Library Progress International
Vol.44 No.3, Jul-Dec 2024: P.20496-20508

Print version ISSN 0970 1052
Online version ISSN 2320 317X

Original Article

Available online at www.bpasjournals.com

Does Ethanol Blended Petroleum Program modulate Current Account Deficit in India

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How to cite this article: N. Kubendran (2024) Does Ethanol Blended Petroleum Program modulate Current Account Deficit in India. *Library Progress International,* 44(3), 20496-20508.

Abstract

This article provides a detailed theoretical and empirical justification for the effectiveness of the Ethanol Blended Petroleum (EBP) program in India in the context of reducing the burden of Current Account Deficit (CAD). The most important research issue is whether the increase in ethanol blending in petroleum reduces the burden of the current account deficit via decreasing oil import bills or not. In order to capture the effect of the EBP program in India, the study uses data on the percentage of ethanol blending in petroleum since the launch of the program, the Oil import bill and the current account deficit. For analysis, the study has applied the Augmented Dickey-Fuller Test, Granger Causality, Regression model and descriptive statistical methods. The descriptive statistical trend line analysis proved the success of the EBP program in India which is observed using the increasing percentage of ethanol blend in vehicular petroleum. As a result of the implementation of the EBP program, the study has observed a constant trend for oil imports and current account deficits even though there was a huge increase in per capita income and automobile sales during the study period. Granger causality test result observed bi-directional causality indicating that the EBP program has a significant impact on oil imports and the current account deficit in India. The regression results also validated Granger causality results by detecting that the EBP program had a significant impact on CAD in India. Finally, the study concludes that the effect of the Ethanol Blending Petroleum Program on the oil Import Bill is effective in curtailing the current account deficit in India. The E20 (Ethanol blending 20 per cent) initiative will have a significant impact on the current account deficit in India. Hence, the government of India must relax the legal issues relating to the production of ethanol from sugarcane and speed up the process of ethanol blending in petroleum products.

JEL Classification: L11, L71, F14, F32, Q4
Keywords: Ethanol, Sugarcane, Oil Imports, Current Account Deficit, EBP Program

Introduction and Background:

The government of India launched the Ethanol Blended Petroleum (EBP) program in 2003 to encourage the use of ethanol, an environmentally benign and renewable fuel, in gasoline. The program's objectives is to decrease fossil fuel imports and the burden of current account deficit (CAD), preserve foreign exchange, and boost value addition in the sugar sector. On June 4, 2018, the Indian government released the National Policy on Biofuels (NPB–2018), which included an indicative aim of a 20 percent ethanol blend in gasoline by 2030 under the EBP Program. For a developing country like India, achieving energy security and making the transition to a thriving low-carbon economy is crucial for long-term growth. India can improve its energy security, encourage farmers to engage in the energy economy, and lower vehicle emissions by blending locally generated ethanol with gasoline (Niti Aayog, 2021).

Being an oil-dependent nation, India has always amassed high bills on the imports of oil. The domestic supply and production for oil is incompetent to match the domestic demand, hence India is left with no other option than shelling out billions of dollars per day to import oil. It is estimated by the Government of India that the oil demand will triple in the next 20 years from 2025 to 2045. Current imports in 2024 rake up nearly 5 million barrels of oil per day.

Historically, India has been an agrarian society and still agriculture sector still contributes significantly to GDP, employment, export earnings and supporting allied industries too. Specifically, sugarcane production in India ranks second globally only to that of Brazil. Indian sugar production has been facilitated by suitable climatic conditions and ever-increasing demand for sugar and byproducts, In India, Sugarcane production employs millions of people in India, directly or indirectly. Sugarcane processing in India is mainly for domestic consumption. Sugarcane is majorly used by industries to make sugar and only a fraction of the production is used to make small-scale Khandsari sugar (unrefined sugar) and Jaggery. The leftover bagasse is used for energy generation, for the production of fiberboard, papers, plastics and furfural. Molasses is used in distilleries for the manufacture of ethyl alcohol, butyl alcohol, citric acid etc. Sugarcane's inclusion in the 'Essential Commodities Act (1955)' allows the government to provide essential tools and subsidies for the growth of the industry. It also allows the government to heavily regulate the market and in efficiency terms, it is a mar on the performance of the sector but can help alleviate bio-fuel issues, if a mandate is issued. In order to protect the domestic sugar industry,GOI increased the import duty on sugar to 100 percent in early 2017 and also waived off export duty. The government made it mandatory for Indian sugar industry millers to export a minimum of two million tonnes of sugar irrespective of prices existing in the global market to ensure competitiveness of India. Indian import bills and current account deficits have been longstanding macroeconomic issues faced by India. They discourage important investment of the government expenditure that could otherwise be employed in the alleviation of other socio-economic problems, to which India is no distant. The cause of concern because of the energy security directive is that the oil price is extremely volatile in the International market. Geopolitical tensions, ongoing bilateral conflicts, policies, embargos etc. Deeply influence the price of oil which can jolt the Indian economy through inflationary pressures. In the future, with the development of the manufacturing sector in India,there is going to be further increased oil demand. It is estimated that India will topple China in oil usage by 2040. With the non-renewable fossil fuels going to peak as per Hubbert's peak oil theory, the prices are going to be heading steadily, which will significantly hamper India's current account balance. There is conclusive evidence suggesting a relationship between Biofuel programs and Import bills in cases of countries such as the USA and Brazil which extrapolate their ethanol from corn and sugarcane respectively. The EBP program in India is still in its primitive stages and long way to go far considerable achievement. With the government targeting ethanol blends of about 20 percent by 2030, it is essential to gauge the pragmatism in this notion.

Literature Review

In recent decades, ethanol has been used as an alternative transport fuel and its blend in petroleum products is also increasing frequently in several countries. Especially after the oil crisis of the 1970s, economies are interested in ethanol blending because of economic as well as environmental considerations (Balat and Balat 2009). The main reason behind the ethanol usage/blending program is that it adds extra oxygen to petrol which helps in reducing of air pollution and harmful emissions in tailpipe exhaust. In comparison to methyl tertiary butyl ether, it is also thought to be less hazardous and more efficient in lowering emissions. Since 2003, More than 300 million tons of carbon dioxide have been removed from Brazil's emissions, which is the same as planting and caring for 2.1 billion trees for 20 years (Miryala and Satana 2016). An alternative trend in petroleum products is the usage of ethanol and the production is increasing over the years simultaneously exports are decreasing in Brazil. Goldemberg et. al. (1985) studied 'Ethanol Fuel: A use of biomass energy in Brazil and gauged the effects of the National Ethyl-Alcohol Policy (NAP) program on Brazil's import bills and sugarcane industry. It was observed that the nation was able to save USD 1.15 billion, and about 30 percent of its oil import bill because of the adoption of the NAP policy. The paper has established a detailed study by analyzing the costs involving setting up of treatment facilities, costs of production of sugarcane, etc. Hill et al. (2006) investigated the environmental, economic and energetic costs and benefits of biodiesel and ethanol biofuels in the United States. They focused on the economies of scope attached to agricultural produce involved in biofuels. The paper has adopted empirical observations and data to provide a basis for the agricultural produce. In theUnited States, corn and soybeans are the major contributors to ethanol. In 2005, 14.3 percent of the U.S. corn harvest was processed to produce 1.48 x 10^10 litres of ethanol,energetically equivalent to 1.72 percent of U.S. gasoline usage. As per the 2005 statistics, devoting entire US corn and soybean production to ethanol and biodiesel would have offset 12 percent and 6.0 percent of U.S.gasoline and diesel demand,

respectively. Biodiesel is also environmentally sustainable and it provides 93 percent more energy than conventional fossil fuels and reduces greenhouse emissions by 41 percent for a similar amount of usage. United States of America's Energy Independence and Security Act (2007) made it mandatory and regularized the 10 percent Ethanol Blend Policy (EBP) across the country. Gorter and Just (2009) take a look at this aspect of the US economy from diverse schools of economic thought. The ethanol blend in the US comes from a vast supply of corn produced domestically. The study emphasized the fallacy in policy implementation of taxation and mandate which is driving away from the undertaken goal of EBP. The usage of tax credits in conjunction with a directive of command induces tax credits to subsidize fuel consumption instead of biofuels. This refutes the goals of the Energy Act by creating a demand for more oil, consequently following no deviation in CO_2 emissions while providing minute assistance to either corn or ethanol producers.

When we move from the Brazil and US context to the Indian context, Ray., et, al (2012) investigated the ethanol blending policy in India and observed that the Indian Government's National Policy on Biofuels contends that the policy of mixing ethanol with gasoline is a good one, but many challenges make the strategy unworkable. Specifically, the two most important challenges are the pricing policy for ethanol and the scarcity of sugar cane needed to produce it.

The fermentation process is the primary method used in India to manufacture ethanol from molasses. Yeast enzymes convert simple carbohydrates to carbon dioxide and ethanol. In India, sugar mills provide almost 90 percent of the ethanol produced (GoI 2015). Another important byproduct of India's integrated sugar mills is ethanol. Since India gained its freedom, the area used for sugarcane has grown by over 2.5 to 3 times (Pohit et al. 2009). National policy, cheap costs, high efficiency, and simplicity of fermentation are the main reasons why the sugar business is being considered for ethanol production. 85–100 kg of sugar and 40 kg of molasses are produced from one tonne of sugarcane (Tsiropoulos et al. 2014). India possesses 0.5 percent of global oil reserves and accounts for 3.4 percent of global oil consumption. As an oil-dependent nation, India has been majorly jolted by oil supply shocks and volatility in the international crude oil market which may arise because of multiple reasons. With an ever-increasing oil demand in the world's fastest-growing economy and the biofuels program in place to surge energy safety, it is necessary to understand if India can meet its biofuel targets. Khanna, Madhu et al (2013) bridged this gap in their study by assessing the practicality of India's biofuel program and what implications it has in store for the fuel prices in the country. The major implication of the study is to speed up the process of ethanol blending in petroleum products.

Mambully Chandrasekharan Gopinathan and Rajasekaran Sudhakaran (2009) analysed the opportunities and challenges for biofuels in India. The paper has broken down its features into different characteristics necessary to understand biofuel programs in India. The study dialogues about the Ethanol Blended Petroleum (EBP) program, which is the foremost step in promoting biofuels in the country. India is an oil-dependent nation and its dependence on oil imports cannot be undermined. EBP aims to hold the import bill while trying to cater to the ever-increasing domestic demand for petroleum products and it also aims to provide a market for sugarcane allied industries in India which were earlier untapped.

De Gorter, Harry et al (2013) analysed the impact of the biofuel sector and efficient use of energy on the economy. The study observed that the energy security for oil-importing and dependent nations has a significant impact on the foreign exchange reserve and the current account balance. The study explores multiple factors that might affect biofuel trade in the international market via the methods of domestic market protectionism. The study suggested that the economic effects of a biofuel subsidy and increased biofuel production would help the rate of growth of the agricultural sector.

Gupta, Nikhil (2018) provides an insight into the impacts of rising oil prices on the Indian economy. India was hugely benefitted by the oil price slump from 2013 to 2018. The theoretical implications would suggest that the rising crude oil price had aggravated the twin deficits problem in India (fiscal and current account deficit). This would have caused spillover effects on the monetary policy, consumption and investment behaviour in the economy.

Reddy, et al (1992) in their review of the energy market scenario has linked the domestic energy needs of India and its effects on the current account deficit in India. The paper investigated the reasons for the worsening of the debt crunch in India during the 80s and '90s and found that poor policy adoption and implementation are the major concerns for the debt crunch. Especially, the study has addressed the concern of

how petroleum imports were one of the major drivers of debt in the 1980s.

The supply shock of 1973 was the first major oil-related disruption in the global economy. Oil-dependent developing countries were severely affected, however, India was not an exceptional case from a payments perspective observed in Kumarasundaram (1986). He compares the exports and imports of crude oil in India and also rakes them against the current account balance of the country. Khosla, K.R., (1990) correlated the Gulf Crisis to that of India's Balance of Payments situation by elucidating the need for energy security. The study has observed that prolonging the crisis in the Middle East would strain India's BOP and macroeconomic situation for the fiscal year 1991. Similar inferences have been drawn in the study by R. M. Hanovar (1974).

The study by Biswajit Dhar, et al (200) observed the growth in imports of petroleum and gold widened the current account deficit in India during the post-2000 period. The study also suggested that the free trade agreements and preferential trade deals have been poised to deteriorate the situation in India resulting consumption-driven economy causing the depletion of forex reserves. It is also observed that oil imports have been one of the major factors to be blamed for the worsening current account deficit and declining stock of forex reserves in India.

Madhurjya et al., (2024) observed ethanol blending program holds the potential to support India's transition into a multitrillion-dollar economy. Recently, the program has saved the country for about 40,000 crores in foreign exchange, reduced the burden on the current account and contributed to India's goal of achieving net zero carbon emissions. However, there are some challenges relating to the production of ethanol from sugarcane and the permitted percentage of blending that need to be addressed. M. M. Roy and Amaresh Chandra (2019) examined the promotion of biofuels, especially the ethanol blending initiative in India. The study has observed that a gradual shift from fossil fuels to renewable fuels is necessary in the perspective of growing energy demands of the road transportation sector and also addressing environmental concerns. The analysis of Roy and Amaresh on the ethanol blend initiative in the Indian context highlighted the present demand scenario, future projections, emerging trends, technologies, policies and institutional framework required for improved availability of ethanol for road the transport sector. It is realized that a dynamic policy that rationalizes the taxation framework and accommodates the agricultural shifts occupies significance.

The current ethanol production capacity in India of 426 crore litres derived from molasses-based distilleries and 258 crore litres from grain-based distilleries is proposed to be expanded to 760 crore litres and 740 crore litres respectively. This would be sufficient to produce 1016 crore litres of ethanol required for EBP and 334 crore litres for other uses. This will require 60 lakh MT of sugar and 165 lakh MT of grains per annum in ESY 2025 to be used for producing ethanol, which the country can support. The committees' generous demand estimates and consequent supply projections give us confidence that our suggested plan for the E20 roll-out is robust (Roadmap for Ethanol Blending in India 2020-25: Ministry of Petroleum and Natural Gas 2021).

Research Gap

Since 1991, there has been a substantial increase in the per capita income in India and the middle-income population has also amplified leading to severe growth in the demand for automobiles and petroleum products. Crude oil imports in 2023 were estimated at over **240 MT**, reflecting growing energy needs. India's refining capacity, now exceeding **250 MT**, allows it to meet both domestic demand and export refined products. However, with rising global oil prices, India's oil import bill remains a significant challenge. India's imports of petroleum products increased dramatically between 1991 and 2024 as its economy and energy requirements grew substantially. Despite efforts to increase domestic refining capacity, the nation's dependence on imported crude oil will still be above 85 percent in 2024. So, the prospect of swapping petroleum for ethanol sounds lucrative and might as well work in the context of a traditional fuel combustion engine. Moreover, ethanol blending in petroleum has a lower density than conventional fossil fuels. The overview of achieving energy security by such measures is a major concern considering that the ethanol required to be blended will pose a direct opportunity cost to the consumption of sugar and related products in India. The prospect of stabilizing the economy through reducing the oil import bill and the burden of the current account deficit is something that intrigues the directive behind this study. Moreover, there are no empirical studies that focus on the significance of the ethanol blended petroleum program and its impact on the Indian economy, especially from

2003 to 2022. Hence, the present study occupies a higher level of significance in social science research in India.

Significance and Research Issues

After the structural adjustment reforms in India in 91, there has been a substantial increase in the living standards of the people and their per capita income. Especially, the middle-income population has expanded from 10 percent in 1991 to nearly 50 percent in 2024. As a result of this, India became the largest two-wheeler market globally, with annual sales of more than 20 million units in 2024. Likewise, Passenger car sales in India reached a record high in 2023, surpassing 4.1 million units, marking the first time this milestone was achieved. This has led to severe growth in the automobile sector in India with multiple manufacturers making cars specifically designed to cater to the Indian market. The growth in the number of cars purchased also transliterates in the amount of fuel input required by those vehicles to continue their functioning.

In 1991, India imported about **30-40 million tonnes (MT)** of crude oil and petroleum products. By the end of the decade, imports had risen steadily and crude oil consumption had increased about 6-8 percent annually. Crude oil imports in 2023 were estimated at over **240 MT**, reflecting growing energy needs. India's refining capacity, now exceeding **250 MT**, allows it to meet both domestic demand and export refined products. However, with rising global oil prices, India's oil import bill remains a significant challenge. From 1991 to 2024, India's petroleum product imports have surged from $5 billion to $170 billion and energy needs expanded exponentially. While the country has worked to enhance domestic refining capacity, it remains heavily reliant on imported crude oil, with over 85 percent dependency in 2024.

The changes in international crude oil prices sway the Indian economy with a negative association. For a country like India, in which most of its import expenditure is directed towards Crude oil, there are hefty repercussions on the macroeconomic variables.The continuing demand for Crude oil and Natural Gas takes a toll on the burden of the current account deficit making the BOP situation worsen. To tackle this issue, the Ethanol Blended Petroleum Program is considered to be the best option to provide a market for the excess sugarcane produce sold in the international market at a cheaper price and boost India’s chances for energy security in the future. The Government of India has heavily invested in this program and believes that this would alleviate some of the demand for petroleum via blending. The support price mechanisms, policies adopted and overall stance advocated thoroughly sight at the aspirations and expectations of the government from EBP program. Several economists and policymakers in India have debated that the aspirations of the government aren’t practical in terms of achieving the necessary ethanol blend targets. So the present study attempted to analyse the EBP program in India and gauge the possibilities of its success and targets by focusing on the challenges for the program in the context of reducing the burden of Current Account Deficit in India.

In this context, the current study has raised several research questions and policy concerns. For instance; Can projected ethanol blending targets be achieved concerning sustainable current account deficit? Should government rather look at alternative vehicular options such as electric vehicles and alternative transportation sources, instead of compensatory expenditures to fuel traditional outsets? Does India possess the necessary infrastructure for the development of this program? With minimal expenditure given to research and development, how will India work with methods which deny import substitution of technology? With the current ordinance of employing electric vehicles going across the global stage and the Indian government’s aspiration to provide 30 percent of all vehicles on the road to be electric by 2030; is this program even necessary? The government at the current stance is looking at methods to import ethanol from ethanol-excess countries such as Brazil. How big of a difference would this make to the current account deficit? Would the deficit widen or slim?

Finding reputable and sensible answers to the aforementioned questions will be a scholarly and practical investigation. The relevance of the answer lies in providing appropriate evidence on the effect of the ethanol blended petroleum program on the current account deficit of India. So, the main aim of this study is to arrive at these policy conclusions. In this context, the major objective of the present study is to evaluate the purpose and effectiveness of the Ethanol Blended Petroleum Program in India. It is also observed from the research issues that there is significance to exploring the relationship between the Ethanol-Blended Petroleum program and the Current Account Deficit in India.

Methodology and Data Sources:

To analyse the relationship between ethanol blend in petroleum products and its impact on the oil bill import as well as current account deficit, this study first uses descriptive statistical methods like trend line analysis, pie chart and bar diagrams. The study also uses empirical analysis by employing Augmented Dickey-Fuller (ADF) test, Granger Causality test and regression equations.

To ensure the consistency of data the study first uses ADF test to check stationary conditions. The ADF test for each of the variables by using the following sequential testing procedure.

$$\Delta X_t = \alpha + \beta X_{t-1} + \sum_{i=1}^{p} \varphi_i \Delta X_{t-1} + \lambda t + u_t \quad (1)$$

If β=0, the data is not stationary and the chosen variable Xt includes a unit root. As a result, t must be included in the equation. In this analysis, only the research may apply the econometric approach for analysis if the trend is stationary and statistically significant.

The link between India's oil import bill, current account deficit, and ethanol mixed petroleum will then be determined using the Granger Causality test. The Granger Causality model's very sensitive directional correlations between two variables may be effectively utilized by including the right amount of delays in the model. If the beta coefficients become zero or less than the standard value of 0.05 and the computed F statistic is low for the first hypothesis in equation (1), it can be deduced from the computed statistical values, based on the provided equations, that the lag variable does not exist in the regression.

The Granger causality test is used to check the effectiveness of the ethanol blended petroleum program in India in the context of reducing the burden on the current account deficit. To check the causality between the changes in EBP with CAD, the following model developed by Engel and Granger, (1987) will be used. The models are;

(a) **Money Supply and Gross Domestic Product (GDP) in India**

$$EBP_t = \beta_0 + \sum_{i=1}^{n} \beta_{1i} EBP_{t-i} + \sum_{i=1}^{n} \beta_{2i} CAD_{t-i} + u_{1t}$$

$$CAD_t = \beta_3 + \sum_{i=1}^{n} \beta_{4i} CAD_{t-i} + \sum_{i=1}^{n} \beta_{5i} \mathrm{EBP} + u_{2t} \quad (2)$$

(b) Money Supply and Current Account Deficit in India

$$OIB_t = \beta_0 + \sum_{i=1}^{n} \beta_{1i} OIB_{t-i} + \sum_{i=1}^{n} \beta_{2i} CAD_{t-i} + u_{1t}$$

$$CAD_t = \beta_3 + \sum_{i=1}^{n} \beta_{4i} CAD_{t-i} + \sum_{i=1}^{n} \beta_{5i} OIB_{t-i} + u_{2t} \quad (3)$$

(c) Money Supply and Capital Outflows from India

$$OIB_t = \beta_0 + \sum_{i=1}^{n} \beta_{1i} OIB_{t-i} + \sum_{i=1}^{n} \beta_{2i} EBP_{t-i} + u_{1t}$$

$$EBP_t = \beta_3 + \sum_{i=1}^{n} \beta_{4i} EBP + \sum_{i=1}^{n} \beta_{5i} OIB_{t-i} + u_{2t} \quad (4)$$

Where, EBP = Ethanol Blended Petroleum Program, CAD = Current Account Deficit, OIB = Oil Import Bill.

Finally, the study will use Regression results using the Least-Squared method. The regression equation of the

model is given below;

$$CAD = \beta_0 + \beta_1 \text{EBP} + \beta_2 \text{OIB} + \mu \quad (5)$$

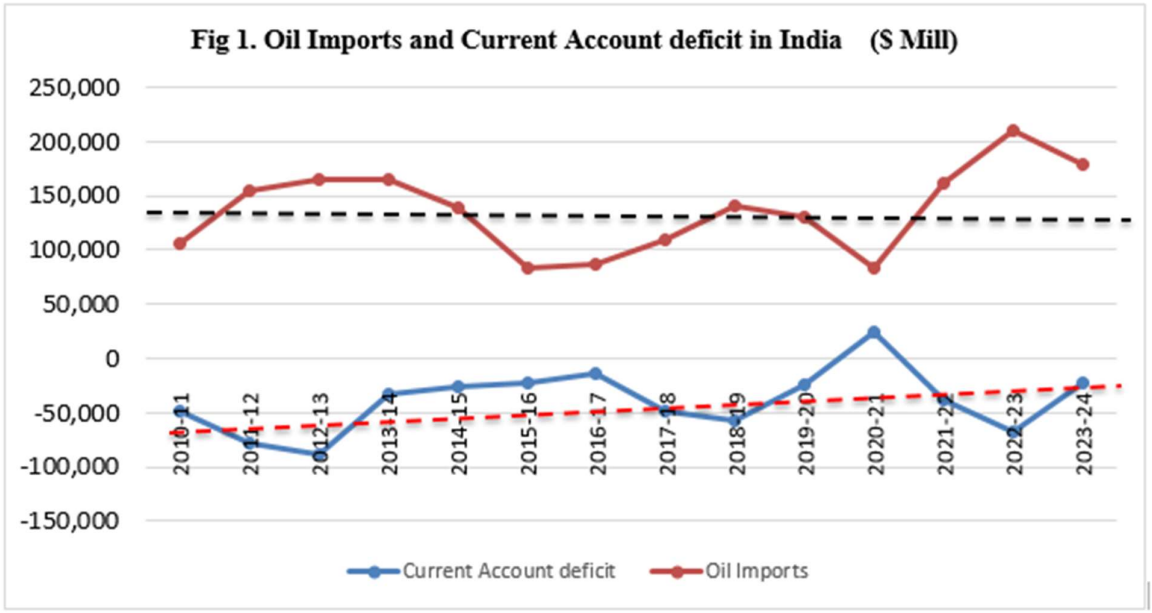
CAD is the dependent variable, Ethanol blended petroleum and oil import bill are the explanatory variables or the independent variables in the model. The lags and leads are used to nullify correlation and also make the stochastic error term independent of the repressors in the model.

The present study uses secondary data collected from the handbook of statistics on the Indian economy and the Ministry of Petroleum and Natural Gas of India. The data figures were further verified from various government reports of the respective years for the EBP, GDP, OIB and Current Account Deficit. The EBP program was launched in 2003 and the data between 2003 and 2011 has been assumed to be Zero because of the lack of a national blending process took place in the pre-2009 period. In 2006, the Ministry of Petroleum and Natural Gas directed the Public Sector Oil producing companies to sell 5 percent EBP in 20 states and 4 UTs on a pilot basis. Until 2009, the blending process took place very meagerly, thereafter the percentage of blending in petroleum products has been increased. So, for descriptive statistical analysis, the study uses 14 years of data from 2010 to 2023 and for empirical analysis, the study uses two decades of data from 2003 to 2022, by considering proxy data until 2009.

An Analysis on the effect of EBP program on CAD in India

Even though there are several positive impacts of ethanol blending in petroleum programs, the specific purpose is to reduce oil import bills and it may reduce the burden of current account deficit. Since oil imports play a crucial role in India's import bill, this study tries to test whether the EBP program helps to reduce the burden of CAD or not. The EBP program was one of the most important policies of the government that not only reduced oil imports but also gave impetus to Indian agriculture via the prospects of ramping up production of bio-ethanol from the sugarcane. In this context, the present study evaluates the impact of ethanol blending in petroleum products in India.

Fig 1 clearly pointed out the relationship between oil imports and the current account deficit in India from 2010-11 to 2023-24. The trend line analysis undoubtedly indicates a direct relationship between the two variables. Almost all the periods, when oil imports trigger the current account deficit to widen, similarly when oil imports decrease causing improvement in the current account balance. So oil imports play a crucial role in determining the current account deficit in India.

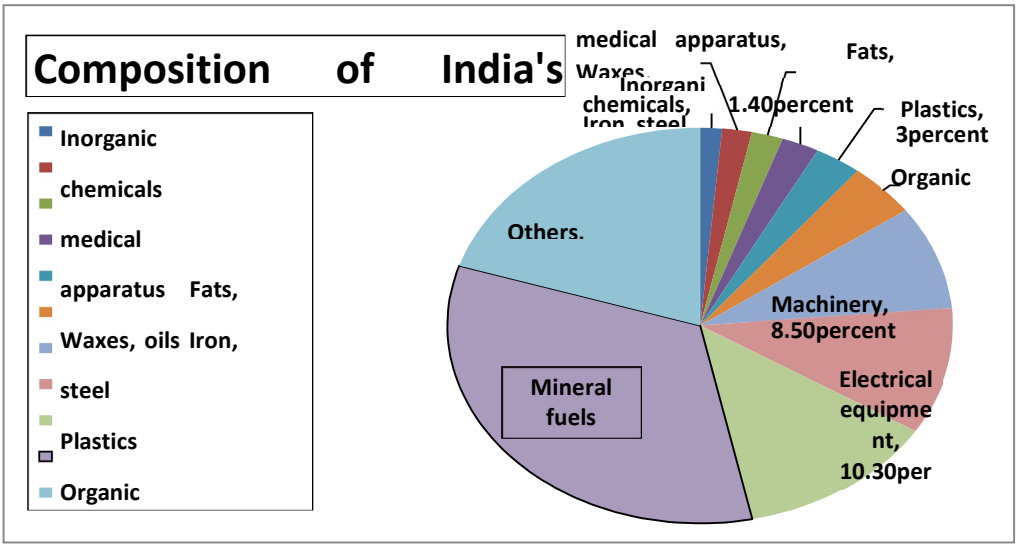


(Source: Computed)

The Indian Current Account Balance is also viewed to analyze the nation's competitiveness and the external sector's performance with the rest of the world.

Fig. 2 explains the composition of the Indian Imports during 2020. The top 10 categories are highlighted with their specific contributions to the Indian Import Bill for the year 2020. This gives an understanding of the importance of Crude Oil Imports on the Indian Import Bill. Since Crude Oil Imports are the highest among all import items, policymakers must restrict the Oil Import bill or make reforms in the refinery sector. Restricting the import of petroleum products will adversely affect the economy and may pose several challenges in the economy. Hence, the viable option to face such kind of challenge is to make reforms in the refinery industries and ethanol blending in petroleum products is considered to be the best option that produces dual benefits to the nation. One is reducing the oil imports and the other is supporting sugarcane production (considered to a cash crop) in India.

Fig. 2: Composition of India's Imports - 2020

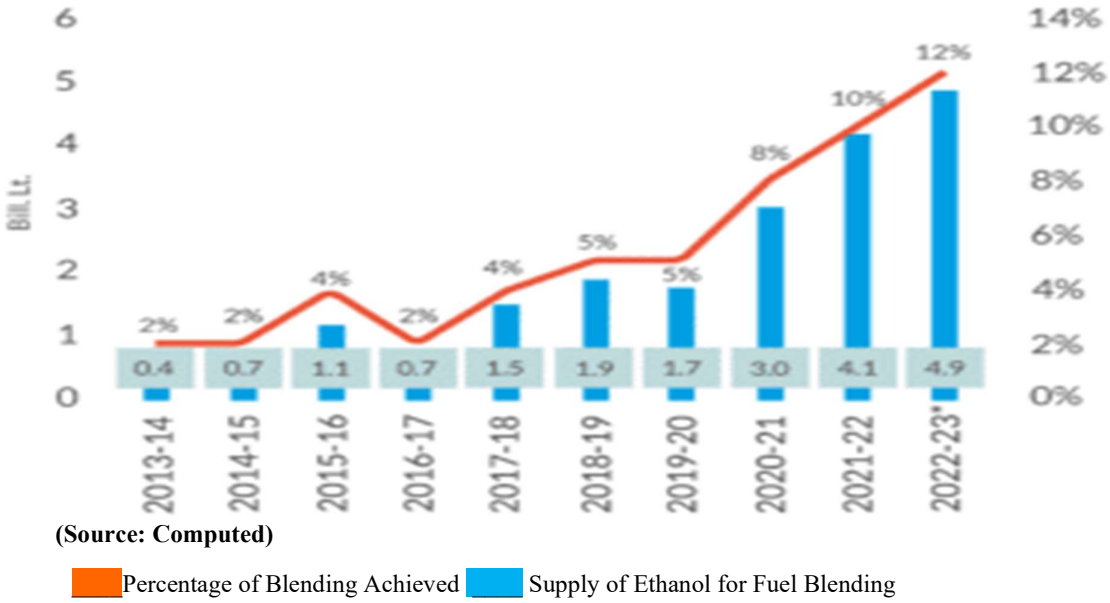


(Source: Computed)

The introduction of the Ethanol Blended Petroleum Program in India happened in the year2003. The targets mapped during the initial sketch were far stretched and beyond the reach of the Indian agriculture and oil manufacturing industry. The success of the EBP program is to be gauged with the percentage of blend used in vehicular petroleum. The lack of support mechanisms and demarcation regarding the sale of cane-produced ethanol had hindered the growth of Ethanol blending in the country. The growth rate of ethanol blending in petroleum in India is depicted in Fig. 3.

Fig. 3: Ethanol Blending Percentage Growth in India

(Source: Computed)



(Source: Computed)

The timeline for the data set is explanatory for the progress of the EBP program in India. Introduction for the EBP in India was in 2003 when 4 states were advised to have a blending rate of 5 percent in their vehicular fuel like a pilot study. In 2010, support measures were introduced by the government with a fixed rate attributed to cane-produced ethanol and a subsidy of 40 percent on the setup of the ethanol-producing factories. Fig. 3 precisely signifies the rise in Ethanol Blending since the legislation and seems on course to meet the revised target of a 10 percent blending rate in 2022 but the EBP program successfully crosses 14 percent of blending in 2024.

Despite the growth shown by India's ethanol industry in recent years, domestic consumption surpassed domestic production for the ninth consecutive year in 2023. The applications for industrial ethanol in India are diverse, but most of the consumption is for biofuels and extra-neutral alcohol. India is producing 13.80 billion litres of ethanol industrially, of which, 8.75 billion litres comes from molasses and 5.05 billion litres comes from grain feed stocks. India achieved a blending record of nearly 14 percent in 2024, in its pursuit of a 20 percent blending target by the end of 2025.

Empirical Results:

To check for the implications from the selected variables, the study first takes into consideration the aspect of stationarity of variables. The Augmented Dickey-Fuller (ADF) statistic is used to test the stationarity of the variables, before running the econometric model.

Table 1: Augmented Dickey-Fuller Test: Unit Root Test

	At level		At 1st Difference		At 2nd Difference	
Variables	**t-value**	**p-value**	**t-value**	**p-value**	**t-value**	**p-value**
CAD	-1.73868	0.3956	-3.63648	0.0172	Not Required	
OIB	-2.23984	0.2011	-3.65087	0.0168		
EBP	1.16228	0.9961	-1.20411	0.6453	-2.99337	0.064

(Source: Computed)

The results documented in Table 1 suggested the p-values for the variables at level, 1st Difference and 2nd Difference. The p-values for all the variables are greater than that of 0.05, leading to the rejection of the hypothesis. The data is Non-stationary at a level. Taking the first difference, the p-value is less than 0.05 for CAD and OIB, which makes their datasets stationary. Since, at 1st Difference, there is non-stationarity for EBP, we take into consideration the 2nd difference, at which the data set is stationary for EBP. The stationarity of data is a necessary condition in order to perform further analysis.

The Granger Causality test is performed to determine whether a one-time series is useful in forecasting another. The test accounts for an empirical data set to find patterns of correlation between the variables and see if a particular variable comes before another in the time series. The Granger Causality test results are depicted in Table 2.

Table 2 Pairwise Granger Causality Tests				
Sample: 2003-2022	**Lags: 2** **Obs: 18**			
Null Hypothesis:		**F- Statistic**	**Prob.**	**Result**
EBP does not Granger Cause CAD		7.32561	0.0095	**Bi-Directional Causality**
CAD does not Granger Cause EBP		3.45474	0.0685	
OIB does not Granger Cause CAD		3.86422	0.0536	**Unidirectional Causality**
CAD does not Granger Cause OIB		2.01469	0.1797	
OIB does not Granger Cause EBP		7.42715	0.0015	**Bi-Directional Causality**
EBP does not Granger Cause OIB		3.38531	0.0371	

(Source: Computed)

The Granger Causality test results for the selected variables are given in Table 2. It is observed from the test results that the p-value for the given hypothesis is less than 0.05 for the cases EBP does not Granger Cause CAD, CAD does not Granger Cause EBP, OIB does not Granger Cause CAD, OIB does not Granger Cause EBP, and EBP does not Granger Cause OIB. In all these cases, the interesting observation is that there is a rejection of the null hypothesis. The lack of causation between the variables begs the question if there is an effect at all between the selected variable in our model, i.e.., CAD does not Granger Cause OIB.

For equations 2 and 4, the study has observed bi-directional causality indicating the rejection of the null hypothesis, meaning the EBP program does cause OIB and CAD. Similarly, OIB and CAD do cause EBP programs in India. From this result, the study can infer that the EBP program has a significant impact on oil imports and the current account deficit in India. The study can conclude Granger Causality results by inferring that the CAD depends on OIB and OIB is also related to the EBP program. Hence, The E20 (Ethanol blending 20 per cent) initiative will have a significant impact on the current account deficit in India.

When we move on to Regression analysis using the least-squared method, the study has analysed the impact of independent variables on the dependent variable and the results are given in Table 3.

Table 3: Regression results using Least-Squared method				
Dependent Variable: CAD		**Method: Least Squares**		
Sample: 2003-2022		**No of observations: 18**		
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	11.68932	17.58043	0.664905	0.0516
EBP	-1.47345	2.829145	-0.52081	0.0610
OIB	0.66929	0.282495	2.36922	0.0317

(Source: Computed)

The regression results from Table 3 also confirmed that the EBP program will have a significant impact on CAD in India. The coefficient value for both the variables called EBP and OIB is significant which can be observed from the p-value which is less than 0.05. It indicates that the EBP and OIB have significance in the explanation of the dependent variable called CAD. Likewise, the coefficient of EBP is negative and OIB is positive indicating when EBP rises CAD decreases and when OIB rises CAD also rises.

Conclusions

The study examined the effectiveness of the Ethanol Blending in Petroleum (EBP) program and its impact on oil imports as well as the current account deficit in India. The study has applied both descriptive statistics and empirical analysis and observed interesting results.

From the trend line analysis, the study has observed a direct correlation between oil imports and the current account deficit in India. During the entire study period, whenever the oil imports increased there was a widening current account deficit, similarly, a decrease in the oil import bill improves the current account position indicates the oil import bill plays a significant role in determining the current account balance in India. From this result, it is clear that there is a necessity to curb oil import bills without creating a negative impact on the nation's GDP. Hence implementing an EBP program is one of the most important policies for a sustainable current account deficit.

For this reason, the government of India implemented an EBP program in 2003 on an experimental basis to evaluate what extent ethanol blends in Petrol help in the reduction of pollution levels of SI engine exhaust emissions. Ethanol blends E5, E10, E15, E20, and E22 (E5 = 5 percentage of blending) were tested and found considerable reductions in the pollutant levels of hydrocarbons and carbon monoxide and these inferences are consistent with that of Rao (2017). From 2013, there was a rapid increase in the blending rate and it crosses 14 percent of blending in 2024 (Fig 3). Considering the growth shown by India’s ethanol industry in recent years, domestic consumption surpassed domestic production for the ninth consecutive year in 2023. Even though, the precise movement of the EBP with OIB and CAD in an ordered method was not discovered by the trend line analysis. Simultaneously, the rise in ethanol blending since its inception targeted 5 percent, later increased target of 10 percent blending rate in 2022 and 14 percent of blending in 2024 evidenced that the EBP program has a major effect on foreign oil imports. The descriptive statistical trend line analysis on the effects of the EBP program is not fully apparent because of India's growing oil consumption, which is linked with increased per capita income and automobile sales throughout the research period. Due to this, the study has observed that the EBP program generates a constant trend for oil imports and current account deficits during the study period.

Granger causality test result observed bi-directional causality indicating the rejection of the null hypothesis and stating that the EBP program does cause OIB and CAD. Similarly, OIB and CAD do cause EBP programs in India. From this result, the study can infer that the EBP program has a significant impact on oil imports and the current account deficit in India. So the study concludes Granger Causality results by inferring that the CAD depends on OIB and OIB is also related to the EBP program. Hence, The E20 (Ethanol blending 20 per cent) initiative will have a significant impact on the current account deficit in India. The regression results from Table 3 also validate Granger causality results by detecting that the EBP program will have a significant impact on CAD in India. The coefficient value for both the variables called EBP and OIB has observed a p-value which is less than 0.05 indicating that the EBP and OIB have significant impact on CAD. Likewise, the coefficient of

EBP is negative and OIB is positive indicating when EBP rises CAD decreases and when OIB rises CAD also rises.

Finally, the study concludes that the effect of the Ethanol Blending Petroleum Program on the oil Import Bill is effective in curtailing the current account deficit in India. Theoretically, it is well understood that the current account deficit is determined by multiple variables in the external sector, but the oil import bill of the country is one of the crucial factors that regulated the current account deficit in India in the past 18 years. However, the trend line analysis did not find the exact movement of the EBP with OIB and CAD in an orderly fashion. It is observed that the EBP program has a significant impact on the oil import from abroad but it is not clearly exposed due to rising oil demand associated with increasing per capita income and automobile sales in India during the study period.

The most important challenge of further expanding the EBP program is that the oil marketing companies are mainly down to the slow implementation set-up of the sugarcane-ethanol-producing factories in India. The problem is more legislative in nature because the directive for ethanol production and blending in India did not come with a well-defined market for the producers to trust effective demand for producing ethanol.

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