

A Systematic Analysis of the Surge in Petrol and Diesel Prices in India Since 2013 An Using by Robust Fuzzy Regression Estimator

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Abstract- India has emerged as the third base-prime trader of crude oil globally, superior previous benchmarks in 2020 and fulfilling completed 84% of its oil needs done imports. This investigates the reasons behind the sharp increases in petrol and diesel prices and their subsequent impact on India's economy. The rapid escalation in crude oil prices exerts significant pressure on the economy, driven by factors such as fluctuating supply and demand, OPEC policies, high government taxes on petroleum products, and the rupee-dollar exchange rate. To address these issues, this paper employs the Robust Fuzzy Regression Estimator (RFRE) to identify and mitigate irregular data points, thereby refining the analysis of price trends. The study finds that rising energy prices contribute to increased manufacturing costs, lower GDP growth, a widening current account deficit (CAD), tax variations, and heightened costs for transportation and essential goods. Contrary to the belief that global crude oil prices are the primary driver of domestic fuel prices, the analysis concludes that the economic policies of both central and state governments play a more critical role. This research provides valuable insights into the complexities of fuel pricing and offers a clearer understanding of the statistical economic implications of energy price volatility.

Keywords— Robust Fuzzy Regression Estimator (RFRE) Tool, Current Account Shortage, Crude Oil Price, Intensification, Petroleum Products, GDP.

I. INTRODUCTION

When Colonel Edwin Drake successfully drilled the first oil well in Titusville, Pennsylvania in 1859, the transformative impact of petroleum on the world was largely unanticipated. Although the advent of electricity, spurred by Thomas Edison's invention of the light bulb, briefly shifted focus away from oil as a primary energy source for lighting, this was only a temporary diversion. The rise of the automobile quickly restored oil's prominence, as the growing vehicle population in subsequent years underscored its critical role. Today, oil remains a cornerstone of national economies and an indispensable element of modern life (Betsy Theodore, Martin L. William, 2019).

The Ordinary Least Squares (OLS) method is a widely recognized and straightforward statistical tool for finding the best-fitting line in a model. This method is defined by an equation involving parameters that

relate to observed data and is commonly used in regression analysis and estimation, with its assumptions readily available in literature. Despite its utility, the OLS method can be less effective when dealing with outliers or when the data's underlying distribution deviates from normality. Consequently, it is important to perform diagnostic checks on the data before applying the OLS method to ensure accurate results. (Kamile Şanlı Kula et al.,2012).

A statistical procedure is considered robust if it remains effective despite the presence of significant errors or outliers in the data. Robust methods are designed to handle situations where even a single outlier might disrupt standard procedures, making them preferable to Ordinary Least Squares (OLS) methods in such scenarios. Fuzzy regression analysis, a variant of classical regression analysis, is used to assess the relationship between dependent and independent variables in environments characterized by uncertainty or imprecision

(Nasrabadi et al., 2004). This type of analysis typically falls into two main categories: one based on the linear programming approach by Tanaka et al. (1982), and the other on the fuzzy least squares approach introduced by Diamond (1988) (Redden et al., 1996, Yang et al., 1997 and Yang et al., 2002).

Petrol and diesel come from crude oil painting which comes from cavernous resistance. Crude oil painting is perfected to make petrol or diesel. Utmost forms of shipping use each petrol or diesel to authority their machines- from lawnmowers, buses, motorcars and motorbikes to veritably large vessels and planes. Everyone's attention has been focused on the government policy of taxing petroleum products and the portion of the global crude oil painting oil price due to the recent increase in the price of gasoline and diesel in India. Between 2014 and 2020, the import of crude oil paint from India arose. The high cost of diesel and petrol in India from 2011 to 2014 may have been caused by the extreme European debt and increased pressure on Iran. The government at the time monitored the regulation of gasoline and diesel prices by adding subvention in the case of high oscillations and crude oil painting oil rises that violated the \$100/cask mark and reached to a high of \$143/barrel. After the quotidian change was addressed in the energy sector, the price of diesel and petrol exceeded the all-time highest on June 16, 2017. The government's high duty on petroleum results is what's causing the problem of the spike in oil painting prices, not the lack of involvement in the price of gasoline and diesel. It has been acknowledged that the only outcome for reasonable pricing is escort petroleum that is less than the excise dimension. This essay examines the causes of India's rising fuel and alcohol prices as well as the arguments made in defines of thrift.

The primary aim of this research is to analyze how different factors influence petrol and diesel prices using an appropriate regression model. Additionally, it seeks to identify any levels of these factors at which petrol prices can be minimized. Given that the study will utilize monthly time series data, it is important to check for and address any potential autocorrelation. The regression model developed should be effective

in including relevant variables to accurately interpret the key determinants of petrol and diesel prices.

II. METHODOLOGY

1. Data Information Collection

The study employs a comprehensive dataset comprising historical prices of petrol and diesel, global crude oil prices, OPEC production policies, government tax rates on petroleum products, and the rupee-dollar exchange rate. The data spans from 2013 to the present to detention equally short-range variations and long-standing tendencies.

2. Robust Fuzzy Regression Estimator (RFRE) Application

The Robust Fuzzy Regression Estimator (RFRE) is employed to handle irregularities and outliers in the data. The RFRE model combines fuzzy logic with robust statistical techniques to refine the dataset. The methodology includes: Outlier Detection: Identifying and mitigating the impact of anomalous data points that could distort the analysis. Model Calibration: Adjusting the RFRE parameters to fit the historical data and improve the robustness of the regression results.

3. Data Collection and Preparation

Data Sources: Gather historical data on petrol and diesel prices, government taxes, global oil prices, and economic indicators from 2013 to the present.

Data Preprocessing: Fresh and preprocess the data, including management lost standards and regularizing data.

4. Fuzzification

Define Fuzzy Sets: Establish fuzzy sets and membership functions for each variable (e.g., petrol and diesel prices, taxes, global oil prices). Common membership functions include triangular, trapezoidal, and Gaussian.

Fuzzify Data: Change crisp data obsessed by fuzzy values by means of the predefined association functions.

5. Fuzzy Regression Model Formulation

Construct Model: Formulate the fuzzy regression model in the following for

$$\tilde{Y} = \beta_0 + \beta_1 \tilde{X}_1 + \beta_2 \tilde{X}_2 + \dots + \beta_p \tilde{X}_p$$

where $\tilde{Y}$ represents the fuzzy petrol and diesel prices, β_j are the fuzzy parameters, and $\tilde{X}_j$ are the fuzzy predictors.

6. Robust Fuzzy Regression Estimation

Select Robust Loss Function: Choose a robust loss function to handle outliers, such as Huber loss or Tukey's biweight loss function:

$$L(y_i, \hat{y}_i) = \frac{1}{2} (y_i - \hat{y}_i)^2$$

$$\text{if } |y_i - \hat{y}_i| \leq C$$

$$C \left[1 - \frac{|y_i - \hat{y}_i|^2}{C^2} \right] \text{ if } |y_i - \hat{y}_i| > C$$

where c is a tuning parameter. where ccc is a tuning parameter.

Parameter Estimation: Use iterative optimization techniques, such as weighted least squares or gradient descent, to estimate the fuzzy parameters $\hat{\beta}_j$

7. Model Evaluation

Goodness of Fit: Assess the model fit using metrics like fuzzy R2 or fuzzy mean squared error.

Validation: Perform cross-validation or use a separate validation dataset to verify the robustness and accuracy of the model.

8. Analysis and Interpretation

Interpret Parameters: Analyze the estimated fuzzy parameters to understand their impact on fuel prices.

Impact of Factors: Evaluate how different factors, such as taxes and global oil prices, affect petrol and diesel prices.

9. Policy Insinuations and References

- Policy Analysis: Deliberate the insinuations of the results for fuel pricing policies and economic planning.
- Recommendations: Provide recommendations for policymakers to manage and mitigate the impact of rising fuel prices.

10. Documentation and Reporting

Report Findings: Document the methodology, results, and conclusions in a comprehensive report.

Present Results: Prepare presentations or publications to share findings with stakeholders and the public.

III. LITERATURE REVIEW

According to Soundarapandiyan (2017), there is a negative correlation between crude oil prices and the Consumer Price Index (CPI), indicating that as the CPI rises, crude oil prices generally fall. However, while the relationship between CPI and GDP is not significantly different, there is a substantial difference between crude oil prices and GDP.

Nguyen Thi Ngoc Trang (2017) employed a vector machine regression model to assess how changes in oil prices impact Vietnam's economy. The study revealed that while the effects of fluctuating oil prices on GDP growth and employment are uncertain, higher oil prices could result in budget deficits and higher inflation in Vietnam. Additionally, a 2016 study using the Structural Vector Auto-Regression (SVAR) method explored the dynamic interactions between oil price changes, exchange rates, and various macroeconomic factors like inflation, interest rates, and investment. The findings suggest three key policy implications: fluctuations in global oil prices can significantly influence India's economy; the Reserve Bank of India (RBI) may find it ineffective to use a depreciating rupee for policy expansion; and changes in the rupee's value could impact global oil prices in the medium to long term, which is an important factor for policymakers to consider.

According to Akansha Sanjay Jain (2015), forecasting future oil prices is difficult, but they are generally

anticipated to rise. The Indian economy is significantly impacted by this increasing dependence on oil and its derivatives. Higher crude oil prices lead to increased government spending on subsidies, decreased exports, reduced investment, and a negative effect on GDP. Sivarajan (2018) highlights a direct connection between international fossil fuel costs and rising energy prices. Various factors have driven recent increases in energy costs. While the government can take measures to alleviate these expenses, it is not solely responsible for the rise in energy prices. Thus, blaming the government alone for these increases is not entirely fair, as it is not the primary cause of energy price changes.

Debjit (2021) reports that elevated fuel prices in India have led to the smuggling of gasoline and diesel across porous land borders into neighboring countries. Although global crude oil prices have risen, pushing up pump rates, the taxes and duties on fuels in India are still very high, accounting for approximately 60% of the final consumer price. To deflect criticism, Prime Minister Narendra Modi and Oil Minister Dharmendra Pradhan have attributed the high costs to previous administrations and production cuts by certain oil-exporting countries.

According to Chakraborty (2021), high fuel prices and increasing infection rates have adversely affected gasoline demand in India, leading to a reduction in sales of this crucial transportation fuel. Data from the three largest retailers show a 2% decrease in gasoline sales last month compared to the previous period. The Indian economy has been negatively impacted by the pandemic and stringent regulations, resulting in record-high fuel prices and decreased sales as consumers became more cost-conscious. This economic pressure has led to job losses and salary reductions. Diesel, the most commonly used energy source in the country, saw an 8.6% drop in trade in February compared to the previous month. In contrast, the use of liquefied petroleum gas (LPG) for cooking has consistently increased, rising by 7.6% compared to the same month in 2020.

Bhanumurthy (2012) found that global oil price shocks have a significantly detrimental effect on

economic growth and other financial indicators. Although there may be a slight reduction in profit shortfall due to lower energy subsidies, the negative impacts would be more pronounced during the shock period if household energy policy shifted from "partial pass-through" to "full pass-through." The study suggests that, in the medium to long term, the adverse effects on growth could be mitigated if increased capital expenditure offsets the reduction in profit shortfall. In the absence of an oil price shock, it would be useful to explore the effects of moving from partial pass-through to full pass-through governance.

According to Aparna (2013), unforeseen fluctuations in oil prices can harm artificial growth, causing substantial increases in the Wholesale Price Index (WPI). Typically, changes in oil prices, rising WPI, and falling Index of Industrial Production (IIP) all have negative effects on the economy. Even brief shocks or disruptions can lead to lasting impacts on economic performance.

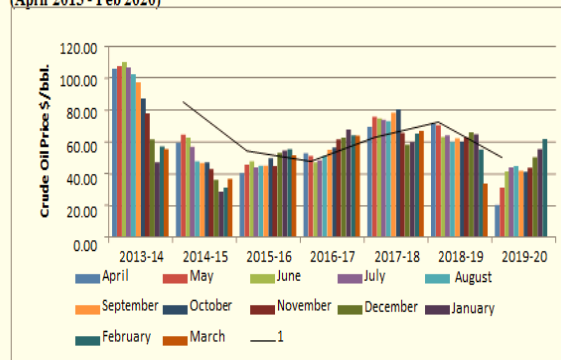
Sources for the Increase in the Price of Gas and Fuel

Here are several factors that contribute to the rising prices of fuel and gasohol in India:

Bear and force formula

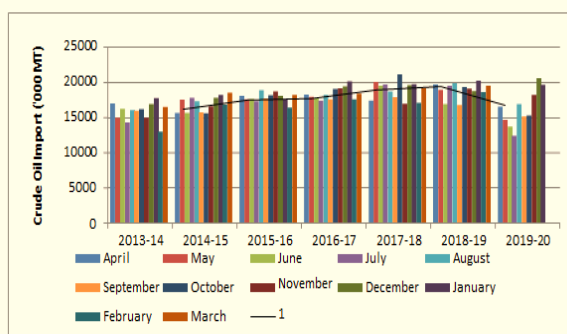
The mandate for crude oil is significantly influenced by economically development rates and specific consumption patterns. Over the past twenty years, the increasing oil demand from China and India has been a major factor driving the surge in oil prices. As a result, oil prices tend to fall when there are shifts in global demand patterns and signs of economic slowdown. Currently, Saudi Arabia, Russia, and the US together account for around 40 percent of worldwide oil manufacture, with the US and Russia alone producing around 35 million barrels per day. Since the US and Russia are not members of OPEC, the organization's contribution to global oil production is less than 33 percent. Historically, shale oil production in the US and Canada has been a significant driver of the market. However, when production costs increase, the supply-demand balance is disrupted, leading to a drop in oil prices.

Figure-1: Average Monthly Crude Oil Price Indian Basket (\$/bbl)
(April 2013 - Feb 2020)



Source: Petroleum Planning and Analysis Cell (PPAC)

Figure-1: Illustrates the average monthly cost of crude oil in India, measured in dollars per barrel, from April 2013 to February 2020. During this period, crude oil prices dropped significantly from \$105.56 per barrel in April 2013 to \$28.08 per barrel by January 2015. Prices then experienced a moderate increase, reaching a peak of \$80 per barrel in October 2017. However, the demand for gasoline saw a dramatic decline during the SARS-CoV-2 pandemic, with prices falling to \$19.90 per barrel in April 2019.



Source: Petroleum Planning and Analysis Cell (PPAC)

Figure 2: Presents India's annual crude oil consumption (in thousands of tonnes) from April 2013 to January 2020. Despite fluctuations in crude oil prices, India's consumption of gasoline has generally been on the rise since 2013, except during the SARS-CoV-2 lockdown period when global demand was significantly impacted. In India, the mandate for crude oil can be accredited to economic growing and increased private consumption. According to the study, India's fuel consumption is expected to remain relatively low, ranging from 2 to 3 percent, during the 2019-2020 period.

OPEC Plans

OPEC, a coalition of 15 nations, accounts for approximately 42.6%. The combination of OPEC's production cuts along with reductions from certain non-OPEC producers, totaling about 1.8 million barrels per day, contributed to less volatile oil prices and a gradual increase in 2018. Factors influencing oil prices in 2017 included OPEC's agreement to cut production, disruptions from the 400,000 barrels per day output in the North Sea, and a sharp decline in Venezuelan oil production.

Additionally, hurricanes led to the shutdown of 13% of refining capacity in the United States. Despite these measures, OPEC's influence on oil prices has been questioned. For instance, after the introduction of the manufacture share scheme in 1982, OPEC struggled to avert price declines during the 1980s. Similarly, in 2008, OPEC could not control the surge in oil prices to \$147 per barrel, nor could it stop the drop in prices in 2014. This raises doubts about whether OPEC ever had the capacity to effectively manage oil prices through production adjustments or if it was merely benefiting from high prices driven by geopolitical instability and internal conflicts among its members.

State-imposed prominent restrictions on fossil fuel products

Since the transition to daily energy price adjustments on June 16, 2018, the increase in fuel and gasohol prices has significantly affected consumers. Previously, prices were updated on the 1st and 16th of each month based on the average international price and exchange rate from the preceding day.

The gradual rise in petrol and diesel prices went largely unnoticed until they reached Rs. 100 in certain regions of India. Experts attribute the rising oil prices to recent high energy taxes imposed by the government rather than to differences between gasoline and diesel prices. Reports indicate that energy prices in India are now higher than in any other Southeast Asian country.

Table-1: Fuel and gasoline wholesale prices in Delhi, as of March 1, 2020, are listed in rupees per liter.

S.no	Components	Unit	Diesel (Rs.)	Fuel (Rs.)
1.	Price for C & F (Cost & Freight) (based on a moving average)	\$/bbl	90.32	98.54
2.	Payment to Trader (VAT and Excise Duty Not Included)	Rs/Ltr	35.22	33.54
3.	Mean Exchange rate	Rs/\$	73.31	73.31
4.	Add: VAT (involving VAT on Dealer Commission)	Rs/Ltr	11.94	21.04
5.	Add: Dealer Commission (Average)	Rs/Ltr	2.51	3.69
6.	Add: Customs Duty	Rs/Ltr	31.8	32.9
7.	Wholesale Selling Price at Delhi (Rounded)	Rs/Ltr	81.47	91.17

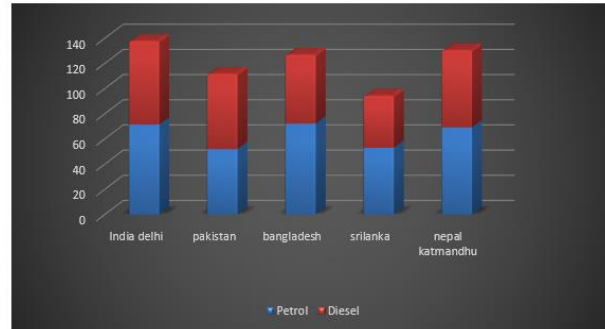


Figure-4: Highlights that as of March 1, 2020, India has the highest market prices for gasoline and fuel likened to its near nations, such as Pakistan and Sri Lanka. This indicates that India collects higher taxes on fuel and gasohol than these nearby nations.

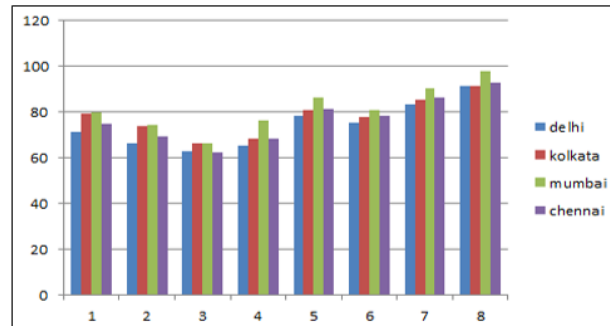


Figure- 5: India's Major Metropolises' Petrol Prices (Rs/Litre) (Jan 2013 to Mar 2020)

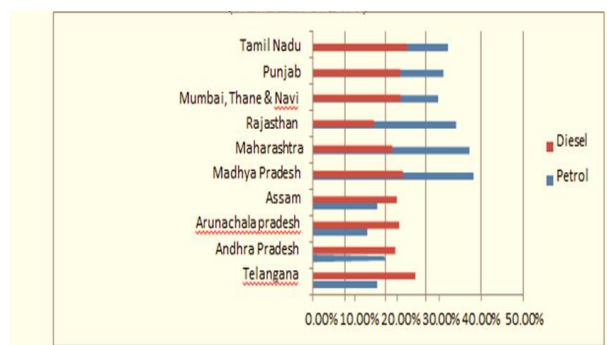


Figure-3: Shows that as of March 1, 2021, Arunachal Pradesh imposes the lowest sales tax/VAT on fuel at 14.50%, while Madhya Pradesh has the highest tax rate at 39% per liter. In contrast, Telangana applies a sales tax/VAT of 27% on gasoline, whereas Rajasthan imposes a lower tax rate of ₹18.82 per liter.

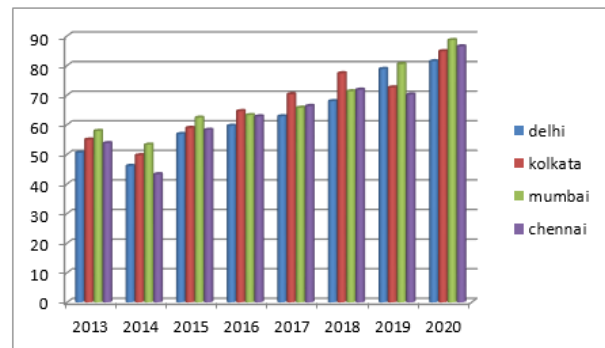


Figure-6: India's Major Metro Cities' Diesel Prices (Rs/Litre) (Jan 2013 to Mar 2020)

Figures 5 and 6 Reveal that from January 2013 to March 2020, the average market price of fuel and gasoline is the lowest in Delhi and the highest in Mumbai. This indicates that Maharashtra imposes higher taxes on gasoline and fuel compared to other regions.

Rupee vs. Dollar Exchange Rate

The US dollar serves as the primary currency for international fossil fuel transactions. Consequently, any increase in the dollar's value significantly affects energy prices in oil-importing countries. In recent years, the strengthening of the dollar against the rupee has led to higher diesel and gasoline prices in India. This rise in fuel costs is further exacerbating the pressure on the weakening Indian rupee.



Figure- 7: Shows the appreciation of the US dollar against the rupee, increasing from 62.33 in 2014 to 74.74 in 2020, and then slightly decreasing to 73.31. Given that the energy sector plays a substantial role in the US GDP, the global decline in fossil fuel prices benefits the US economy.

IV. IMPACT OF INCREASING FUEL PRICES

1. Increase the cost of construction

Increasing petroleum values cause a ripple outcome on trade costs crossways numerous subdivisions, leading to higher raw substantial prices. Consequently, this results in increased costs for the final buyer. This phenomenon is known as the cost-push factor. Since packaging materials are derived from fuel products, rising fuel prices significantly impact profit margins.

2. Elevated pace of intensification

When inflation is high, the RBI raises interest rates. This impacts individuals with existing credit and those seeking new loans. The negative effect of rising energy prices on inflation, which constitutes 2.4% of the total Consumer Price Index (CPI), depends on how much of the price increase is transferred to consumers. Stocks that are sensitive to

interest rates may perform poorly as both inflation and interest rates are expected to rise.

3. Weak GDP growth, a rise in the current account deficit, and fluctuations in tax revenues

For each \$10 per drum increase in oil prices, GDP could increase by 0.3 to 0.4 percentage points, while the present explanation shortfall may worsen by about \$10 billion. Rising oil prices lead to higher importations, which strains the global balance of payments, increases the deficit, and weakens the currency. Consequently, the rise in oil prices negatively affects fiscal policy and the Canadian dollar, significantly impacting monetary policy, consumption, and investment in the economy.

4. Effects on production

Increasing fuel costs directly affect industries that use petroleum as a feedstock, such as those producing wax, paint, tires, fertilizer, shoes, construction materials, and cement. The primary sectors impacted by rising fossil fuel prices include the aviation industry, lubricant production, paint manufacturing, rubber production, and plastic manufacturing.

5 Increase in transportation costs and essential goods

Record-high gasoline and gasohol prices are driving up transportation costs nationwide, leading to a surge in the prices of essential goods and food items. If fuel prices remain elevated for an extended period, household disposable income may decrease, necessitating a reallocation of resources.

V. CONCLUSION

The conclusion drawn from a factual analysis of the factors contributing to the increase in petrol and diesel prices in India is that taxes levied by both the federal and state governments, rather than fluctuations in the price of fossil fuel internationally, are the real source of these price hikes. 4,444 customers' savings have decreased as a result of rising fuel prices, and their discretionary expenditure has decreased. Fuel prices are also largely driven by supply-side variables, most notably OPEC's output cut programme. Federal and state taxes are

identified as the major contributors to rising fuel prices, overshadowing the effects of global oil price fluctuations. This underscores the substantial role of domestic fiscal policies in shaping fuel costs. The increase in fuel prices has led to a decrease in consumer savings and has reduced discretionary expenditure, affecting overall household budgets and spending patterns. Supply-side variables, particularly OPEC's production cut programs, also play a crucial role in driving fuel prices. These external factors compound the effects of domestic taxation. To mitigate the impact of rising fossil fuel imports, there is potential to offset this through increased oil and non-oil exports. This could help balance the trade deficit created by higher fuel costs. Using robust fuzzy regression methods, the study confirms that while international price fluctuations are a factor, the predominant influence on the surge in fuel prices is domestic taxation and regulatory policies. To alleviate the financial burden on consumers and manage fuel price volatility, policymakers might consider revising tax structures or exploring alternative measures to stabilize fuel prices.

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