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Determinants of India's petroleum exports: Extended gravity model estimation

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Abstract
Petroleum products have become India's topmost export item comprising more than 10 percent share in total export earnings after 2000. Being contrary to the Hecksher-Ohlin perspective of international trade, this phenomenon demands analysis of its important determinants. That's why present study explores determinants of India's petroleum exports using an extended gravity model approach. Fixed and Random effect panel data regression has been used to estimate the model. The findings of the study report that India has become one of the world's top 20 petroleum exporters with an average market share of 2.01% for the period 2002-2019. Over a while, the growth rate of India's petroleum exports is higher than the world's petroleum exports between 2002-2019. Favourable domestic policy and increasing demand are the major derivers of multiple increase in India's refined petroleum exports.

Keywords: Determinants, fixed and random effects, gravity, india, petroleum exports

Introduction

Indian economy has experienced impressive growth during post trade liberalisation period and moved away from Hindu Rate of growth (Nayar, 2006) [17]. Being significant portion of total trade, oil trade has increased exponentially both in volume and value terms (MOPNG, 2017). In the 1990s, the share of POL imports in total imports has fluctuated between 25 percent and 30 percent (World Bank, 2019). The proportion of POL imports to total imports has been steadily increasing over the last decade. POL accounted for 33 percent of our total import expenditure in 2007-08, i.e. one-third of our total import expenditure. In 2011-12, India's petroleum imports accounted for 32.92 percent of total imports, while in 2018-19, they accounted for 24.9 percent. This was also attributed to a rise in the price of crude oil around the world. Given these estimates, a significant portion of India's GDP is spent on the purchase of oil.

On the other side, India's export sector has also registered outstanding growth since 1991 and have undergone paradigm changes in its structure (Singh, 2014). Most interestingly, the refined petroleum products have been emerged as India's topmost export item especially after 2000 (Kumari, 2022). In 1980, POL (Petroleum, oil & lubricants) exports made up 0.37 percent of India's total exports. This was mostly due to India's emphasis on primary product exports rather than oil exports. This ratio peaked at 4.1 percent in 2000-01 (WDI, 2020). Since 2001-02, there has been an impressive increase in petroleum exports. The proportion of POL exports to total exports was as high as 14.8 percent in 2006-07 and further to 15.6 percent in 2007-08 (World Bank, 2019). India's petroleum exports were 19.41 percent of total exports in 2011-12 but fell to 11.6 percent in 2017-18 (MOPNG, 2017). POL exports are currently ranked second in terms of export earnings, behind engineering products (Chakrabarty & Chakrabarty, 2012) [9]. Unequivocally, the increase in the proportion of petroleum products in total exports reflected not only higher POL prices, but also increased capability (The Economic Survey, 2007-08). India's production of petroleum products has also steadily increased (Export-Import Bank of India, 2018) [12]. India has facilitated this by exporting refined petroleum products. India is now Asia's largest exporter of petroleum products and the world's seventh-largest exporter of refined petroleum products (BP Statistical Review of World Energy, June 2019).

Presently, India's is also the largest importer of crude oil products as well as it has become one of major refined petroleum exporting nation. The production of these products requires the availability of crude oil as raw material, high technology, and huge capital outlays which are scare in Indian case. Given the lack of all these three inputs, the exponential growth of petroleum exports from India is surprising and thus contrary to tradition international trade theories especially Hecksher-Ohlin version. However, this can be justified in the context of Belassa (1977) observations that reductions in existing trade barriers, as well as the avoidance of new barriers in the latter, would significantly aid the expansion of exports by developing countries to developed countries. given this context, it is becomes pertinent to examine the determinates of refined petroleum export growth in India and the present study is an attempt in this regard.

This paper is structured into four broad sections. Section I presents introduction with the problem and section II deals with methodology and data used in the analysis. Section III presents results and discussion in the context of model estimations and finally the section IV outlines major conclusions and policy suggestions.

Methodology And Data

For exploring determinants of India's petroleum exports growth, extended gravity model has been utilised and it has been estimated with the help of random and fixed effects panel regression. The Dutch economist Timbergen has first applied the gravity model to study the volume of trade between countries in 1962 [21]. According to this model, the amount of trade exchange between two countries is proportional to their GDP and inversely proportional to their distance. The generalized gravity model equation is specified as follows:

$$X_{!"\#} = A \ \frac{\$_{\%}{}^{!"}!}{\$"^{\$"}} \quad \ldots\ldots\ldots\ldots \ (1)$$

Where, $T_{\&,}$ = the total trade flow from host country i to destination country j; $Y_{\&}Y_{,}$ =the economic size of two countries i and j.$Y_{\&}$, $Y_{,}$ are usually gross domestic product (GDP) or Gross national product (GNP); $D_{\&,}$= the distance between country i and j; A is a constant term.

Finally, an extended gravity model can be specified by taking the natural log on both sides of equation (1) and augmenting it with other variables as follows

$$LXit = b_0 + b_1LX_{it-1} + b_2LGDP_{it} + b_3LGDP_{jt} + b_4LWDS_{ijt} + b_5\ LRER_{ijt} + b_6\ LOPN_{it} + b_7\ LOPN_{jt} + b_8\ LPOP_{it} + b_9\ LPOP_{jt} + b_{10}LFDIit + b_{11}\ LIQI_{it} + aa_i + U_{it} \ldots\ldots (2)$$

Equation (2) depicts a panel data model comprising important determinants of outcome variable (LX_{it}) along with its lagged value as one covariate on the right-hand side of the equation. Use of fixed and random effect panel model is justified given exports to every partner are independent of each other and have different intercept term. Further, for determining suitability of fixed or random effect models, Houseman test been used.

Variable Description and Expected Sign

X_{ijt} refers to an annual volume of petroleum goods export of India to its major trade partners which is measured in barrels, while X_{ijt-1} stands for one period lagged volume of petroleum goods exports to each country. In addition, Egger (2002) [11] recommended using the first lag of the outcome variables as a covariate rather than searching for some optimal lag length. RER_{ij} refers to the real exchange rate, and the coefficient of this variable is expected to be positive, while the coefficient of foreign direct investment of India, FDI_i is expected to be positive.

The variables GDP_{it} and GDP_{jt} of India and its major trade partners, respectively, and trade theory predicts they have a positive effect on the volume of trade flows (Negussie & Desalegn, 2014) [18]. The sign of the coefficients of population size of exporting country POP_{it} and the population size of partner county POP_{jt} depend on the relative strength of the absorption effect and economies of scale of a large population (Gebreyesus & Bahre, 2015; Wondesen & Fekadu, 2019) [13, 22]. The coefficient of the weighted distance between exporting country and partner country (WDS_{ijt}) is expected to be negative (Karagoz & Saray,2008) [15]. The coefficients of trade openness of India (OPN_{it}) and trade openness of partner country (OPN_{jt}) are expected to be positive in the above model. Finally, the institutional quality index of India is expected to affect the trade flows of India and its partner countries positively (Alekaw,2016; Wondesen & Fekadu, 2019) [1, 22].

Data Sources and Variables

Secondary data was derived from a variety of sources in order to meet the aim of the study. We have taken the period from 1990-1991 to 2018-19, which is thirty years. The data was collected in US dollars for oil exports, and GDP at constant prices. The World Development Indicator (WDI) provided the GDP, export volume to each country, total population, and exchange rate. In addition, data on total export and import values were collected from the World Bank national accounts data, and OECD National Accounts data files. In addition, the World Development Indicator (WDI) provided data on the consumer price index, foreign direct investment, and openness. Finally, the Worldwide Governance Index (WGI) and an online distance calculator were used to acquire statistics on the Institutional Quality Index and the distance between India and its key trade partners, respectively. Depending on data availability, a total of 40 main trade partners of India from Asia, Europe, America, Africa, and Oceania were included in this study. Similarly, almost 80% of India's total petroleum exports is constituted by the selected 40 partners.

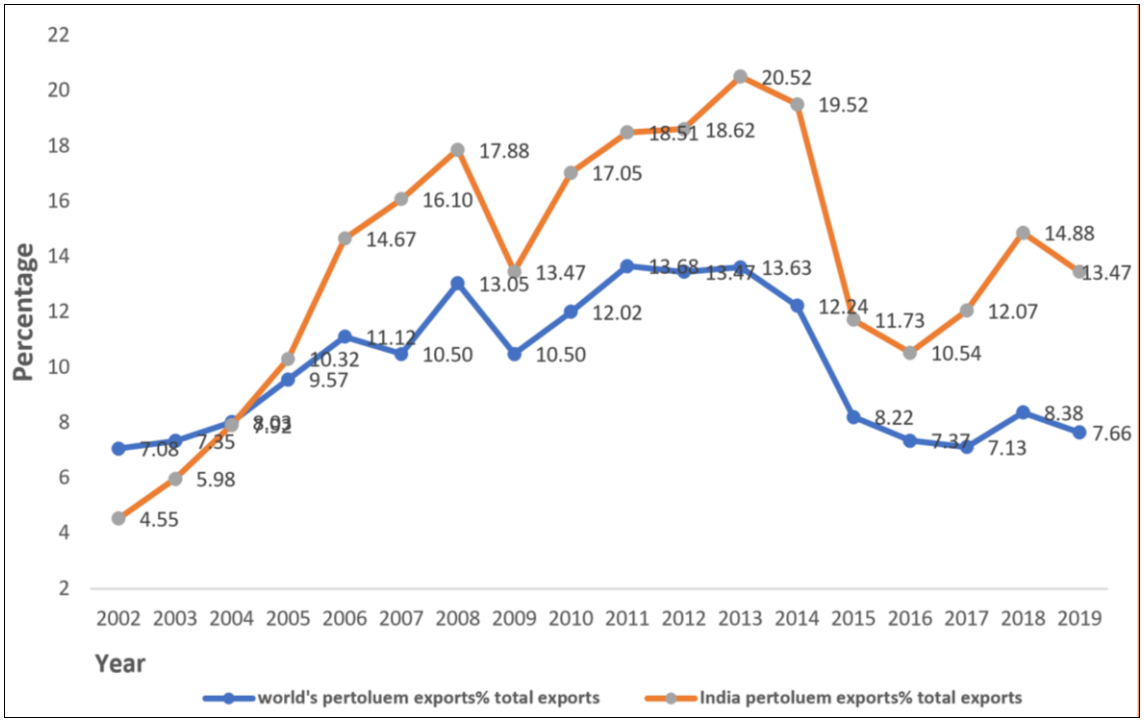
The data of the selected variables for India and different partners countries have been obtained from Comtrade-WITS (World Integrated Trade Solution) Database; Central Statistical Organization, Govt. of India, WDI, WGI, and the Reserve Bank of India (RBI).

From the above-mentioned sources as we also collected the WPI data. In this regard, as we have considered only oil exports and oil imports, we considered the price index for fuel; power light & lubricants (FPL & L) This is because both the oil exports and oil imports data were given in current prices and we had to transform the given data to constant prices. By taking the relatively recent period of 1993/94 as the base year, the link relatives were determined for the entire range of study. Thereafter, the natural log values of the given time since were considered. The natural log values of oil imports are denoted by 'LM', oil exports by 'LX', and that of GDP by 'LG'.

Results And Discussion

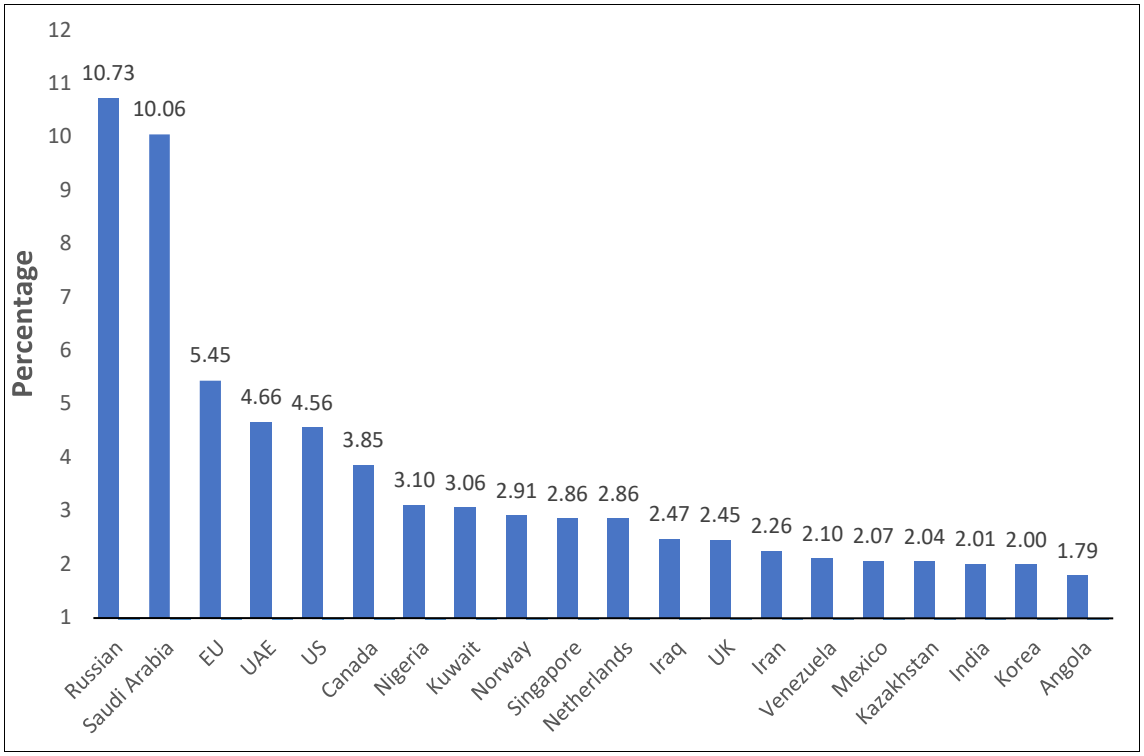
Results of Descriptive Data Analysis

In Figure 1, the changing contribution of the petroleum exports in total exports is indicated from 2002 to 2019. The share of Indian petroleum exports is rising continuously than the world's share of petroleum exports. The growing percentage share of India's petroleum exports from single-digit to double-digit indicates that its contribution has increased substantially between 2002-2019. The share has increased from 7.08% to 13.47% from 2002 to 2019 respectively. Over time the percentage share of India's petroleum exports is higher than the world's share with periodical fluctuations, which results in greater benefit with surprising gainful phenomena.



Source: Authors' computations

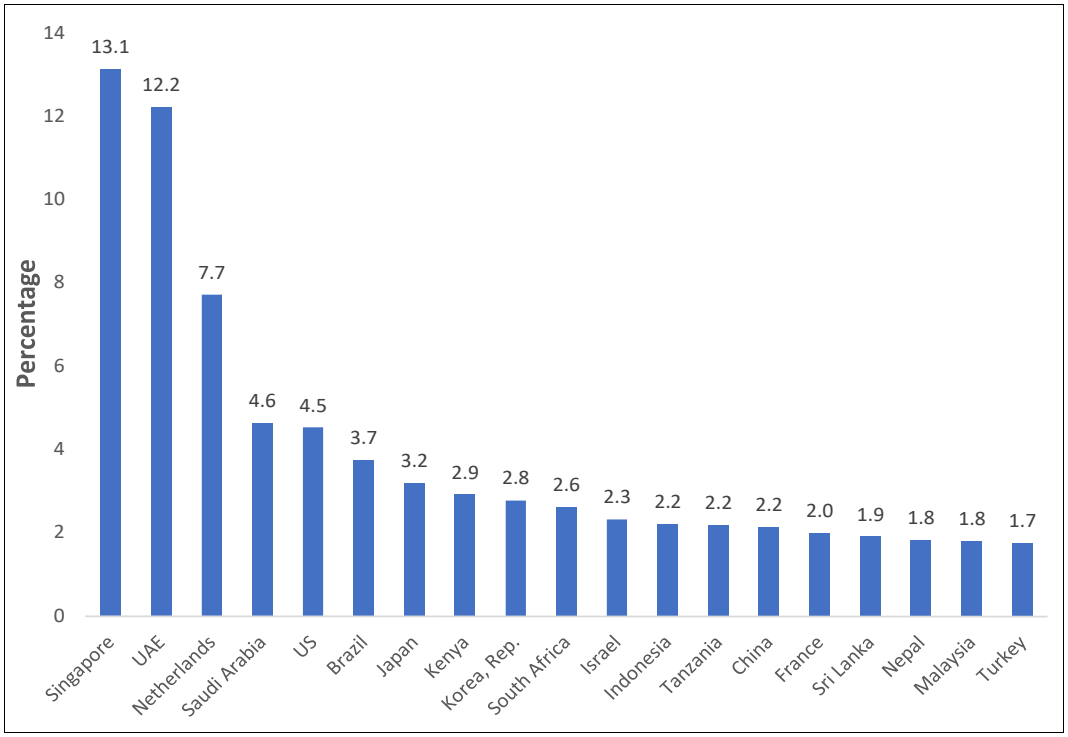
Fig 1: Percentage Share of Petroleum Exports in Total Exports: India and World (2002-2019)



Source: Author's computations

Fig 2: World's Top 20 Petroleum Exporters (Average Market Share 2002-19 in %)

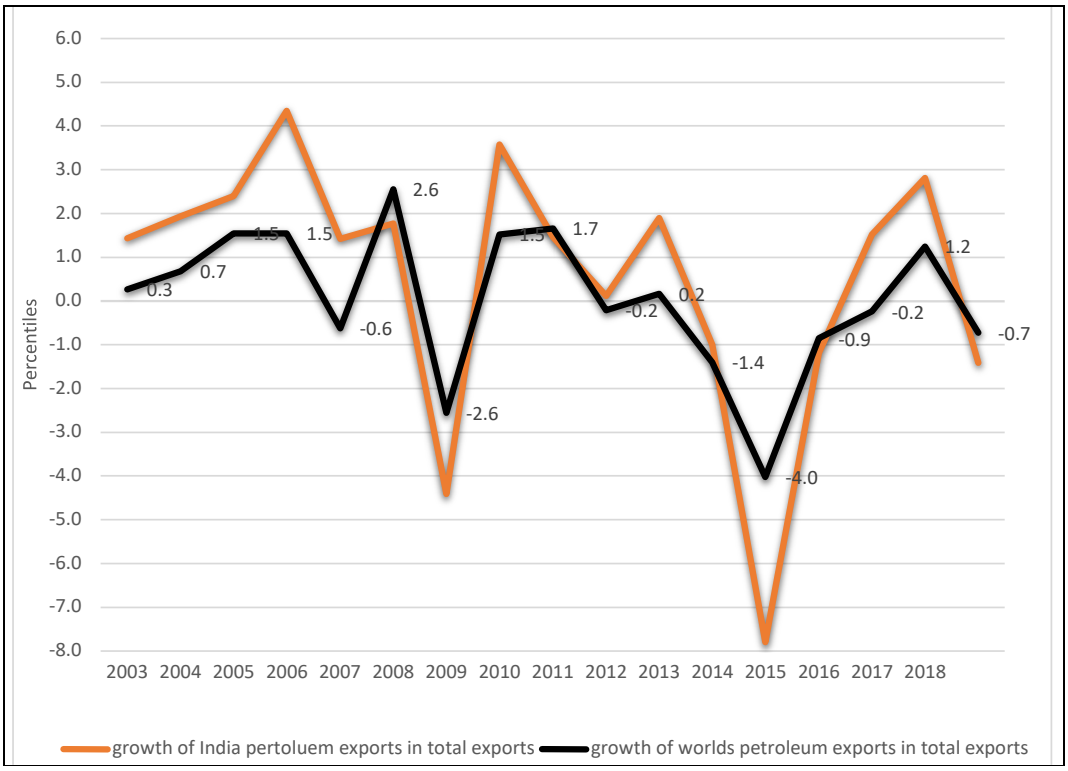
On the other hand, Russia, the top petroleum exporter in the world, on average, and supplied 10.73% to the international market. As indicated in Figure 2, 10.06% and 5.45% of the total petroleum exports of Saudi Arabia and the EU were directed to the international market, respectively, for the period 2002-2019. India ranked at the 18th position while placing itself in the list of the world's top 20 petroleum exporters with an average market share of 2.01% for the period 2001-20019.As evidenced from Figure 3, Singapore and UAE were the top petroleum export partners of India, 13.10% and 12.20% respectively, for the period of 2002-2019. Likewise, 7.7% of petroleum exports of India were directed to the Netherlands over the same years. India has shown great potential by itself among the world's top 20 petroleum exporters in the world market.



Source: Authors' Computations

Fig 3: India's Top 20 Petroleum Export Partners (Average Percentage Share 2002-2019 in %)

As indicated in Figure 4, the average growth rate of Indian petroleum exports is more than the World's average growth rate with a greater level of fluctuations for the period 20022019. This periodical upside-down rise and fall in average growth exhibit a higher level of instability and growth simultaneously. With the higher average growth rate share, this study becomes more relevant to determine India's petroleum exports share in the World market.



Source: Authors' Computations

Fig 4: India and World's Average growth rate of petroleum exprots (2002-2019)

Results of Gravity Model using Fixed and Random Panel Regression : Results of Descriptive statistics of all the variables analysed in this study are presented in Table 1, Table 2 and furthermore Table 3 shows correlation matrix of all variables which shows correlation among expansional variables.

Table 1: Descriptive Statistics of Selected Variable

Variables	N	Min.	Max.	Mean	Sd
LXi	685	-0.64	6.92	5.04	1.30
LGDPi	685	11.71	12.46	12.16	0.22
LGDPj	685	9.23	13.33	11.37	0.88
LWDSi	685	1.15	3.18	2.4	0.34
LRERij	685	-2.35	2.26	0.71	1.17
LOPENi	685	1.47	1.75	1.64	0.07
LOPENj	685	1.32	2.65	1.86	0.28
LPOPi	685	9.04	9.14	9.09	0.02
LPOPj	685	5.49	9.15	7.43	0.73
LFDIi	685	9.57	10.7	10.35	0.35
LIQIi	685	1.63	1.68	1.66	0.01

Source: Authors' Computations

Table 2: Results of Levin, Lin and Chu t-Statistics for Data Stationarity

Variables	Levin, Lin and Chu t-Statistics	P-Value	Types of Equation	Remarks
LXi	-22.763***	0.0001	No Intercept, No trend	Stationary
LGDPi	-16.968***	0.0000	No Intercept, No trend	Stationary
LGDPj	-17.601***	0.0000	No Intercept, No trend	Stationary
LWDSi	-23.462***	0.0000	No Intercept, No trend	Stationary
LRERij	-27.843***	0.0000	No Intercept, No trend	Stationary
LOPENi	-16.103***	0.0001	No Intercept, No trend	Stationary
LOPENj	-22.708***	0.0002	No Intercept, No trend	Stationary
LPOPi	-16.198***	0.0000	No Intercept, No trend	Stationary
LPOPj	-18.301***	0.0000	No Intercept, No trend	Stationary
LFDIi	-18.029***	0.0001	No Intercept, No trend	Stationary
LIQIi	-20.079***	0.0000	No Intercept, No trend	Stationary

Source: Authors' Computations

Note: *, **, *** indicates the significance at 10 percent, 5 percent and 1 percent level respectively

An extensive effort has been made to comprehend the performance of India's petroleum exports using the panel regression random effect model. First of all, all the variables are checked for stationarity using the Levin, Lin & Chu t-test (2002). The results of the test are presented in Table 2, which explicates that all the variables are statistically significant (p-value <. 01) at a 1 percent level of significance and thus all variables of the specified model are stationary.

Table 3 shows the results of correlation among dependent and independent variables of petroleum exports used for the analysis in the present work. The correlation coefficient matrix is calculated to check the multicollinearity among the explanatory variables. If the value of the correlation coefficients is greater than 0.9, then there exists a problem of multicollinearity. Our results satisfied the condition that only one of the coefficients of explanatory variables is greater than 0.9. Rest of the coefficients are significant at both 1 percent levels of significance, and most of the coefficients are negatively related among themselves.

Table 3: Correlation Matrix of the Selected Variables

Variables	LXi	LGDPi	LGDPj	LWDSi	LRERij	LOPENi	LOPENj	LPOPi	LPOPj	LFDIi	LIQIi
LXi	1.0000										
LGDPi	0.1220* (0.0012)	1.0000									
LGDPj	-0.2384* (0.0000)	0.1776* (0.0000)	1.0000								
LWDSi	0.0796* (0.03490)	0.6839* (0.0000)	0.2461* (0.0000)	1.0000							
LRERij	-0.0123 (0.7447)	0.0431 (0.2541)	0.1449* (0.0001)	0.0738 (0.0506)	1.0000						
LOPENi	0.0010 (0.9797)	0.5302* (0.0000)	0.1183* (0.0000)	0.3729* (0.0000)	0.0413 (0.2744)	1.0000					
LOPENj	0.0655 (0.0785)	0.5377* (0.0000)	0.3341* (0.0000)	0.2304* (0.0000)	0.2680* (0.0000)	0.0669* (0.0000)	1.0000				
LPOPi	0.1690* (0.0000)	0.9843* (0.0000)	0.1760* (0.0000)	0.6353* (0.0000)	0.0402 (0.2880)	0.4248* (0.0000)	0.0101* (0.0000)	1.0000			
LPOPj	-0.3048* (0.0000)	0.0509* (0.0000)	0.6980* (0.0000)	0.0547* (0.0000)	-0.1417* (0.0000)	0.0371* (0.0000)	0.1105* (0.0034)	0.0545* (0.0000)	1.0000		
LFDIi	-0.4146* (0. 0481)	0.8202* (0.0000)	0.1670* (0.0000)	0.5842* (0.0000)	0.0442 0.2417	0.6477* (0.0000)	0.5307* (0.0000)	0.8651* (0.0000)	0.0461* (0.000)	1.0000	
LIQIi	-0.0710* (0.0000)	0.4126* (0.0000)	0.0535* (0.0000)	0.2686* (0.0000)	0.0396 (0.2947)	0.2013* (0.0000)	0.5371* (0.0000)	0.4572* (0.0000)	0.0224* (0.000)	0.4153* (0.0000)	1.0000

Source: Authors' Computations

Note: * are significant at level 5%.

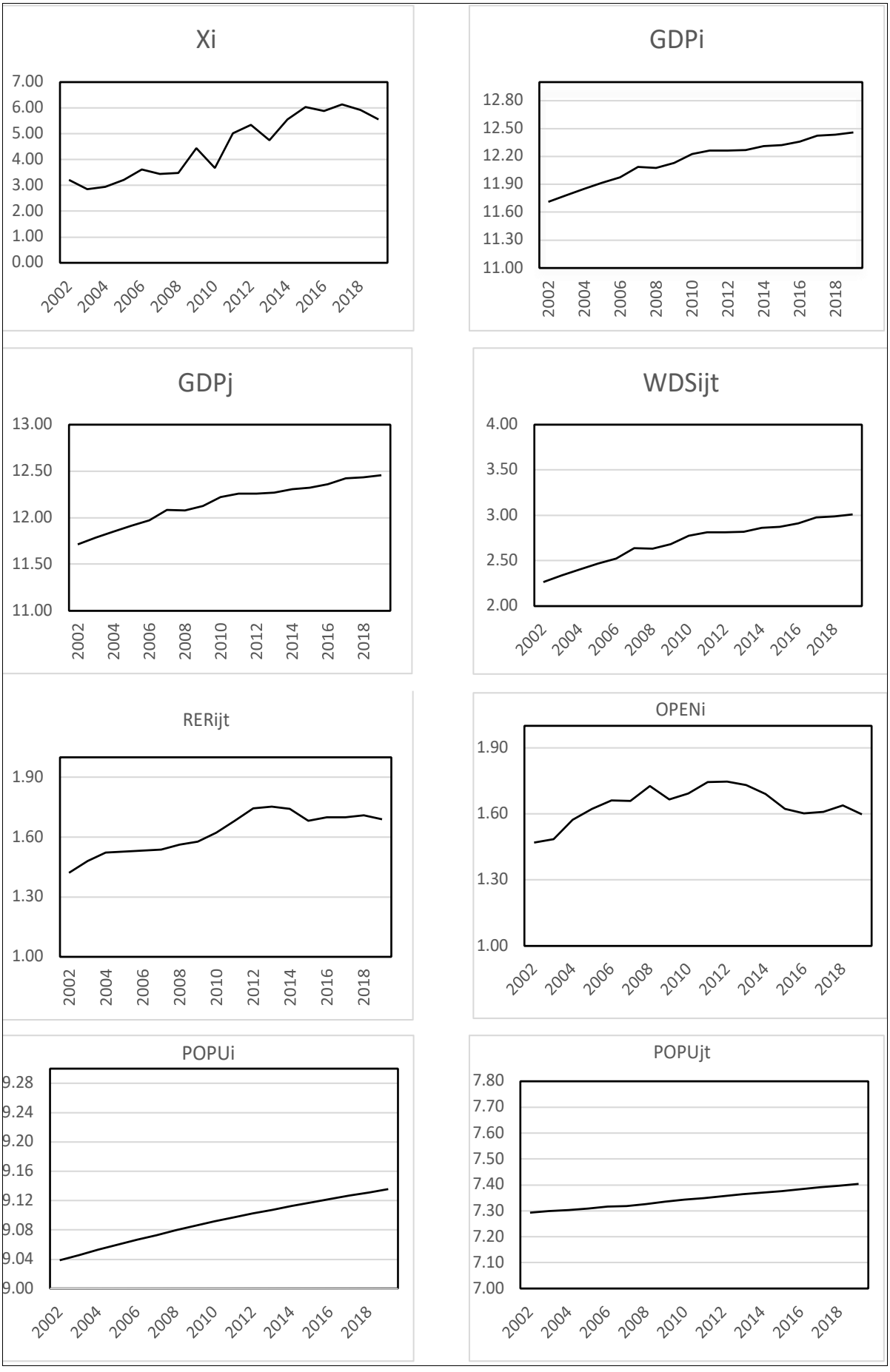


Fig 1: Graphic description of the variables selected for the study

Table 4: Model Estimation

	Dependent Variable = LXi (random effect model)			
Variables	**Coefficient**	**Std. Error**	**t-Statistic**	**p-value**
CONSTANT	−116.796	99.1174	−1.178	0.2387
LGDPi	1.81040	1.88364	0.9611	0.3365
LGDPj	0.323531	0.0850150	3.806	0.0001***
LWDSi	−1.07132	0.170855	−6.270	3.60e-10***
LRERij	−0.108303	0.0460294	−2.353	0.0186**
LOPENi	6.46256	1.18236	5.466	4.61e-08***
LOPENj	0.660858	0.210275	3.143	0.0017***
LPOPi	8.86386	13.1425	0.6744	0.5000
LPOPj	0.276222	0.119683	2.308	0.0210**
LFDIi	−0.809621	0.342480	−2.364	0.0181**
LIQIi	7.38867	4.43731	1.665	0.0959*
LXit-1	0.104084	0.0348224	2.989	0.0028***
	Diagnostic Statistics			
R-square		Chi-square	p-Value	Hausman Test	P-Value
0.3519		360.506	1.4474e-70*	23.9726	0.0128491**

Source: Authors' Computations

Table 5: Model Estimation

Dependent Variable = LXi (Fixed effect model)				
Variables	**Coefficient**	**Std. Error**	**t-Statistic**	**p-value**
CONSTANT	−148.458	102.730	−1.445	0.1489
LGDPi	1.12639	1.96586	0.5730	0.5669
LGDPj	0.320680	0.0892902	3.591	0.0004***
LWDSi	−1.06385	0.174492	−6.097	1.94e-09***
LRERij	−0.0989539	0.0477332	−2.073	0.0386**
LOPENi	6.46056	1.20874	5.345	1.29e-07***
LOPENj	0.631250	0.214868	2.938	0.0034***
LPOPi	13.3909	13.6484	0.9811	0.3269
LPOPj	0.272993	0.126908	2.151	0.0319**
LFDIi	−0.736497	0.348361	−2.114	0.0349**
LIQIi	6.36144	4.50509	1.412	0.1585
LXit-1	0.0747511	0.0357985	2.088	0.0372**
Diagnostic Statistics				
R-square		0.36		
F-Statistics		7.810973*		
p-value		1.84e-38***		

Source: Authors' Computations

Table 4 shows the OLS regression results where LXi is the dependent variable and others are the explanatory variables. The results reveal that LGDPj, LWDSij, LRERij, LOPENi, LOPENj, LPOPj, LFDIi, LIQIi, and LXi are statistically significant at the 1 percent, 5 percent, and 10 percent level of significance in the random effect model. Moreover, the coefficients of all the explanatory variables are positively related except LGDPi and LPOPi, which are negatively related to the dependent variable that is LWDSi, LRERij, and LFDIi. The negative relation between LXi and LWDSij explicates that the exports (LXi) will be less if the weighted distance (LWDSi) keeps increasing and the real exchange rate will also be negatively related to petroleum exports. In other words, more the distance between two countries less will be the trade between them and the negative exchange rate states that the value of your currency will be weaker against the dollar, which will later reduce the value of exports. On the other hand, the negative sign of variable LFDIi exhibits that the foreign direct investment in the crude oil sector is minimalistic against the other sectors. In the fixed-effect model, only LGDPi, LWDSi LOPENi, LOPENj, and LXi are statistically significant at the 1 percent level of significance. Moreover, most of the coefficients of the explanatory variables are positively related, but a few such as LWDSi, LRERij, and LFDIi are negatively associated with the dependent variable.

The Hausman test is applied to find the substantial difference between random and fixed-effect models. The Hausman test checks the null hypothesis that there is no difference between the random and fixed-effect model. In our case, the null hypothesizes are rejected, which indicate that the fixed effect model is more appropriate and more preferable over the random effect model (Gujarati, 2004). The F-statistic that measures the overall significance of the regression analysis indicates that the model is highly significant.

Conclusion

According to the results of descriptive analysis, India is ranked among the world's top 20 petroleum exporters with an average market share of 2.01% for the period 2002-2019. Over a while, the growth rate of India's petroleum exports is higher than the world's petroleum exports between 2002-2019. The share of India's petroleum exports is rising at a greater pace against the world's share of petroleum goods exports. The continuous fluctuation in India's petroleum exports signifies the insatiability along with a greater potential growth rate in the world market covering the well-blended combination of both the developed and developing nations.

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