A Process Driven Dynamic Model for Petroleum Product Demand in Transportation Sector of India

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Abstract **– This paper proposes a dynamic process to identify factors influencing the demand of transport fuel in India. Factors like inter-fuel substitution by CNG, environmental concerns, economic outlook and price sensitivity must be incorporated in the demand estimation model. Differential subsidy in India on diesel and petrol affects its demand and the choice of vehicle ownership. A self designed questionnaire is used to survey and identify the factors affecting the demand for petrol and diesel. Multiple regression models are formulated for demand estimation of petrol and diesel with principal factors. Models are validated with real time data.**

Keywords – *Dynamic process, inter fuel substitution, price sensitivity, factors of demand, test of Sphericity, demand estimation model, multiple regression, validation of model*

1. Introduction and background

The Report of the working group on petroleum and natural gas sector for the XII Five Year plan (2012-17) states, 'Efficient and reliable energy supplies are a precondition for accelerated growth of the Indian economy. While the energy needs of the country, especially oil and gas, are going to increase at a rapid rate in the coming decades, the indigenous energy resources are limited oil and gas constitute around 45% of the total energy consumption. At the same time, the dependents on imports of petroleum and petroleum products continue to be more than 75% of total oil consumption in the country.

The demand of petroleum products in India has increased from 129 MMT in 2007-08 to 147 MMT in 2011-12 at a CAGR of 4.2%. When compared to the consumption in other developing countries, demand for POL in India is lower than China, although it is much higher than other developing countries like Indonesia and South Africa. Average growth in demand for petroleum products in relation with an average annual growth in GDP (gross domestic product at factor cost) at constant prices of 8.2% suggests the demand elasticity of POL product for eleventh plan at 0.49. Demand elasticity in India during last two plans has been stable as shown below in Table-1.

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Table 1. POL demand elasticity in India

Particulars	**X Plan (2002-06)**	**XI Plan (2007-11)**
POL demand growth	3.8	4.0
GDP growth	7.8	8.2
Demand Elasticity	0.49	0.49

Demand elasticity of Petroleum Oil & Lubricants (POL) products to GDP in other developing countries namely Brazil, China, Indonesia, Malaysia and South Africa during 2006-10 varied vastly and were 1.19, 0.65, 0.53, -0.01 and -0.05 respectively.' While the demand elasticity of petroleum products during the last two plans has been stable at 0.49, the transport fuel demand elasticity varied widely from 0.65 to 1.13, as shown below in Table-2. [1]

Table 2. Transport fuel demand elasticity in India

Particulars	**X Plan (2002-06)**	**XI Plan (2007-11)**
Transport fuel demand growth	5.1	9.3
GDP growth	7.8	8.2
Transport fuel demand Elasticity	0.65	1.13

The wide variation in elasticity is a challenge to policy makers and requires physical prudence over and above major infrastructure growth to support such increase in the coming years. Such a major increase also requires estimation of demand based on the underline factors like inter fuel substitution, environmental concerns, economic outlook and price sensitivity, for proper planning of refinery infrastructure, storage locations and marketing spread.

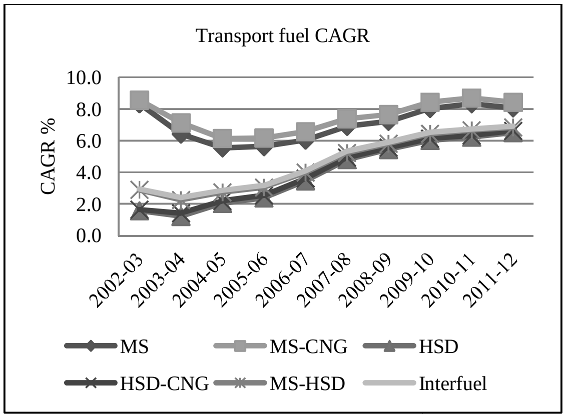

Figure 1. Transport Fuel CAGR

The CAGR is higher in case of petrol than diesel as depicted in Figure 1. Petrol growth increased from 5.5 to 8.3 percent and diesel growth increased from 1.2 to 6.5 percent for the financial years 2002-03 to 2011-12. This is mainly due to the fact that ratio of average petrol to diesel sales is 1:5. Similar trend is noticed in the ratio of vehicle numbers driven by petrol and diesel.

It should be noted that the growth of petrol sale with Compressed Natural Gas (CNG) is higher than only of petrol. This phenomenon is also seen in case of diesel. In case of CNG plus petrol, the growth numbers increased from 6.1 to 8.7 during the same period when only petrol increased from 5.5 to 8.3 percent. In case of CNG plus diesel, the growth numbers increased from 1.4 to 6.6 percent against 1.2 to 6.5 for only diesel. This is due to inter fuel substitution. Gradually over the years inter fuel substitution has taken place by CNG to both consumption of petrol and diesel. In Figure 2, it can be seen that since 2004-05 onwards, there is a steep rise in diesel growth and moderate rise in petrol, which is attributed to lower artificial price of diesel due to subsidy in Indian market. Similarly since 2009-10 onwards, due to policy decision of subsidy removal on petrol, the growth has tapered down. This is more clearly evident by plotting the year on year growth of most preferred transport fuels. In the above graph from 2009-10 onward the decreasing year on year growth of petrol signifies the fact that in spite of multiple efficient vehicle choice in India, due to freeing of petrol price by Government of India the choice of vehicle shifted to diesel. This is also evident from the diesel graph.

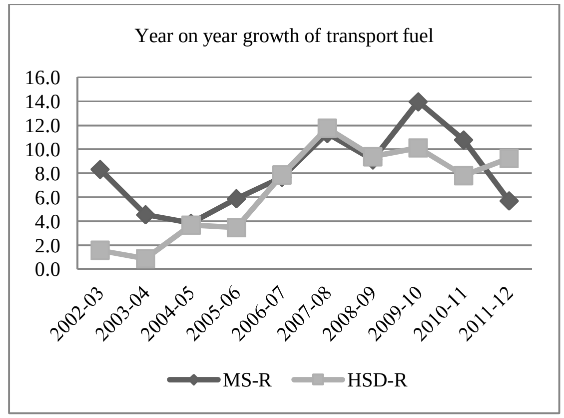

Figure 2. Year on year growth of transportation fuel in India

Diesel is considered to be most used transport fuel even today and major attraction for Indian market has been the subsidy. For Indian condition, inter fuel substitution by CNG is slow but steady. In all the combinations, namely only petrol, only diesel, or petrol plus diesel, the combination of CNG increased the growth numbers in any specific year.The gap between the growth numbers with and without CNG is wide in case of petrol and marginal in case of diesel. This states that more value is derived by switching petrol vehicles to CNG. Such reasons are also supported by the fact that infrastructure on CNG network or outlets have not proliferated across the country as yet in the same pace that of petrol and diesel retail outlets. For diesel alone, the intensity is still increasing while the gap between the petrol and diesel growth as a choice of fuel is showing reducing trend. The intensity will be driven by the price of fuel type, availability on mobility, due to inter fuel substitution and environmental policies restricting certain transport fuel for use.

2. The transport sector petroleum product consumption in India

The road sector gasoline fuel consumption per capita (KT of oil equivalent) in India was 10.61 in 2009, according to a World Bank report, published in 2010. Gasoline is a light hydrocarbon oil used in internal combustion engine such as motor vehicles, excluding aircraft (Figure 3)

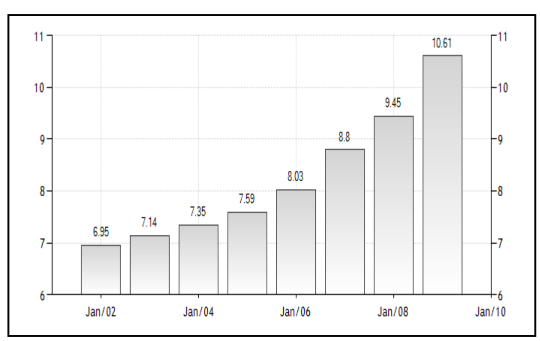

Figure 3. Gasoline fuel consumption per capita in India

The road sector diesel fuel consumption per capita (KT of oil equivalent) in India was 25.98 in 2009, according to a

World Bank report, published in 2010. Diesel is a heavy oil used as a fuel for internal combustion in diesel engines (Figure 4). [2]

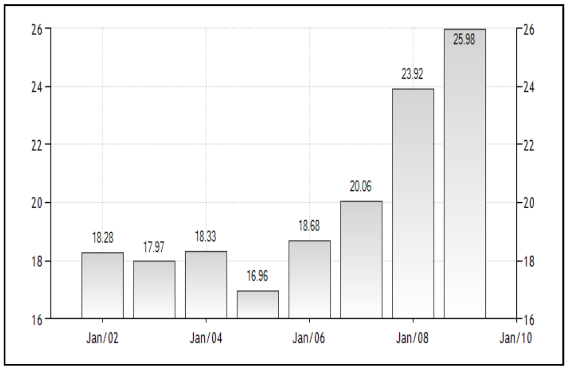

Figure 4. Diesel fuel consumption per capita in India

The preface to The Expert Group on A Viable and Sustainable System of Pricing of Petroleum Products writes, 'India's growing dependence on imported oil products and the dramatic rise in the prices of crude oil to as high as $148/bbl the international market in July 2008, followed by an equally dramatic fall, pose significant policy challenges. The Government's efforts to insulate domestic consumers, at least to some extent, resulted in huge fiscal burden for the Government and financial problems for the public sector oil marketing companies. But for the steep fall in crude price, it would have most likely disrupted the growth process of our economy. It is, therefore, important that we evolve a viable and sustainable pricing policy for the four major oil products, namely, petrol, diesel, kerosene and LPG, which constitute 63% of total consumption of petroleum products in 2008-09 and whose market prices are currently controlled by the Government.' [3]

Since then a lot of change has taken place in Indian Petroleum sector. Petrol pricing was completely freed. On domestic Liquid Petroleum Gas (LPG), cap was introduced to restrict each household to fixed numbers per annum. Dual pricing is introduced in diesel pricing, separating bulk/direct consumers from the retail customers. Only Superior Kerosene Oil (SKO) pricing continues as earlier and needs the well planned unique Identity or UID to be implemented where the beneficiary will receive the subsidy on SKO directly while the product will be sold at market driven price.

Arora (2006) said 'Over 70% of India's crude oil requirements are imported and the figure may well reach 85% by the end of the decade. By 2030 India's consumption of petroleum products may quadruple. The impact of rising oil prices on Indian economy is, therefore, a matter of grave concern. The Indian economy has been badly signed whenever global oil prices have flared. In 1973, GDP fell by 0.3% and inflation was up at 20.2%; in 1979 the corresponding figures were 5.2% and 17.1%. The GDP grew by meager 1.3% in 1990, while inflation topped 14%.' [4]

Hydrocarbon vision 2025 states, 'the hydrocarbon sector plays a vital role in the economic growth of the country. It is necessary to have a long term policy for the hydrocarbon sector, which would facilitate meeting the future needs of the country. Oil and gas continue to play a pre-eminent role in meeting the energy requirements of the country. 45% of the total energy needs would be met by the oil and gas sector, though some amount of interchange between oil and gas is foreseen.' [5]

Lawrence (2009) noted that, 'nearly all motorized vehicles necessitate the combustion of petroleum-based fuels. In India transport accounted for nearly half of petroleum products consumption in 2004/05. The growth in transport demands directly weigh on the country's need for oil. India's oil dependency has increased over time and is at 76% of total crude oil refinery requirement in 2005 (MOSPI, 2006). In 1990, crude oil dependency was only 39%. This reflects the increasing need for petroleum products to feed the growing Indian vehicle market. Refinery capacity covers all of the needs of the domestic markets and exports a very small quantity'. [6]

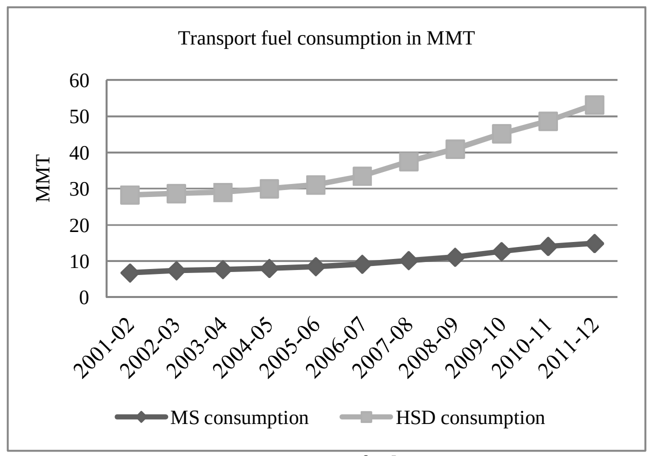

Figure 5. Transport fuel consumption

From 2001-02 to 2011-12 consumption of petrol has increased double fold from 6.8 million metric tonne (MMT) to 14.9 million metric tonne (MMT). During the same period, diesel consumption increased from 28.3 MMT to 53.2 MMT. The steep rise in diesel consumption from 2005-06 onward are attributed to many factors like subsidy on diesel, over all GDP of the country, increase in the road density (kilo meter of road per square kilo meter of the land area), increase in total road network (km) in India, increase in vehicles per kilo meter of road in India, increase in employed persons to mention a few. The gap between the consumption of petrol and diesel increased from 22.6 MMT in 2005-06 to 38.6 MMT in 2011-12 (Figure 5). The year on year growth of diesel as a preferred transport fuel was high since 2006-07. In 2006-07, in grew by 6.7% over 2005-06, similarly, in 2007-08 by 11.1%, 8.5% in 2008-09, 8.9% in 2009-10 and 6.5% in 2010-11. Similar trend is also seen in petrol as in 2006-07 it grew by 7.4% over 2005-06, 11.3% in 2007-08, 9% in 2008-09, 13.9% in 2009-10 and 10.8% in 2010-11. Thus CGAR between 2000-01 and 2010-11 for petrol works out to 7.9% for diesel 4.7% compared to over all petroleum product CAGR of 3.5%. In other words, the importance of transport fuel like petrol and diesel is very predominant in overall growth of petroleum products in India. This is the primary reason that the transport sector fuel needs more focus and assessing future requirement is essential for the entire transport sector supply chain.

The 'Report on the Working Group on Petroleum and Natural Gas Sector for the XII Five Year plan (2012 - 2017)' by Ministry of Petroleum and Natural Gas states that the formulation of the XII Five Year Plan assumes significance as the task to provide road map for the economy at a very critical stage with a large parts of developed world is in the midst of a double dip recession and developing economies are leading the overall economic growth. At the domestic front the country has been able to perform well over the XII plan period and aims at achieving 'faster, sustainable and more inclusive growth' in the XII plan. However, the increase in volatility in the prices of crude and other important mineral resources and enhanced energy requirements poses series challenges for the economy.' [1]

With these as the background, the study on transport sector fuel demand in the future is more important as it contributes over 40% of the entire petroleum product requirement. The report also states that 'Energy security remains a concern for India as the country faces challenges in meeting its energy needs. The country depends on imports to meet more than 75% of its hydrocarbon energy requirements. The growth in domestic oil and gas production is not commensurate with the growing consumption of petroleum products in the first developing economy like India.' [1] Hence the role of transport sector fuel demand becomes very critical for the fast developing economy like India.

3. Literature Review

The literature is reviewed and has been classified under mobility, economic factors, urbanization and population growth, subsidy on petrol and diesel, price of transport fuel, vehicle population and infrastructural development.

3.1 Mobility

Lawrence (2009) noted that 'existing research has addressed the major modes in road transport, namely cars, two wheelers, auto-rickshaw and buses. Singh (2006) estimated the passenger mobility on road and the major drivers from 1950 to 2000. Earlier, research done by Bose (1998) has formulated a simulation model to analyze the drivers in road transport in four Indian metropolises. Many other studies have also been focused on passenger transport, and some detailed analysis has been conducted for few major cities in India. For example, Reddy (2000) analyzed the trend in passenger transport in Mumbai and Maharashtra, and estimated the energy consumption from 1987 to 1996. Das (2004) looked at the different growth scenarios in vehicles and travel demand up to 2020 in Mumbai and Delhi, and estimated energy needs and environmental implications. However, no comprehensive data collection or analysis has yet been done and current studies have lacked detailed on energy demand and fuel mix for each mode.' [6]

Centre for science and environment (2012) in response to the estimate of diesel consumption in private cars used in the planning commission note states that 'given the fact that the petrol car segment uses about a third of the total petrol consumed (the rest is used by two-wheelers and three-wheelers) – use of diesel is already more than 40 percent of the total fuel used in the car and jeep segment. Therefore, it is not possible to hide dieselization and its consequences in any case. [7]

According to PPAC the growth rate for diesel has already exceeded that of petrol. The effect of the increased consumption of subsidized diesel in cars is so dramatic that the excise earnings from both diesel and petrol has nearly equalled despite the fact that petrol pays seven times more excise than diesel. The real concern is the rapid increase in the use of diesel in car and SUV segments. In 2010-11 car industries have sold about 800,000 diesel cars which was 32 per cent higher than the previous year. Even if we assume a much moderate and flat growth rate of 20 per cent a year until 2020, the total diesel cars will be double the size of the total car sales today. The implications for diesel fuel use for public health will be enormous and deadly.' [8]

Lawrence (2009) states, 'energy consumption in the transport sector is evenly distributed between freight and passenger transportation. Road transport is the most used mean of transport followed by air and rail. Finally, a very small quantity of energy is used for water ways transport.

Energy consumption in the transport sector is particularly sensible for two main reasons. First, immediate substitution to other fuels is impossible and requires waiting until the end of life of the vehicle owned. Second, transport mobility is necessary but not vital and people tend to restrain their need and/or switch to more economical mode of transport. The price of petrol and especially diesel has increased sharply over the last ten years. In order to assess the impact of price on diesel consumption regression of diesel use on GDP and diesel prices were carried out. GDP is considered as the main driver and is used as a surrogate for other economic variables influencing the growth of fuel consumption, such as urbanization, increase in stock, etc. The correlation of GDP and diesel consumption was found to be statistically significant with a R^2 of 71%. When independent variable price was added, the R^2 adjusted was greater with 87%. It was found that over the period 1996 to 2005, price had an inverse impact on fuel consumption.

Future mobility in India will increasingly be met with private cars. The introduction of small and cheap cars such as the new Nano car from Tata group priced at $2,500 is rising rapidly in the Indian market. Multinationals see India as a manufacturing hub for small cars. Sales of vehicles in India have increased very rapidly over the last 15-20 years. Sales data from the society of Indian automobiles manufactures (SIAM, 2007) show that total vehicle sales increased by an annual average rate of 15% over the last five years. The highest increase was in the light to heavy commercial vehicles that grew at an average annual rate of 26%. Growth in commercial vehicles contrasts with trends of diesel consumption that has levelled off between 1998 and 2005. ' [6]

3.2 Economic factors

Suleiman (2009) states that, 'this accelerated growth in the consumption of petroleum products could arguably be attributed to an interplay of some economic and non-economic factors, including an increase in income, energy pricing and taxation policies of Indonesian government, and a high level motorization in big cities such as Jarkata brought by urbanization and consequent rise in the stop of vehicles triggered by an increase in demand for personal mobility. Increase in per capita gross domestic product (GDP) is one of the most import factors in stimulating ownership of personal vehicles, leading to a consequent increase in the transportation sector's demand for petroleum products in Indonesia. Relatively low oil prices are another factor that encourages increase in consumption of oil in Indonesia. Over the years, the prices of petroleum products have been heavily subsidized by the government of Indonesia as a deliberate policy. In addition to economic factors enumerated earlier, structural factors such as population growth and urbanization also play an important role in petroleum consumption in Indonesia. In addition to having the fourth largest population in the world, Indonesia is amongst the countries in south East Asia that witnessed a rapid growth in urban areas because of migration from rural areas to cities.
These factors led to a shift from non-motorized transportation such as walking and cycling to an increase in demand for motorized transportation in these areas. Some studies show that these factors led to a unprecedented price in the stock of vehicles in Indonesia, particularly in Jarkata. ' [9]

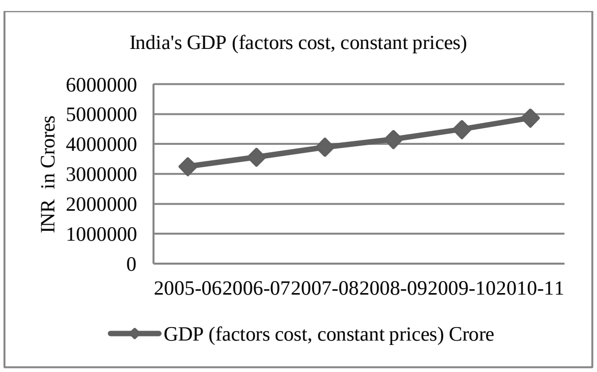

Figure 6. India's GDP at factor cost, constant prices

India's GDP is on growth path as seen above and had an impact on the transport mobility decision of the people. With increased personal mobility vehicle aspiration and positive economic activities, the overall transport sector petroleum product demand also increased steadily as explained earlier (Figure 6).

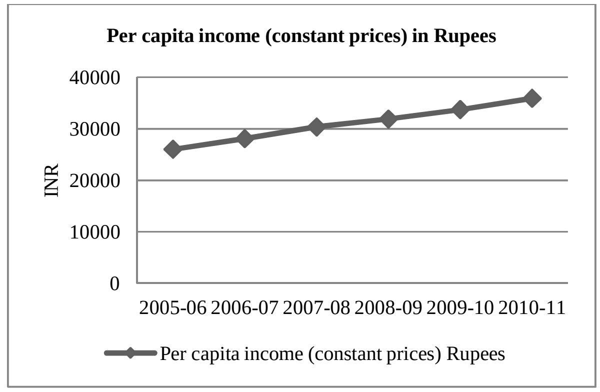

Figure 7. Per capita income at constant price in Rupees of Indians

The similar impact is seen on the per capita income of Indians. Due to increase in the number of people with more disposable income, the personal mobility choice changed and that increased the overall transport petroleum product demand (Figure 7).

3.3 Urbanization and Population growth

India's diverse economy encompasses traditional village farming, modern agriculture, handicrafts, a wide range of modern industries, and a multitude of services. Services are the major source of economic growth. The economy has posted an average growth rate of more than 7% in the decade since 1997, reducing poverty by about 10 percentage points.

As discussed in the international seminar on Fuel Efficiency Standards (2007), 'Transport Sector uses 20% of the worldwide all sector energy consumption and projected to use over 60% of all energy usage by 2025. Due to strong economic activity and high population growth, energy usage in most of the Asian Countries has increased dramatically with major contribution coming from India and China. It has been projected that both these economies put together shall consume 45% of the total world increase in oil by 2025. While China's energy usage for transportation is expected to grow by 6-9% per year, India's demand shall grow by 3%. The emerging Asian economies are net oil importers and any increase in demand puts a pressure on the budget and therefore it becomes imperative that more and more fuel efficient and cleaner technologies are put in place, which can provide both global and local environmental sustainability. ' [10]

3.4 Subsidy on Petrol and Diesel

Coming back to the main issues, it is found that, in the background of the Report of The Expert Group on A Viable and Sustainable System of Pricing of Petroleum Products it is stated that, India's imports of oil are increasing. Our import dependence has reached 80 per cent and is likely to keep growing. At the same time 2008 saw an unprecedented rise in oil price on the world market. Oil price volatility has also increased. Though future oil prices are difficult to predict, they are generally expected to rise. Given our increasing dependence on imports, domestic prices of petroleum products have to reflect the international prices.

When the average monthly price of Indian basket of crude oil on the world market increased from US$ 36 / barrel in May 2004 to US$132.5 / barrel in July 2008, the government did not permit Public Sector Oil Marketing Companies (OMCs) to pass the full cost of imports on to domestic consumers of major oil products, i.e., petrol, diesel, domestic LPG (i.e., LPG used by the households) and PDS kerosene (i.e., Kerosene sold through Public Distribution System of the Government). The consumers of these products thus received large subsidies. As a consequence, OMCs had large under-recoveries, which were financed partly by Government of India, and partly by upstream public sector companies like ONGC, OIL, and GAIL. The OMCs also absorbed a part of the under-recoveries themselves.

These policies had a number of consequences. They put stress on government's finances. They reduced the cash surplus of upstream public sector oil companies restricting their ability for exploration of domestic fields and acquisitions overseas. As the subsidies are received at a later date by the OMC; they created cash flow problems for OMCs who had to borrow from the market, which increased interest payments and reduced their surplus. Since only the OMCs were provided financial support, the private sector companies withdrew from oil marketing. This not only made in fructuous the large investments they had made in setting up retail outlets, it also reduced competition in oil marketing. Subsidizing domestic consumers also did not incentivize them to economize on use of petroleum products. Rather, as prices remained low, and personal incomes rose, the demand for petroleum products such as petrol and diesel recorded double digit growth – higher than the GDP growth. PPAC site (2012) states that the sharp rise and volatility of prices of oil and petroleum products in the international markets since 2004 has become a matter of global concern. The Indian basket of crude oil, which averaged $79.25 per barrel during 2007-08, had gone up to an unprecedented level of $142.04 per barrel on 3rd July 2008 before declining sharply. However, the crude prices have been steadily increasing since December 2008, largely due to the global economic recovery and increase in demand from the emerging economies. The average price of the Indian basket of crude oil for the current financial year 2010-11 (up to 11.11.2010) has been $77.50 per barrel against the average price of $ 69.76 per barrel during 2009-10. [8]

As India imports about 80% of its crude oil requirement, international oil prices play a decisive role in the domestic pricing of sensitive petroleum products. The Public Sector Oil Marketing Companies (OMCs) viz. Indian Oil Corporation Limited, Bharat Petroleum Corporation Limited and Hindustan Petroleum Corporation Limited pay Trade Parity Price to refineries when they buy Diesel, and pay Import Parity Price for PDS Kerosene and Domestic LPG. Accordingly, they ought to fix retail prices based on this cost. However, the retail prices, which are modulated by the Government, are generally lower. The difference between the required price based on Trade Parity / Import Parity and the actual selling price realized (excluding taxes and Dealer's Commission) represents the under-recoveries of OMCs (Table 3).

Table 3. Under recovery

Under recovery in Rs Crore	**2005-06**	**2006-07**	**2007-08**	**2008-09**	**2009-10**	**2010-11**
Petrol	2723	2027	7332	5181	5151	2227
Diesel	12647	18776	35166	52286	9279	34706

3.5 Price of transport fuel

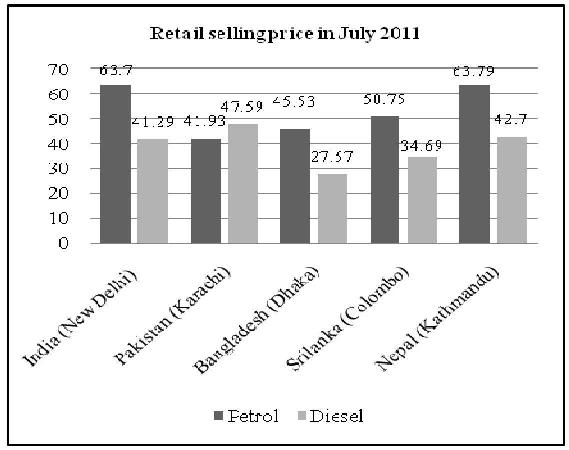

Figure 8. Transport fuel retail selling prices in neighboring countries

The retail price of petrol has been left to the oil companies to decide and as in July 2011, comparison in the above chart shows that in India the price of petrol is the highest. In contrast to petrol the diesel prices are at comparable rates. This only shows that while petrol prices are market driven, the diesel price is protected by the government of India. This is the reason of diesel demand increase over the years. Such a trend is artificial and is not long term. Price benefit in the short term has to end and to assess the demand of transport fuel, like diesel it is necessary to identify the underlying factors rather than any symptomatic remedies.

3.6 Vehicle Population

The Motor vehicles (per 1000 people) in India was 18 in 2009, according to a World Bank report, published in 2010. Motor vehicles include cars, buses, and freight vehicles but exclude two-wheelers. Population refers to midyear population in the year for which data are available (Figure 9). [2]

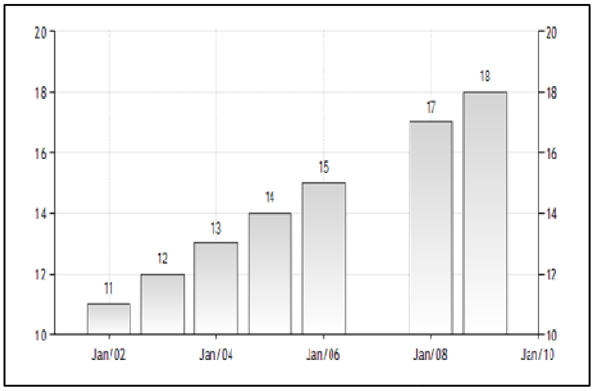

Figure 9. Motor vehicles per thousand people in India

Similarly, the Passenger cars (per 1000 people) in India were 12 in 2009, according to a World Bank report, published in 2010. Passenger cars refer to road motor vehicles, other than two-wheelers, intended for the carriage of passengers and designed to seat no more than nine people including the driver (Figure 10).

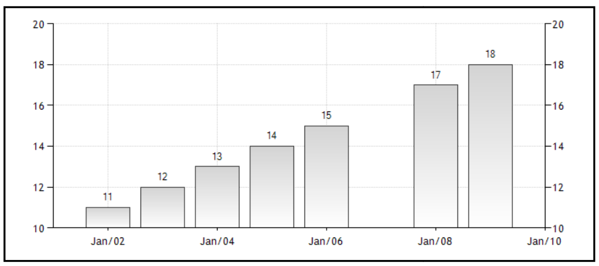

Figure 10. Passenger cars per thousand people in India

The Vehicles (per km of road) in India was reported at 5 in 2008, according to the World Bank. Vehicles per kilometre of road include cars, buses, and freight vehicles but do not include two-wheelers. Roads refer to motorways, highways, main or national roads, secondary or regional roads, and other roads. A motorway is a road specially designed and built for motor traffic that separates the traffic flowing in opposite directions (Figure 11). [2]

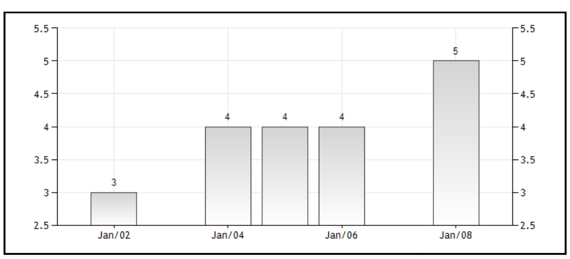

Figure11. Vehicles per kilometre of road in India

In all the cases mentioned above, the indications are that there is an increasing trend in vehicle population and density in India. This means by sheer increase in numbers the demand of transport fuel also will increase. However, such numbers are difficult to ascertain as many sources are showing wide variation. Adding up all types of vehicles and assessing the demand will not be practically possible. There must be an easily implementable solution for the issue at hand.

3.7 Infrastructural development

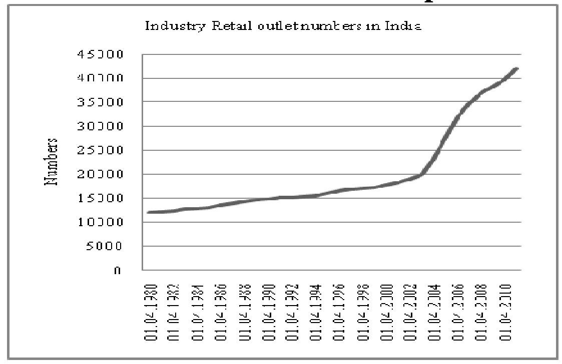

Figure 12. Number of retail outlets in India over the years

Even for transport fuel availability across the country we find in the chart above (figure 12) that from 2004 onward the number of retail outlets grew much higher compared to the earlier period since 1980. Here also, beside the mission to make petroleum available throughout the country, the main driver was the subsidy on the petroleum products. Due to subsidy, the demand for diesel driven vehicles went past the petrol version. By adding up the sales of all the retail outlets also we will not be able to assess the future demand as with the growth in the number of retail outlets, the profitability of individual outlets have become a major issue. As oil companies are now to free to commission their infrastructure, in a reasonably profitable market, while one outlet could suffice, all have marked their presence. This trend cannot continue in the same pace and it is also very difficult to predict the future pace of the growth of the outlets So for a fair assessment of future transport fuel demand, the growth percent of outlets may not be a proper measure.

Lawrence (2009) noted that 'energy consumption in the transport sector currently represents a small share of the total energy consumption in India (15%). However, motorized vehicle ownership is increasing very rapidly as well as the need to transport goods across the country. Car ownership in India remains very low compared to developed countries indicating that the rate of growth will continue to accelerate. Nearly all motorized vehicles necessitate the combustion of petroleum-based fuels. Indian transport accounted for nearly half of petroleum products considered in 2005. The growth in transport demands directly weigh on the country needs for oil imports. Unfortunately, existing energy data do not provide all the information on driving forces behind energy used and sometimes show large inconsistencies. ' [6]

4. Motivation of the study

There are two motivations for this study. First, the rising trends in the consumption of petroleum products in the transportation sector of India and its consequence on the domestic sector provide a good rational to study the demand for petroleum transport fuels. Secondly, no such study has been conducted in the recent past that is based on process driven dynamic model. By process we mean the process of identifying the underlying factors of demand that will vary over the years. It is necessary to understand the major changes in the environment and business process and capture the same in the list of factors before developing the model of demand.

There is a mention of 'processes in the works of Brown and Virmani (2007). In their work, they attempted to answer the divergent views in prices of gasoline and crude oil. 'As everyone knows, gasoline prices have been high in recent years. Most people also understand that the price of gasoline is closely linked to the price of oil. But occasionally, the two diverge. Gasoline prices were rising in the spring of 2007, while oil prices were falling. Later in the year, crude prices were back up, but gasoline prices did not change. So, one might ask, what is it – other than the price of crude oil – that drives U.S. gasoline prices? They examined several other factors that affect gasoline prices and build a succession of econometric models to isolate and quantify the various factors. The first model uses two factors – crude oil prices and gasoline prices – and the authors state that the "model explains nearly 98 percent of U.S. gasoline prices." To explain the other 2 percent, Brown and Virmani (2007) expand their model by adding factors one by one. Thus, for the second model, they add a seasonal component. Empirical data show that demand for gasoline is highest during the summer months, spikes around Thanksgiving and Christmas, and is lowest in February. The second model incorporates this pattern and explains some of the fluctuation between the prices of gasoline and crude oil. Next, the authors look at "aberrations," non- seasonal factors such as Hurricanes Katrina and Rita, which "shut down over a fourth of U.S. refinery capacity and sent gasoline prices sky-rocketing" in 2005. They find that these non-seasonal aberrations have a measurable effect on gasoline prices. Because crude oil prices can vary by region in the short run, the last model incorporates this factor and finds that it too has some effect on the price of gasoline in the United States.' [11]

5. Methodology

5.1 Methods

The research methods followed are both primary and secondary. Under primary method, a survey was planned to identify the factors affecting the demand of petroleum products. With the help of a self designed questionnaire, primary data was collected from around four hundred respondents. The respondents were from across India, with wide ranging experience either in service or business. The reliability of questionnaire was tested through a pilot study. The responses were tabulated and statistically analyzed by SPSS software.

The self designed questionnaire as a tool was used to identify the factors that affect the demand of transport petroleum products. The choice of fuel covered the inputs from availability, quality, price, economic, technological, inter-fuel substitution and environmental aspects. After the responses were tabulated, it was subject to Kaiser-Meyer-Olkin measure of sampling adequacy (NSA) to determine the need to further reduce the factors for more practical and effective assessments. The sampling size of four hundred was found very adequate as a true representation of the population consisting of experienced citizens of India. After the factors were reduced through factor analysis, the demand model was formulated through multiple regression. For multiple regression, secondary data was collected from a number of reliable government and private sources.

Niles (2006), writes in order to have confidence that the survey results are representative, it is critically important that we have a large number of randomly selected participants in the survey group. For a 95% confidence level, which means 5% chance of sample results differing from the true population average, a good estimate of the margin of error or confidence interval is given by $1/\sqrt{N}$ where N is the number of participants or the sample size. With a sample size of four hundred, the margin of error fraction is 0.05 and percentage margin of error is 5%. This is narrow margin of error and survey of four hundred randomly selected participants is well accepted for having confidence in the results. [12]

5.2 Process

The potential benefit of petroleum transport fuel demand lies in the realm of decision making so as to exert control over environment and infrastructure capacity in the country. Transport fuels are a vital input to both passenger and freight mobility. The demand for it is growing at an increasing rate from an ever expanding set of diverse vehicles. This in turn places increasing demands on infrastructure, environment protection, technology and manpower. Accessing the consumption needs has thus become a significant element of the planning exercise in the petroleum sector. Therefore, it is of great importance that the underlying factors are judiciously identified. If the basic factors become erroneous both infrastructure and capital investment will be imbalanced. This could affect the oil companies and the economy of the country.

Md. Muassam et al (2008) noted that, 'There is an array of methods available today for demand forecasting. An appropriate method is to be chosen on the basis of availability of the data (frequency, cross section, time series, panel data, etc.) and the desired nature of the forecasts. In the past, linear extrapolations of historical energy consumption trends worked well. However with a changing lifestyle, structural breaks in the economy and the evolution of complex energy-economy linkages, it has become imperative to use other modelling techniques, which capture the effects of factors such as prices, income, population, inter-fuel substitution, technology and other economic, demographic, policy and technological variables. The process of specifying a forecasting model involves (1) selecting the variables to be included, (2) selecting the form of the equation of relationship, and (3) estimating the values of the parameters in that equation. After the model is specified, (4) its performance characteristics should be verified or validated by comparison of its forecasts with historical data for the phenomenon it was designed to forecast. Although the forecasting analyst might simply guess at the optimal form of the equation of relationship and the likely values of the parameters, both the equation form and the parameters values can usually be estimated more accurately with reference to historical data for the phenomenon. Thus, an historical data base is useful both to the specification and to the validation phases of model construction.' [13]

5.3 Selecting the variables to be included

Interpretation of the SPSS output of petrol (Motor Sprit - MS)

Robin Beaumont (2012), in an introduction to Principal Component Analysis & Factor Analysis writes, 'all factor analysis techniques try to clump sub groups of variables together based upon their correlations. Besides looking at the correlations, one can also consider some other matrices that the various statistical computer programme produce.

First the Barlett's test of Sphericity and Kaiser-Meyer-Olkin measure of sampling adequacy (MSA) was carried out. The Bartlett test of Sphericity compares the correlation matrix with a matrix of zero correlations, or the identity matrix, which consists of all zeros except the one's along the diagonal. From the test we are looking for a small p value indicating that it is highly unlikely for us to have obtained the observed correlation matrix from a population with zero correlation. The MSA does not produce a p value but we are aiming for a value between 0.5 to 0.8. [14]

Table 4. KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.781
Bartlett's Test of Sphericity	Approx. Chi-Square	1295.730
	Df	78
	Sig.	.000

It is observed that good values are there for all variables for the MSA, with the overall value of 0.781. The Barlett's test of Sphericity has an associated p value, shown as significance of less than 0.001 as by default SPSS reports p values less than 0.001 as 0.000. Hence from the above results, valid factor analysis can be performed.(Table 4). The interpretation of the SPSS output are explained and factors identified based on 'Marketing Research Text and Cases' by Rajendra Nargundkar. [15]

The first step in interpreting the output is to look at the factors extracted, their Eigen values and their cumulative percentage of variance (Table 5 in Annexure).

It is observed that the 'cumulative %' column under 'Total variance explained' table that the seven (7) factors extracted together account for 78.2% of the total variance (information contained in the original thirteen (13) variables). This is a pretty good bargain, because it is able to economize on the number of variables (from 13 the reduction is to 7 underlying factors), while about 21.8 percent of the information content is lost (78.2 percent retained by the 7 factors extracted out of the 13 original variables). Now the second task which follows is that of interpreting what these 7 extracted factors represent. This can be accomplished by looking at Tables 7 and 6 (both in Annexure), the rotated and un-rotated factor or component matrices. Looking at Table 7, the rotated factor matrix, we noticed that variable numbers 2, 5, 7 and 8 have loading of 0.850, 0.811, 0.663 and 0.610 on component 1 (we look down the component 1 column in Table 6 and look for high loadings closed to 1.00).

This suggests that component 1 is a combination of these four original variables. Table 5 also suggests similar grouping. Therefore, there is no problem interpreting factor or component 1 as a combination of 'Price of Compressed Natural Gas (CNG) per kg' (variable 2), 'Number of vehicles on CNG' (variable 5) 'Growth of number of vehicles on CNG' (variable 7), and 'Efficiency of vehicles in terms of kilometer per kg of CNG' (variable 8).

At this point, the researcher's task is to find a suitable phrase, which captures essence of the original variables which continues to form the underlying concept of the 'Factor or Component'. In this case, the factor or component 1 could be named 'Substitution by Compressed Natural Gas (CNG)' represented by the most prominent variable, that is variable 2 or 'Price of Compressed Natural Gas (CNG) per kg'. So, for this analysis the factor 1 will be represented as 'Price of CNG per kg' in subsequent steps.

Now we will attempt to interpret factor or component 2. We look at Table 7, down the column for component 2 and find variable 1 and variable 6 have high loadings of 0.654 and 0.854 respectively. This indicates that factor 2 is a combination of these two variables. We will continue with the loading on variable as in Table 7 for component 2 as they indicate the effect of price of petrol or motor spirit (MS) affecting the growth of petrol vehicles.

For interpreting factor 3, we look at the column 3 labeled components 3 in Table 7 and find that variable 3 and variable 4 are loading high on factor or component 3. According to the un-rotated factor matrix of Table 6, only variable 3 loads high on factor 3. Supposing we stick to Table 7 then the combination of 'Availability of CNG' and 'Number of vehicles on MS' could be 'Number of Outlets of CNG'.

For component 4 to 7, only one variables loads high on each factor. So, the variables that load high on specific component is retained. Like 'Gross Domestic Product or GDP' loads high on component or factor 4. 'Efficiency of vehicles in terms of kilometer per litre of MS' loads high on factor 5. 'Per capita income' loads high on factor 6 and 'Emission norms of Sulphur' loads high factor 7.

So the final factors identified through factor analysis are 7 in number out of the 13 variables and they will be used for further analysis in the following names and variable representation (Table 8).

Table 8. Petrol demand factors identified through factor analysis

	Factor Name	Combining original variable numbers
1	Price of CNG per kg	2,5,7 & 8
2	Price of MS per litre	1 & 6
3	Number of CNG outlets	3 & 4
4	Gross Domestic Product (GDP)	12
5	Efficiency of MS vehicle	9
6	Per capita income	13
7	Emission norms of Sulphur	11

Theoretically, all seven factors are meaningful and explain the major factors that influence demand of motor spirit. However, factor 5, in terms of efficiency will have host of values with respect to different type of cars. The brand of cars will determine its fuel efficiency. To find out a single variable representing the efficiency of all the various models will be out of scope of this research. So, it is prudent to specify the efficiency of the cars sold maximum in the country and we specify Maruti 800 and now Maruti Alto as the benchmark efficiency for subsequent analysis.

For 'Emission Norms of Sulphur', we will consider the MS specification IS 2796 value over the years specified by Bureau of Indian Standards. This will include the period before Implementation of Auto Fuel Policy in India to at present when Bharat Stage III and IV have been implemented. This will not affect the fact of definition as for both the III and IV stage the Sulphur emission maximum limit has been kept the same.

The final list of factors used for subsequent analysis will read as below (Table 9).

Table 9. Final list of petrol demand factors

	Factor Name	Combining original variable numbers
1	Price of CNG per kg	2,5,7 & 8
2	Price of MS per litre	1 & 6
3	Number of CNG outlets	3 & 4
4	Gross Domestic Product (GDP)	12
5	Efficiency of Martui 800 and Alto	9
6	Per capita income	13
7	Emission norms of Sulphur as in IS 2796	11

Interpretation of the SPSS output of diesel (High Speed Diesel - HSD)

Barlett's test of Sphericity and Kaiser-Meyer-Olkin measure of sampling adequacy (MSA) for diesel was carried out.

Table 10. KMO and Bartlett's Test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.689
Bartlett's Test of Sphericity	Approx. Chi-Square	681.381
	df	55
	Sig.	.000

The overall value of MSA is 0.689 and is acceptable. The Barlett's test of Sphericity is highly significant with a 'p' value of less than 0.001 and indicated in the report as 0.000. The above results indicates that we can now continue and perform a valid factor analysis (Table 10). The interpretation of the SPSS output for diesel is also explained and factors identified based on 'Marketing Research Text and Cases' by Rajendra Nargundkar. [15]

In the first step observe at the factors extracted, their Eigen values and their cumulative percentage of variance (Table 11 in Annexure).

It is observed that the 'cumulative %' column under 'Total variance explained' table that the four (4) factors extracted together account for 60.0% of the total variance (information contained in the original eleven (11) variables). This is a pretty good bargain, because it is able to economize on the number of variables (from 11 the reduction is to 4 underlying factors), while about 40 percent of the information content is lost (40 percent retained by the 4 factors extracted out of the 11 original variables).

Now the second task which follows is that of interpreting what these 4 extracted factors represent. It can be accomplished by looking at Tables 12 (in Annexure), the rotated factor or component matrices.

Looking at Table 12, the rotated factor matrix, it is noticed that variable numbers 4, 5, 6 and 8 have loading of 0.770, 0.609, 0.728 and 0.719 on component 1 (we look down the component 1 column in Table 12 and look for high loadings closed to 1.00).

This suggests that component 1 is a combination of these four original variables. Therefore, there is no problem interpreting factor or component 1 as a combination of 'Number of diesel run Rail locomotives' (variable 4), 'Number of fishing boats ' (variable 5) 'Number of ships using diesel for DG sets' (variable 6), and 'Addition of new Railway engine on diesel' (variable 8). Identify a suitable phrase, which captures essence of the original variables which continues to form the underlying concept of the 'Factor or Component'. In this case, the factor or component 1 could be named 'Number of rail locomotive and ships on diesel'. So, for this analysis the factor 1 may be represented as 'Number of rail locomotive and ships on diesel' in subsequent steps.

To interpret factor or component 2, observe Table 12, down the column for component 2 and find variable 2, variable 7, variable 9 and variable 11 have high loadings of 0.511, 0.591, 0.690 and 0.744 respectively. This indicates that factor 2 is a combination of these four variables. The loading on variable as in Table 12 for component 2 indicate the effect of comparative price of diesel affecting the choice of energy and vehicle. This factor is best reflected by variable number eleven that is 'Subsidy on HSD'. For the analysis, factor 2 will be represented as 'Subsidy on HSD'. Retain Factor 3, 'number of diesel run vehicles', as it is due to its high loading of 0.824.

For interpreting factor 4, take a look at the column 4 labeled components 4 in Table 12 and find that variable 1 and variable 10 are loading high on factor or component 4. The combination of 'Price of HSD' and 'Efficiency of vehicles in terms of kilometer per litre' could be represented as 'Price of HSD'.

So the final factors identified through factor analysis are 4 in number out of the 11 variables and they will be used for further analysis in the following names and variable representation (Table 13).

Table 13. Diesel demand factors identified through factor analysis

	Factor Name	**Combining original variable numbers**
1	Number of Rail locomotives and ships on diesel	4,5,6,8
2	Subsidy on HSD	2,7,9, 11
3	Number of diesel run vehicles	Retained
4	Price of HSD	1, 10

Theoretically, all four factors are meaningful and explain the major factors that influence demand of motor spirit. However, factor 1, in terms of number of rail locomotives and ships on diesel are difficult to assess authentically and is not practical. However, both are impacted due to an economic factor i.e. IIP or Index of Industrial Production. With the increase or decrease of economic activities, the Railway and water ways activities are influenced and are captured in the index of industrial production. This is a published data and can suitably replace the identified factor 'Number of Rail locomotives and ships on diesel' with 'Index of Industrial Production'.

The final list of factors used for subsequent analysis of diesel will read as below (Tale 14)

Table 14. Final list of diesel demand factors

	Factor Name	Combining original variable numbers
1	Index of Industrial Production	4,5,6,8
2	Subsidy on HSD	2,7,9, 11
3	Number of diesel run vehicles	Retained
4	Price of HSD	1, 10

6. Model formulation for petrol demand function

The SPSS correlation and regression output is reported on 'Marketing Research Text and Cases' written by Rajendra Nargundkar. Correlation and regression are performed together. The main objective of regression analysis is to explain the variation in one variable based on the variation in other variables. A pre-conceived approach to regression through a survey, is taken. First observe the correlation of all the variables with petrol sales and each other. Looking at the first column, it is found that except for 'Emission norms of Sulphur as in IS 2796', all other variables have high positive correlation ranging from 0.833 to 0.986 with historical Petrol sales. Only the 'Emission norms of Sulphur as in IS 2796' has a strong negative correlation of -0.880 with petrol historical sales.

This means a fairly good set of independent variables are chosen namely, Price of CNG per kg, Price of MS per litre, Number of CNG outlets, Gross Domestic Producg(GDP), Efficiency of Maruti 800, Alto and Per Capita Income and Emission norms of Sulphur as in IS 2796 (Table 15 in Annexure).

The other point to be noted in the correlation table is whether independent variables are highly correlated with each other. Like in Table 15, this may indicate that the variables are not independent of each other. Hence eliminate some independent variables by approaching step wise process (Table 16 in Annexure).

The results (output) of this step wise regression model are shown in Table 17 (in Annexure). Column 3 of the table, titled 'B' lists all the coefficients for the model. Parameters that best explain the most suitable model will be used.

Table 18: Model Summary[e]

Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**	**Durbin-Watson**
4	1.000[d]	1.000	1.000	49.334	2.198

a. Predictors: (Constant), Gross Domestic Product (GDP), constant price, factor cost

b. Predictors: (Constant), Gross Domestic Product (GDP), constant price, factor cost , Per capita income, NNP at factor cost

c. Predictors: (Constant), Gross Domestic Product (GDP), constant price, factor cost , Per capita income, NNP at factor cost , Price of MS per litre

d. Predictors: (Constant), Gross Domestic Product (GDP), constant price, factor cost , Per capita income, NNP at factor cost , Price of MS per litre, Price of CNG per kg

e. Dependent Variable: MS-R

The analysis of variance table, Table 19 indicates the p-level to be 0.000. This indicates that the model is statistically significant at a confidence level of (1-0.000) x 100 or nearly 100%. The p-level indicates the significance of F value.

Table 19: ANOVA[a]

Model		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
4	Regression	51861799.203	4	12965449.801	5327.159	.000[e]
	Residual	12169.197	5	2433.839		
	Total	51873968.400	9			

a. Dependent Variable: MS-R

b. Predictors: (Constant), Gross Domestic Product (GDP), constant price, factor cost

c. Predictors: (Constant), Gross Domestic Product (GDP), constant price, factor cost , Per capita income, NNP at factor cost

d. Predictors: (Constant), Gross Domestic Product (GDP), constant price, factor cost , Per capita income, NNP at factor cost , Price of MS per litre

e. Predictors: (Constant), Gross Domestic Product (GDP), constant price, factor cost , Per capita income, NNP at factor cost , Price of MS per litre, Price of CNG per kg

From Table 20 (in Annexure) of 'Coefficients', it is noted that t-tests for significance of individual independent variables indicate that all the four identified variables are statistically significant in the model. In the model the independent variables 'Gross Domestic Product' , 'Per Capita Income' , 'Price of MS per litre' and 'Price of CNG per kg' have a significance of 0.000, 0.001, 0.000 and 0.014 respectively.

The equation we have obtained is with the following coefficients,

a (intercept) = 7956
b1 (x4) = 0.012
b2 (x6) = -1.363
b3 (x2) = -93.478
b4 (x1) = 45.243

These values can be used to form a model, for MS sales prediction,

Petrol sales = 7956 + 0.012 (GDP) – 1.363 (Per Capita Income) – 93.478 (Price of MS per litre) + 45.243 (Price of CNG per kg)

The equation we have obtained means, in effect, that sales will increase with the increase in GDP, and Price of CNG per kg. While has a negative correlation with Per Capita Income and Price of MS per litre. Only the coefficient b2 for the factor x6 i.e. Per Capita Income has a negative correlation with sales does not make too much intuitive sense. It only states that at this point of time increase in per capita income may not result in buying more petrol or petrol driven vehicle and the customer will switch to alternative high priced vehicle using other substitute low price fuel. With more money in the hands of the people as indicated in the increase in per capita income, the aspiration will be to switch over to a low recurring cost alternative fuel like CNG or subsidized HSD.

From the 7 factors identified through factor analysis, by step wise regression it could end up with only 4 factors which can explain over 99.99 percent of the variance in the dependent variable as petrol sales.

The regression equation is judged for its usefulness based on,

1. The overall F- test for the model. In this case, it is significant at 99.99 percent confidence level. This indicates that the model is good overall. This shows up as a p-value of 0.000 on the ANOVA table (Table 12) in the regression output.
2. The variables in the model are good explanatory variables of the dependent as the individual t-test for each variable is significant and less than 0.05.
3. The R2 value 1.000 of the model tells us that 99.9 percent of the variation in the dependent variable is explained by all the independent variables in the model.

7. Model formulation for diesel demand function

Looking at the correlation of all the variables with diesel sales and each other, it is found that all variables have high positive correlation with diesel historical sales. Hence, a fairly good set of independent variables are chosen namely, Index of Industrial Production, Subsidy on HSD, Number of diesel run vehicles and Price of HSD.

There are a number of diesel run vehicles. To understand which type of vehicle has a greater impact, we did the regression with number of diesel run vehicles broken up into segments like passenger vehicles, commercial vehicles and three wheelers. The published data of SIAM gives information regarding the above segmentation. However, published data on type of fuel used in such vehicles were not found. To overcome this, we have assumed that 60% of passenger cars, 100% commercial vehicles and 90% of three wheelers consume diesel. Moreover rather than sale of the three categories of vehicles we have used the production numbers of all three type of vehicles. The production numbers are more accessible and historical references are readily available. The results (output) of the step wise regression model are shown in Table 21. Column 3 of the table, titled 'B' lists all the coefficients for the model.

Table 21: Coefficients[a]

Model		**Unstandardized Coefficients**		**Standardized Coefficients**	**t**	**Sig.**
		B	Std. Error	Beta		
2	**(Constant)**	28071.247	1472.726		19.061	.000
	Passenger Vehicles	.030	.005	1.504	6.562	.000
	Commercial Vehicles	-.027	.011	-.559	-2.441	.045

a. Dependent Variable: HSD TMT

It is found that there are only two significant independent variables, namely, number of passenger vehicles and commercial vehicles. Looking at the statistical significance of the model and the R^2 value, it is evident from the model summary in Table 22 that the R^2 is 0.958.

Table 22: Model Summary

Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**	**Change Statistics**				
					R Square Change	**F Change**	**df1**	**df2**	**Sig. F Change**
2	.984[b]	.968	.958	1776.98415	.028	5.958	1	7	.045

a. Predictors: (Constant), Passenger Vehicles

b. Predictors: (Constant), Passenger Vehicles, Commercial Vehicles

The analysis of variance table in Table 23 indicates the p-level is 0.000. This indicates that the model is statistically significant at a confidence level of (1-0.000) x 100 or nearly 100%. The p-level indicates the significance of F value.

Table 23. ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
2	Regression	661426841.774	2	330713420.887	104.733	.000[c]
	Residual	22103708.626	7	3157672.661		
	Total	683530550.400	9			

a. Dependent Variable: HSD-R TMT
b. Predictors: (Constant), Passenger Vehicles
c. Predictors: (Constant), Passenger Vehicles, Commercial Vehicles

From Table 14 of 'Coefficients', we also note that t-tests for significance of individual independent variables indicate that the identified variables is statistically significant in the model.

The equation we have obtained is with the following coefficients,
a (intercept) = 8071.247
b1 = 0.30
b2 = -0.027
Using the values the model suggested for HSD sales prediction,
HSD sales = 28071.247 + 0.30(Passenger Vehicle) – 0.027(Commercial Vehicle)

The number of passenger vehicles produced tends to overestimate the diesel sale prediction. This overestimation of prediction is balanced by the commercial vehicle production numbers. This is the reason why the passenger vehicle has a positive coefficient while the commercial vehicles have a negative coefficient.

From an identified 7 factors through factor analysis, by step wise regression we could end up with only 4 factors which can explain over 99.99 percent of the variance in the dependent variable as petrol sales. Here we find that though the survey indicated 11 factors, the factor analysis suggested only 4 variables. On step wise regression, out of the 4 variables, only one i.e. the number of diesel run vehicles was found to be significant and the other three namely Index on Industrial Production, Subsidy on diesel and Price of HSD were not significant. On segmenting the overall diesel run vehicles into passenger, commercial and three wheelers in the step wise regression, it was found that passenger vehicles and commercial vehicles have significant relation in predicting the diesel sales. This is rightly so as the choice of fuel by passengers are governed by the differential price between petrol and diesel in the market. Petrol prices being considerably higher compared to diesel, the obvious choice of diesel as a passenger car fuel is seen from the number of diesel run vehicles sold in the market.

While subsidy on diesel appears to be a logical decision making argument for using diesel as a fuel, the regression shows that in the mind of the customer this does not play any role. In the mind of the customer, it is the apparent price difference between petrol and diesel that motivates higher diesel passenger car sales. Though the Index of Industrial Production is a important parameter observed through the survey for affecting the overall activity of the industry leading to higher goods and services, while determining the HSD sales, it is not significant. Price of HSD also does not have any effect on sale of diesel as the proliferation of CNG in the country is not significant and in most of the areas barring the metro and larger cities, the availability of CNG is an issue. This makes diesel a non-replaceable fuel, which is essential for their survival without any choice of selection. Due to the above, all the three other parameters have low correlation with diesel sale prediction.

Validation of the models

The parameters those were valid in 2011-12 in relation to the petrol sales prediction are considered. This is the actual situation used for validation of the model. In 2011-12 the relevant independent variables are shown in Table 24.

Table 24. Data for the year 2011-2012

Price of CNG per kg	**Price of MS per litre**	**Gross Domestic Product (GDP), constant price, factor cost**	**Per capita income, NNP at factor cost**
Rs/Kg	Rs/litre	Rs Crore	Rs
33.75	64.42	5202514	37851

Using the model identified for petrol sale prediction,
Petrol sales = 7956 + 0.012 (GDP) – 1.363 (Per Capita Income) – 93.478 (Price of MS per litre) + 45.243 (Price of CNG per kg)

Predicted value of MS-R for year 2011-12 is 14300.35 as against actual observed value of 14862. The error in prediction is 3.78% under-estimated. Similarly for diesel, the parameters valid in 2011-12, namely production of passenger and commercial vehicles run on diesel are shown in Table 25.

Table 25. Model outcome

Passenger Vehicles (60%)	Commercial Vehicles(100%)
Number	Number
1874117	911574

Using the model identified for diesel sale prediction,
HSD sales = 28071.247 + 0.30(Passenger Vehicle) – 0.027(Commercial Vehicle),
The predicted value is 59682.26 of diesel sale in 2011-12 as against actual observed value of 64680. The error is 7.71% under-estimated.

8. Conclusion

The objective of the paper was to gain insight in the demand of petroleum products in the transportation sector in India and suggest a process driven dynamic model. The survey conducted clearly brought out the underlying factors of demand. The dynamic change in the environment and business process will be the base for identifying the initial factors and that need to be incorporated through industry experience, contemporary literatures from the Government of India and other reliable private publication and an independent survey. The survey is to be an integral part of the process and will be carried out after major environmental changes in the transportation sector of India. The effects can be major policy changes like the auto fuel policy, environmental policy restricting liquid fuel use in some area and so on. What is suggested is an open information channel to capture changes that impact the transport sector in India and be alive to consider them through a suitable factor. This is both and art and a science. The subsequent research in this area will have to bear this in mind.

The two models suggested have very high adjusted R square value and individual factors also are very significant. On validating the model for the year 2011-12, it was within acceptable errors. Both the objectives were met with qualitative and quantitative methods keeping in mind the relevance of present environment guiding the transportation sector in India. In future research, a composite efficiency factor may be identified to represent all vehicles using motor spirit or diesel.

References

[1] Chaturvedi G.C, Narasimha Raju D.N, Gupta L.N, Kumar V, Dr Mathur Archana S, Dr Mohanty B, “Report of the Working Group on Petroleum and Natural Gas Sector for the 12th Five Year Plan (2012 – 2017)”, Government of India, Ministry of Petroleum and Natural Gas, Chapter – 5, 5.1 Introduction, pp 33, November 2011

[2] Trading Economics/New York City/Lisboa, http://www.tradingeconomics.com/india/road=sec, 26-11-2013

[3] Parikh Kirit S, “Report of the Expert Group on A Viable and Sustainable System of Pricing of Petroleum Products”, New Delhi, GOI, 02-02- 2010

[4] Arora AK, “ Petroleum Federation of India”, New Delhi, forward, Page ii., 24-08- 2006

[5] Government of India, Ministry of Petroleum & Natural Gas, http://www.petroleum.nic.in/reports.htm, India Hydrocarbon vision 2025, introduction, 19-08-2013

[6]Lawrence Ernest Orlando, “Residential and transport energy used in India: past trend and future outlook, Berkeley National Laboratory , pp18- 28, January 2009

[7] Centre for science and environment, “Response to the estimate of diesel consumption in private cars used in the Planning Commission note on Emissions from use of Fuels in Transport Sector and Improving its Quality to BS V & BS VI Standards”, GOI, New Delhi, India, pp3, 20-01- 2012

[8] Petroleum Planning & Analysis Cell, (PPAC) (Ministry of Petroleum & Natural Gas, Government of India), www.ppac.org.in, 18-10-2013

[9] Saad Suleiman, “Transportation demand for petroleum products in Indonesia: a time series analysis”, Organization of the Petroleum Exporting Countries, Energy Review June 2009, Journal Compilation pp140-154, 2009

[10]PCRA ,“Transport Sector Going Green”, International Seminar on Fuel efficiency standards and labelling of vehicles in India, MOP&NG, GOI, pp1, 2007

[11]Monthly Labor review, http://www.bls.gov/opwb/mlr/2008/11/precis.pdf Bureau of Labor Statistics, Washington DC, 26-11-2013

[12] Robert Niles.com, http://www.robertmiles.com/stats/, 26-11-2013

[13]Md. Muassam and Bhupinder Singh, Deputy Directors, Central Electricity Authority, “Demand Forecasting, Urjavaran,”, August – September, 2008

[14] Robin Beaumont, “An introduction to Principal Component Analysis & Factor Analysis using SPSS 19 and are (Psych package)”, Monday, 23-04-2012, Clause 3.2, pp6.

[15] Nargundkar Rajendra, Marketing Research Text and Cases, third edition, Tata McGraw-Hill, 2008

Annexure

Table 5. Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.840	29.537	29.537	3.840	29.537	29.537	2.498	19.214	19.214
2	1.629	12.533	42.070	1.629	12.533	42.070	1.499	11.532	30.747
3	1.342	10.320	52.391	1.342	10.320	52.391	1.491	11.469	42.216
4	1.042	8.014	60.404	1.042	8.014	60.404	1.224	9.413	51.629
5	.864	6.647	67.051	.864	6.647	67.051	1.217	9.359	60.988
6	.744	5.721	72.772	.744	5.721	72.772	1.146	8.814	69.802
7	.708	5.447	78.218	.708	5.447	78.218	1.094	8.416	**78.218**
8	.619	4.764	82.982						
9	.584	4.494	87.477						
10	.511	3.928	91.405						
11	.420	3.231	94.636						
12	.379	2.918	97.553						
13	.318	2.447	100.000						

Extraction Method: Principal Component Analysis.

Table 6. Component Matrix (a)

	Component						
	1	2	3	4	5	6	7
Price of MS per liter	.610		-.488				
Price of Compressed Natural Gas (CNG) per kg	.669						
Availability of CNG	.449		.635				
Number of Vehicles on MS		.526					
Number of vehicles on CNG	.679						
Growth of number of vehicles on MS	.426	.581					
Growth of number of vehicles on CNG	.677						
Efficiency of vehicles in terms of kilometer per kg of CNG	.682						
Efficiency of vehicles in terms of kilometer per liter of MS	.484	.461					
Emission norms of Benzene	.563			.570			
Emission norms of Sulphur	.407		-.483		.404		.539
Gross Domestic Product (GDP)	.587					-.729	
Per Capita Income		.540			.526		

Extraction Method: Principal Component Analysis.
a 7 components extracted.

Table 7. Rotated Component Matrix(a)

	Component						
	1	2	3	4	5	6	7
Price of MS per litre		.654					
Price of Compressed Natural Gas (CNG) per kg	.850						
Availability of CNG			.769				
Number of Vehicles on MS			.722		.418		
Number of vehicles on CNG	.811						
Growth of number of vehicles on MS		.854					
Growth of number of vehicles on CNG	.663						
Efficiency of vehicles in terms of kilometer per kg of CNG	.610						
Efficiency of vehicles in terms of kilometer per liter of MS					.796		
Emission norms of Benzene				.426		-.531	
Emission norms of Sulphur							.959
Gross Domestic Product (GDP)				.912			
Per Capita Income						.849	

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.
a Rotation converged in 10 iterations.

Table 11. Total Variance Explained

Total Variance Explained									
Component	Initial Eigen values			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.684	24.403	24.403	2.684	24.403	24.403	2.365	21.500	21.500
2	1.548	14.070	38.473	1.548	14.070	38.473	1.695	15.410	36.910
3	1.281	11.644	50.117	1.281	11.644	50.117	1.334	12.126	49.035
4	1.090	9.909	60.025	1.090	9.909	60.025	1.209	10.990	60.025
5	.847	7.704	67.729						
6	.782	7.105	74.835						
7	.726	6.599	81.434						
8	.620	5.635	87.069						
9	.570	5.184	92.253						
10	.461	4.187	96.440						
11	.392	3.560	100.000						

Extraction Method: Principal Component Analysis.

Table 12. Rotated Component Matrix (a)

Rotated Component Matrix[a]				
	Component			
	1	2	3	4
Price of HSD				.772
Cost of power generated by DG sets	.376	.511	-.511	
Number if diesel run vehicles			.824	
Number of diesel run railways locomotives	.770			
Number of fishing boats	.609			
Number of ships using diesel for DG sets	.728		.307	
Growth of diesel run vehicles		.591	.396	
Addition of new Railway engine on diesel	.719			
Availability of power		.690		
Efficiency of vehicles in terms of kilometer per liter				.753
Subsidy on HSD		.744		

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.[a]

a. Rotation converged in 5 iterations.

Table 15. Correlation

Pearson Correlation	MS-R	Price of CNG per kg	Price of MS per litre	Number of CNG outlets	Gross Domestic Product (GDP), constant price, factor cost	Efficiency of Martui 800 and Alto	Per capita income, NNP at factor cost	Emission norms of Sulphur as in IS 2796
MS-R	1	0.907	0.904	0.965	0.986	0.833	0.981	-0.88
Price of CNG per kg	0.907	1	0.774	0.813	0.853	0.86	0.841	-0.698
Price of MS per litre	0.904	0.774	1	0.967	0.955	0.589	0.957	-0.931
Number of CNG outlets	0.965	0.813	0.967	1	0.989	0.712	0.99	-0.918
Gross Domestic Product (GDP), constant price, factor cost	0.986	0.853	0.955	0.989	1	0.749	1	-0.931
Efficiency of Maruti 800 and Alto	0.833	0.86	0.589	0.712	0.749	1	0.735	-0.584
Per capita income, NNP at factor cost	0.981	0.841	0.957	0.99	1	0.735	1	-0.935
Emission norms of Sulphur as in IS 2796	-0.88	-0.698	-0.931	-0.918	-0.931	-0.584	-0.935	1

Table 16. Corelation (one tailed)

Sig. (1-tailed)	MS-R	Price of CNG per kg	Price of MS per litre	Number of CNG outlets	Gross Domestic Product (GDP), constant price, factor cost	Efficiency of Martui 800 and Alto	Per capita income, NNP at factor cost	Emission norms of Sulphur as in IS 2796
MS-R	.	0	0	0	0	0.001	0	0
Price of CNG per kg	0	.	0.004	0.002	0.001	0.001	0.001	0.012
Price of MS per litre	0	0.004	.	0	0	0.037	0	0
Number of CNG outlets	0	0.002	0	.	0	0.01	0	0
Gross Domestic Product (GDP), constant price, factor cost	0	0.001	0	0	.	0.006	0	0
Efficiency of Martui 800 and Alto	0.001	0.001	0.037	0.01	0.006	.	0.008	0.038
Per capita income, NNP at factor cost	0	0.001	0	0	0	0.008	.	0
Emission norms of Sulphur as in IS 2796	0	0.012	0	0	0	0.038	0	.

Table 17: Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Zero-order	Partial	Part	Tolerance	VIF
4	(Constant)	7956.681	1017.315		7.821	.001					
	Gross Domestic Product (GDP), constant price, factor cost	.012	.001	4.192	10.561	.000	.986	.978	.072	.000	3357.601
	Per capita income, NNP at factor cost	-1.363	.177	-2.985	-7.708	.001	.981	-.960	-.053	.000	3197.496
	Price of MS per litre	-93.478	7.580	-.301	-12.332	.000	.904	-.984	-.084	.079	12.676
	Price of CNG per kg	45.243	12.128	.077	3.730	.014	.907	.858	.026	.111	9.009

a. Dependent Variable: MS-R

The statistical significance of the model and the R^2 value are observed. It is evident from the model summary in Table 18 that the R^2 is 0.999.

Table 20: Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Zero-order	Partial	Part	Tolerance	VIF
4	(Constant)	7956.681	1017.315		7.821	.001					
	Gross Domestic Product (GDP), constant price, factor cost	.012	.001	4.192	10.561	.000	.986	.978	.072	.000	3357.601
	Per capita income, NNP at factor cost	-1.363	.177	-2.985	-7.708	.001	.981	-.960	-.053	.000	3197.496
	Price of MS per litre	-93.478	7.580	-.301	-12.332	.000	.904	-.984	-.084	.079	12.676
	Price of CNG per kg	45.243	12.128	.077	3.730	.014	.907	.858	.026	.111	9.009