Fuel Demand in Pakistan's TRansport Sector

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Abstract

Road transport is playing a leading role in the economic activities of Pakistan. For net oil importers like Pakistan, an analysis of future fuel requirements is crucial given the uncertainties involved in fuel supply and price in the international market. The study estimate demand for petrol and diesel in the road transport of Pakistan for the period 1971-72 to 2016-17. Using these demand estimates, it forecasts demand for these two products up to 2024-25 under different scenarios of economic growth and petroleum product pricing. On average the study finds a growth of about 12.5 percent in the demand for petrol and about 9.6 percent in the demand for diesel in the road transport of Pakistan. Findings suggest careful planning to ensure sufficient supplies to meet future demand for petroleum products.

Keywords: Petroleum Products, Demand, Transport, Forecast
JEL Classification: C53, Q41, Q47, R49

1. Introduction

Transport contributes directly and indirectly to economic growth by connecting production markets to consumption markets and by facilitating the travel of populace. Concurrently, transport is one of the major consumer of petroleum products. For an oil importing country, a significant proportion of export earnings is required for importing crude oil and petroleum products, which otherwise could have been utilized in other productive and development activities.

[1] The author alone is responsible for any error or omission in the paper.

Pakistan is a net importer of oil and its products. Beyond that, transport is the second largest user of energy after industry and accounts for about 34 percent of total final energy consumption and almost 59 percent of liquid fuel consumption in Pakistan. That is, air, sea and road transport account for more than half of oil consumption (59 percent) followed by power sector (32 percent) and industry (8 percent)[2]. As reported in Pakistan Vision 2025[3], transport contributes about 10 per cent to the GDP, employs over 6 percent of labour force in the country and accounts for approximately 15 per cent of the Public Sector Development Projects (PSDPs). Road transport is the mainstay of Pakistan's transportation system, and accounts for 96 percent of all passenger and freight traffic in the country.

As of now Pakistan's economy is growing[4] and the significance of transport in the growth process cannot be ignored. If this growth trend continues, the demand for road transport and the energy required to run it will also increase accordingly. At present, about 17 million registered motor vehicles are on road in Pakistan (Government of Pakistan, 2018) which is expected to surpass 30 million by 2025[5]. Demand for oil consumption in the transport sector will also increase accordingly by 2025, which at present is about 302 thousand barrels per day.

The energy security of this fastest growing sector is a must for the smooth flow of economic and human activities[6]. In the last few years, Pakistan witnessed only a small increase in domestic oil production. Thus has to rely increasingly on imports to meet domestic requirements. This validate the need to evaluate the demand outlook of petroleum products in

[2] Pakistan Energy Yearbook (2017) is the main source for data figures in text, unless mentioned.
[3] Pakistan Vision 2025_ prepared by Ministry of Planning, Development and Reforms, Government of Pakistan in 2014.
[4] After an average growth of less than 3 percent for five years, Pakistan's economy is growing since 2014. GDP growth was recorded at 5.7 percent in 2016-17.
[5] Author's projections based on previous year's growth.
[6] In January 2015, as world was gaining from the lowest fuel prices in years, Pakistan was hit with petrol shortage in the major cities of Punjab. The affected not only the general public but it also created difficulties for goods transportation. The shortage was caused because of the shortage of imported fuels as demand for fuels was not correctly anticipated.

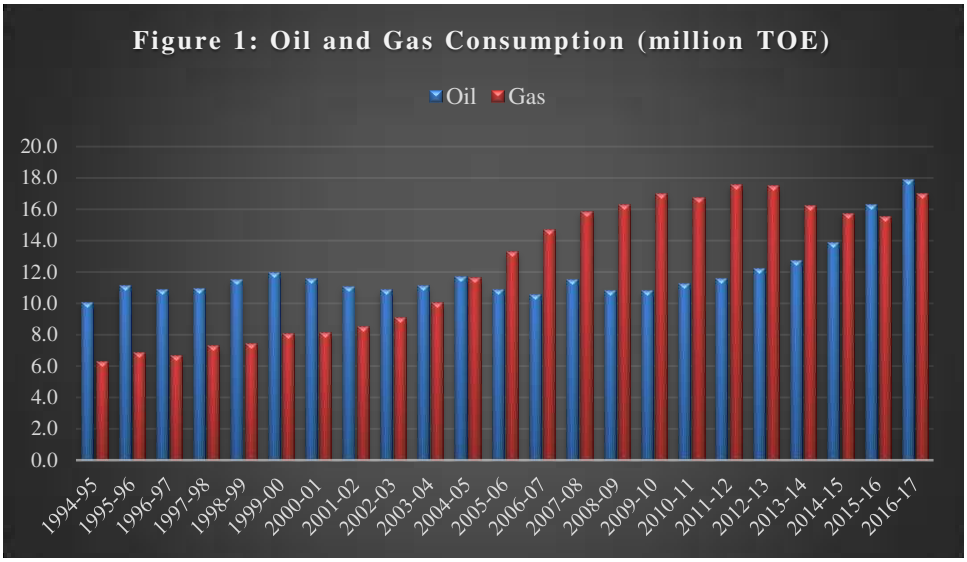
Pakistan. An estimate of future petroleum requirement in the road transport will give some info on foreign exchange required to import and on investments required in the refinery sector. Therefore, the aim here is not only to find fuel demand in the road transport of Pakistan but also to forecast medium to long-term fuel demand in the road transport of Pakistan.

The literature on the subject with reference to Pakistan is limited. To the best of my knowledge, this is the only comprehensive study that investigates the demand of petroleum products (specifically future forecasts) in the road transport sector for Pakistan and uses the longest available data from 1971-72 to 2016-17, making the assessment more reliable. The focus here is on road transport and two fuels that is, petrol (motor spirit) and diesel (high speed diesel) primarily used in the road transport of Pakistan. Here we put forward an approach to translate exogenous pathways of GDP, population, technological advancements, energy prices and dependence on private vehicles into final energy pathways in the road transport sector.

Rest of the paper is organized as: the next section deliberate upon some stylized facts with respect to Pakistan's energy sector and future energy demand. In the third section, literature on the subject is discussed. Section four describes data and methodology. Section five reports the estimated elasticities of petrol and diesel demand. Section six forecasts fuel demand (petrol and diesel) in the road transport of Pakistan from 2017-18 to 2024-25 based on an econometric approach (in-sample and out-of-sample selection criteria). Section seven concludes the discussion.

2. Pakistan's Energy Sector and Demand for Petroleum products: Some Stylised Facts

As a developing country, Pakistan's energy requirements are growing gradually over time, from 7 million TOE in 1971-72 to 50 million TOE in 2016-17. Over the years, the country has seen a change in its energy mix from the dominance of oil in 1990s to dominance of gas until 2015-16. With the depletion of natural gas resources and fall in international oil prices, the trend again upturned in 2016-17, and oil consumption exceeds gas consumption (Figure 1). Coal, Electricity and LPG have about 12 percent, 15 percent and 3 percent share respectively in the total energy consumed in 2016-17.



Source: Pakistan Energy Yearbook (various years).

Petroleum products account for more than 50 percent of modern energy consumption in Pakistan. Petroleum consumption is dominated by furnace oil (35 percent)[7] and high speed diesel (34 percent) followed by petrol (27 percent). The demand of petroleum products in the country is about 26 million TOE in 2016-17, out of which hardly 15 percent is met through local resources while the balance is met through imports. Pakistan spent almost 20 percent of its export earnings on oil imports in 1994-95 which increased to almost 61 percent in 2012-13. But due to the

[7] Furnace oil is mainly used in thermal power plants.

decline in international oil prices it has come down slightly. In 2016-17, Pakistan spent 46 percent of its export earnings on oil imports.

Moreover, demand for refined petroleum products is quite above the domestic oil refining capacity, almost 63 percent of our imports are refined products. So besides import of crude oil for domestic refineries, diesel and petrol (in quantity) accounts for 26 percent and 31 percent of petroleum product imports respectively. In money terms, petrol has the highest share (38 percent) followed by diesel (28.2 percent) and high sulphur furnace oil (28 percent) in the above mentioned import bills.

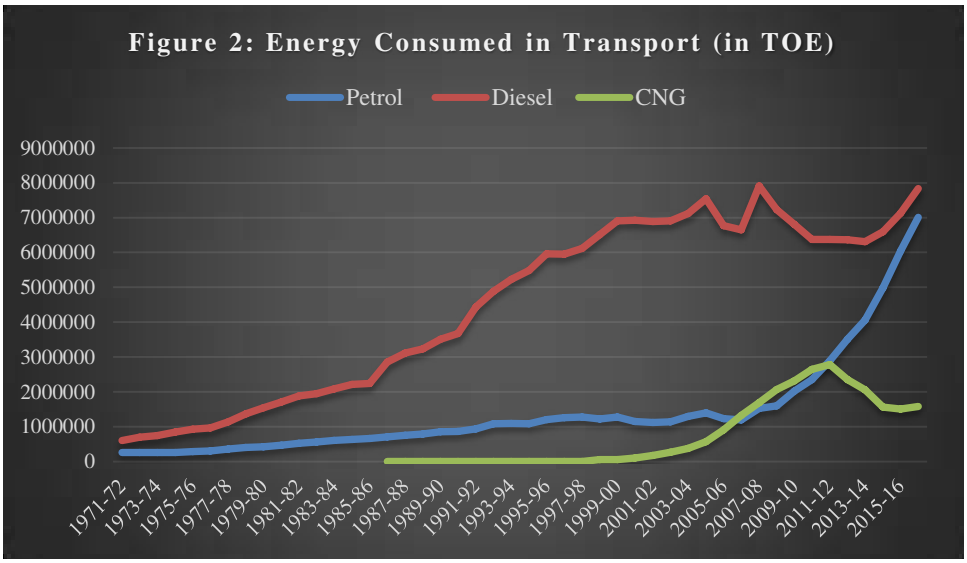
During 2013-14 the import bill of petroleum group was US $ 15.5 billion. Out of which US $ 8.9 billion was for petroleum products and remaining for petroleum crude. This import bill decreased to US $ 7.4 billion in 2015-16 due to the fall in international prices. However, due to increased consumption of petroleum products, in particular petrol, import bill increased to US $ 9.1 billion in 2016-17. Petrol consumption increased because of increased number of vehicles on roads as well as due to the shortage of compressed natural gas (CNG). With limited indigenous oil reserves, Pakistan's net oil imports are likely to rise substantively in future as demand is expected to grow faster than the local production.

Road transport, is the biggest sector in terms of consuming oil, that is, about 300472 barrels per day was consumed in road transport in 2016-17. The demand for fuels in the road transport is increasing mainly due to population growth, rising urbanization, farm mechanization, increased share of trucks as compared to rail in freight transportation and due to increase in per capita income with corresponding increase in private vehicles.

Lack of sufficient public transport services in urban areas in particular, has resulted in increased number of private vehicles on roads thus increasing demand for energy. Focus in

Pakistan has remained on the development of road infrastructure and hardly on mass transport system. Extraordinary expansion in road transport network along with growing population density is aggravating the problem. There were about 2 million motor vehicles on road during 1989-90, and this number increased to almost 17 million in 2016-17.

Road transport is heavily concentrated with respect to fuel type used, that is, diesel and petrol with a share of almost 52 percent and 47 percent. High octane blending component (HOBC) has a very minor share of 1 per cent in 2016-17[8]. Since 1971-72, petrol and diesel consumption are grown at 7.5 percent and 5.9 percent respectively. The usage of CNG increased from zero in 1985-86 to 2.78 million TOE in 2011-12 but in 2016-17, its consumption decreased to 1.57 million TOE due to the shortage of indigenous natural gas resources. Consequently, increasing demand for petrol (Figure 2).



Source: Pakistan Energy Yearbook, Various Issues

Road transport faces a challenging future in Pakistan because of its dependence on oil. Despite an exemplary growth in vehicle stocks over the years, majority of its inhabitants are

[8] Fuel share consumption including CNG in road transport in 2016-17 is: Petrol (43 percent), HSD (47 percent), CNG (10 percent) and HOBC (1 percent).

without personal vehicles and several of its areas are still not connected to any form of motorised transport. Thus, a robust growth in transport activity is anticipated in the coming years. With a business-as-usual scenario it would mean significant increases in imported fuel costs.

Pakistan's economy is on high growth path since 2014 and under China Pakistan Economic Corridor (CPEC), it is expected to grow even further with positive impact on per capita income and thus more access to personal vehicles. Pakistan is targeting to achieve and maintain a GDP growth of 7-8 percent (on average) in the next few years. Energy security is a pre-requisite for maintaining high economic growth. Vice versa, this much growth if achieved is going to accelerate transport demand, and in turn increase in demand for petroleum products. Unless there is a major shift away from current patterns and preferences in transport usage, transport energy use is going to accelerate.

Undoubtedly, availability of transport acts as a stimulus for trade and economic specialization, thus resulting in economic development. Urbanization and industrialization are the most noticeable facets of economic development. Pakistan is urbanizing swiftly. At present, almost 38 per cent of Pakistan's population is urban-based. By 2025, this figure is expected to reach nearly 50 percent[9]. Further, being part of CPEC, both urbanization and industrialization are expected to flourish in Pakistan[10]; subsequently per capita income will go up. Thus more demand for transport and in turn more demand for fuel. Population growth has also played an important role in petroleum products consumption in Pakistan.

Besides increase in per capita income relatively low fuel price (especially prior to 2007-08 and after 2014-15) has encouraged consumption of oil in Pakistan. For many years, the prices

[9] For details see Kugelman, 2014.
[10] CPEC is a mix of infrastructure projects, development of rail and road links as well as energy producing units and industrial zones along the corridor routes. It will lay a firm foundation for industrialization (see Ashraf, 2018).

of petroleum products (especially kerosene and diesel) have remained heavily subsidized by the government as a deliberate policy.

In short, in Pakistan, medium to long-term fuel requirements depend upon Gross Domestic Product (GDP) growth and associated increase in per capita income; industrialization, urbanization and population (which impact upon new car sales); fuel price, fuel efficient vehicles (technological advancements); and the availability of alternative fuels.

3. An Overview of Existing Research

Road transport is one of the main energy consuming activity in Pakistan. As the country is dependent on imports for its fuel requirements, examination and forecasting of road transport energy demand is crucial for its energy policy. Despite its importance from policy perspective, no significant study has been conducted on the subject. Only exception is Shrestha (2015) who analysed road transport energy situation and trends in the SAARC countries (including Pakistan). The focus is on energy efficiency improvement and oil saving. The road transport energy demand has been forecasted for each member state under different scenarios for thirty years using Long-range Energy Alternatives Planning System (LEAP). However, absence of relevant data made author to generate variables based on assumptions. Analysis based on so many assumptions (in the absence of actual data) minimizes its significance from policy perspective. Besides Shrestha (2015), Omer (2018) only examines fuel demand elasticities of petrol, diesel and compressed natural gas (CNG) for Pakistan using quarterly data for ten years.

In general, road transport energy demand has been of interest to economists for a long time and there are several studies investigating the demand for oil or its products. Some studies have focused on overall demand for oil (or its products, mainly gasoline and diesel), while others

have focused on transport sector exclusively. Most of them are cross-country studies, but country specific studies are also in great numbers. In general, the studies on petroleum demand have stick to the standard demand function, estimating income and price elasticities of demand for oil and petroleum products (Garbacz, 1989; Dahl and Sterner, 1991; Dahl, 1993; McRae, 1994; Samimi, 1995; Al-Faris, 1997; Ramanathan, 1999; Cooper, 2003; Agrawal, 2015; Blundell, Horowitz, and Parey, 2012; Yousef, 2013; Lin and Prince, 2013; Taghvaee and Hajiani, 2014; Sulaimon, 2014; Abdullahi, 2014; Karimu, 2014; Jobling and Jamasb, 2015).

Some studies have extended the demand analysis to include not only per capita GDP or economic growth and petroleum prices, but also population, urbanization, fuel taxes, vehicle stocks, vehicle miles travelled, passenger and freight turnover, fuel prices in neighbouring countries, and oil shocks in different combinations (Chai, Wang, Wang, and Guo, 2012; Lin and Zeng, 2013; Gao, Liao, Brke and Wei, 2014; Polemis, 2006; Singh, 2006; Pongthanaisawan, Sorapipatana and Limmeechokchai, 2007; Samimi, 1995; Sulaimon, 2014; Abdullahi, 2014; Baranzini and Weber, 2013; Lin and Zeng, 2013; Bhattacharyya and Blake, 2009; Yousef, 2013).

Some of the studies have gone a little further to forecast future energy demand in the transport sector. For instance, Chai *et al*. (2012) examined transport energy demand and forecast demand for petrol (gasoline) and diesel in China using Bayesian linear regression theory and Markov Chain Monte Carlo method (MCMC). Ghosh (2006) used in-sample and out-of-sample criteria to forecasts total petroleum products and middle-distillates demands in India.

The contribution of our study is to fill the gap with reference to Pakistan. The paper is distinguished by its focus on a single developing country_ Pakistan. To my knowledge, forecasts of future demand of petrol and diesel in Pakistan is not done in any previous study (as discussed above only exception is the cross-country study of Sheresta (2015)). While Omer (2018) only

determines fuel demand elasticities. This study is different from both these studies in terms of sample selected as well as methodology used.

4. Methodology and Data

As discussed earlier, the main goal of the study is to determine the demand for petrol and diesel in the transport sector of Pakistan over the period 1971-72 to 2016-17 using various socioeconomic indicators. Second main objective is to forecast demand for these two products over the period 2017-18 to 2024-25. To provide medium to long-term demand analysis for petrol and diesel an econometric approach (in-sample and out-of-sample selection criteria) is applied.

Following empirical literature (e.g., Polemis, 2006; Chai *et al*., 2012; Roming and Leimbach, 2015) and in the light of country specific conditions (as discussed in Section 2), a demand models of petrol consumption and diesel consumption are developed. Petrol demand analysis is based on a single-equation market demand model, where per capita petrol demand is related to per capita income (GDP), real petrol price, per capita vehicle stock, real price of substitute fuel and technological advances[11]. Petrol consumption, real income (GDP) and vehicle stock are included in equation in terms of population; as population significantly effects petrol demand and it also captures the impact of urbanization. To incorporate inter-fuel substitution by compressed natural gas (CNG) a dummy is included. CNG was introduced in 1986-87; this dummy is zero prior to 1986-87 and one otherwise. Lagged dependent variable is also included to capture the dynamic effects.

That is, final demand for petrol consumption in log-linear form is stated as:

[11] This variable is assumed to capture vehicle efficiency through technological advancements. It would also partly covers growth in non-fossil alternative fuels. Explicit data on these important variables is not available for Pakistan.

$$\text{Ln}(PC_t) = \alpha_0 + \alpha_1 \text{Ln}(Y_t) + \alpha_2 \text{Ln}(PP_t) + \alpha_3 \text{Ln}(DP_t) + \alpha_4 \text{Ln}(Veh_t) + \alpha_5 CNG + \alpha_6 Tr + \alpha_7 \text{Ln}(PC_{t-1}) + \mu_t \quad \ldots\ldots (1)$$

Where, PC is petrol consumption per capita; Y is real GDP per capita, PP is real price of petrol, DP is real price of diesel (to represent price of an alternative fuel), Veh is vehicle stock per capita; and CNG is a time dummy representing the availability of CNG, Tr is trend included to represent any technological advancements, α_0 to α_7 are parameters, t represents time; and μ is the residual error term, describing the effect of other factors on petrol except for explanatory variables selected here.

In equation (1), it is expected that an increase in per capita income, price of alternative fuel (diesel), vehicles stock per capita would increase petrol demand (i.e., α_1, α_3, and α_4 are expected to be positive); whereas an increase in own price (i.e., petrol price), availability of CNG and technological advances (Tr) would reduce petrol demand in Pakistan (i.e., α_2, α_5 and α_6 are expected to be negative).

Similarly, final demand for diesel consumption in log-linear form is stated as:

$$\text{Ln}(DC_t) = \alpha_0 + \alpha_1 \text{Ln}(Y_t) + \alpha_2 \text{Ln}(DP_t) + \alpha_3 \text{Ln}(PP_t) + \alpha_4 \text{Ln}(Veh_t) + \alpha_5 Tr + \alpha_6 \text{Ln}(DC_{t-1}) + \mu_t \quad \ldots\ldots (2)$$

Where, DC is diesel consumption per capita, Y is real GDP per capita, DP is real price of diesel; PP is real price of petrol (to represent price of an alternative fuel), Veh is vehicle stock per capita, Tr is trend included to represent any technological advancements, α_0 to α_6 are parameters, t represents time, and μ is the residual error term, describing the effect of other

factors on diesel other than explanatory variables selected here. Since CNG kit is mainly substituted in petrol based vehicles in Pakistan, therefore this dummy is not included in the demand function for diesel[12]. Lagged dependent variable (Ln DC_{t-1}) will capture the dynamic effects.

In equation (2), it is expected that an increase in per capita income, price of alternative fuel (petrol), vehicles stock per capita would increase diesel demand (i.e., α_1, α_3, and α_4 are expected to be positive); whereas an increase in diesel prices and any technological advancements are expected to reduce diesel demand in Pakistan (i.e., α_2 and α_5 are expected to be negative).

The main source of historical data on final petrol and diesel consumption and their prices are Pakistan Energy Yearbook for various years and Oil Companies Advisory Committee (OCAC). The data source for real GDP and population is the World Development Indicators Database. For stock of registered vehicles we relied on various issues of Pakistan Economic Survey.

5. Empirical Estimates

As normal procedure, first we tested for the stationarity of variables using Augmented Dickey-Fuller (ADF) test. All variables are found to be integrated of order one, I (1) at the 5 percent significance level. This suggests for the cointegration estimation. Therefore as a second step, we apply Johnson cointegration test. In both the cases, that is, a linear deterministic trend in data with intercept and no trend or with intercept and trend, the null hypothesis of one cointegrating relationship between real demand (consumption) of petrol and the right hand sight

[12] Diesel remained more subsidized, thus cheaper relative to petrol prior to 2009-10.

variables in equation (1) is not rejected at the 5 percent level, because the estimated statistic is greater than the critical value, implying a stable long run relationship between petrol demand and all the explanatory variables. Similarly, the null hypothesis of one cointegrating relationship between real demand (consumption) of diesel and the right hand sight variables in equation (2) is not rejected at the 5 percent level, as the estimated statistic is greater than the critical value. Finally we estimate equation (1) and (2) by Newey-West method[13].

Just to elude the potential loss of valuable information and obscure outcomes variables are used in level. Table 1 below report results of long-run demand for petrol and diesel.

Table 1: Long Run Demand for Petrol and Diesel

	Constant	Y	PP	DP	CNG	Tr	Veh	PCt-1	DCt-1	Adj. R^2
Petrol Demand (PCt)	-2.89 (-1.81)*	0.33 (2.15)**	-0.36 (-3.64)**	0.05 (0.74)	-0.07 (-1.81)*		0.004 (1.74)*	0.86 (14.11)**		0.98
Diesel Demand (DCt)	-3.99 (-1.96)**	0.36 (1.99)**	0.06 (0.78)	-0.16 (-2.71)**		-0.002 (-0.44)			0.83 (15.3)**	0.99

Note: value in parenthesis is t-statistics. * significant at 5 % and ** significant at 1%.

The reported equations (models) are chosen by goodness of fit and signs and significance of the parameters. These are dynamic equations which allow for lagged demand of petrol and diesel to affect current demand of petrol and diesel respectively. Both the estimated demand equations display high adjusted R^2. Further, there is no sign of econometric problems as revealed by the p-values of the diagnostic tests (Jarque–Bera (JB) for normality of residuals and the Ramsey's RESET test for functional specification) in both the demand models. These tests validate the estimated demand function for petrol and diesel. Thus, these estimated equations may be used to forecast petrol and diesel demand in the road transport of Pakistan.

[13] Newey-West method check for autocorrelation and heteroscedasticity (Heij, Boer, Franses, Kloek, and Dijk, 2004, p. 360).

In the petrol demand equation, the coefficient of real per capita income (Y_t) is positive and statistically significant. The estimated income elasticity of petrol demand is 0.33, which indicates 1 percent increase in per capita income leads to 0.33 percent increase in petrol demand in the long run. The coefficient of real petrol price (PP_t) is negative and highly significant. The estimated price elasticity of petrol demand is 0.36, which indicates that with 1 percent increase in the real price of petrol would reduce petrol demand by 0.36 percent. The estimated coefficient of dummy variable (CNG) is negative and significant (0.07), indicating the negative influence of CNG availability on the demand for petrol. The coefficient of vehicle stock per capita (Veh_t) is positive and significant, indicating that 1 percent increase in vehicle stocks per capita will lead to 0.004 percent increase in the demand for petrol. As far as the coefficient of an alternative fuel price is concerned, although positive but is insignificant. In other words, no significant substitution effect with respect to diesel. Time trend variable is ignored in the reported equation, as its coefficient (although negative as expected) was not only insignificant but effecting other main variables.

In the diesel demand equation, the coefficient of real per capita income (Y_t) is positive and statistically significant at the 5 percent level. The estimated income elasticity of diesel demand indicates 1 percent increase in per capita income leads to 0.36 percent increase in diesel demand in the long run. The coefficient of real diesel price (DP_t) is negative and significant. The estimated price elasticity of diesel demand indicates that with 1 percent increase in the real price of diesel would reduce diesel demand by 0.16 percent. The estimated coefficient of trend variable is negative, however insignificant, indicating no significant influence of technological advancements on long run diesel demand. The coefficient of vehicle stock per capita (Veh_t) was

insignificant and effecting other variables therefore ignored in the final reported equation[14]. As far as the coefficient of an alternative fuel price is concerned, although positive (with cross price elasticity of 0.06), but it is insignificant.

From policy perspective, the stability of coefficients in the above estimated equation (1) and equation (2) is important. Hence, stability tests like the cumulative sum of recursive residuals (CUSUM) and the cumulative sum of square of recursive residuals (CUSUMSQ) tests are performed to analyse coefficients' stability in both the equations. Neither the CUSUM nor the CUSUMSQ test statistics exceed the bounds of 5 per cent levels of significance, thus, indicating the estimated demand model for petrol and diesel stable and correctly specified (Figure 3a and 3b).

Figure 3a: CUSUM and CUSUM of Square_ Petrol Demand Equation

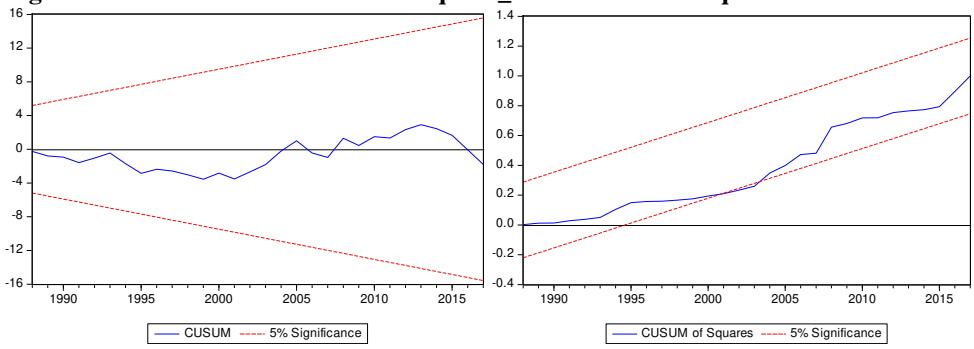
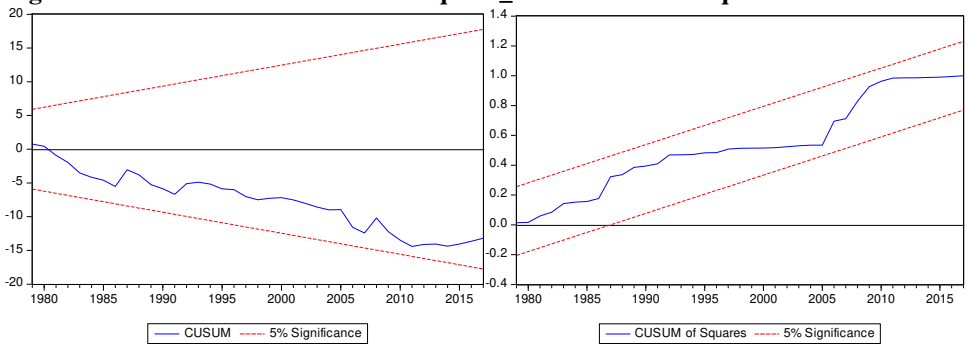


Figure 3b: CUSUM and CUSUM of Square_ Diesel Demand Equation



[14] Separate data for vehicles using diesel as fuel is not available, therefore ignored in the final reported equation.

6. Forecast Analysis

In this section we simulate the expected future demand for petrol and diesel in the Pakistan's road transport until 2024-2025 using the estimated demand elasticities in equation (1) and (2) in the previous section.

6.1.In-sample Forecast Evaluation

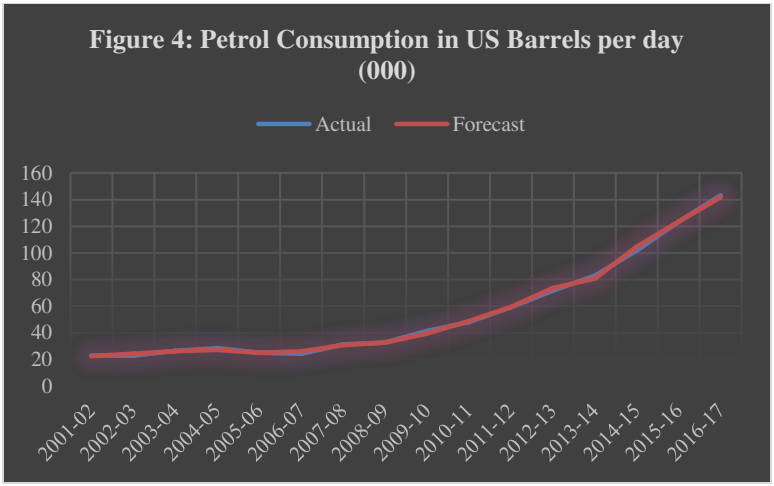
We need models that qualify as best models for forecasting future demand for liquid fuels. Both of our estimated models (as reported in Table 1) are well-specified with high value of R^2 and adjusted R^2 and with significant coefficients. However, it does not essentially suggest a good performing model. The benchmark to judge the estimated equations' is how closely the dependent variable follows its corresponding historical data (Ra and Rhee, 2005; Khan and Din, 2011 and Khan, 2015). Therefore, the validity of each equation is gaged using the mean absolute percentage error (MAPE) and Theil's inequality coefficient (U). These statistics calculate the level of accuracy of the forecasted values in comparison to the actual. Theil's inequality coefficient compares the forecast with the random walk and lies between zero (perfect fit) and one (i.e., forecast is not better than that of the random walk). While MAPE is not normalized but it should as small as possible.

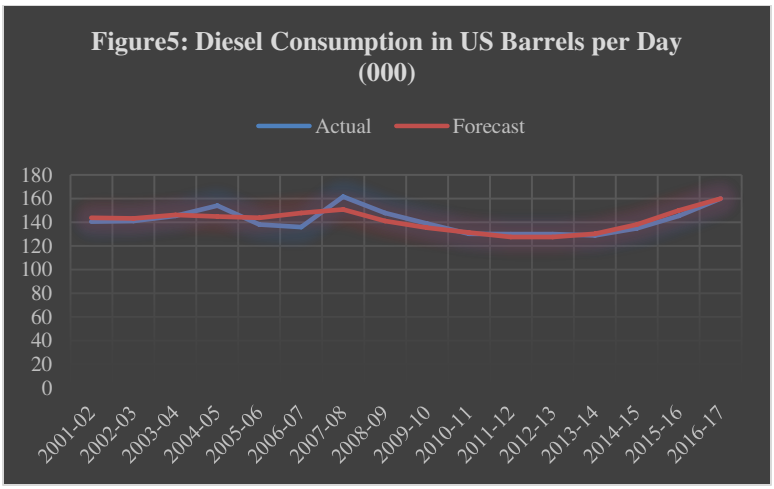
Table 2 encapsulates the forecast evaluation for petrol demand and diesel demand for the period (1971-72 to 2016-17). Both MAPE and U-statistics prove a high degree of accuracy with respect to estimated equations. The value of MAPE for petrol demand and diesel demand is 1.46 percent and 1.16 percent respectively. While Theil's inequality coefficient is close to zero in both the equations (0.009 for petrol demand and 0.007 for diesel demand). Thus, these statistics validate the suitability of estimated equations to forecast.

Table 2: Model Validation Statistics

	MAPE	Theil's Inequality Coefficient
Petrol Demand (Eq 1)	1.46	0.009
Diesel Demand (Eq 2)	1.16	0.007

Next we have assessed the in-sample forecasting capacity of the model and compare actual and forecasted petrol consumption data over the period 2001-2 to 2016-17. Similarly, for the diesel consumption. The solution paths for the endogenous variables_ petrol consumption and diesel consumption are illustrated in Figure 4 and Figure 5. Both figures illustrates the trails of the ex-post simulation along with the actual values of the endogenous variables over the period 2001-2015; the simulation tracks actual time paths superbly in both the cases.





For petrol consumption, the forecasted data departs from the actual data with absolute percentage forecast error ranging from 0 percent to 6.4 percent. Whereas for diesel consumption the absolute percentage forecast error ranges from 0.1 percent to 8.8 percent. This validate the capacity of both the petrol demand equation and diesel demand equation to provide a future demand outlook with a sufficient degree of accuracy.

6.2.Out-of-Sample Forecast

As mentioned earlier one of the objective of the current study is to forecast future values of endogenous variables. For this purpose, the estimated petrol demand equation and the diesel demand equation for the road transport in Pakistan are simulated to get their future paths under different assumptions and by allowing projected values of some of the selected exogenous variables. That is, each simulation experiment is performed to determine the future values of the petrol consumption and diesel consumption based on different set of assumptions about the growth rate of GDP, population, petrol and diesel prices, inflation rate, registered vehicles on the road and values of estimated parameters. The ex-post projections cover the period from 2017-18 to 2024-25 based on the data from 1971-72 to 2016-17.

6.3.Scenario Design

The basic scenario is based on Pakistan Vision 2025 where Pakistan's population is projected to increase to over 227 million by 2025 (at the rate of about 1.8 percent per annum); and number of registered vehicle number will rise to 33 million at an annual rate of 8 percent[15]. Regarding the average annual GDP growth rates, it is worth noting that GDP growth rates were 6.8 percent in the 1960s, 4.8 percent in the 1970s, 6.5 percent in the 1980s, 4.6 percent in the 1990s, and 4.9 percent in 2000s. Overall, Pakistan's average economic growth rate since independence has been almost 5.5 percent. Further, Pakistan Vision 2025 is targeting to achieve and maintain an average GDP growth of 7-8 percent till 2025.

From these considerations and trends, it is quite possible that the average GDP growth rate over the next decade would be between 5 percent and 8 percent. Thus, we consider three likely scenarios for the average annual GDP growth rate until 2025:

Baseline scenario with average annual GDP growth rate of 5 percent; Normal scenario with average annual GDP growth rate of 6 percent; and Optimistic scenario with average annual GDP growth rate of 8 percent.

With reference to fuel prices, a likely scenario for the probable growth rates of fuel prices domestically is harder to decide given the high volatility of international oil prices.

Since 1970s oil price changes are making it difficult for the policymakers to take decisions. Specifically, in the last ten years or so oil price fluctuations have remain quite intense. After remaining around US$20 in the 1990s and early 2000, oil prices started rising and reached an unprecedented level of around US$ 150 per barrel in the middle of 2007-08. However, by the end of 2007-08 it decreased to US$ 30 per barrel. But this decline was for a short period and

[15] Since 1990, registered vehicles are increasing at the rate of 8 percent per annum. It is assumed it will kept the same pace and increase at the same rate by 2025.

prices increased again (with minor drops in between) to an average of about US$ 104 per barrel in 2012-2013. Yet again, in the last quarter of 2014, oil prices were recorded at about US$ 57 per barrel, which even plummeted to US$ 47 per barrel in the beginning of 2015. And for now as per the World Bank's commodity forecast, the average price of Brent, West Texas Intermediate (WTI) and Dubai crude oil will continue to rise to reach US$ 70 per barrel in 2030[16].

As far as domestic prices of petrol and diesel are concerned (in Pakistani Rupees and in real terms), we note an average annual growth rate of petrol and diesel of around 1.46 percent and 1.70 percent respectively (or almost 2 percent) between 1971-72 and 2016-17. Domestic prices of petrol and diesel differ considerably from crude oil price, probably because petrol and diesel prices also include refining, freight charges, taxes as well as subsidies used many times to protect diesel and petrol prices from rising (or falling) in reaction to rising (or falling) international crude oil prices. Given the past trends, and the fact that international oil prices have a vital role behind inflation rates in Pakistan, especially when oil prices have risen uninterruptedly over the past 1 year (Malik, 2016); we have established four likely scenarios for real price of petrol and diesel.

Real fuel prices (petrol and diesel) will remain constant; Real fuel prices (petrol and diesel) will grow at 2 percent per annum; Real fuel prices (petrol and diesel) will grow at 3 percent per annum; and Real fuel prices (petrol and diesel) will grow at 4 percent per annum by 2025.

6.4.Future Demand (petrol and diesel) Projections

[16] http://pubdocs.worldbank.org/en/678421508960789762/CMO-October-2017-Forecasts.pdf
https://knoema.com/yxptpab/crude-oil-price-forecast-2017-2018-and-long-term-to-2030

Table 3 reports projections of petrol consumption in Pakistan using the estimated equation (1) and the above-mentioned three scenarios for the likely GDP growth rates and the likely fuel prices under these growth scenarios.

In the baseline scenario where GDP is assumed to grow at 5 percent, petrol consumption is expected to grow at 11.3 percent, 8.9 percent, 7.7 and 6.5 if petrol prices remain constant, grow at 2 percent, 3 percent and 4 percent respectively. On average, if GDP growth remains around 5 percent, petrol consumption in the transport sector will grow from 135 thousand US barrels per day in 2016-17 to 262 thousand US barrels per day in 2024-25.

In the normal scenario where GDP is assumed to grow at 6 percent, petrol consumption is expected to grow at 13.9 percent, 11.5 percent, 10.3 and 9.1 if petrol prices remain constant, grow at 2 percent, 3 percent and 4 percent respectively. On average, if GDP grow at about 6 percent, petrol consumption in the transport sector will grow from 135 thousand US barrels per day in 2016-17 to 317 thousand US barrels per day in 2024-25.

In the optimistic scenario, where economy would grow at about 8 percent, petrol consumption is expected to grow at 19.4 percent, 16.8 percent, 15.5 and 14.3 if petrol prices remain constant, grow at 2 percent, 3 percent and 4 percent respectively. On average, if GDP grow at about 8 percent, petrol consumption in the transport sector will grow from 135 thousand US barrels per day in 2016-17 to 460 thousand US barrels per day in 2024-25. The average growth in petrol consumption of 12 different scenarios is 12.5 percent by 2024-25.

Table 4 reports projections of diesel consumption in Pakistan using the estimated equation (2) and the above-mentioned scenarios for the likely fuel prices and GDP growth rates by 2024-25. In the baseline case where GDP is assumed to grow at 5 percent, growth in diesel consumption is expected to vary from 7 percent to 8.4 percent if prices rise by 4 percent, 3

percent, 2 percent or remain constant. On average, if GDP growth remains around 5 percent by 2024-25, diesel consumption in the transport sector will grow from 161 thousand US barrels per day in 2016-17 to 290 thousand US barrels per day in 2024-25.

In the normal scenario where growth is assumed to be 6 percent, diesel consumption in the road transport will grow by 8.4 percent, 8.7 percent, 9.1 percent and 9.9 percent respectively if prices increase by 4 percent, 3 percent, 2 percent, or remain constant. On average, if GDP growth remains around 6 percent, diesel consumption in the transport sector will grow from 161 thousand US barrels per day in 2016-17 to 321 thousand US barrels per day in 2024-25.

In the optimistic scenario, where economy will grow at about 8 percent, diesel consumption is expected to grow at 12.8 percent, 12 percent, 11.6 percent and 11.2 percent if prices of petroleum products remain constant, grow at 2 percent, 3 percent and 4 percent respectively. On average, if GDP grow at about 8 percent, diesel consumption in the road transport will grow from 161 thousand US barrels per day in 2016-17 to 396 thousand US barrels per day in 2024-25. The average of 12 different scenarios (in Table 5) is 336 thousand US barrels per day, i.e., growth of about 9.6 percent by 2024-25.

It is clear from these projections that a significant increase in demand for petrol and diesel is awaited by 2024-25. These are not exaggerated figures as such. With economic development, income level goes up, thus raising the purchasing power of people for cars, motor cycles etc., which in turn increase the demand for petrol and diesel. Further, rising population and rapid urbanization increase the demand for transportation with corresponding increase in demand for petroleum products. Under CPEC, both urbanization and industrialization are expected to grow, thus more demand for road transport and consequently more demand for petrol

and diesel in Pakistan. Therefore, policy makers must plan to ensure an adequate supply to meet the rising demand, which is expected to be more than double in the next 7 to 8 years.

Table 3: Gasoline Demand Forecasts in Thousand US Barrels per Day

	Baseline Scenario_ GDP growth 5%				Normal Scenario_ GDP growth 6%				Optimistic Scenario_ GDP growth 8%			
	Constant Prices	Prices growth 2%	Prices growth 3%	Prices growth 4%	Constant Prices	Prices growth 2%	Prices growth 3%	Prices growth 4%	Constant Prices	Prices growth 2%	Prices growth 3%	Prices growth 4%
2017	135	135	135	135	135	135	135	135	135	135	135	135
2018	162	159	156	154	168	164	162	160	182	178	175	173
2019	182	174	169	165	195	186	181	176	224	214	209	203
2020	203	189	182	175	222	207	200	192	271	252	243	234
2021	224	204	195	185	252	230	219	208	321	292	279	265
2022	246	220	207	195	282	252	238	224	374	334	315	297
2023	269	235	219	205	314	275	257	239	431	377	352	328
2024	292	250	231	214	348	298	275	255	492	421	389	360
2025	316	265	243	223	382	321	294	270	555	466	427	392

Table 4: Diesel Demand Forecasts in Thousand US Barrels per Day

	Baseline Scenario_ GDP growth 5%				Normal Scenario_ GDP growth 6%				Optimistic Scenario_ GDP growth 8%			
	Constant Prices	Prices growth 2%	Prices growth 3%	Prices growth 4%	Constant Prices	Prices growth 2%	Prices growth 3%	Prices growth 4%	Constant Prices	Prices growth 2%	Prices growth 3%	Prices growth 4%
2017	160.9	160.9	160.9	160.9	160.9	160.9	160.9	160.9	160.9	160.9	160.9	160.9
2018	174.2	173.8	173.6	173.4	175.2	174.8	174.6	174.4	177.4	177.0	176.8	176.5
2019	189.2	188.0	187.3	186.6	192.2	190.9	190.2	189.5	198.6	197.3	196.6	195.9
2020	205.8	203.2	201.9	200.5	211.6	209.0	207.6	206.1	224.4	221.7	220.2	218.7
2021	223.7	219.5	217.2	214.9	233.3	228.8	226.5	224.1	254.7	249.8	247.3	244.7
2022	243.0	236.5	233.1	229.7	257.3	250.4	246.8	243.2	289.5	281.8	277.7	273.7
2023	263.5	254.3	249.6	244.9	283.3	273.4	268.3	263.3	328.8	317.2	311.4	305.5
2024	285.2	272.6	266.4	260.2	311.4	297.7	290.9	284.2	372.6	356.2	348.0	340.0
2025	307.8	291.4	283.5	275.7	341.4	323.2	314.4	305.8	420.7	398.3	387.4	376.7

Conclusion

At present, about 46 percent of total commercial energy supplies in Pakistan are imports. With the exhaustion of indigenous gas resources along with no new oil and gas recoveries in near sight, this dependence on imported fuels is expected to increase even further. Thus, in this paper we develop petrol demand model and diesel demand model in the road transport of Pakistan and estimate long run elasticities of income and price using annual data from 1971-72 to 2016-17. Our results show positive income elasticity of 0.33 for petrol and 0.36 for diesel and negative price elasticity of 0.36 for petrol and 0.16 for diesel. Cross price elasticities are insignificant in both the demand functions. However, in the petrol demand model, availability of CNG is a significant substitute for petrol.

Secondly, we forecast demand for these two fuels for the period (2017-18 to 2024-25) using different growth scenarios and the likely fuel prices under these growth scenarios. The results of the simulation exercise indicates that the rise in fuel prices in different growth scenarios help (to a certain extent) in restricting rise in demand for petrol and diesel over the medium term to long term.

These estimates are important for a country like Pakistan, which is largely dependent on imports to meet its fuel requirements. The slip in crude oil prices from US $118 in March 2012 to as low as US $30 a barrel in November 2015 have resulted in a significant cut in the country's import bill. However, in the last few years increased focus on infrastructure and transport in CPEC related activities, and growth in automobile sales, consumption of both petrol and diesel have gone up significantly. To a certain extent, the government pricing strategy is also responsible for the increase in retail fuel consumption, particularly of petrol. This encouraged oil

imports and put burden on current account deficit. But now prices are rising again[17]. This rise in international fuel prices will have additional negative impact on Pakistan's foreign exchange reserves.

The petroleum group is about 19 percent of imports and any cut in this import group would be significant. Therefore, Pakistan should take various steps towards demand management of these fuels. Besides encouraging energy-efficient vehicles, market oriented prices for petrol and diesel are required. Petroleum subsidies also need to be curtailed and well-targeted. Pakistan also needs to promote the use of other alternative energy sources, like biofuels to decrease its dependence on imported fuels. Given its dependence on oil imports, Pakistan should make serious efforts to boost its exports to counter high oil payments.

Transportation is an important economic activity in Pakistan, dependent almost entirely on the consumption of petrol and diesel. In future, its reliance on transport will increase even further. Given the energy security issues, careful planning to guarantee future petroleum supplies is critical for sustainable economic growth.

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[17] In October 2018, crude oil price was US $ 77 per barrel.

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