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URBAN TRAVEL BEHAVIOR IN THE MIDDLE EAST AND NORTH AFRICA

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URBAN TRAVEL BEHAVIOR IN THE MIDDLE EAST AND NORTH AFRICA

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MODELING AND FORECASTING CAR OWNERSHIP BASED ON SOCIO-ECONOMIC AND DEMOGRAPHIC INDICATORS IN TURKEY

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ABSTRACT

Since car ownership is an important determinant to analyze car travel behavior especially in developing countries, this paper deals with modeling and forecasting car ownership in Turkey based on socio-economic and demographic indicators such as Gross Domestic Product (GDP) per capita, Gasoline Price (GP), car price and number of employees by using multiple nonlinear regression analysis. Although most of the studies on this subject prefer using annual data, we use monthly data for the analysis of car ownership since all explanatory variables and exchange rates used for the modeling are unstable and vary even in a short period in developing countries such as Turkey. Thus, it may be possible to reflect the effects of socio-economic and demographic indicators on car ownership more properly. During the modeling process, exponential and polynomial nonlinear regression models are set up and then tested to investigate their applicability for car ownership forecasting. Based on results of the Kolmogorov-Smirnov test, the polynomial models has been selected to forecast car ownership for the year 2035. In order to reveal the possible different trends of the independent variables in future, car ownership is forecasted along the scenarios which are related to the GDP per capita and GP. Results show that Turkey's car ownership may vary between 230 and 325 per thousand capita in 2035 depending on economic achievements, global oil prices and national taxation policies. The lowest and the highest values of the car ownership may provide insight to car producers and transport planners in Turkey. Another significant result presented in this study is that car ownership rate will be substantially lower in Turkey than that in the European Union countries despite it has an increasing trend in the past two decades.

KEYWORDS:
Car ownership; Socio-economic and demographic indicators; Multiple nonlinear regression

1 INTRODUCTION

Beginning from the second half of the 20th century, there is a substantial increase in car ownership in almost all industrialized countries, and more recently in many of the developing countries (Dargay & Gately, 1997). Thus, car ownership has received considerable attention especially for three decades because of its increasing trend over the years and also its important role in the overall planning for transportation decision-makers and car manufacturers. As known, although some additional costs arise after owning a car by a household (i.e. fixed costs, taxes, parking costs, car inspection costs, etc.), environmental and road infrastructure related problems come to exist resulting from high use of car rather than owning a car. However, it is clear that there is a non-negligible relationship between car ownership and car use. For this reason, modeling and forecasting car ownership has been one of most studied topics in the transportation field for many years regarding to importance both in land-use and transportation road network planning as well as its relationship transport related problems such as energy consumption, environmental and health effects. Thus, the objective of this study is to develop a forecasting model for car ownership and apply it to determine future trends of car ownership in Turkey for the year 2035.

Before presenting the literature review in the context of car ownership, in connection with this issue, it should be noted that Turkey applied for full membership to the European Union (EU) in 1987 (Ministry for EU Affairs, 2018). However at that time, the EU's decision about the accession of Turkey to the EU was not positive although the EU underlined Turkey's eligibility for membership. The accession of Turkey was prevented by the EU's own situation on the eve of the single market completion which prevented the consideration of further enlargement. The EU also pointed out that Turkey needs to improve its economy and make some improvements in related policies and social fields. In the context of car ownership which may be a sign for development level of a country, car ownership rate in Turkey was significantly less than those in European countries in the year of accession application to the EU made by Turkey as can been seen in Fig. 1. The figure illustrates the variation of car ownership rates of European countries per thousand capita from 1990 to 2015 based on the data provided by Eurostat (2018a). The rate of car ownership in Turkey was 29 per thousand capita in 1990 which is the smallest rate of car ownership among the European countries.

This value was nearly half of the car ownership rate of Romania which has the second lowest car ownership rate in 1990. In addition to this, other statistic shows the seriousness of the situation in terms of Turkey is that the average rate of car ownership was 290 per thousand capita in European countries at the same year. This situation can be seen in the Figure 1 such that car ownership rates were higher than the value of 300 per thousand capita in several west European countries while it was above 400 per thousand capita in many others in 1990. In the later years, increasing trend of car ownership continued in most of the European countries such that particularly Italy reached the value of 533 per thousand capita in 1995. At that time, this value was more than ten times of Turkey's car ownership of 49 per thousand capita. By the time Turkey solely reached the value of 100 passenger cars per thousand capita in 2010, the average car ownership was 448 per thousand capita in EU countries. By the year of 2015, Turkey was one of the six countries with less than 200 passenger cars per thousand capita in Europe as can be seen in Figure 1. These statistics clearly show that the modeling and forecasting car ownership in Turkey needs to be seriously taken into consideration and reasons for significantly low rates of car ownership in Turkey have to be revealed by considering effective parameters. As known, car ownership can be modeled as a function of socio-economic and demographic variables (Ben-Akiva et al., 1981; Janson, 1989). Additionally, there are two types of car ownership models such as disaggregate and aggregate. In disaggregate models, which may be called as micro analysis, the household is the basic unit for modeling car ownership whilst the aggregate model is interested in modeling car ownership on a macroscopic level within the range from a city zone to a country.

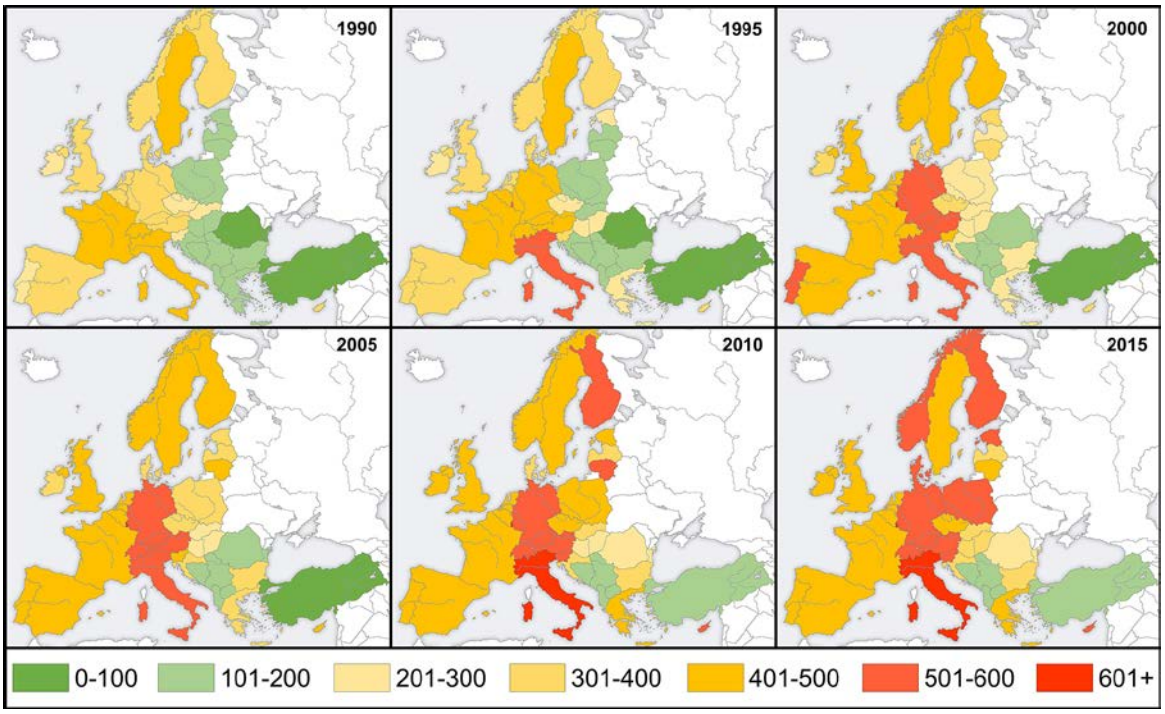

Fig. 1 Historical development of car ownership in European countries between 1990 and 2015 (per thousand capita)

In this context, one of the first studies was presented by Meurs (1993) in which car ownership level by household has been investigated using a panel data model. It has been found that owning the second car by household was more sensitive to changes in the explanatory variables of the model. Dargay & Gately (1997) forecasted the growth in car ownership until 2015 for Organization for Economic Cooperation and Development (OECD) and six Asian countries. They forecasted car ownership using Gombertz function regarding to independent variables such as income and population. They found that the increase on fuel consumption and emissions on those countries were about the same trend within studied period. Afterwards, Dargay & Gately (1999) projected car growth and total vehicle stock until 2015 for OECD countries including three Asian countries. The projections were executed based on the estimated model that explains the growth of car ownership as a function of Gross Domestic Product (GDP) per capita. In addition to these studies, the effect of income distribution was studied by Dargay (2001). It was found that the income elasticity on car ownership was significantly greater with respect to the rising income than the elasticity with respect to the falling income. From a different viewpoint, Romilly et al. (2001) addressed some quite new techniques to avoid uncertainties caused by some methods in car ownership modeling. They proposed five alternative methods by considering relationships between car ownership, income, motoring costs and bus fares. Another contribution to the literature from this study, the inclusion of bus fare variable in the model makes it more sensitive and it also allows to consider different assumptions regarding to the public transport user costs. Similarly to the study by Romilly et al., Medlock & Soligo (2002) modelled car ownership by considering related data from 28 countries. One of the most important results was that the income elasticity falls whereas countries become increasingly developed contrary to the widely held view in the literature. Similarly, Lam & Tam (2002) presented a car ownership model by using eight independent variables effecting car ownership. Results showed that the GDP per capita has positive effect on the growth of the total number of private cars and motorcycles while average first registration tax and annual passenger trips on public transport have negative effect on car ownership. Öğüt (2004) modelled car ownership in Turkey by using three different models namely Logistic, Power growth and Gompertz curves for the year 2020. Results emphasized that the future trends of car ownership for the models Power growth and Gompertz curves were quite similar to each other. Kumar & Rao (2006) conducted a stated preference experiment by using

multinomial logit model in order to determine the growth of car ownership in the context of household surveys. Their results revealed that stated preference approach may help planners who need to determine car ownership decisions of households in especially developing countries. It can be seen from the revealed literature, researchers have used several methods for modeling car ownership by looking from different perspectives so far. At this point, a fuzzy multiple-regression model was used to determine car ownership in Turkey over the period of 1970-2000 by Öğüt (2006). The major reason for applying fuzzy regression was to overcome the inter-correlation problem associated with the independent variables. Results showed that the proposed model provided an output range about the growth of car ownership in Turkey between 1970 and 2000 by applying fuzzy regression. Clark (2007) remarked that income is a significant determinant for car ownership modeling. In addition to this, it has also been emphasized in this study that the use of cross-sectional data by modeling may lead to an overall conclusion which does not reflect the variation of local circumstances. Potoglou & Susilo (2008) compared multinomial logit, ordered logit and ordered probit car ownership models by using different data sets in terms of evaluation measures. Results showed the advantage of the use of multinomial logit car ownership model in the level of household by comparison of three models. From the point of disaggregate models, one of the pioneer works in the literature has been conducted by Potoglou & Kanaroglou (2008). They examined the influence of micro level data in modeling car ownership in the context of household. The reason which differs this study from the others is that the neighborhood characteristics were included in the model by introducing several measures related to the neighborhood household. Additionally, the effect of urban structure which is another efficient parameter on household car ownership has been studied in the work by Matas et al. (2009). In their study, urban structure has been considered by means of accessibility to employment by public transport. Results showed that the most important variable affecting to the growth of car ownership is spatial variable. As another point of view, Çodur & Tortum (2009) proposed an Artificial Neural Network (ANN) approach for modeling car ownership in Turkey based on aggregate data such as GDP per capita, petrol prices, car prices, and road lengths. The proposed model has been compared with the multiple linear regression model. It has been concluded that the ANN approach outperforms the linear regression model and it is more reliable in terms of the ability of nonlinear behavior. Woldeamanuel et al. (2009) addressed that analyzing the factors affecting car ownership of household requires time-dependent behavior of family members. Thus, a panel data model has been applied to examine variation of car ownership by considering this issue. Acker & Witkox (2010) used car ownership as mediating variable in order to determine the relationship between car use and built environment by using a structural equation modeling approach which validates the proposed hypothesis. Azadeh et al. (2012) proposed a new approach combined the ANN and Fuzzy Linear Regression to forecast car ownership much more reliably in uncertain environments. Results confirmed that the proposed approach provided more reliable forecasting for car ownership by considering socio-economic and demographic variables. Chen and Zhang (2012) investigated the growth of car ownership by using city-level aggregate data under different policies implemented in megacities in China. In their study, a principal component analysis has been applied and the results indicate that the relationship between income and the growth of car ownership was very strong in China. Ritter & Vance (2013) analyzed specifically the effect of family size on car ownership in Germany. They used multinomial logit model considering other explanatory variables namely the availability of public transport, fuel prices and land use density. Results showed that the proposed model estimated increasing trend in the number of cars although the population decreased. Another study conducted in city-level by Anowar et al. (2014) examined the effect of population on car ownership rather than other exogenous variables by using ordered and multinomial logit models. According to the results, the ordered logit model clearly revealed the advantage of considering of segmentation in the population. A different type of logit models namely sequential logit model has been proposed to forecast car ownership in Turkey by Akay & Tümsel (2015). Based on disaggregated data provided by 3722 households in the year of 2013, the dominant parameter affected the probability of owning a car of household was

found as income. In another study conducted in Turkey by Yayar et al. (2015), disaggregate data has been used to model car ownership in the city-level. The model was estimated by using binary logit model. It has been found that car ownership of a household was positively affected if household head was a homeowner and had high income. Guerra (2015) looked the problem from different perspectives and investigated the relationship between car ownership and suburbanization. Results relied on mixed logit model showed that both variables are highly correlated with each other and move hand in hand. To further illustrate the concept of disaggregate data, Yagi & Managi (2016) performed an empirical study of the car cohort model with demographic determinants of car ownership in Japan. One of the significant results drawn from this study is that the elasticities of income and fuel prices on car ownership have a tendency to decrease. Shen et al. (2016) examined the factors affecting car ownership using different types of logit models. The major finding in this study is that car ownership tends to decrease when households in suburban are benefited from rail transit. Korkmaz et al. (2016) proposed artificial bee colony algorithm to forecast car ownership in Turkey for 2025 based on some variables such as population, GDP per capita, and fuel prices. They have found that the car ownership rate in Turkey will be reach to the value of 150 per thousand capita in 2025 according to considered explanatory variables. Recently, Yang et al. (2017) investigated how the growth of car ownership affects the use of urban space and environment. Using aggregated data within the years 1994 and 2012 the proposed model has been applied to 293 cities in China. Results showed that car ownership was directly related to GDP per capita, built-up area, road area, urban density and number of taxis. Transport planners frequently require information on car ownership and they utilize it for designing transportation infrastructure, determining travel behaviors, planning road safety measures etc. For example, Sinniah et al. (2014) investigated residential location preferences related to travel behavior. In the study, after it is stated that the relevant literature concentrates on the preferences in relation to physical and demographic aspects, such as land uses, car ownership, income, etc., it is suggested that social and cultural issues such as racial diversity should be taken into account for residental location preferences. For this purpose, reliability analysis and factor analysis are applied to determine that religious and culture are influential in terms of residential location preferences. In the conclusions, it is indicated that this approach adds a different perspective on travel behavior studies. Soltanzadeh and Masumi (2014) investigated the most influential determinants of modal choices in Kerman, Iran. It is indicated that accessibility to public transportation and convenience of it may convince people to shift from car driving to public transit use. In addition, it is pointed out that the four variables of gender, household size, age, and car ownership significantly affect modal choice decisions. From a different viewpoint, there is a well-known paradox between transport planners and car manufactures such that one usually tries to reduce car use while the other one tries to maximize sales figures. Nevertheless, forecasting car ownership may help car producers to manage their selling business and transport planners to plan their policies related to transportation infrastructure and safety measures. In this study, it is considered that the most important parameters affecting the growth of car ownership in Turkey are GDP per capita, Gasoline Price (GP), Car Price (CP), and Number of Employees (NE). Thus, this study deals with modeling and forecasting car ownership by using multiple nonlinear regression model based on explanatory variables under different scenarios. The paper is organized as follows. The model variables with their historical development for the observation period and multiple nonlinear regression models are given in the next section. Forecasting car ownership and related scenarios are presented in Section 3. Finally, last section is about conclusions and future directions.

2 MATERIALS AND METHODS

2.1 MODEL VARIABLES

Determining and taking into account the parameters affecting car ownership have been the topic of many researchers. Most of the existing studies relied on socioeconomic and demographic indicators such as financial data and population. In this study, car ownership in Turkey is modeled and forecasted based on GDP per capita, gasoline prices, car prices and number of employees. In this section, historical data for the model variables are presented.

Car ownership

In the early 1970's, car ownership was considered a privilege or a luxury that there were only 4 cars per thousand capita in Turkey (Öğüt, 2006). This value has reached 134 per thousand capita at the end of 2015. The historical development of car ownership in monthly basis between January 1997 and December 2015 is given in Figure 2 (TSI, 2018a).

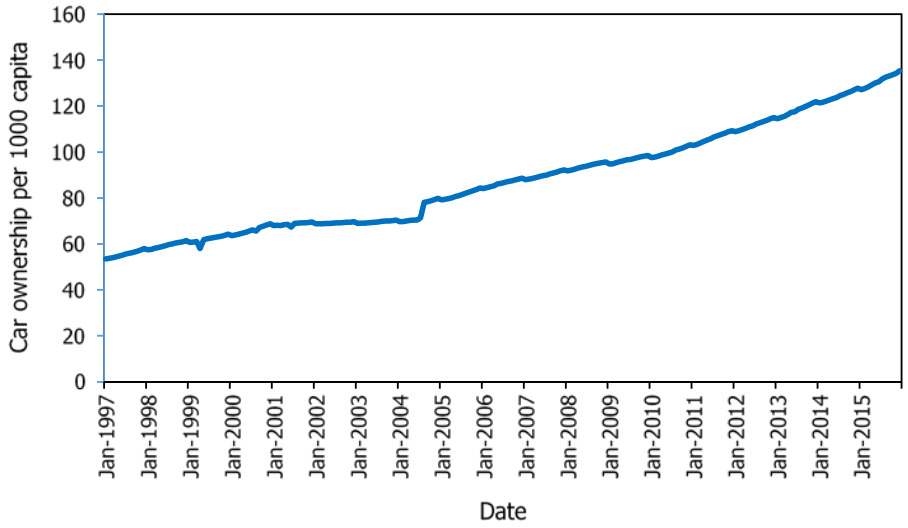

Fig. 2 Historical development of car ownership in Turkey, 1997-2015

As can be seen in Figure 2 that the tendency to increase in car ownership between 1997 and 2000 has stopped due to the 2001 Turkish economic crisis and this steady state continued until the middle of 2004. Together with the reduction in the impacts of the economic crisis, a large amount of car sales realized due to the long-suppressed car ownership demand in 2004, and the car ownership has continued to grow since then. Another reason for this sudden spike in car ownership in 2004 is that a tax incentive implemented by the central government of Turkey between August 2003 and December 2004 in order to renew the passenger car stocks by Turkish Law Number 4962. With this regulation, the average age of passenger car stock in Turkey rapidly decreased from 6.1 to 5.3 at the end of 2004, while this value has slightly decreased to the value of 4.3 in 2015 (Eurostat, 2018b). These results clearly show that this tax incentive had a direct effect on car sales and passenger car stock has continued to be renewed depending on new car sales in Turkey. However, the rate of car ownership in 2015 in Turkey is still much less than that in European countries because of several reasons related to socio-economic and demographic determinants.

GDP per capita

GDP per capita is one of the most important parameters in car ownership decision, particularly for a household owning a second car as mentioned in the previous section. Wu et al. (2014) indicated that there is an S-shaped relationship between GDP per capita and car ownership rates in their study. It means that there is a saturation point for car ownership. In this context, Rota et al. (2016) determined the saturation

level of car ownership based on the aggregated data from 59 countries including EU members as about 622 per thousand capita. As the rate of car ownership in Turkey is still substantially lower than this value, it is strongly expected that it continues to grow depending on the development of the GDP per capita. In this context, the International Monetary Fund (IMF) recognizes Turkish economy as an emerging market economy as one of the world's newly industrialized countries (IMF, 2011). Main economic sectors of Turkey are agricultural, industrial, service, construction and contracting sectors. With the 5.1 percent growth in 2017, Turkey has played an important role on short-term growth on emerging and developing European economy (IMF, 2017a). According to the IMF, Turkey has the world's 13th largest GDP by purchasing power parity and 17th largest nominal GDP (IMF, 2017b). The historical development of GDP per capita in Turkish Lira (TL) and USD exchange rate in monthly basis between January 1997 and December 2015 is given in Figure 3 (TSI, 2018b).

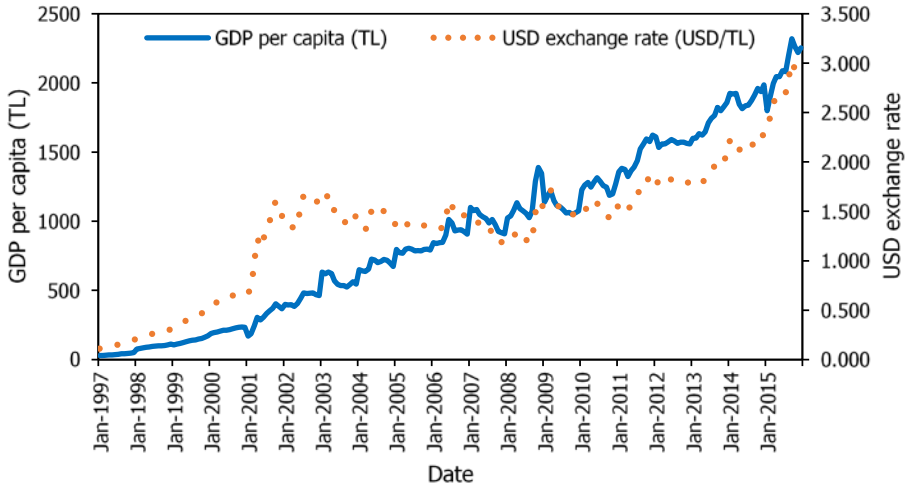

Fig. 3 Historical development of GDP per capita in Turkey, 1997-2015.

It can be seen in Figure 3 that TL has appreciated and depreciated periodically between 1997 and 2015. This fluctuation and sudden spikes in inflation rate leads to an unstable GDP per capita growth in Turkey. On the other hand, it may be clearly seen that the GDP per capita has increased in the last two decades in Turkey and will increase about %29 by 2022 (IMF, 2017b). In Figure 4, passenger vehicle stocks with respect to the GDP per capita in Purchasing Power Standards (PPS) is illustrated for the EU countries and Turkey for 2015 (Eurostat, 2018a; 2018c).

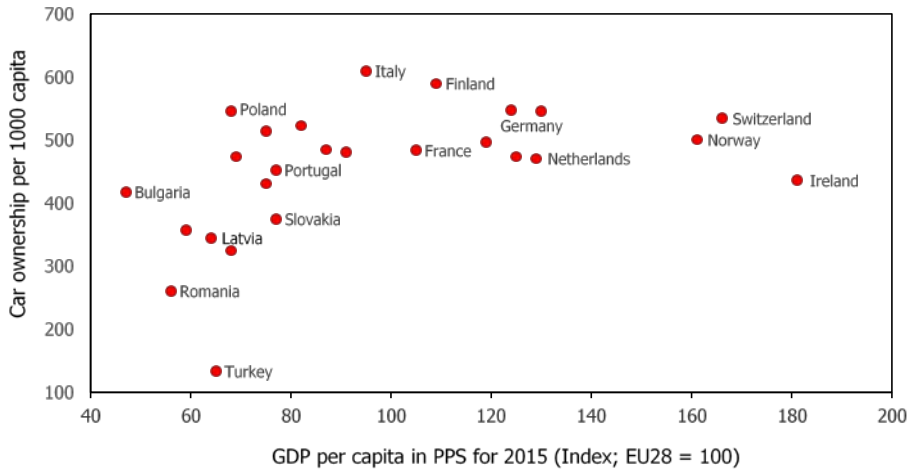

Fig. 4 Car ownership and GDP per capita in EU countries and Turkey

As can be seen in Figure 4 that car ownership value is around 500 per thousand capita in several EU countries in which GDP per capita is above 70. As for the rest, the passenger car stock varies between 250 and 400 while it is 134 for Turkey. It should be noted that the car ownership ratio in Turkey is three times lower than Latvia although similar PPS values are observed in two countries. Therefore, car ownership rate is still substantially lower in Turkey than in the European Union countries despite an increasing trend in the past decades.

Car prices

Individual car ownership in Turkey began with opening two new automobile factories, Tofaş-Fiat and Oyak-Renault in 1968 and 1969, respectively. In the following years, Ford, Honda, Hyundai and Toyota has produced automobiles in their factories in Turkey. Although the Turkish automotive industry becomes an important actor of the national economy, it serves for the production of foreign brands and countries. For instance, 0.6 million passenger cars were registered in Turkey in 2014 and about 65% of total registrations were imported from France, Germany, Italy, Korea, Japan and United States (TSI, 2018a). Therefore, car prices not only are dramatically affected by the inflation and tax rates, but also depend on USD and EURO exchange rates. While the average car price is about 1500 TL in 1997, this value exceeded 50,000 TL at the end of 2015. The historical development of average car prices and USD exchange rate in monthly basis between January 1997 and December 2015 is given in Figure 5 (TSI, 2018c).

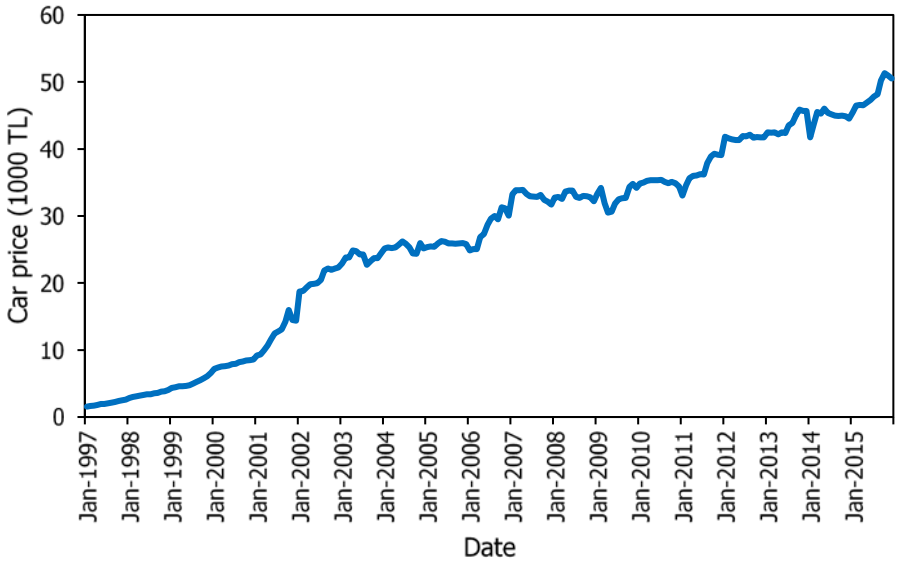

Fig. 5 Historical development of car prices in Turkey, 1997-2015

In addition to the car prices, impact of tax policies can be considered as a very strong determinant in car ownership decision in Turkey. The central government of Turkey implements a policy called “Special Consumption Tax” (SCT) in car sales means that a buyer has to pay the SCT up to 110% of the net price of the car that he wants to purchase. Furthermore, 18% value added tax is implemented on net price plus SCT at purchase. Due to this taxation system, buyers have to pay almost two times more for owning a new car in Turkey. Despite the high tax rates, the car ownership in Turkey continues to grow and it may be useful to investigate the potential impacts of car prices on car ownership.

Gasoline prices

Energy demand of Turkey rapidly grows as well as the increase of population and growing industrialization. According to the Ministry of Energy and Natural Resources (MENR), domestic crude oil resources could meet only 7.7% of demand in 2017 (MENR, 2018).

Therefore, Turkey's major imported energy source is mineral fuels including crude oil. In order to provide a trade balance between import and export, high tax policies are implemented and the consumers face very high retail prices of diesel, gasoline and LPG. The historical development of gasoline prices between January 1997 and December 2015 is given in Figure 6 (TSI, 2018c).

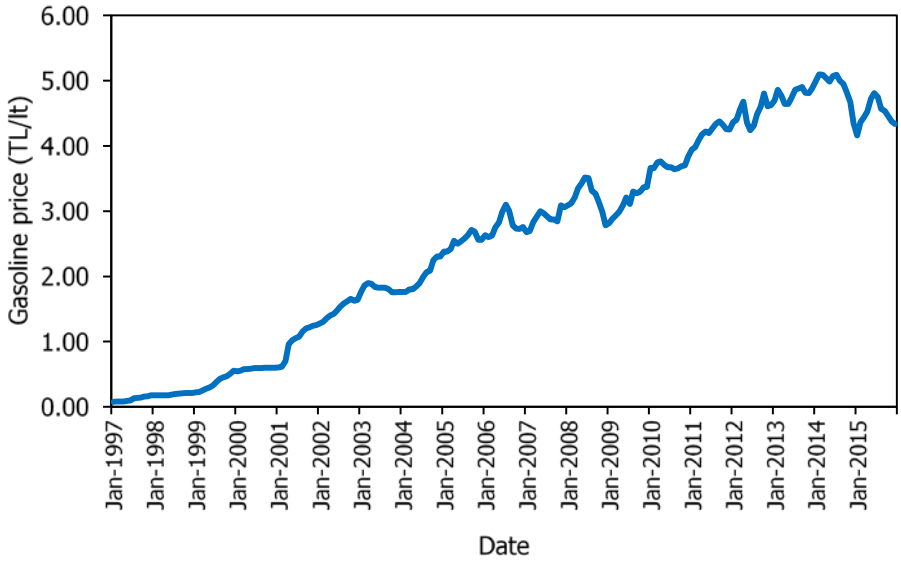

Fig. 6 Historical development of gasoline prices in Turkey, 1997-2015

As can be seen from Figure 6 that the gasoline price was about 0.08 and 4.37 TL/litre in January 1997 and December 2005, respectively. It should be noted that gasoline prices have been fluctuated quite often in Turkey. Rapid decreases on retail prices arise from decrease on global oil prices while spikes arise from increase on global oil prices and taxes. It should also be noted that this fluctuation depends on appreciation and depreciation of Turkish currency against the US dollar as well.

In the point of view of tax policies on gasoline prices, Turkey can be considered as one of the countries which has the highest gasoline prices in the world owing to high excise taxes on gasoline prices (OECD, 2016). According to the statistics by Republic of Turkey Energy Market Regulatory (EMRA, 2017), net gasoline prices in December 2017 in Istanbul was 1.77 TL/lt but its value reached to 5.57 TL/lt with excise taxes and other expenditures such as wholesale margin, income share and retail margin. Thus, this determinant should be taken into account to model and forecast car ownership in Turkey as it is one of most important determinants to decide having a car for buyers with its significantly high price when considered operating cost of a car.

Number of employees

The rate of car ownership is sensitive to the changes in the ratio of the working population to the total population over time. Especially in Europe and Japan, while the working population has changed more slowly in the last 30 years, this rate has increased more rapidly in developing countries (Pişkin, 2017). The main reasons for this may be the demand in agricultural labor force decreased in rural areas and a large amount of people migrated to the cities in which growing industrialization revealed new job opportunities. The historical development of Urban Population Rates (UPR) of EU countries and Turkey between 1960 and 2016 is given in Figure 7 (The World Bank, 2018).

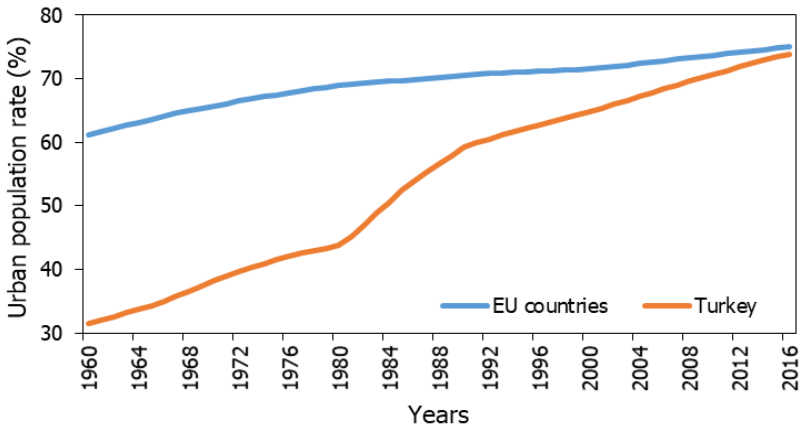

Fig. 7 Historical development of urban population rates of EU countries and Turkey, 1960-2016

In can be seen from Figure 7 that the UPRs are about 61% and 32% in 1960 for EU countries and Turkey, respectively. The UPR in Turkey increased about 134% between 1960 and 2016 while it increased only 23% in EU that most EU countries may have approached a saturation level. On the other hand, from 1960s, urbanization and industrialization developed in Turkey and growing number of people began to move to the cities and the urban population rate dramatically converged to the EU average in 2016 with the value of 74% which may be considered as a near-saturation point for Turkey. Therefore, it can be stated that the UPR in Turkey would not rise steeply in the medium and long term. However, car ownership rate is still substantially lower in Turkey than in the EU countries despite an increasing trend in the past decades. A reason for the lower car ownership rates in Turkey is that young (dependent) population ratio is relatively higher than developed countries. In order to evaluate the potential future labor force of Turkey, proportion of young population in five most populated EU countries and Turkey between 1997 and 2015 is given in Figure 8 (Eurostat, 2018d).

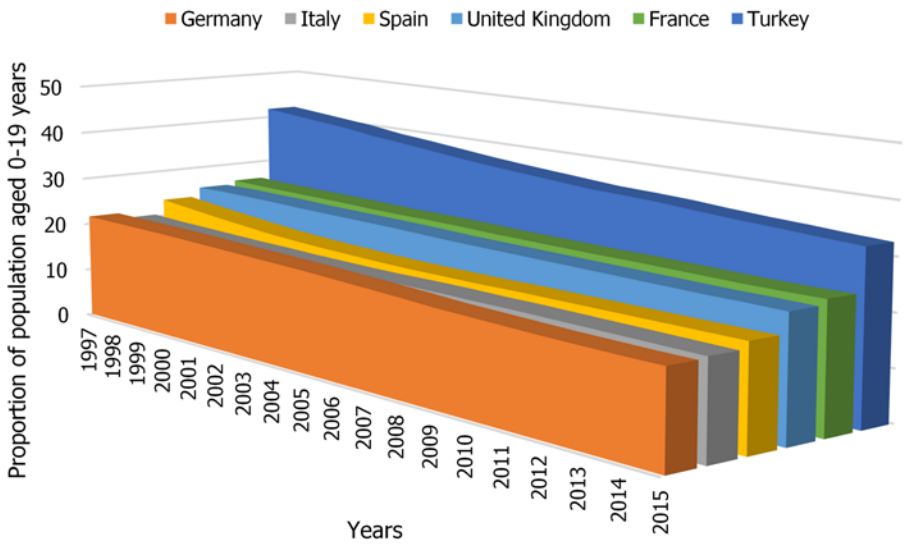

Fig. 8 Proportion of young population in five EU countries and Turkey, 1997-2015

As can be seen from Figure 8 that Turkey has higher proportion of young population than five most populated EU countries. It may be stated that the potential future labor force may lead to an increase of car ownership in Turkey. The historical development of number of employees between January 1997 and December 2015 is given in Figure 9 (TSI, 2018d). It can be seen in the figure that the number of employees

in Turkey is above 26 million in 2015 while it is about 21 million in 1997. It should be noted that the demand for seasonal wage labor in agriculture and tourism increases the number of employees between May and October every year.

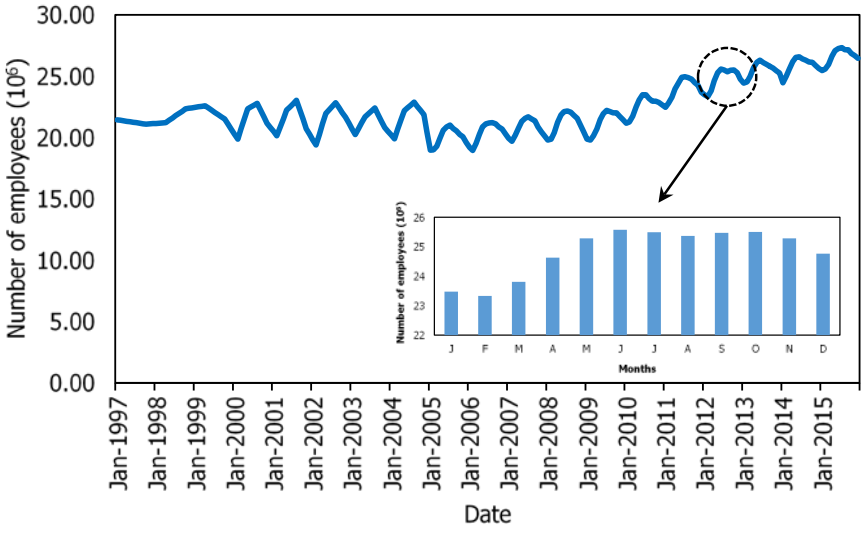

Fig. 9 Number of employees in Turkey, 1997-2015

2.2 MULTIPLE NONLINEAR REGRESSION MODELS

Before implementing the multiple regression models, the correlation coefficients given in Table 1 were calculated in order to show the relationships between explanatory variables affecting car ownership. It can be seen from the table that all determinants were correlated with car ownership and the highest correlation was demonstrated between car ownership and GDP per capita as 0.989. On the contrary, the lowest correlated determinant with car ownership was found as NE with the value of 0.744. Although the second highest correlated determinant with car ownership was GP with the value of 0.964, previous study presented by Baskan et al. (2008) demonstrated that the increase on gasoline prices may not considerably affect the rate of car ownership. In fact, historical development of gasoline prices in Turkey given in Figure 6 clearly shows the reason for this contrast. The GP has an increasing trend over the years and its value reached to 5.7 TL/lt from 0.08 TL/lt at the end of 2017[1]. Thus, especially in recent years, the gasoline price has started to be effective determinant to decide buying a car for community living in Turkey due to its high increase.

	GDP PER CAPITA	GP	NE	CP	CAR OWNERSHIP
GDP PER CAPITA	1.000				
GP	0.972	1.000			
NE	0.716	0.648	1.000		
CP	0.968	0.978	0.601	1.000	
CAR OWNERSHIP	0.989	0.964	0.744	0.947	1.000

Tab. 1 Correlation coefficients of car ownership and its determinants

Nonlinear regression models play a more important role day by day since many engineering problems can be better expressed by using nonlinear models than linear. The reason is that many of explanatory variables affecting dependent variable have nonlinear relationship with each other.

[1] The data until at the end of 2015 are used for the whole analysis because of absence of data between the years 2015 and 2017 for other determinants.

There is also a nonlinear relationship between dependent and independent variables for many complex problems occurred in nature. Thus, the nonlinear model is commonly preferred option to analyze for such problems. Usually, a nonlinear model can be presented with the following equation:

$$y = f\left(x, \phi\right) + \xi \tag{1}$$

where y is the dependent variable i.e. response variable, f is the model, x is the independent variable, ϕ represents the model parameters to be estimated and ξ is the error term. It can be stated that a regression model becomes nonlinear when its parameters are nonlinear. For this, each of model parameters should be evaluated whether it is nonlinear or not. The nonlinearity of a model parameter can be decided by whether its second derivative equals to zero or not. Thus, the model can be recognized as nonlinear, linear or a mix of linear and nonlinear parameters depending on whether all parameters of a model are nonlinear or not (Archontoulis & Miguez, 2015). Choosing a suitable regression model fitting to data is always a hard task. First thing to do in this issue is to decide whether the model is linear or nonlinear. Although nonlinear models have some disadvantages, parsimony, interpretability and prediction ability are their main advantages (Bates & Watts, 2007). One of the widely used nonlinear models is in exponential form as given in the following equation:

$$Y = w_1 + w_2 \cdot e^{w_3 \cdot X_{GDP}} + w_4 \cdot e^{w_5 \cdot X_{GP}} + w_6 \cdot e^{w_7 \cdot X_{CP}} + w_8 \cdot e^{w_9 \cdot X_{NE}} \tag{2}$$

where Y is car ownership, X_{GDP}, X_{GP}, X_{CP}, and X_{NE} are explanatory i.e. independent variables, and w_i (i=1,2,..,9) is the set of coefficients. In this study, multiple nonlinear regression analyses are carried out using XLSTAT software (XLSTAT, 2018). Considering the coefficients of the regression analysis given in Table 2 the model can be represented as given in Eq. (3).

VARIABLE	COEFFICIENT	VALUE
	w_1	4.50460
GDP PER CAPITA	w_2	97.98317
	w_3	0.00024
GP	w_4	-35.76402
	w_5	-0.11878
CP	w_6	-58.63220
	w_7	-0.12495
NE	w_8	-6.63064
	w_9	0.01489

Tab. 2 Coefficients of multiple nonlinear regression model in exponential form

$$Y = 4.50 + 97.98 \cdot e^{0.00024 \cdot X_{GDP}} - 35.76 \cdot e^{-0.11878 \cdot X_{GP}} - 58.63 \cdot e^{-0.12495 \cdot X_{CP}} - 6.63 \cdot e^{0.01489 \cdot X_{NE}} \tag{3}$$

It can be concluded from the analysis that although the observed and predicted values are well fitted with high R^2 value of 0.98, a statistical test has been carried out to ensure whether the model is suitable to forecast car ownership or not. In this context, the Kolmogorov-Smirnov (KS) as goodness of fit test has been used as it is one of the mostly used statistical test to verify suitability of nonlinear regression models. The two sample KS test is used to test whether observed and predicted values of car ownership come from the same distribution. The KS statistic quantifies a distance between the empirical distribution function of two samples.

In the KS test, H_0 hypothesis is considered that two samples follow the same distribution.

On the other hand, the value of α (i.e. significance level) is the probability of making the wrong decision when the null hypothesis is true. The critical value of *D* obtained from the KS table at the 0.05 α level has been found as 0.096 which is less than the value of *D* as seen in Table 3. This means that null hypothesis is rejected and it can be concluded that the observed and predicted car ownership values come not from the same distribution.

	VALUE
D	0.110
p-value (two-tailed)	0.129
a	0.05

Tab. 3 Results of two-sample Kolmogorov-Smirnov test (two-tailed)

Thus, the other mostly used type of nonlinear regression models namely polynomial has been used to fit the observed and predicted data. The mathematical form of the regression model is given in Eq. (4).

$$Y = w_1 + w_2 \cdot X_{GDP} + w_3 \cdot X_{GP} + w_4 \cdot X_{CP} + w_5 \cdot X_{NE} + w_6 \cdot X_{GDP}^2 + w_7 \cdot X_{GP}^2 + w_8 \cdot X_{CP}^2 + w_9 \cdot X_{NE}^2 \quad (4)$$

where Y is car ownership, X_{GDP}, X_{GP}, X_{CP}, and X_{NE} are explanatory i.e. independent variables, and w_i (i=1,2,..,9) is the set of coefficients. Coefficients of multiple nonlinear regression model in polynomial form are found as given in Table 4 by using the XLSTAT software. The polynomial regression model can be represented as given in Eq. (5).

VARIABLE	COEFFICIENT	VALUE
	w_1	106.74185
GDP PER CAPITA	w_2	0.01725
	w_6	0.000001
GP	w_3	17.52527
	w_7	-1.70376
CP	w_4	-1.52711
	w_8	0.02274
NE	w_5	-4.71569
	w_9	0.11733

Tab. 4 Coefficients of multiple nonlinear regression model in polynomial form

$$Y = 106.74 + 0.017 \cdot X_{GDP} + 17.52 \cdot X_{GP} - 1.53 \cdot X_{CP} - 4.72 \cdot X_{NE} + 0.000001 \cdot X_{GDP}^2 - 1.70 \cdot X_{GP}^2 + 0.023 \cdot X_{CP}^2 + 0.117 \cdot X_{NE}^2 \quad (5)$$

Car ownership has been predicted by using polynomial regression model for the observation period 1997-2015 with coefficient of determination (R^2) value of 0.99 as given in Figure 10 which visualizes the quality of the fit by comparing the predicted values to the observed values. According to the KS test result for polynomial model the computed *D* value of 0.083 is less than the critical value of *D* obtained from the KS table which is 0.096 at the 0.05 α level. This means that null hypothesis is accepted and the polynomial form of the multiple regression model can be used to forecast car ownership.

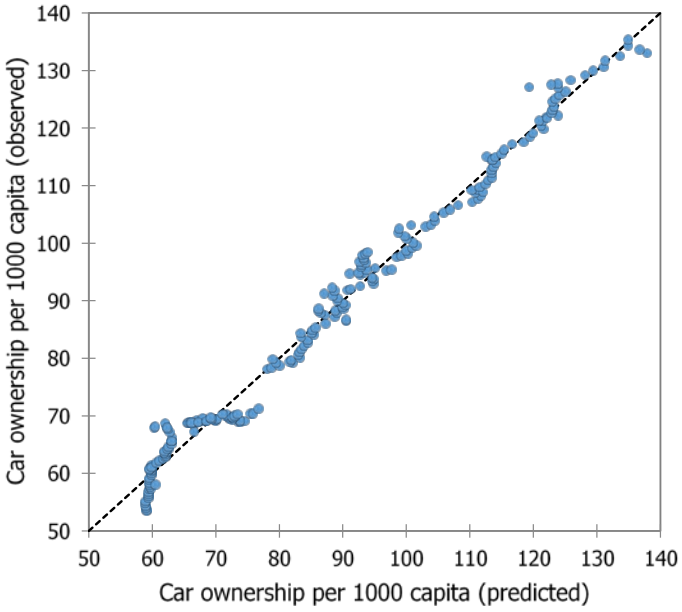

Fig. 10 Relationship between the observed and predicted values of car ownership

3 FORECASTING CAR OWNERSHIP IN TURKEY

As car ownership is most likely sensitive to the changes in the values of the parameters given in the previous section, a scenario based approach is used to explore future car ownership ratio in Turkey. In this context, future trends for all four parameters are identified based on their values observed between January 1997 and December 2015. Resulting future trend equations and their related R^2 values are given in Figure 11.

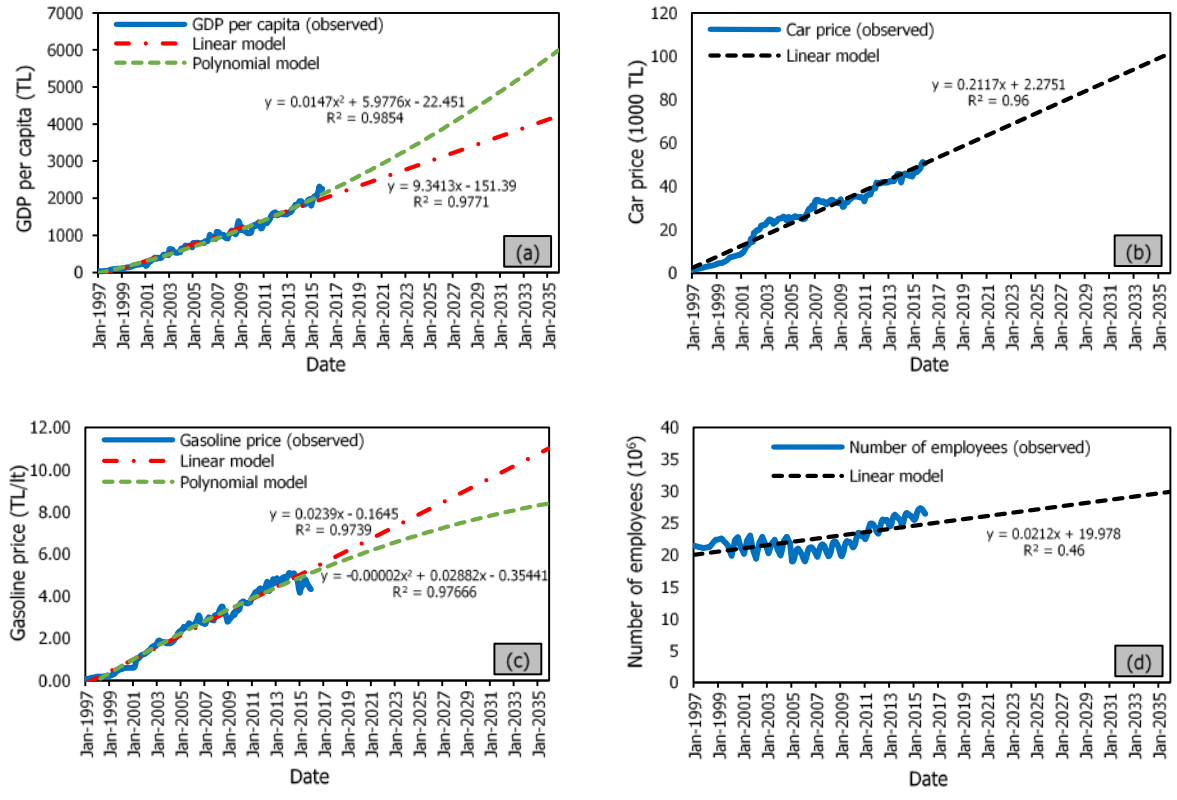

Fig.11 Future trend equations for GDP per capita, CP, GP and NE

As can be seen in Figure 11 that the projection of parameters CP and NE were conducted based on fitting linear trends which are well suited to their historical development. The NE is assumed to increase in the similar tendency with the growing population unless new employment opportunities are created or new labor market regulations are considered in Turkey. As an upper-middle-income country, Turkey is the 17th-largest economy in the world with $10,891 GDP per capita and macroeconomic stability dramatically improves Turkey's economic performance since 2000 (World Bank, 2017). It may be assumed that Turkey may move into the high-income status in case of overcoming domestic challenges and recovering geopolitical environment. From this point of view, polynomial increase in GDP per capita represents an optimistic perspective while linear increase represents the current growth as seen in Figure 11. On the other hand, direct and indirect fuel taxation play an important role in fiscal consolidation strategy in Turkey. Additionally to the value added tax system, a special consumption tax has been applied to the fuel prices in Turkey since 2002 and total tax ratio in retail gasoline price reached up to 64% in 2015 (EMRA, 2016). Considering that Turkey faces with budget deficits, revenue from taxes on fuel will be the most decisive factor in retail gasoline price. In future, total tax rate in gasoline prices may be decreased depending on the positively changed economic indicators in Turkey. Therefore, projection of GP is executed based on two trends namely linear and polynomial which represent current growth and an optimistic perspective, respectively as illustrated in Figure 11. In order to represent the effect of different growth patterns of GDP per capita and GP on car ownership in 2035, four scenarios are generated as given in Table 5.

	GROWTH PATTERNS FOR EXPLANATORY VARIABLES			
SCENARIO NO	GDP PER CAPITA	GP	NE	CP
1	Polynomial	Polynomial	Linear	Linear
2	Polynomial	Linear	Linear	Linear
3	Linear	Polynomial	Linear	Linear
4	Linear	Linear	Linear	Linear

Tab. 5 Generated scenarios for car ownership estimation

For all scenarios, Turkey's car ownership until 2035 is calculated using Eq. (5) and the results are illustrated in Figure 12.

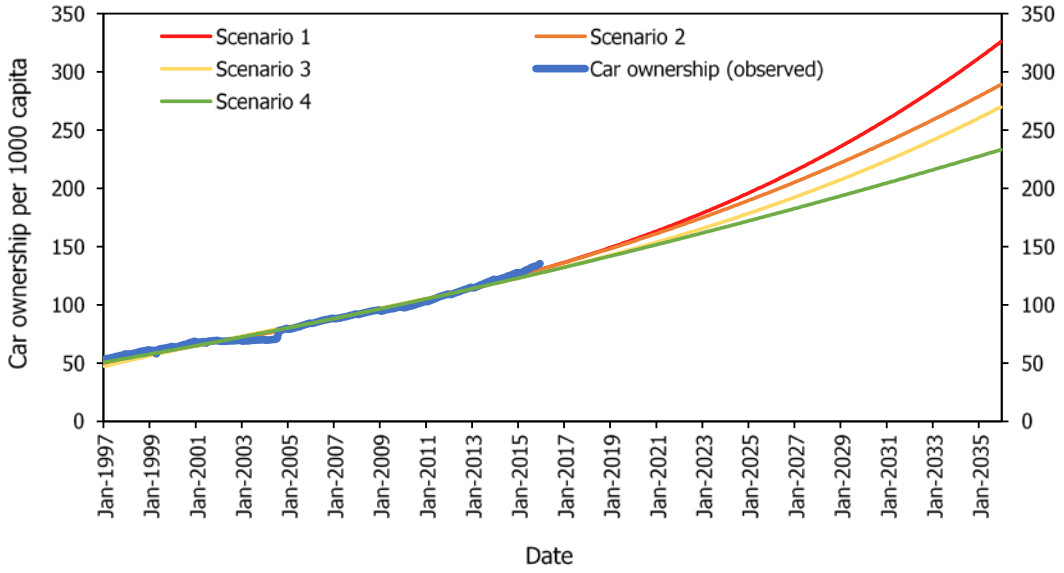

Fig. 12 Forecasted values of car ownership based on four scenarios

It can be seen in Figure 12 that Scenario 4 with a linear increase in GPD per capita and GP reveals the lowest car ownership rate about 230 passenger cars per thousand capita in Turkey for 2035. On the other hand, car ownership in Turkey may reach up to 325 per thousand capita according to Scenario 1, which represents achieving economic success of Turkey that GDP per capita increases more than current growth rate with decreasingly growing gasoline prices. It can obviously be seen that even though Scenario 1 provides the highest car ownership rate, passenger car stocks per thousand capita in Turkey for 2035 will be significantly less than the most of the EU countries have already had in 2015.

It should also be noted that the point of saturation in per capita car stocks will probably not be reached by 2035 in Turkey. This can be clearly seen from the figure where car ownership rate in Turkey continues to rise according to the all scenarios even in the year of 2035.

4 CONCLUSIONS

This study deals with modeling and forecasting car ownership based on explanatory variables such as gross domestic product per capita, gasoline prices, car prices, and number of employees which were considered the most effective parameters for households owning a car in Turkey. Multiple nonlinear regression analysis has been selected for modeling car ownership because of its ability to represent the effect of instable determinants and to provide a perfect fit to the observed data set. The data were used on a monthly basis due to some disadvantages of the use of annual data. We have utilized two set of nonlinear regression models namely polynomial and exponential. Polynomial regression model were preferred to forecast car ownership for the year of 2035 since exponential model did not meet the requirement according to the results of Kolmogorov-Smirnov test.

In order to forecast car ownership, the explanatory variables were fitted to the observed data and their future trends were determined. In order to represent the effect of different trends of explanatory variables for 2035, car ownership was forecasted along four scenarios which were related to different expected values of gross domestic product per capita and gasoline prices. It can be concluded that the lowest and highest values of car ownership may provide insight to car producers and transport planners in Turkey. Another result can be drawn from this study might be that car ownership in Turkey with the value of 325 per thousand capita will be significantly less than the average value for European countries even the best optimistic scenario was taken into consideration.

Although the present study provides useful insights for transport planners and car manufacturers in terms of future trends of car ownership in Turkey based on optimistic and pessimistic scenarios, car ownership could not be forecasted by using disaggregated data which is not collected regularly in Turkey.

In the future, car ownership must be modeled and forecasted by using disaggregated data which might be more reliable.

REFERENCES

Acker, V. V., & Witlox, F. (2010). Car ownership as a mediating variable in car travel behaviour research using a structural equation modelling approach to identify its dual relationship. *Journal of Transport Geography*, 18(1), 65-74. doi:http://dx.doi.org/10.1016/j.jtrangeo.2009.05.006

Akay, E., & Tümsel, B. (2016). An Empirical Investigation of Household Automobile Ownership: A Sequential Logit Model. *Social Sciences Research Journal*, 4(4), 35-45. Available at: http://dentaworld.dergipark.gov.tr/ssrj/issue/22475/240409

Anowar, S., Yasmin, S., Eluru, N., & Miranda-Moreno, L. F. (2014). Analyzing car ownership in Quebec City: a comparison of traditional and latent class ordered and unordered models. *Transportation*, 41(5), 1013-1039. doi:http://dx.doi.org/10.1007/s11116-014-9522-9

Archontoulis, S. V., & Miguez, F. E. (2015). Nonlinear Regression Models and Applications in Agricultural Research. *Agronomy Journal*, 107(2), 786-798. doi:http://dx.doi.org/10.2134/agronj2012.0506

Azadeh, A., Neshat, N., Rafiee, K., & Zohrevand, A. (2012). An adaptive neural network-fuzzy linear regression approach for improved car ownership estimation and forecasting in complex and uncertain environments: the case of Iran. *Transportation Planning and Technology*, 35(2), 221-240. doi:http://dx.doi.org/10.1080/03081060.2011.651887

Baskan O., Ceylan H., Haldenbilen S., & Ceylan H. (2008). Spreadsheet Modeling Approach for Estimating Car Ownership. *8th International Congress on Advances in Civil Engineering*, September 15-17, Cyprus.

Bates, D. M., & Watts, D. G. (2007). Nonlinear regression analysis and its applications. New York: Wiley. doi:http://dx.doi.org/10.1002/9780470316757

Ben-Akiva, M., Manski, C. F., & Sherman, L. (1981). A Behavioral Approach to Modelling Household Motor Vehicle Ownership and Applications to Aggregate Policy Analysis. *Environment and Planning A*, 13(4), 399-411. doi:http://dx.doi.org/10.1068/a130399

Chen, X., & Zhang, H. (2012). Evaluation of Effects of Car Ownership Policies in Chinese Megacities. *Transportation Research Record: Journal of the Transportation Research Board*, 2317, 32-39. doi:http://dx.doi.org/10.3141/2317-05

Clark, S. D. (2007). Estimating local car ownership models. *Journal of Transport Geography*, 15(3), 184-197. doi:http://dx.doi.org/10.1016/j.jtrangeo.2006.02.014

Çodur, M. Y., & Tortum, A. (2009). Modelling car ownership in Turkey using neural networks. *Proceedings of the Institution of Civil Engineers - Transport*, 162(2), 97-106. doi:http://dx.doi.org/10.1680/tran.2009.162.2.97

Dargay, J., & Gately, D. (1997). Vehicle ownership to 2015: Implications for energy use and emissions. *Energy Policy*, 25(14-15), 1121-1127. doi:http://dx.doi.org/10.1016/s0301-4215(97)00104-3

Dargay, J., & Gately, D. (1999). Incomes effect on car and vehicle ownership, worldwide: 1960–2015. *Transportation Research Part A: Policy and Practice*, 33(2), 101-138. doi:http://dx.doi.org/10.1016/s0965-8564(98)00026-3

Dargay, J. M. (2001). The effect of income on car ownership: evidence of asymmetry. *Transportation Research Part A: Policy and Practice*, 35(9), 807-821. doi:http://dx.doi.org/10.1016/s0965-8564(00)00018-5

Energy Market Regulatory Authority. (2016). Turkish Petroleum Market Report 2015. Retrieved December 24, 2017, available at: http://www.emra.org.tr/TR/Dokuman/8321

Energy Market Regulatory Authority. (2017). Turkish Petroleum and LPG Market Report 2017. Retrieved March 6, 2018. Available at: http://www.epdk.org.tr/TR/Dokumanlar/Petrol/YayinlarRaporlar/Fiyatlandirma

Eurostat-Statistical office of the European Union. (2018a). Retrieved January 02, 2018. Available at:http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=road_eqs_carhab&lang=en

Eurostat-Statistical office of the European Union. (2018b). Retrieved March 06, 2018. Available at: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=road_eqs_carage&lang=en

Eurostat-Statistical office of the European Union. (2018c). Retrieved January 02, 2018. Available at: http://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&language=en&pcode=tec00114&plugin=1

Eurostat-Statistical office of the European Union. (2018d). Retrieved January 02, 2018. Available at: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=demo_pjanind&lang=en

Guerra, E. (2015). The geography of car ownership in Mexico City: a joint model of households' residential location and car ownership decisions. *Journal of Transport Geography*, 43, 171-180. doi:http://dx.doi.org/10.1016/j.jtrangeo.2015.01.014

International Monetary Fund. (2011). World Economic Outlook April 2011, Tensions from the Two-Speed Recovery Unemployment, Commodities, and Capital Flows. Retrieved January 02, 2018. Available at: http://www.imf.org/en/Publications/WEO/Issues/2016/12/31/Tensions-from-the-Two-Speed-Recovery-Unemployment-Commodities-and-Capital-Flows

International Monetary Fund. (2017a). World Economic Outlook October 2017, Seeking Sustainable Growth: Short-Term Recovery, Long-Term Challenges. Retrieved January 02, 2018. Available at: http://www.imf.org/en/Publications/WEO/Issues/2017/09/19/world-economic-outlook-october-2017

International Monetary Fund. (2017b). Retrieved January 02, 2018. Available at: http://www.imf.org/external/pubs/ft/weo/2017/02/weodata/weorept.aspx?sy=2017&ey=2022&scsm=1&ssd=1&sort=country&ds=.&br=1&pr1.x=44&pr1.y=16&c=186&s=NGDPD%2CNGDPDPC%2CPPPGDP%2CPPPPC%2CPPPSH%2CLUR%2CLP&grp=0&a

Jansson, J. (1989). Car Demand Modelling and Forecasting: A New Approach. *Journal of Transport Economics and Policy*, 23(2), 125-140. Available at: http://www.jstor.org/stable/20052878.

Korkmaz, E., Doğan, E., & Akgüngör, A. P. (2016). Estimation of Car Ownership in Turkey Using Artificial Bee Colony Algorithm. *3th International Conference on Traffic and Transport Engineering*, November 24-25, Belgrade, Serbia. Available at: http://ijtte.com/uploads/news_files/ICTTE%20Belgrade%202016_Proceedings.pdf.

Kumar, M., & Rao, K. V. (2006). A Stated Preference Study for a Car Ownership Model in the Context of Developing Countries. *Transportation Planning and Technology*, 29(5), 409-425. doi:http://dx.doi.org/10.1080/03081060600917793

Lam, W. H., & Tam, M. (2002). Reliability of territory-wide car ownership estimates in Hong Kong. *Journal of Transport Geography*, 10(1), 51-60. doi:http://dx.doi.org/10.1016/s0966-6923(01)00038-2

Matas, A., Raymond, J., & Roig, J. (2009). Car ownership and access to jobs in Spain. *Transportation Research Part A: Policy and Practice*, 43(6), 607-617. doi:http://dx.doi.org/10.1016/j.tra.2009.04.003

Medlock, K. B., & Soligo, R. (2002). Car Ownership and Economic Development with Forecasts to the Year 2015. *Journal of Transport Economics and Policy*, 36(2), 163-188. Available at: http://www.ingentaconnect.com/contentone/lse/jtep/2002/00000036/00000002/art00001

Meurs, H. (1993). A panel data switching regression model of mobility and car ownership. *Transportation Research Part A: Policy and Practice*, 27(6), 461-476. doi:http://dx.doi.org/10.1016/0965-8564(93)90052-m

Ministry for EU Affairs, Republic of Turkey (2018). Retrieved January 04, 2018. Available at: https://www.ab.gov.tr/111_en.html

Ministry of Energy and Natural Resources, Republic of Turkey - Petrol. (2018). Retrieved January 02, 2018, available at: http://www.enerji.gov.tr/en-US/Pages/Petrol

Organization for Economic Cooperation and Development. (2016). Fossil Fuel Support Country Note: Turkey. Retrieved March 06, 2018, available at http://stats.oecd.org/wbos/fileview2.aspx?IDFile=0144c270-446f-48db-88f0-4ea1542244a5

Öğüt, K. S. (2004). S-Curve Models to Determine the Car Ownership in Turkey. *ARI Bulletin of the Istanbul Technical University*, 54(2), 70-76. Available at: http://web.itu.edu.tr/oguts/S-curve%20car%20ownership.pdf

Öğüt, K. S. (2006). Modeling Car Ownership in Turkey Using Fuzzy Regression. *Transportation Planning and Technology*, 29(3), 233-248. doi:http://dx.doi.org/10.1080/03081060600811004

Pişkin, S. (2017). Automotive Sector Report. (in Turkish). Retrieved January 02, 2018, available at http://www.tskb.com.tr/i/content/3081_1_Otomotiv%20Sektor%20Raporu.pdf

Potoglou, D., & Susilo, Y. (2008). Comparison of Vehicle-Ownership Models. *Transportation Research Record: Journal of the Transportation Research Board*, 2076, 97-105. doi:http://dx.doi.org/10.3141/2076-11

Potoglou, D., & Kanaroglou, P. S. (2008). Modelling car ownership in urban areas: a case study of Hamilton, Canada. *Journal of Transport Geography*, 16(1), 42-54. doi:http://dx.doi.org/10.1016/j.jtrangeo.2007.01.006

Ritter, N., & Vance, C. (2013). Do fewer people mean fewer cars? Population decline and car ownership in Germany. *Transportation Research Part A: Policy and Practice*, 50, 74-85. doi:http://dx.doi.org/10.1016/j.tra.2013.01.035

Romilly, P., Song, H., & Liu, X. (2001). Car ownership and use in Britain: a comparison of the empirical results of alternative cointegration estimation methods and forecasts. *Applied Economics*, 33(14), 1803-1818. doi:http://dx.doi.org/10.1080/00036840011021708

Rota, M. F., Carcedo, J. M., & García, J. P. (2016). Dual approach for modelling demand saturation levels in the automobile market. The Gompertz curve: macro versus micro data. *Investigación Económica*, 75(296), 43-72. doi:http://dx.doi.org/10.1016/j.inveco.2016.07.003

Shen, Q., Chen, P., & Pan, H. (2016). Factors affecting car ownership and mode choice in rail transit-supported suburbs of a large Chinese city. *Transportation Research Part A: Policy and Practice*, 94, 31-44. doi:http://dx.doi.org/10.1016/j.tra.2016.08.027

Soltanzadeh, H., & Masumi, H. E. (2014). The Determinants of Transportation Mode Choice In The Middle Eastern Cities: The Kerman Case, Iran. *TeMA Journal of Land Use, Mobility and Environment*, 7(2), 199-222. doi:http://dx.doi.org/10.6092/1970-9870/2518

Sinniah, G. K., Shahi, M. Z., Vigar, G., & Aditjandra, P. T. (2014). Residential Location Preferences. The Significance of Socio-Cultural and Religious Attributes. TeMA Journal of Land Use, Mobility and Environment, 7(2), 223-238. doi:http://dx.doi.org/10.6092/1970-9870/2656

The World Bank. (2017). An overview of the World Bank's work in Turkey. Retrieved January 02, 2018, available at:http://pubdocs.worldbank.org/en/254861507539327826/Turkey-Snapshot-Fall2017.pdf

The World Bank. (2018). The United Nations Population Division's World Urbanization Prospects. Retrieved March 06, 2018, available at https://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS?end=2016&locations=TR-EU&start=1960&view=%20chart&year_high_desc=true

Turkish Statistical Institute. (2018a). Retrieved January 02, 2018, available at https://biruni.tuik.gov.tr/medas/?kn=89&locale=en

Turkish Statistical Institute. (2018b). Retrieved January 02, 2018, available at http://www.turkstat.gov.tr/VeriBilgi.do?alt_id=1020

Turkish Statistical Institute. (2018c). Retrieved January 02, 2018, available at https://biruni.tuik.gov.tr/tufedagitimapp/

Turkish Statistical Institute. (2018d). Retrieved January 02, 2018, available at http://www.turkstat.gov.tr/PreTablo.do?alt_id=1007

Woldeamanuel, M. G., Cyganski, R., Schulz, A., & Justen, A. (2009). Variation of households' car ownership across time: application of a panel data model. *Transportation*, 36(4), 371-387. doi:http://dx.doi.org/10.1007/s11116-009-9210-3

Wu, T., Zhao, H., & Ou, X. (2014). Vehicle ownership analysis based on gdp per capita in China: 1963– 2050. *Sustainability*, 6(8), 4877-4899. doi:http://dx.doi.org/10.3390/su6084877

XLSTAT [Computer software]. (2018) Retrieved January 02, 2018, available at https://www.xlstat.com/en/

Yagi, M., & Managi, S. (2016). Demographic determinants of car ownership in Japan. *Transport Policy*, 50, 37-53. doi:http://dx.doi.org/10.1016/j.tranpol.2016.05.011

Yang, Z., Jia, P., Liu, W., & Yin, H. (2017). Car ownership and urban development in Chinese cities: A panel data analysis. *Journal of Transport Geography*, 58, 127-134. doi:http://dx.doi.org/10.1016/j.jtrangeo.2016.11.015

Yayar, R., Çoban, M. N., & Tekin, B. (2015). Identifying the Factors Affecting the Car Ownership: A Case Study in Urban Areas of the Province of Tokat. *Journal of Management and Economics*, 22(2), 603-617. doi:http://dx.doi.org/10.18657/yecbu.30802

IMAGE SOURCES

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Fig. 1-12: created by the authors

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