ENERGY SECURITY FOR INDIA: PETROLEUM DEMAND ESTIMATIONS AND PROJECTIONS

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INTRODUCTION

Crude oil and other petroleum products play an important role in India's energy security and in sustaining its high growth rate. Against that background, this document empirically analyses petroleum demand; estimates demand functions for crude oil, diesel, and petroleum; and projects demand for these products up to 2025 for several different reasonable scenarios of GDP growth and crude oil prices. This analysis should help policy makers make appropriate supply arrangements and improve India's energy security.

THE MODEL

We follow the traditional demand function for petroleum products, where demand is simply a function of the real prices and the real national income, which can be well proxied by real GDP at factor cost:

$$Log\ D_i = \alpha_i\ \beta_i\ LogP_i + \gamma_i\ LogY + u_t \qquad (1)$$

where D_i and P_i are the demand and real price respectively of the three products (i takes the value c for crude oil, d for diesel and P for petrol);
Y is the real GDP at factor cost;
α_i, β_i, γ_i are the parameters to be estimated for the three products; u_t is the error term.

It is expected that an increase in price would reduce demand of a commodity ($\beta<0$) whereas an increase in real GDP would imply greater industrial production and increased transportation of goods and people, leading to increasing commodity demand ($\gamma>0$). The above relation will be used to estimate the magnitude of the income and price elasticities, which determines the changes in demand in response to changes in its price and the real GDP and, thus, has major implications for projecting the future demand of petroleum products.

ECONOMETRIC METHODOLOGY AND DATA SOURCES

Since most variables were found to be non-stationary and integrated of order one (I(1)), we estimate the demand for crude oil, petrol, and diesel in India using the auto-regressive distributed lag (ARDL) co-integration procedure proposed by Pesaran et al. (2001).

The present study is based on yearly data for 1970–2011. The data for India's crude oil, petrol, and diesel consumption (in million tonnes) were collected from the Ministry of Petroleum and Natural Gas (MoPNG), Government of India. We used the dollar price of the Indian basket crude oil (essentially same as the international Brent crude oil price) in US$ per barrel from www.indexmundi.com, and then converted it into constant rupee (or 'real') price of crude oil by using the official exchange rate and then dividing by India's wholesale price index (WPI). In the case of petrol and diesel, we used the data on their retail prices in Delhi collected from the MoPNG. We then converted the nominal price into real price by dividing it with the WPI (base year 2004–05). The real GDP at factor cost (in 2004–05 prices) data are collected

Table 1 Elasticities estimated (1970-2011)						
Demand Equation	*Price elasticity*	*Income elasticity*	*ARDL bounds F-Test*	*DW*	*Functional form [χ²(1)]*	*Heterosce-dasticity [χ²(1)]*
Crude oil	-0.41*	1.00**	3.92**	2.14	2.02	0.003
Diesel	-0.56**	1.02*	11.73**	1.50	0.02	0.31
Petrol	-0.85*	1.39*	2.81**	1.87	1.87	0.16

Note: * and ** denote significance at 5% and 1% significance levels

from the Handbook of Statistics on Indian Economy (Reserve Bank of India 2011-12).

ESTIMATION RESULTS

We carried out estimation for the long-run demand function gives for crude oil, diesel, and petrol separately. The results are summarised in Table 1.

The elasticity with respect to income (or GDP) is found to be positive and significant at about 1.0 for crude oil, 1.02 for diesel, and 1.39 for petrol. The price elasticity is found to be negative and significant at -0.41 for crude oil, -0.56 for diesel, and -0.85 for petrol.

The F-statistics for each equation confirms the co-integration relationship as its values are above the upper bound at the 1% significance level. Further, diagnostic tests show that serial correlation in the error term is not significant, functional form is not rejected, normality of error term is not rejected, and there is no heteroscedasticity in the model. These tests corroborate the validity of the estimated demand function. The stability of coefficients was also corroborated by tests of cumulative sum (CUSUM) and the square of cumulative sum (CUSUMSQ) of recursive residuals.

The above empirical estimations of demand functions for crude oil, diesel, and petrol can be used to project their future demand for various likely scenarios regarding real GDP growth and crude oil prices. Such projections should help policy makers know the likely future demand and help them design supply side policies to meet the expected demand. The next section attempts such projections up to 2025.

PROJECTIONS OF DEMAND FOR CRUDE OIL, DIESEL, AND PETROL IN INDIA

The estimated demand elasticities can be used to predict the likely demand for petroleum products. Differentiation of the demand equation (1) with respect to time yields the relation (where a hat (^) over a variable denotes its growth rate).

$$\hat{D} = \beta_i \hat{P} + \gamma_i \hat{Y} \qquad (2)$$

which can then be used to project future demand starting from base year t,:

$$D_{t+1} = D_t + \beta_i P_i + \gamma_i Y \qquad (3)$$

Using (3), the future demand for crude oil, diesel and petrol can be projected using the likely scenarios for growth rates of real GDP and the real price of crude oil, petrol, and diesel respectively. These are discussed next.

Likely Growth Rates of GDP and Petroleum Prices
Looking at the growth rates of GDP, crude oil prices, petrol and diesel prices between 1970 and 2011, we determine their likely future growth rates. From these considerations, we consider three likely scenarios for average annual GDP growth rate until 2025: (1) a normal scenario with average annual GDP growth rate of 7%; (2) an optimistic scenario with average annual GDP growth rate of 8%; and (3) a pessimistic scenario in which real GDP grows at an annual average rate of 6%. Considering that crude oil prices have grown at an average rate of about 5.5% over 1970 to 2011, our three scenario for the probable growth rates of crude oil prices assume them to be growing at average rates of about 4%, 5.5%, and 7% respectively. Similarly,

Table 2 Projections of India's Crude Oil Demand for 2012-2025 (million tonnes)

Year	Crude oil demand projection at 6% real GDP growth and at following growth rate of crude oil prices			Crude oil demand projection at 7% real GDP growth and at following growth rate of crude oil prices			Crude oil demand projection at 8% real GDP growth and at following different growth rate of crude oil prices		
	4%	5.5%	7%	4%	5.5%	7%	4%	5.5%	7%
2011	The actual demand for crude oil in 2011 is about 147.24 million tons								
2015	174.53	170.42	166.38	181.31	177.08	172.93	188.28	183.93	179.66
2020	215.85	204.59	193.85	235.18	223.02	211.43	256.03	242.92	230.40
2025	266.96	245.61	225.85	305.06	280.88	258.50	348.16	320.82	295.48
Total Increase in Projected Crude Oil Demand from 2011 to 2025									
	81.31	66.81	53.39	107.19	90.77	75.56	136.46	117.89	100.68
Annualized Growth Rate of Projected Crude Oil Demand over 2011 to 2025									
	4.34	3.72	3.10	5.34	4.72	4.10	6.34	5.72	5.10

since diesel and petrol prices have grown at an average of about 3% in the past (because of slower growth in processing costs and various taxes), three scenarios of annual growth rate of 2%, 3%, and 4% are used for projecting diesel and petrol demand. The results of the projections of demand are discussed next.

Table 2 shows projections for crude oil demand until 2025: the compounded increase by 2025 in crude oil demand for various scenarios of GDP and oil price growth rates could vary between 53% and 136%. The average for these scenarios, as also for our most likely case of the real GDP growth at 7% and crude oil price growth at 5.5% indicate that the crude oil demand would likely increase from 147 million tonnes in 2011 to 281 million tonnes in 2025, i.e., an increase of about 90% from 2011 to 2025 or an annualised growth rate of about 4.7%.

Table 3 shows projections for diesel demand until 2025: the compounded increase by 2025 in diesel demand for various scenarios of GDP and oil price growth rates could vary between 70% and 158%. The average for these scenarios, as also for our most likely case of the real GDP growth at 7% and diesel price growth at 3% suggest that the diesel demand would likely increase from 67 million tonnes in 2011 to 133 million tonnes in 2025, i.e., an increase of about 110% from 2011 to 2025 or an annualised growth rate of about 5.3%.

Table 3 Projections for India's Diesel Demand for 2012-2025 (million tonnes)

Year	Diesel demand projection at 6% real GDP growth rate and at following growth rate of diesel prices			Diesel demand projection at 7% real GDP growth rate and at following growth rate of diesel prices			Diesel demand projection at 8% real GDP growth rate and at following growth rate of diesel prices		
	2%	3%	4%	2%	3%	4%	2%	3%	4%
2011	The actual demand for diesel in 2011 is about 63.70 million tonnes								
2015	77.37	75.71	74.07	80.42	78.71	77.02	83.57	81.80	80.06
2020	98.66	93.94	89.42	107.63	102.53	97.65	117.31	111.81	106.53
2025	125.79	116.56	107.96	144.03	133.56	123.80	164.69	152.83	141.76
Total Increase in projected diesel demand from 2011-2025									
	97.47	82.97	69.47	126.09	109.65	94.33	158.53	139.91	122.53
Annualized growth rate of projected diesel demand over 2011-2025									
	4.98	4.41	3.84	6.0	5.43	4.86	7.02	6.45	5.88

Table 4 Projections of India's Petrol Demand for 2012-2025 (million tonnes)

Year	Petrol demand projection at 6% real GDP growth rate and at following growth rate of petrol prices			Petrol demand projection at 7% real GDP growth rate and at following growth rate of petrol prices			Petrol demand projection at 8% real GDP growth rate and at following growth rate of petrol prices		
	2%	3%	4%	2%	3%	4%	2%	3%	4%
2011	The actual demand for petrol in 2011 is about 15.01 million tonnes								
2015	19.41	18.80	18.20	20.44	19.80	19.18	21.51	20.85	20.20
2020	26.76	24.90	23.16	30.07	28.01	26.07	33.74	31.45	29.30
2025	36.91	33.00	29.47	44.25	39.61	35.44	52.92	47.45	42.50
Total Increase in Projected Petrol Demand from 2011 to 2025									
	145.97	119.90	96.42	194.86	163.99	136.15	252.66	216.18	183.24
Annualised Growth Rate of Projected Petrol Demand over 2011-2025									
	6.64	5.79	4.94	8.03	7.18	6.33	9.42	8.57	7.72

Table 4 shows projections for petrol demand until 2025: the compounded increase by 2025 in petrol demand for various scenarios of GDP and oil price growth rates could vary between 96% and 252%. The average for these scenarios, as also for our most likely case of the real GDP growth at 7% and petrol price growth at 3% suggest that the petrol demand would likely increase from 16 million tonnes in 2011 to about 39.6 million tonnes in 2025, i.e., an increase of about 164% from 2011 to 2025 or an annualised growth rate of about 7.2%.

CONCLUSION AND RECOMMENDATIONS

It is clear from the above analysis that demand for crude oil, petrol, and diesel will increase substantially (around 90%, 110%, and 165%, respectively) between 2011 and 2025. If we assume that crude oil price too could increase by 50% to 100% by 2025, India's crude oil import bill could increase threefold or fourfold (i.e., about $450 to $600 billion) by the year 2025.

Considering that India's total exports were only $305 billion in 2011–12, this is a worrisome scenario and requires urgent action. India should take various energy efficiency and demand conservation measures to manage the growing demand of crude oil, petrol, and diesel in the long run. This should include market-linked prices for petrol and diesel. Petroleum subsidies on fertilisers, kerosene, and liquefied petroleum gas (LPG) need to be well targeted and minimised to the extent possible. Vehicle producers should be required or incentivized to produce more fuel efficient vehicles. India also needs to enhance petroleum supplies through increased domestic explorations as well as other measures, such as participation in exploration and production in foreign oil fields by Indian oil companies (which the Chinese are using extensively). India needs to use renewable energy sources (hydro, wind, solar, bio-fuels, nuclear, etc.) on a much larger scale as Western European countries are doing. Finally, India should also take measures to increase exports to meet its growing future oil import requirements.

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