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Research Paper

Prediction of the Exchange Rate of India Considering a Causal Relationship with Crude Oil Consumption

Shiv Kumar Singh Pundhir[1]*, Seemant Kumar Yadav[1] and Anand Mohan Agrawal[2]

[1]Institute of Business Management, GLA University Mathura, Uttar Pradesh, India
[2]United University, Prayagraj, Uttar Pradesh, India

*Corresponding author: shiv.pundhir@gla.ac.in (**ORCID ID:** 0000-0001-6249-6943)

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ABSTRACT

A good prediction of the exchange rate is crucial in the economy. Exchange rate variations highly affect the economy of a country. Over time, so many methods were adopted to predict exchange rates. In this work,data on crude oil consumption and exchange rate from 1992 to 2021 is analyzed. The causal relationship between the exchange rate of India with crude oil consumption of India is tested using the Granger Causality test. To predict the exchange rate of India a causal model is developed. The crude oil consumption of India is predicted for 2020 to 2040 using HoltWinters and ARIMA models. Since the forecast accuracy of the ARIMA model is found good so the ARIMA model is used to predict the crude oil consumption of India. Predicted values of the crude oil consumption of India for the years 2030 and 2040 are found 6.018 and 7.261 million barrels per day respectively. These values are used for the regression model to predict the exchange rate of India. So the exchange rate of India for 2030 and 2040 will be 82.57 and 96.33 US dollars respectively.

HIGHLIGHTS

- A causal relationship is found between the exchange rate and crude oil consumption of India.
- The regression model is developed to predict the exchange rate of India.
- Crude oil consumption is predicted using the ARIMA method.

Keywords: Exchange Rate, Crude oil consumption, Causal relationship, Forecasting, ARIMA

Crude oil consumption and exchange rates are very important for any country for economic growth. This crude oil consumption can be used to predict the exchange rate. Several researchers predicted the exchange rate using various techniques. Refenes *et al.* (1993) applied a neural network model to predict exchange rates. Ince and Trafalis (2006) applied the non-parametric (ANN, SVR) and parametric (ARIMA and VAR) combination to predict the exchange rate. Galeshchuk (2016) predicted daily, monthly, and quarterly exchange rates using the neural network method. Filippou, *et al.* (2022) applied machine learning concepts to predict monthly exchange rates. Lisi and Schiavo (1999) predicted the exchange rate of the French Franc, British Pound, Deutschmark, and Italian Lira against the US dollar using the neural network and chaotic models. Ni and Yin (2009) recommended hybrid models to predict exchange rates using RSOM and SVR models. Pandey *et al.* (2020) found that a neural network model should be applied to predict exchange rates in place of MLP and linear models. Several researchers found that the exchange rate of any country affects the economic growth of the country, so it's very important to correctly predict the exchange rate. Shaik & Rao (2020) found a significant impact of the exchange

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rate on the crude oil consumption of India. Bibi, et al. (2014) found that the economy of Pakistan is affected by the exchange rate. Koirala (2018) found the impact of the exchange rate (on the economic growth of Nepal. Dickson (2012) analyzed the data from 1970 to 2009 to find the impact of the exchange rate volatility on Nigerian economic growth. Semuel & Nurina (2014) in the study found that the exchange rate has a positive impact on the crude oil consumption of Indonesia. Umaru *et al.* (2018) found a negative causal relationship between the exchange rate and the crude oil consumption of West African countries. Rodrik (2008) found the impact of the exchange rate on thecrude oil consumption of developing countries. Alagidede & Ibrahim (2017) studied the effects of fluctuations in the exchange rate on the economic growth in Ghana. Wong (2013) found that the exchange rate positively affects the economic growth in Malaysia. Lee *et al.* (2010) analyzed the data from 1997-2006 to find the impact of the exchange rate on the economic growth of developing countries. Domac & Shabsigh (1999) studied the impact of the real exchange rate misalignment (RERMIS) on the economic growth of Jordan, Egypt, and Tunisia. Vasani *et al.* (2019) studied the effect of the exchange rate on the economy of India and found a linear relationship between the exchange rate and the Indian economy. Akram & Rath (2017) found an impact of the exchange rate on the Indian economy.

MATERIALS AND METHODS

In this section historical data on the exchange rate of India and crude oil consumption for the years 1992 to 2021 is analyzed to predict the exchange rate of India.

Table 1: Exchange rate and crude oil consumption of India from 1992 to 2021

Year	Crude (million barrels per day)	Exchange rate (US dollar)
1992	1.296	25.92
1993	1.313	30.49
1994	1.406	31.37
1995	1.573	32.43
1996	1.705	35.43
1997	1.835	36.31
1998	1.971	41.26
1999	2.173	43.06
2000	2.287	44.94
2001	2.31	47.19
2002	2.359	48.61
2003	2.413	46.58
2004	2.553	45.32
2005	2.603	44.1
2006	2.748	45.31
2007	2.936	41.35
2008	3.074	43.51
2009	3.233	48.41
2010	3.308	45.73
2011	3.475	46.67
2012	3.674	53.44
2013	3.717	56.57
2014	3.832	62.33
2015	4.147	62.97
2016	4.544	66.46
2017	4.724	67.79
2018	4.974	70.09
2019	5.148	70.39
2020	4.65	76.38
2021	4.9	74.57

Prediction of the Exchange Rate of India Considering the causal relationship with crude oil consumption in India

Correlation analysis between the exchange rate of India and the crude oil consumption of India: A high correlation of 0.954 is found between the exchange rate of India and crude oil consumption. So a causal model can be developed to predict the exchange rate considering dependent on the crude oil consumption of India.

Granger Causality Test

To find the causal relationship between the exchange rate of India and the crude oil consumption of India, the Granger causality test is performed.

Ho: Exchange rate does not Granger cause crude oil consumption of India

Ho: Exchange rate Granger cause crude oil consumption of India

Granger Causality test with the help of R software provides the following outcomes.

Granger causality test

Model 1: exchange rate ~ Lags (exchange rate, 1:1) + Lags (crude, 1:1)

Model 2: exchange rate ~ Lags (exchange rate, 1:1)

Res.Df Df F Pr(>F)

1 26

2 27 -1 6.7957 0.01493 *

Since the p-value is less than 0.05 so alternate hypothesis is accepted and the exchange rate can be predicted caused by the crude oil consumption of India.

Regression Model to Predict the Exchange Rate of India

In this section, a regression model will be developed to predict the exchange rate of India. Here exchange rate is considered caused to the crude oil consumption of India which is verified by the Granger Causality test and correlation analysis. The regression model is developed using R software. The following results are obtained by regression analysis:

Call:

lm(formula = exchangerate ~ crude, data = economy)

Residuals:

Min 1Q Median 3Q Max

-7.7608 -2.1849 -0.0902 3.3640 8.9463

Coefficients:

Estimate Std. Error t value Pr(>|t|)

(Intercept) 15.9756 2.1324 7.492 3.69e-08 ***

crude 11.0663 0.6569 16.846 3.47e-16 ***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 4.196 on 28 degrees of freedom

Multiple R-squared: 0.9102

Adjusted R-squared: 0.907

F-statistic: 283.8 on 1 and 28 DF

p-value: 3.467e-16

From the above outputs, we can see that the p-value is less than 0.05 so the regression model is significant to predict the exchange rate of India.

So regression model will be Exchange rate = 15.9756 + 11.066*crude

Accuracy of the Regression Model

In this section exchange rate of India is predicted for 1992 to 2021 using the regression model. The accuracy of the model is checked using Mean Absolute Percentage Error (MAPE) and Mean Absolute Error (MAE).

Table 2: Prediction of the exchange rate of India using the linear regression model

Year	Crude oil consumption	Crude	Exchange rate	Pred_ exchange rate	MAPE
1992	288.2084	1.296	25.92	30.32	16.97
1993	279.296	1.313	30.49	30.51	8.51
1994	327.2756	1.406	31.37	31.53	5.85
1995	360.282	1.573	32.43	33.38	5.12
1996	392.8971	1.705	35.43	34.84	4.43
1997	415.8678	1.835	36.31	36.28	3.70
1998	421.3515	1.971	41.26	37.79	4.38
1999	458.8204	2.173	43.06	40.02	4.71
2000	468.3949	2.287	44.94	41.28	5.09
2001	485.441	2.31	47.19	41.54	5.78
2002	514.9379	2.359	48.61	42.08	6.47
2003	607.6993	2.413	46.58	42.68	6.63
2004	709.1485	2.553	45.32	44.23	6.31
2005	820.3816	2.603	44.1	44.78	5.97
2006	940.2599	2.748	45.31	46.39	5.73
2007	1216.735	2.936	41.35	48.47	6.45
2008	1198.896	3.074	43.51	49.99	6.94
2009	1341.887	3.233	48.41	51.75	6.94
2010	1675.615	3.308	45.73	52.58	7.36
2011	1823.05	3.475	46.67	54.43	7.83
2012	1827.638	3.674	53.44	56.63	7.74
2013	1856.722	3.717	56.57	57.11	7.43
2014	2039.127	3.832	62.33	58.38	7.38
2015	2103.588	4.147	62.97	61.87	7.15
2016	2294.798	4.544	66.46	66.26	6.87
2017	2651.473	4.724	67.79	68.25	6.64
2018	2702.93	4.974	70.09	71.02	6.44
2019	2831.552	5.148	70.39	72.94	6.34
2020	2667.688	4.65	76.38	67.43	6.52
2021	3173.398	4.9	74.57	70.20	6.50

The mean Absolute error (MAE) of the model is found 3.1 and the mean absolute percentage error (MAPE) is found 6.5, so the regression model can be considered a good predictive model to predict the exchange rate of India considering its dependent on crude oil consumption in India.

Prediction of the Crude Oil Consumption of India

To predict the exchange rate of India using a regression model, the crude oil consumption of India is predicted using R software. Data on crude oil consumption for 1992 to 2021 is analyzed using HoltWinters and ARIMA models. A model with good forecast accuracy is considered to predict the crude oil consumption of India.

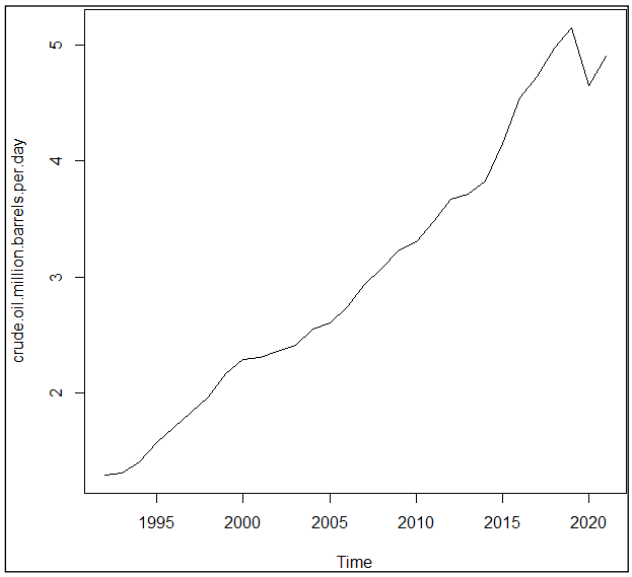

Fig. 1: Yearly crude oil consumption (million barrels per day) of India from 1992 to 2021

Trend Analysis of the Crude Oil Consumption of India Using Holtwinters and ARIMA Models Using R Software

Data on the crude oil consumption of India is analyzed using R software. HoltWinters and ARIMA models are developed to predict the crude oil consumption of India. The accuracy of the HoltWinters and ARIMA models is given in the table below. Since MAPE and other forecast accuracy tools are found good for the ARIMA model, the ARIMA model is used to predict the crude oil consumption of India.

Table 3: Forecast Accuracy of HoltWinters and ARIMA models to predict yearly crude oil consumption of India

Method	ME	RMSE	MAE	MPE	MAPE	MASE	ACF1
Holt-Winters	0.032	0.159	0.099	1.548	3.244	0.622	-0.014
ARIMA	0.00003	0.141	0.082	-0.252	2.513	0.518	-0.034

Table 4: Predicted crude oil consumption of India for 2022 to 2040 using the ARIMA model

Year	Forecast	LO 80	HI 80	LO 95	HI 95
2022	5.024	4.836	5.213	4.736	5.312
2023	5.149	4.882	5.415	4.741	5.556
2024	5.273	4.947	5.599	4.774	5.772
2025	5.397	5.020	5.774	4.821	5.973
2026	5.521	5.100	5.943	4.877	6.166
2027	5.646	5.184	6.107	4.940	6.351
2028	5.770	5.272	6.268	5.008	6.532
2029	5.894	5.361	6.427	5.079	6.709
2030	6.018	5.453	6.584	5.154	6.883
2031	6.143	5.547	6.738	5.232	7.054
2032	6.267	5.642	6.892	5.312	7.222
2033	6.391	5.739	7.044	5.393	7.389
2034	6.516	5.836	7.195	5.477	7.554
2035	6.640	5.935	7.345	5.562	7.718
2036	6.764	6.035	7.494	5.648	7.880
2037	6.888	6.135	7.642	5.736	8.041
2038	7.013	6.236	7.789	5.825	8.200
2039	7.137	6.338	7.936	5.915	8.359
2040	7.261	6.440	8.082	6.006	8.517

These predicted values of crude oil consumption are used to predict the exchange rate of India. So as per the model Exchange rate = 15.9756 + 11.066* crude, the exchange rate of India for 2030 and 2040 can be predicted by putting the predicted crude oil consumption for 2030 (6.018) and 2040 (7.261) respectively. So exchange rate of India for 2030 and 2040 will be 82.57 and 96.33 US dollars respectively.

CONCLUSION

In this work, a causal relationship between the exchange rate and the crude oil consumption of India is developed using a regression model by analyzing the data from 1992 to 2021. Correlation analysis and the Granger Causality test are performed to verify the causal dependency of the exchange rate

on the crude oil consumption of India. To predict the exchange rate of India, crude oil consumption of India is predicted using HoltWinters and ARIMA models. Since the accuracy of the ARIMA model is found better, the expected crude oil consumption of India for the years 2030 and 2040 is found 6.018 and7.261 respectively. These values are used for the regression model to predict the exchange rate of India. So exchange rate of India for the years 2030 and 2040 is found 82.57 and 96.33 US dollars respectively.

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