A Regional Demand Forecasting Study for Transportation Fuels in Turkey

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Fuel demand in the transportation sector has received considerable attention for the last decades. Population growth and economic development in the past few decades have caused a growing demand for fuel in transportation sector in Turkey. However, gasoline consumption has been constantly decreasing in Turkey since 2006, whereas diesel consumption reached record levels in the same period. The demand for LPG (Liquefied Petroleum Gas) remained rather stable. Model projections indicate in all regions in Turkey a shift away from gasoline-fueled vehicles towards diesel-fueled ones.

The main objectives of this study are to analyze past Gasoline, Diesel and LPG consumption in Turkey's transportation sector and to identify the main factors affecting future demand. To achieve these objectives, six different categories of models are developed based on 11-year historical data include Multi Linear Regression Models, Moving Average (MA), Double Moving Average (DMA), Simple Exponential Smoothing (SES), Double Exponential Smoothing (DES), Time series models Holt–Winters' model. The results indicate that Multiple Regression Analysis provides relatively better solutions for explaining the fuel demand. The growth of fuel consumption creates trending data, therefore the most reliable forecast methods would be the ones which take trend into account. So it is not a surprise that Regression and DES perform better than the others. With the help of these models, it is possible to perform sales forecasts in terms of different fuel types, sectors and geographical regions. Figure 1 shows that these regions in Turkey can be categorized in twelve categories according to TUIK (Turkish Statistical Institute). In addition to that, the regional shares of gasoline, diesel and LPG consumptions in 2013 are shown in Figure 1.

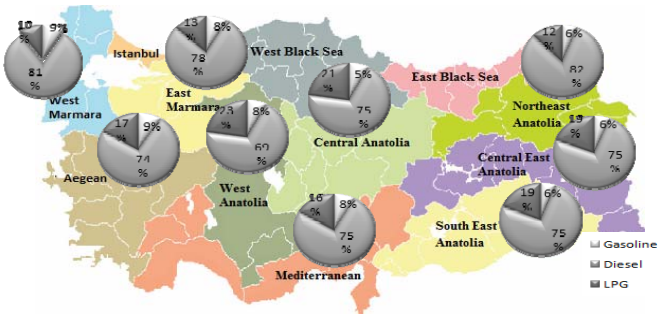

Figure 1. TUIK Regions Used in the Analyses [7], [8]

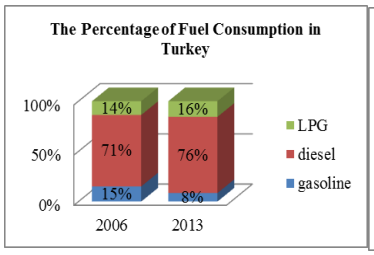

Figure 2. LPG, Diesel and Gasoline Shares in Turkey[7]

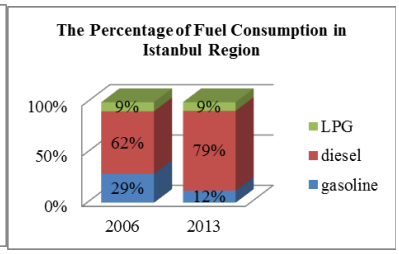

Figure 3. LPG, Diesel and Gasoline Shares in Istanbul[7]

Gasoline demand decreased linearly between the years 2006 and 2012 in, whereas diesel consumption reached to record levels in the same period. There is not a dramatic change in the consumption of LPG. In Figure 2, the shares of types of fuel consumptions are displayed for the years 2006 and 2013.

Figure 3 presents the shares of types of fuel consumptions in Istanbul region for the for the years 2006 and 2013. The gasoline consumption in 2006 is 17% larger than in 2013. The difference in diesel consumption between the years 2006 and 2013 is significant, about 17%. As a result, Turkey's dependence on diesel could reach to precarious levels in the next decade.

In addition to the forecasting of fuel demand, several independent variables of the regression models were projected including population, gross value added of the transport sector, fuel prices, vehicle stock and utilization rates etc. All projections have been calculated with different methods so as to make use of the most reliable forecasts. Gross Value Added (GVA) is the key economic metric used to measure all economic activity within a geographical area over a given period. Understanding GVA and its calculation is essential when trying to measure economic impact. 2013 forecast value for GVA is calculated with the help of Moving Average Method. The objective is to use past to data to develop a forecasting model for future periods. For the fuel prices there is a small improvement within consecutive years. Therefore taking the average of small periods is expected to give more reliable results as a consequence. In addition to that, the selling price of LPG has an upward trend. For that reason regression analysis is considered to be an alternative method for Moving Average Method. The Vehicle Fuel Usage Indicator is an independent variable for the Multiple Regression Analysis. During the creation of the Vehicle Fuel Usage Indicator Population, GVA, the Vehicle Fuel Usage Indicator which belongs to past years independent variables have been tested. In general, the rate of GVA and Population, and the Vehicle Fuel Usage Indicator from the previous

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years have been effective in these Multiple Regression Model. However, the rate of GVA and Population is not an independent variable for some regions. For example, the Regression Analysis for West Marmara Region, East Black Sea Region, and Northeast Anatolia Region shows that the rate of GVA and Population do not affect the Vehicle Fuel Usage Indicator. Vehicle fuel usage indicator defines the number of road motor vehicles by kind of fuel used. Multiple Regression Analysis is performed to achieve long-term projection of demand forecasting in this study. The data of GVA, fuel prices, vehicle fuel usage indicator, types of fuel, and population have been used. In order to compare the various forecasting methods and check model accuracy, MSE (Mean Squared Error), MAD (Mean Absolute Deviation) and MAPE (Mean Absolute Percentage Error) are analyzed. For the fuel demand the best result can be derived by regression analysis. Assumptions of normality and independence of errors are validated for each region. Table 1 shows the percentage changes compared to previous year's gasoline, diesel and LPG demand together with the best performing methods.

Regions	The Best Performing Method	2013	2014	Regions	The Best Performing Method	2013	2014
Istanbul Region	Regression (G)	26%	29%	Central Anatolia Region	Regression (G)	4%	6%
	MA=3 (D)	7%	2%		Regression (D)	-7%	-5%
	Regression (LPG)	-1%	-1%		Regression (LPG)	-9%	-9%
West Marmara Region	Regression (G)	-2%	6%	West Black Sea Region	Regression (G)	-1%	1%
	Regression (D)	-6%	-8%		Regression (D)	-2%	1%
	Regression (LPG)	-10%	-10%		DES (LPG)	-10%	-18%
Aegean Region Region	Regression (G)	-0,37%	3%	East Black Sea Region	Regression (G)	0,95%	3%
	Regression (D)	-3%	-5%		Regression (D)	-5%	-12%
	DES (LPG)	-10%	-19%		DES (LPG)	-10%	-18%
East Marmara Region	Regression (G)	3%	6%	Northeast Anatolia Region	Regression (G)	4%	8%
	DMA=2 (D)	-8%	-14%		Regression (D)	-4%	-3%
	Regression (LPG)	-2%	-1%		Regression (LPG)	14%	10%
West Anatolia Region	Regression (G)	6%	9%	Central East Anatolia Region	MA=3 (G)	-0,24%	0,48%
	Regression (D)	-4%	-4%		Regression (D)	-5%	-10%
	DES (LPG)	-8%	-15%		Regression (LPG)	-10%	-19%
Mediterranean Region	SES (G)	11%	13%	South East Anatolia Region	SES (G)	-10%	-11%
	Regression (D)	8%	-7%		Regression (D)	-11%	-9%
	DES (LPG)	-11%	-20%		Regression (LPG)	-7%	-9%

G: Gasoline, D: Diesel, LPG: Liquefied Petroleum Gas

Table 1. Best Performing Methods and Percent Change Projections for Fuel Demand

Turkey has the highest gasoline price among all the OECD (Organisation for Economic Co-operation and Development) member states due to the high taxes that are reflected at the level of retail price. As gasoline prices increase dramatically, consumers are shifting to diesel and LPG in Turkey [2]. Taxis run almost exclusively on diesel or LPG. Since the late 1990s, the European diesel car market boomed whereas diesel vehicles were phased out of the Japanese market and remained at a negligibly small level in the United States while gaining popularity recently. Registrations for diesel cars and sport utility vehicles rose 24 percent in the United States from 2010 through 2012 [3]. The main reason for the attractiveness of diesel cars is fuel efficiency, as diesel engines are 20 percent to 40 percent more fuel efficient than equivalent gasoline engines. However, diesel fuel contains about 15% more carbon per litre reducing the CO2 emission advantage by favourable fuel efficiency. It is expected that increasingly stringent emissions regulations and the high cost of new anti-pollution technology will make diesel engines much more expensive [4]. Criticism of diesel vehicles has recently increased and expectations changed such that diesel automobiles will see a downward trend (e.g. [5], [6]). Results of this study indicate that this will not be the case in Turkey in the short term unless there is a new environmental tax policy or standard to discourage the use of diesel fuel.

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