Dalei, HiranmoyRoy,Anshuman Gupta (2017)Crude oil import of India from its major oil trade partner countries: An empirical evidence using panel data analysis. International Journal of Advanced Research and Development,ISSN: 2455-4030, Vol 2; (6) 2017;726-735
   www.advancedjournal.com
10. Chaoqing Yuan ,SifengLiu,Zhigeng Fang:(2016) Comparison of China's primary energy consumption forecasting by using ARIMA (the autoregressive integrated moving average) model and GM(1,1) model, Energy 100:384-390
    Https://www.researchgate.net
11. ChaidoDritsaki&DimitriosNiklis&PavlosStamatiou, (2021.) Oil Consumption Forecasting using ARIMA Models: An Empirical Study for Greece::International Journal of Energy Economics and Policy,ISSN:2146--4553;Econjournals, vol. 11(4), pages 214-224.
12. http://www.econjournal.com
13. www.energy.gov.says
14. https://www.iea.org
15. https://www.ppac.gov.in/content/212_1_ImportExport.aspx