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CRUDE OIL: ELIXIR OF MODERN CIVILISATIONS

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ABSTRACT :

This paper focuses on three major aspects related to the crude oil market and crude oil-based industries. That is the volatility of Crude Oil pricing, effect of global Crude Oil markets on the Indian Economy and the impact of the Coronavirus Pandemic on the crude oil markets.

The aim of the this project is to use statistical tools like Time Series Analysis and Multiple Linear Regression to model and forecast the prices of crude oil and its derivatives.

Techniques like Multiple Linear Regression have been used to capture the relationship between the various economic factors used the gauge the economic progress of the country and crude oil prices. Crude oil pricing is an important phenomenon that affects a lot of things in our daily life. Thus, our project aims to statistically measure the relationship between Crude Oil prices and the economy and shed some light on the volatility of the crude oil pricing that is prevalent globally.

KEYWORDS :

- *Understanding the Importance of Crude Oil as a resource*
- *Understanding different Economic Indices – To understand how economic growth is gauged using measures like GDP, Inflation, GNI, GVA, Exchange rate, Economic Growth*
- *Analysis of Effect of crude oil prices on the Indian Economy: Using statistical tools like regression to find the linear relationship between various economic indices and crude oil prices*

Prediction of Oil Prices using time series analysis:

- *Different oil prices as seen globally such as WTI, Brent Oil, Dubai Intermediate etc.*
- *Prediction using AR, MA, ARMA and ARIMA*
- *Analysing the impact of crude oil price on Consumers fuel*

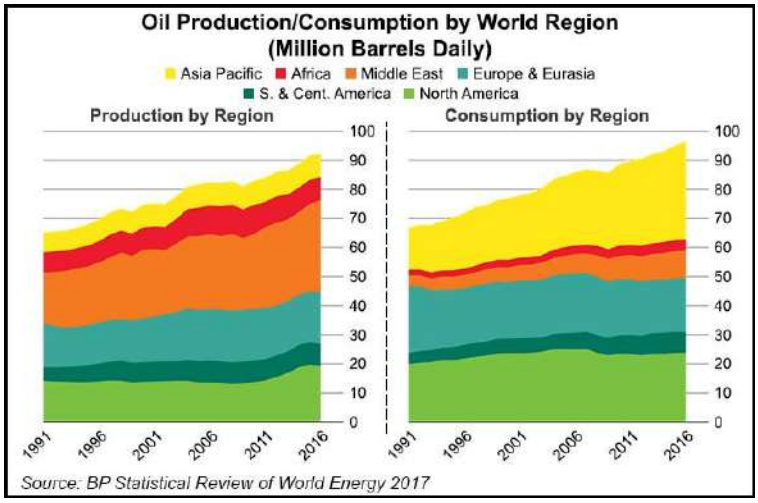
INTRODUCTION:

Many economists view crude oil as the single most important commodity in the world as it is currently the primary source of energy production. Oil is the elixir of modern civilization. For more than a century, technologies have been built around what this fossil fuel can provide. It has helped us become a thriving and developed world where lifestyles are better and safer than ever before.

These benefits have not come without a cost. Oil energy is one of the most pollution-rich types of energy consumption that modern technology offers. This has released emissions into the atmosphere that have

prompted several calls to reduce or eliminate them because of the potential warming effect they may cause.

Oil has made a massive contribution to human society, including its demographics and economic and social development. Its availability to society is linked to the general trend of settlement and growth. An energy surplus enables society to create a division of labour, develop more specialised individuals and grow cities. It is less than 200 years since the first commercial oil was produced in Pennsylvania. This process of development has led to the continuous discovery and depletion of oil and fossil fuels as we look to the future of 'peak oil' and its alternatives. The economic fluctuations of the world are highly correlated to variations in the price and availability of energy.



Major Oil producing countries:

United States: The United States is the top oil-producing country in the world, with an average of 19.47 million barrels per day (b/d), which accounts for 19% of the world's production. The U.S. has been a net exporter of oil (i.e., exports exceed imports) since early 2011.

1. Saudi Arabia: The Kingdom of Saudi Arabia contributes 11.62 million b/d, representing 12% of the world's total production.1 Saudi Arabia is the only member of the Organization of the Petroleum Exporting Countries (OPEC) to make this list.
2. Russia: While Russia has fallen in the ranks, it remains one of the world's top oil producers, with an average of 11.49 million b/d in 2019, accounting for 11% of total world production.
3. Canada: Canada holds the fourth spot among the world's leading oil producers, with an average production of 5.50 million b/d in 2019, accounting for 5% of global production.
4. China: China produced an average of 4.89 million b/d of oil in 2019, which accounts for 5% of the world's production.1 That being said, China is a net importer of oil, as the country consumed an average of 13.89 million b/d in 2018, which made it the second-largest oil consumer in the world (14% of the total world share) after the United States.

Major oil consuming countries:

1. United States: The United States, the world's biggest oil consuming country, consumed 18.5 million barrels of oil per day (mbd) in 2012, which accounted for nearly 20% of the world's total oil consumption per day. Consumption has since been declining.
2. China: China's oil consumption stood at 10.3mbd in 2012, accounting for about 11.7% of the world's total oil consumption making it the second biggest oil consumer after the US. China is also the second biggest oil importing country in the world currently and its net oil imports have steadily climbed up from 3.43mbd in 2008 to 5.86mbd in 2012. The country is likely to surpass the US as the biggest oil importing country in the near future.

3. Japan: Japan consumed 4.7mbd of oil in 2012, becoming the world's third biggest oil consumer, with about 5.3% of the world's total oil consumption. Japan possesses very limited oil resources and is the third biggest oil importing country after the US and China. Japan has the fourth biggest refinery capacity in the world and most of its crude oil imports are from the Middle East.
4. India: India ranks fourth among the world's biggest oil consuming countries, its oil consumption in 2012 stood at 3.6mbd, accounting for about 4.2% of the world's average oil consumption per day during the year. India is also the fourth biggest oil importer in the world and its net oil imports doubled over 12 years. The country imports most of the crude oil from the Middle East and has the fifth biggest refinery capacity in the world.
5. Russia: At 3.2mbd accounting for about 3.6% of the world's total oil consumption per day in 2012, Russia is fifth among the world's biggest oil consuming countries.

Russia is the third biggest oil producer after the United States and Saudi Arabia, and the second biggest oil exporter after Saudi Arabia.

What Affects Oil Prices?

- Oil prices are heavily influenced by traders who bid on oil futures contracts in the commodities market based on their perceptions of the future supply and demand for oil. Futures contracts and oil derivatives are traded daily, which acts to influence the price of oil. This causes the price of oil to change daily because it all depends on how trading went that day.
- Traders base their bids on their perceptions of supply and demand. Other entities, such as governments and the Organization of the Petroleum Exporting Countries (OPEC) can affect the traders' bidding decisions by influencing trade or adjusting the amount of oil produced and stored.Oil is commonly referred to as being the most volatile of commodities.

- **Effect of Disasters on Oil Prices:**

Natural and man-made disasters can impact oil prices if they are dramatic enough. Recently, pandemics and natural disasters have wreaked havoc on oil prices.

- **How World Crises Impact Oil Prices:**

- World crises in oil-producing countries, or concern about crises, dramatically increase oil prices. This is because traders worry the crisis will limit the supply of oil, increasing demand and therefore prices.
- World unrest also causes high oil prices . Earlier, in March 2011, investors became concerned about unrest in the countries of Libya, Egypt, and Tunisia (called the Arab Spring). Oil prices rose above $100/b in early March and peaked at around $113/b in late April.

DATA:

1. For the Regression Analysis we have compiled a dataset which includes the Dubai Crude oil prices over a period of 60 years (1960-2019) and the respective GDP rates, CPI rates, US-India Exchange rates, GVA and GNI.

Year	Crude oil, Dubai ($/bbl)	GDP (in usd)	CPI (Inflation)	Exchange Rate	GVA(Gross Value Added)	GNI
1960	1.63	37029883875.4573	1.779881791	4.7619000038	34994675141.8283	36878683724.2571
1961	1.57	39232435784.0946	1.6952335608	4.7619000038	36928627622.7871	39026635578.2944
1962	1.52	42161481858.7014	3.6322081327	4.7619000038	39486583751.222	41934681631.9011
1963	1.50	48421923458.7413	2.9461536428	4.7619000038	45127852020.1187	48186723223.541
1964	1.45	56480289940.8261	13.3552524507	4.7619000038	52721425818.429	56175789636.3258
1965	1.42	59554854574.7942	9.4747516903	4.7619000038	55202516367.983	59210461462.6564
1966	1.36	45865462033.91	10.8018601487	6.3591250054	42744144682.4849	45536890605.3386
1967	1.33	50134942203.4467	13.0622016027	7.5000000065	46883252372.6851	49790942203.4467

1968	1.32	53085455870.8227	3.237419305	7.5000000065	49441023869.452	52745455870.8227
1969	1.27	58447995016.8493	-0.5841427525	7.5000000065	54371579972.2747	58086661683.516
1970	1.21	62422483054.5173	5.0922555943	7.5000000065	57838263436.0013	62043816387.8507
1971	1.69	67350988020.9041	3.0799428698	7.491935231	62020937617.8159	66959943084.3313
1972	1.82	71463193830.4064	6.4421047323	7.5944683739	65672870824.897	71072538512.5786
1973	2.81	85515269585.5221	16.9408097832	7.7420385621	79128776460.1381	85101941339.3056
1974	10.97	99525899115.7756	28.598730457	8.1016032272	91825363863.7819	99161036284.1391
1975	10.43	98472796457.114	5.748428514	8.3758919457	89887191072.3375	98178114597.9604
1976	11.63	102717164465.894	-7.6339318169	8.9604127281	93542576801.1993	102456488498.428
1977	12.57	121487322474.298	8.3074691041	8.7385761713	111446335241.383	121215205685.977
1978	12.92	137300295308.038	2.5230370203	8.1928403484	124976822546.47	137110195139.872
1979	29.82	152991653792.864	6.2756934431	8.1257909464	138566651994.13	153181094632.843
1980	35.85	186325345089.754	11.3460553263	7.8629447011	169451747878.765	186762452326.729
1981	34.29	193490610032.1	13.1125513323	8.6585228171	175366835789.5	193535405875.045
1982	31.76	200715145360.918	7.8907481204	9.4551319335	181692473538.896	200056669825.258
1983	28.73	218262273410.099	11.8680725082	10.098898244	198431115643.681	217346843963.138
1984	27.49	212158234164.06	8.3189177429	11.3625833327	193322399019.772	210960266670.706
1985	26.46	232511877842.041	5.5564248421	12.3687499996	209831010617.321	231344146134.325
1986	13.20	248985994044.2	8.7297093227	12.6108333333	223910354064.298	247574348949.764
1987	16.94	279033584092.159	8.8011469383	12.9615	250269334523.387	277014075282.35
1988	13.22	296588994812.059	9.383465632	13.9170833333	267558923501.819	293483314650.144
1989	15.70	296042354986.126	7.0742804827	16.2255	267801009345.678	292602874479.116
1990	20.46	320979026419.633	8.971229653	17.5035	289602203565.216	316775332517.636
1991	16.56	270105341879.226	13.8702400467	22.7424333333	244573341067.598	265995400854.861
1992	17.19	288208430383.964	11.7878213152	25.9180833333	260425017041.948	283799332762.87
1993	14.94	279296022987.919	6.3268930717	30.4932916667	254898664589.996	275444510280.797
1994	14.67	327275583539.559	10.2479338044	31.3737425	297407251967.501	323108717813.725
1995	16.12	360281952716.797	10.2248846949	32.4270766667	326727432293.752	356252331233.451
1996	18.54	392897054348.071	8.9771471458	35.4331733333	358403958082.635	389212066967.505
1997	18.10	415867753863.874	7.1642474726	36.3132858333	380773981737.593	412314039081.443
1998	12.13	421351477504.743	13.2308486767	41.259365	387763650365.411	417792938008.473
1999	17.17	458820417337.807	4.6698151554	43.0554283333	419115138188.775	455259488556.383
2000	26.08	468394937262.37	4.0094391915	44.941605	428039125050.618	463418960201.815
2001	22.71	485441014538.638	3.7792900971	47.1864141667	445781166605.163	481233322101.917
2002	23.72	514937948870.08	4.2971580369	48.6103191667	473263315962.244	511490036313.605
2003	26.74	607699285433.872	3.8058690199	46.5832841667	558503852715.304	603192892963.386
2004	33.46	709148514804.659	3.767236944	45.3164666667	646379339766.045	704168745465.35
2005	49.29	820381595512.902	4.2463508276	44.099975	751444143042.355	814482820622.222
2006	61.43	940259888792.141	5.7965179204	45.3070083333	862969752565.222	932915277249.473
2007	68.37	1216735441524.86	6.3728813559	41.3485333333	1115278150615.86	1211640646849.16
2008	93.78	1198895582137.51	8.3492670491	43.5051833333	1124686481358.28	1191737412305.19
2009	61.75	1341886602798.69	10.8823529412	48.4052666667	1259367622700.17	1333877109441.3
2010	78.06	1675615335600.56	11.9893899204	45.7258121212	1554725332690.26	1657660320258.9
2011	106.03	1823050405350.42	8.8583609664	46.6704666667	1691714157528.46	1807019187629.77
2012	108.90	1827637859135.7	9.3124456049	53.4372333333	1691388408216.64	1806177662220.11
2013	105.43	1856722121394.53	10.9076433121	58.5978454167	1712863994624.96	1833601556952.76
2014	96.66	2039127446298.55	6.3531945441	61.0295144608	1881518177418.41	2015015376660.84
2015	51.18	2103587817041.78	5.8724265947	64.1519444633	1920694486661.52	2079182325742.91
2016	41.20	2294797978291.98	4.9410264584	67.1953128074	2082120735925.57	2247940124045.8
2017	53.12	2652754685834.59	2.4908869988	65.1215686451	2406818100718.49	2624081509582.67
2018	69.15	2713165057513.35	4.8606994665	68.3894670935	2451265837086.28	2684229691550.26
2019	63.18	2868929415617.02	7.6596947428	70.420340536	2587307959140.72	2837687527302.99

REGRESSION ANALYSIS: DOES CRUDE OIL PRICING AFFECT THE INDIAN ECONOMY?

Our aim in this regression analysis is to see what impact the change in global crude oil prices have on the Indian economy. For this analysis we have compiled a dataset of data which includes the

Dubai Crude oil prices over a period of 60 years (1960-2019) and the respective GDP rates, CPI rates, US-India Exchange rates, GVA and GNI.

Exploratory Data Analysis - Correlation Analysis

Correlation is the extent of linear relationship between random variables.

We use a scatter plot and a correlation heatmap to check correlation initially.

Let,

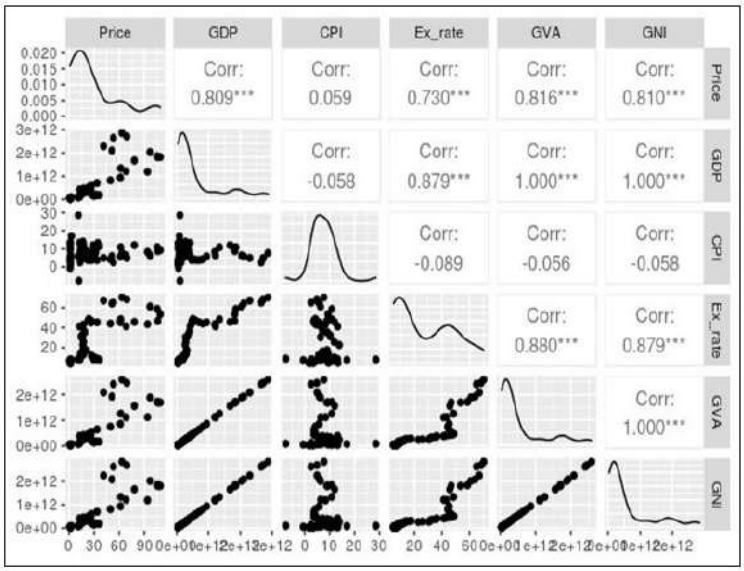
X1 denote Price of Dubai Crude Oil in USD per barrel ($/bbl)

X2 denote Gross Domestic Product of India (in USD)

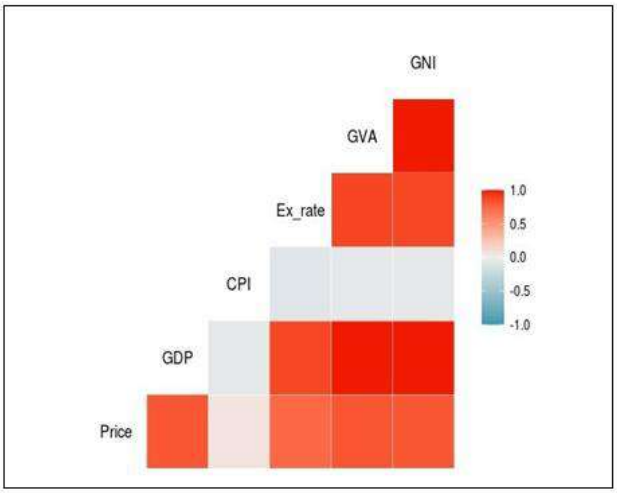
X3 denote Cost Price Index (measure of inflation)

X4 denote USA-India Exchange Rate

X5 denote Gross Value Added (in USD) X6 denote Gross National Income (in USD) where X1, X2, X3, X4, X5, X6 are the random variables under consideration.



Scatter Plot



Correlation Heatmap

Correlation matrix:

```
> cor(d)
            Price         GDP         CPI     Ex_rate         GVA
GNI
Price   1.00000000  0.80919937  0.05856183  0.72979227  0.81570632
0.81033132
GDP     0.80919937  1.00000000 -0.05775816  0.87880895  0.99988606
0.99999032
CPI     0.05856183 -0.05775816  1.00000000 -0.08936266 -0.05554465 -
0.05766661
Ex_rate 0.72979227  0.87880895 -0.08936266  1.00000000  0.87964024
0.87891042
GVA     0.81570632  0.99988606 -0.05554465  0.87964024  1.00000000
0.99989737
GNI     0.81033132  0.99999032 -0.05766661  0.87891042  0.99989737
1.00000000
```

Interpretation of Scatter Plot:

1. Crude Oil Price and Gdp of India are highly positively correlated.

We get r = 0.80919937 which shows that there is significantly high positive correlation.

2. There is almost no correlation between the Crude Oil Price and CPI of the country.

We get r = 0.05856183 which is very close to zero. This is quite anomalous because we understand that if the price of fuels like petrol and diesel increases it results in the overall increase in prices of all goods and services. This anomaly is due to the fact that CPI is not able to capture the taxes and other refining costs that are added to the price of crude oil before a finished product like petrol and diesel is sold.

3. There is high positive correlation between the Crude Oil Price and US-INR Exchange Rate. We get r = 0.72979227 which shows that there is significantly high positive correlation.

4. There is high positive correlation between the Crude Oil price and Gross Value Added of the country. We get r = 0.81570632 which shows that there is significantly high positive correlation.

5.There is high positive correlation between the Crude Oil price and Gross National Income of the country. We get r = 0.81033132 which shows that there is significantly high positive correlation.

Model-1 : Regression of GDP on Crude Oil Price

We try to see how the change in crude oil price affects the GDP of the country. Let Y denote Gross Domestic Product of India (in USD) and X denote the Price of Dubai Crude Oil in USD per barrel ($/bbl) where Y, X are the random variables under consideration.

From the above analysis we already can see that the correlation coefficient r = 0.80919937 which shows that there is significantly high positive correlation between Y and X.

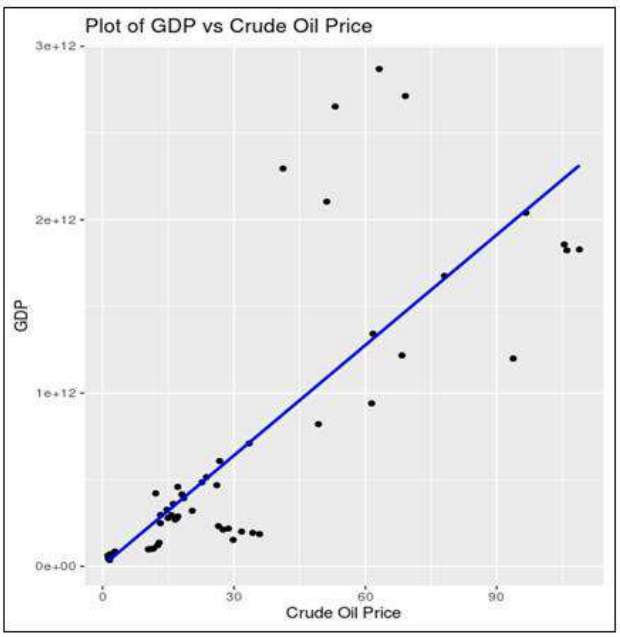
```
> lm1=lm(x1_gdp ~ price)
> print(summary(lm1))

Call: lm(formula =
x1_gdp ~ price)

Residuals:
      Min         1Q     Median         3Q
Max
-7.937e+11 -1.479e+11 -2.614e+09  2.311e+10
1.525e+12

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  3.692e+09     8.406e+10       0.044
0.965       price           2.121e+10   2.022e+09
10.489 5.13e-15 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05
'.' 0.1 ' ' 1

Residual standard error: 4.614e+11 on 58 degrees of
freedom
Multiple R-squared:  0.6548,    Adjusted R-squared:
0.6489
F-statistic:   110 on 1 and 58 DF,  p-value:
5.134e-15
```



Y = 2.121e+10 X + 3.692e+09 is the regression line obtained.

Significance of Regression Coefficients:

H_0: $\beta_1 = 0$
H1: $\beta 1 \neq 0$
Test Statistic t = 10.489
P-value = 5.13e-15 < 0.01

Hence we reject H_0, which implies that the regressor X is highly significant at 1% level of significance.

As we have only one regressor here we conclude that the model is significant.

Coefficient of Determination:

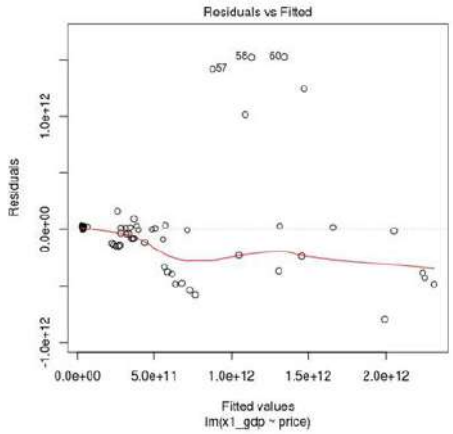
R-squared: 0.6548,
Adjusted R-squared: 0.6489

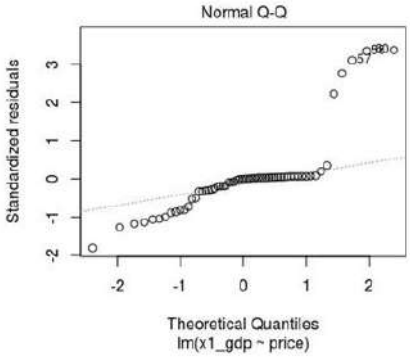
The coefficient of determination is relatively high which implies that the regression model captures most of the variability expressed in GDP.

Model Adequacy Checking:

From the Q-Q plot we observe that the most of the points lie approximately on a straight line. Hence we can say that errors of our model are normally distributed and the normality assumption is not violated.

From the plot of Residuals vs fitted values we observe that most of the observations lie in a horizontal band. This indicates the model is adequate and constant variance assumption is not violated.






```
> lm1=lm(x1_gdp ~ price)
> influence.measures(lm1)
Influence measures of
lm(formula = x1_gdp ~ price) :

     dfb.1_  dfb.pric     dffit cov.r   cook.d    hat inf
49  2.09e-01 -5.49e-01 -6.03e-01 1.020 1.75e-01 0.0964   *
51 -2.23e-03  8.03e-03  9.38e-03 1.104 4.48e-05 0.0623   *
52  1.56e-01 -3.59e-01 -3.85e-01 1.149 7.41e-02 0.1296   *
53  1.89e-01 -4.27e-01 -4.55e-01 1.149 1.03e-01 0.1383   *
54  1.37e-01 -3.17e-01 -3.40e-01 1.155 5.79e-02 0.1279   *
55  4.07e-03 -1.03e-02 -1.12e-02 1.155 6.42e-05 0.1037   *
56  5.60e-02  2.24e-01  3.76e-01 0.889 6.58e-02 0.0258   *
57  1.86e-01  1.77e-01  4.73e-01 0.735 9.51e-02 0.0194   *
58  6.71e-02  3.90e-01  6.21e-01 0.693 1.59e-01 0.0275   *
59 -9.52e-02  5.25e-01  6.53e-01 0.820 1.88e-01 0.0471   *
60 -5.01e-02  5.64e-01  7.48e-01 0.696 2.29e-01 0.0387   *
```

This R command uses the residuals to find out which observations have the maximum influence on shifting the model towards them. It compares that with the distance of those points from the line. The points which are shown above indicate the outliers in the data. We notice that these points represent the crude oil prices in the years 2008, 2009-2019. Crude Oil Prices are very volatile, but as these years are crucial for the prediction hence we do not remove these points even though they are potential outliers.

Interpretation:

This regression model shows us that if the crude oil price increases then it will lead to increase in Gross Domestic Product of the country.

This is in line with the understanding that as crude oil price increases the prices of goods and commodities goes up. This in turn leads to people spending more on the same goods and commodities. That would lead to a growth in GDP of the country as more money is being pumped into the economy.

Model – 2 : Regression model of GNI on Crude Oil Price

We try to see how the change in crude oil price affects the Gross National Income of the country. Let Y denote Gross National Income (in USD) and X denote the Price of Dubai Crude Oil in USD per barrel ($/bbl) where Y, X are the random variables under consideration.

From the above analysis we already can see that the correlation coefficient r = 0.8103313 which shows that there is significantly high positive correlation between Y and X.

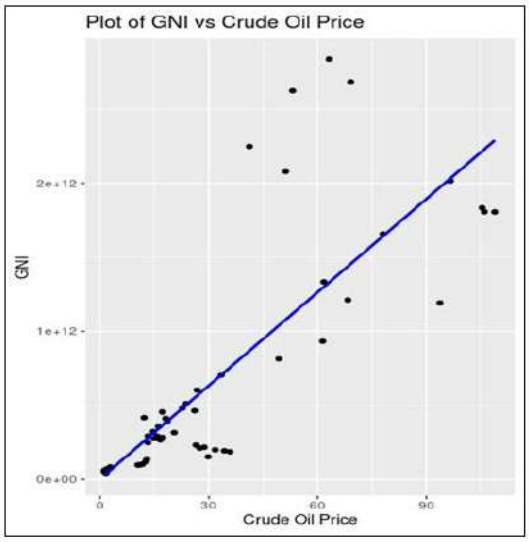
```
> lm4=lm(x5_gni ~ price)
> print(summary(lm4))

Call: lm(formula =
x5_gni ~ price)

Residuals:
      Min          1Q      Median          3Q
Max
-7.802e+11 -1.458e+11 -1.616e+09  2.300e+10
1.508e+12

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)   3.950e+09     8.284e+10       0.048
0.962       price           2.099e+10   1.993e+09
10.532 4.39e-15 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05
'.' 0.1 ' ' 1

Residual standard error: 4.547e+11 on 58 degrees of
freedom
Multiple R-squared:  0.6566,    Adjusted R-squared:
0.6507
F-statistic: 110.9 on 1 and 58 DF,  p-value:
4.394e-15
```



Y = 2.099e+10 X + 3.950e+09 is the regression line obtained.

Significance of Regression Coefficients:

H_0: $\beta_1 = 0$
H1: $\beta 1 \neq 0$
Test Statistic t = 10.532
P-value = 4.39e-15 < 0.01
Hence we reject H_0, which implies that the regressor X is highly significant at 1% level of significance. As we have only one regressor here we conclude that the model is significant.

Coefficient of Determination:

R-squared: 0.6566 Adjusted R-squared: 0.6507

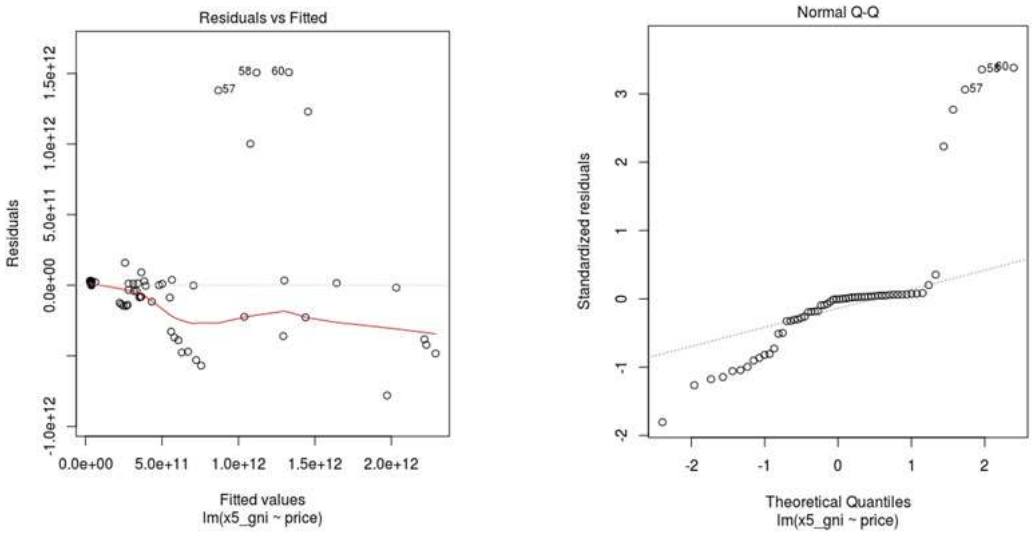
The coefficient of determination is relatively high which implies that the regression model captures most of the variability expressed in the GNI.

Model Adequacy Checking:

From the Q-Q plot we observe that the most of the points lie approximately on a straight line.

Hence we can say that errors of our model are normally distributed and the normality assumption is not violated.

From the plot of Residuals vs fitted values we observe that most of the observations lie in a horizontal band. This indicates the model is adequate and constant variance assumption is not violated.



Outlier Detection:

```
> lm4=lm(x5_gni ~ price)
> influence.measures(lm4)
Influence measures of
lm(formula = x5_gni ~ price) :

     dfb.1_   dfb.pric     dffit cov.r   cook.d
hat inf 49   0.208938 -5.47e-01 -0.601836 1.021
1.74e-01 0.0964    *
51 -0.002145  7.74e-03  0.009042 1.104 4.16e-05 0.0623   *
52  0.155362 -3.58e-01 -0.383961 1.149 7.37e-02 0.1296   *
53  0.191101 -4.31e-01 -0.459719 1.148 1.05e-01 0.1383   *
54  0.138650 -3.21e-01 -0.344714 1.154 5.96e-02 0.1279   *
55  0.004938 -1.25e-02 -0.013626 1.155 9.45e-05 0.1037   *
56  0.056067  2.24e-01  0.376695 0.888 6.60e-02 0.0258   *
57  0.183527  1.74e-01  0.466255 0.742 9.27e-02 0.0194   *
58  0.067399  3.92e-01  0.623970 0.691 1.60e-01 0.0275   *
59 -0.095547  5.27e-01  0.655347 0.818 1.90e-01 0.0471   *
60 -0.050331  5.66e-01  0.750618 0.694 2.30e-01 0.0387   *
```

Similar to the previous model, we notice that these points represent the crude oil prices in the years 2008, 2009-2019. Crude Oil Prices are very volatile, but as these years are crucial for the prediction hence we do not remove these points even though they are potential outliers.

Interpretation:

This regression model shows us that if the crude oil price increases that will lead to increase in Gross National Income of the country.

This is in line with the understanding that as crude oil price increases the prices of goods and commodities goes up. This in turn leads to people spending more on the same goods and commodities. That would lead to a growth in income of the people as all industries that are part of the economy will benefit from this extra expenditure.

Model – 3 : Regression model of GVA on Crude Oil Price

We try to see how the change in crude oil price affects the Gross Value Added of the country. Let Y denote Gross Value Added (in USD) and X denote the Price of Dubai Crude Oil in USD per barrel ($/bbl) where Y, X are the random variables under consideration.

From the above analysis we already can see that the correlation coefficient r = 0.8157063 which shows that there is significantly high positive correlation between Y and X.

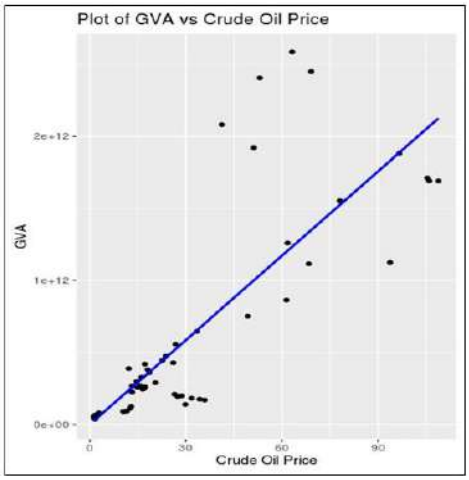
```
> lm3=lm(x4_gva ~ price)
> print(summary(lm3))

Call: lm(formula =
x4_gva ~ price)

Residuals:
      Min          1Q      Median          3Q
Max
-7.066e+11 -1.339e+11 -8.163e+08  2.719e+10
1.369e+12

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  2.090e+08     7.558e+10       0.003
0.998        price           1.952e+10   1.818e+09
10.739 2.07e-15 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05
'.' 0.1 ' ' 1

Residual standard error: 4.149e+11 on 58 degrees of
freedom
Multiple R-squared:  0.6654,    Adjusted R-squared:
0.6596
F-statistic: 115.3 on 1 and 58 DF,  p-value:
2.067e-15
```



Y = 1.952e+10 X + 2.090e+08 is the regression line obtained.

Significance of Regression Coefficients:

H_o: $\beta_1=0$
H_i: $\beta_1 0$
Test Statistic t = 10.739
P-value 2.07e-15 <0.01
Hence we reject H . which implies that the regressor X is highly significant at 1% level of significance. As we have only one regressor here we conclude that the model is significant.

Coefficient of Determination:

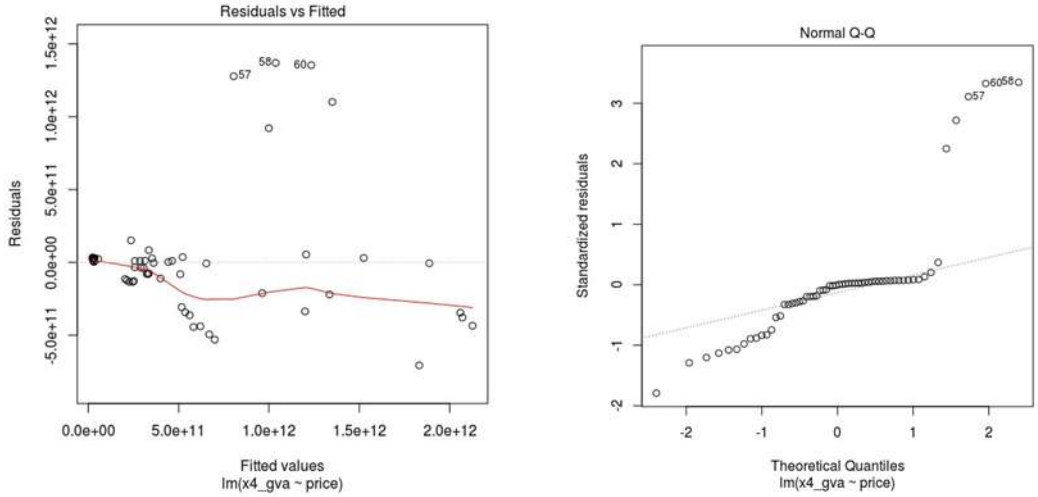
R-squared: 0.6654
Adjusted R-squared: 0.6596
The coefficient of determination is relatively high which implies that the regression model captures most of the variability expressed in the GVA.

Model Adequacy Checking:

From the Q-Q plot we observe that the most of the points lie approximately on a straight line.

Hence we can say that errors of our model are normally distributed and the normality assumption is not violated.

From the plot of Residuals vs fitted values we observe that most of the observations lie in a horizontal band. This indicates the model is adequate and constant variance assumption is not violated.



Outlier Detection:

```
> lm3=lm(x4_gva ~ price)
> influence.measures(lm3)
Influence measures of
lm(formula = x4_gva ~ price) :

     dfb.1_  dfb.pric     dffit cov.r   cook.d    hat inf
49  0.207278 -0.543016 -0.597054 1.023 1.71e-01 0.0964   *
51 -0.004587  0.016548  0.019337 1.104 1.90e-04 0.0623   *
52  0.152756 -0.352421 -0.377521 1.151 7.13e-02 0.1296   *
53  0.188569 -0.425409 -0.453628 1.149 1.02e-01 0.1383   *
54  0.137252 -0.318228 -0.341240 1.155 5.84e-02 0.1279   *
55  0.001855 -0.004690 -0.005120 1.155 1.33e-05 0.1037   *
56  0.056584  0.226460  0.380166 0.885 6.71e-02 0.0258   *
57  0.186829  0.177354  0.474643 0.733 9.55e-02 0.0194   *
58  0.067149  0.390550  0.621658 0.693 1.59e-01 0.0275   *
59 -0.093535  0.515741  0.641544 0.827 1.83e-01 0.0471   *
60 -0.049320  0.554838  0.735547 0.705 2.23e-01 0.0387   *
```

Similar to the previous model, we notice that these points represent the crude oil prices in the years 2008, 2009-2019. Crude Oil Prices are very volatile but as these years are crucial for the prediction hence we do not remove these points even though they are potential outliers.

Interpretation:

This regression model shows us that if the crude oil price increases that will lead to increase in Gross Value Added of the country.

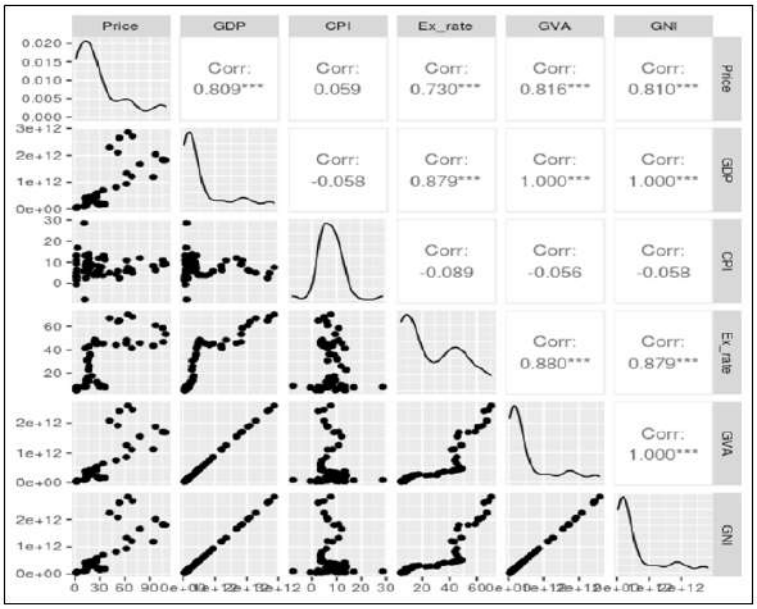
This is in line with the understanding that as crude oil price increases the prices of goods and commodities goes up. This in turn leads to people spending more on the same goods and commodities. That would in turn lead to a increase in contribution of all industries to the economic development and overall growth of the country.

Model – 4 : Regression model of GDP on Crude Oil Price, Exchange Rate, GNI and GVA

We try to see how the change in crude oil price affects the GDP of the country. Let Y denote Gross Domestic Product of India (in USD) and X1 denote the Price of Dubai Crude Oil in USD per barrel ($/bbl) and X2 USA-India Exchange Rate and X3 denote Gross Value Added (in USD) and X4 denote Gross National Income (in USD) where X1, X2, X3, X4 are the random variables under consideration.

We revisit the correlation matrix that we had seen before:

We notice that X3(GVA) and X4(GNI) are highly correlated with each other. They have a correlation coefficient value of 1. This indicates we have data based multicollinearity.
We also notice that correlation coefficient between GDP and GNI is perfectly 1.
This is actually because both GVA and GNI are actually linear functions of GDP.
Hence we decide to drop X3 and X4 from the regression model.



We consider the regression model of GDP on Crude Oil Price and Exchange Rate:

```
> lm5=lm(x1_gdp~price+x3_ex)
> print(summary(lm5))

Call: lm(formula = x1_gdp ~
price + x3_ex)

Residuals:
      Min          1Q      Median          3Q
Max
-5.455e+11 -2.137e+11  2.123e+10  1.465e+11
9.426e+11

Coefficients:
             Estimate   Std.   Error   t   value
Pr(>|t|)              (Intercept)    -2.648e+11
6.839e+10      -3.871   0.000281   ***   price
9.412e+09   2.078e+09     4.530  3.06e-05  ***
x3_ex           2.267e+10   2.914e+09    7.780
1.60e-10 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05
'.' 0.1 ' ' 1

Residual standard error: 3.241e+11 on 57 degrees of
freedom
Multiple R-squared:  0.8326,    Adjusted R-squared:
0.8267
F-statistic: 141.7 on 2 and 57 DF,  p-value: <
2.2e-16
```

$Y = 9.412e+09\ X_1 + 2.267e+10\ X_2 + -2.648e+11$ is the regression line obtained.

Significance of Regression Coefficients:

1. H0: $\beta 1 = 0$ H1: $\beta 1 \neq 0$

Test Statistic t = 4.530

P-value = 3.06e-05 < 0.01

Hence we reject H_0, which implies that the regressor X_1 is highly significant at 1% level of significance.

2. H0: $\beta 2 = 0$ H1: $\beta 2 \neq 0$

Test Statistic t = 7.780

P-value = 1.60e-10 < 0.01

Hence we reject H_0, which implies that the regressor X_2 is highly significant at 1% level of significance.

As both the regressors are significant, here we conclude that the model is significant.

Coefficient of Determination:

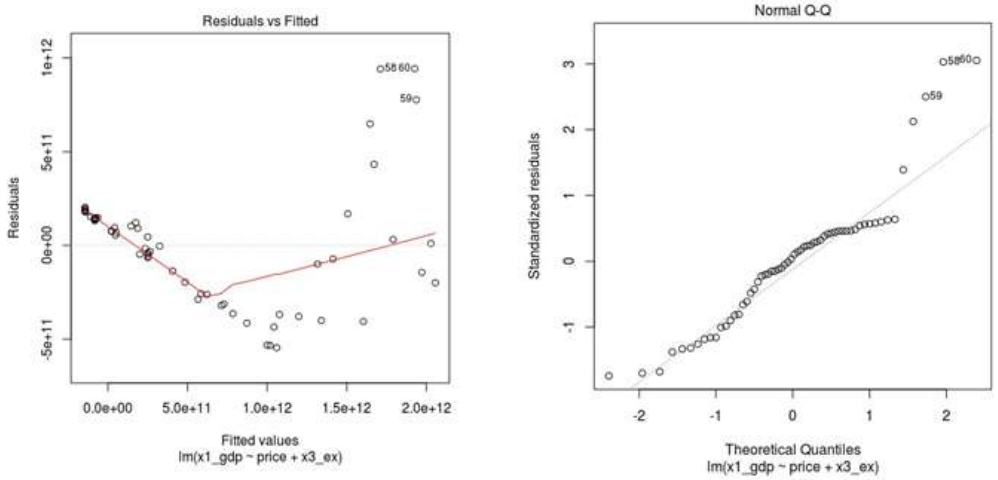
R-squared: 0.8326 Adjusted R-squared: 0.8267

The coefficient of determination is relatively high which implies that the regression model captures most of the variability expressed in the GDP.

Model Adequacy Checking:

not violated.

violated.



Outlier Detection:

From the Q-Q plot we observe that the most of the points lie approximately on a straight line. Hence we can say that errors of our model are normally distributed and the normality assumption is From the plot of Residuals vs fitted values we observe that most of the observations lie in a horizontal Band this indicates that the model is adequate and the constant variance assumption is not violated Similar to the previous model, we notice that these points represent the crude oil prices in the years 2010-2019. Crude Oil Prices are very volatile but these years are crucial for the prediction hence we do not remove these points even though they are potential outliers.

Interpretation:

This regression model shows us that if the crude oil price increases and the IND-USD exchange rates go up then that will lead to increase in Gross Domestic Product of the country. This is in line with the understanding that as crude oil price increases, the prices of goods and commodities goes up. This in turn leads to people spending more on the same goods and commodities. Also as the exchange rates go up the income from net exports goes up and that extra income would also lead to a growth in the economy.

Conclusion :

We were able to quantify the linear relationship that the Gross Domestic Product of country has with the other economic indices and crude oil prices. We observed that the crude oil price is very closely linked to the economy of our country.

CONCLUSION

I was able to quantify the linear relationship that the Gross Domestic Product of country has with the other economic indices and crude oil prices. We observed that the crude oil price is very closely linked to the economy of our country. This relationship signifies that a rise within the crude oil costs would end in the economic development of the country. This is often because there would be a increase in producing of products and that would eventually lead the country to become self reliant.

A subtle point to note here is that if the country has a net import of crude oil then it will to the increase in inflation of the country. That will eventually lead to the reduction in economic growth over time.

Using time series analysis we were also able to forecast that oil prices would increase gradually in 2021-2022 provided the COVID pandemic subsides. We also noticed that forecasts for 2021-2022 indicate that prices for crude oil based derivatives like natural gas would also increase gradually.

We also saw that cheaper global crude oil pricing doesn't not necessarily mean cheaper petroleum products like diesel and petrol. This was seen in the case of fuel pricing in India. This was

primarily due to India's heavy taxation policies. A global rise in crude oil prices could cause inflation to go up in India and that would also eventually lead to a recession if not brought under control.

This kind of analysis can be extended and carried out by a lot of global authorities as it is of prime importance to us. Hence a deep statistical analysis would surely help everyone understand this commodity much better.

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