Application of Quantile Regression of Used Vehicle Purchasers in Turkey

Funda Bayrakdaroglu[1] | *Muğla Sıtkı Koçman University, Muğla, Turkey*
Hatice Hicret Ozkoc[2] | *Muğla Sıtkı Koçman University, Muğla, Turkey*

Abstract

The automotive sector is one of the leading industries in Turkey, and therefore worthy of examination, both in terms of its size and its economic impact. The Turkish automotive sector can be divided into the sale of new vehicles and their resale as used vehicles. It is notable that the used vehicle market in Turkey is economically more significant, hence the current study's focus is on Turkey's used vehicle market. According to the study's findings, which aims to analyze the used vehicle market in the context of consumer demographics through ordinary least squares and quantile regression method and data obtained from the Turkish Statistics Institution (TURKSTAT), meaningful segments related to demographic characteristics such as income and education level were reached.

Keywords

Used vehicle market, consumer demographics, linear regression, quantile regression, Turkey

JEL code

M30, C21

INTRODUCTION

Vehicles, which were initially only used to meet transportation needs, now go far beyond this basic function in meeting many of the emotional needs of today's consumers such as self-realization, social status gain, or living a "flashy" lifestyle whereby a vehicle is commonly seen as a status symbol. With the increased production of automobiles following the end of the Second World War through to the current era, having a vehicle has become amongst the most essential needs for many of today's consumers.

The used vehicle market has become one of the most important areas of modern consumerism, and represents an economic phenomenon that needs to be considered and analyzed economically, both in terms of Turkey's domestic market economy as well as internationally. The used vehicle market has become one of the leading commercial sectors, and, according to Asilkan and Irmak (2009), used vehicle sales in many countries now outnumber new vehicle sales. Although this rate varies from country to country, Duvan and Ozturkcan (2009) stated that the rate of used vehicle sales is now two or three times higher than for new vehicles. For example, in the United States, three out of four vehicle sales

[1] Muğla Sıtkı Koçman University, Faculty of Economics and Administrative Sciences, Kötekli Campus, 48000 Kötekli, Muğla, Turkey.
[2] Muğla Sıtkı Koçman University, Faculty of Economics and Administrative Sciences, Kötekli Campus, 48000 Kötekli, Muğla, Turkey. Corresponding author: e-mail: hatice.ozkoc@mu.edu.tr, phone: (+90)2522115103.

correspond to transactions involving used vehicles (Used Car Market Report, 2017). In addition to its economic potential, there exists a notable gap in the literature when it comes to studies based on the used vehicle market. In other words, whilst there is a significant level of research and statistics published in the literature on new vehicle sales, there is little information on the used vehicle market (Akci, 2016). In addition, Turkey gives the appearance of an unsaturated market when compared to many other countries in terms of car ownership, with 189 out of every 1 000 individuals in Turkey owning a car. However, this rate increases to 569 in Europe and 808 in the United States (Piskin, 2017). Moreover, the structure and maturity of the used vehicle market varies dramatically from country to country, and even for countries located geographically close to each other (CIRP II, 2007). The current Turkish used vehicle market is therefore significant both in terms of its academic standing and its economic potential for the country.

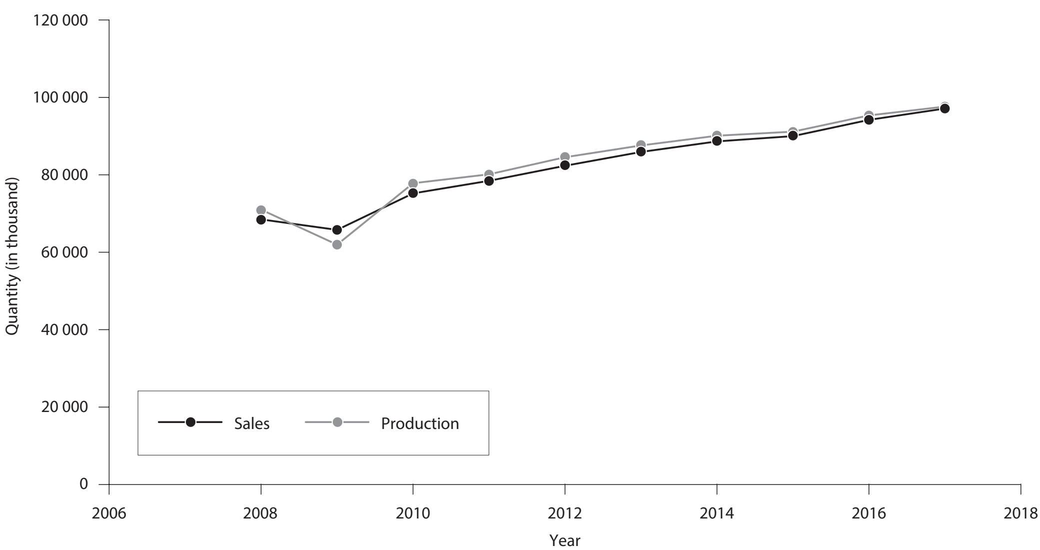
From this perspective, the current study aims to examine the demographic segmentation of used vehicle purchasers based on actual purchasing data for 2018 obtained from the Turkish Statistics Institution (TURKSTAT). As a result of this actual market data analysis, it will be possible to evaluate how consumers who bought used cars are grouped in the context of various demographic perspectives.

1 LITERATURE REVIEW

Inspired initially by the invention of the wheel, the practitioners first invented commercial transportation and farming vehicles for the purposes of trading. Later on, the automotive sector market started to transform personal travel with the aim to improve the comfort of human travel, resulting in a transformed automotive sector that today supplies one of the most widely used commodities and the most heavily invested sectors in human history (Yayar and Yilmaz, 2018). Production and vehicular sales worldwide have increased massively over the years, and run almost in parallel (Figure 1).

As seen in Figure 1, the number of sales and production in automotive industry in the world has increased year by year. However, both sales and production have decreased from 2008 to 2009. This may has been caused by 2008 global financial crisis.

Figure 1 Worldwide production and sales numbers (2008–2017)



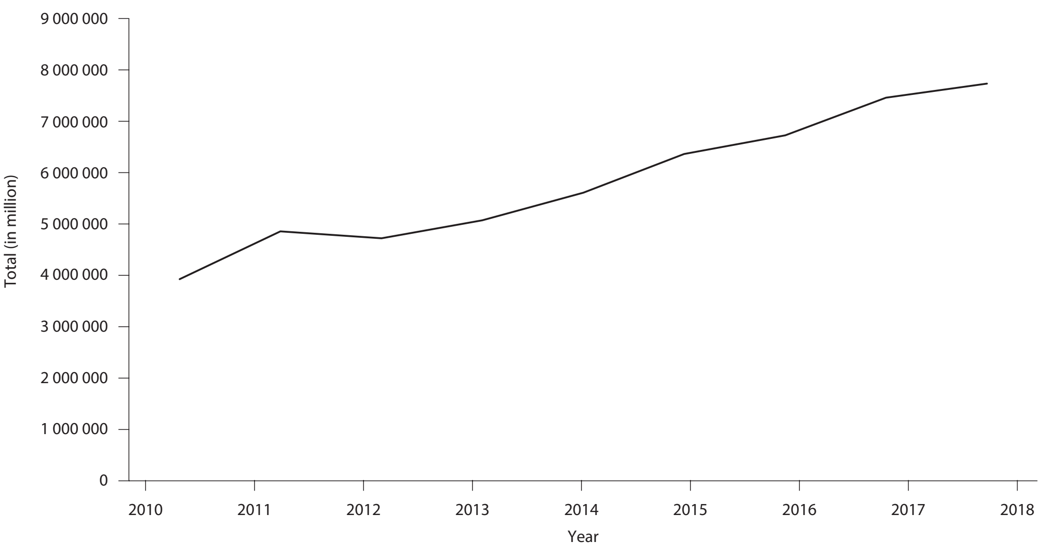
Source: KPMG (2019)

The automotive sector is often seen as an indicator of industrialization, with the sector closely related to other industries also increasing in importance (Karaatli et al., 2012). In addition to the contribution of vehicle taxation (from sales, annual road-use levies, and fuel taxes) and fuel expenditures to the national economy, vehicle owners can now independently travel with relative ease for the purposes of retail shopping, showing the potential increased economic impact of vehicle ownership compared to non-vehicle owners in both economic terms and as a social phenomenon (Balce, 2016).

The used vehicle market, which has become an important part of the automotive sector, includes private transactions (where both the buyers and sellers are individuals) and resale (where vehicles are remarketed by vehicle dealers for commercial gain) (Duvan and Ozturkcan, 2009). Dealers sell vehicles in two ways: as vehicles registered to them; or as an authorized seller on behalf of the vehicle's owner. As private sellers, individual vehicle owners have more alternatives available to them; from authorizing commercial vendors to present their vehicle at regularly held vehicle markets or auctions which are located in most cities on certain days of the week, promoted for private sale via the Internet (known as the "used vehicle e-market"), or by placing a sales advertisement on the vehicle itself (Balce, 2016).

The United States, United Kingdom, and also France present what are probably the best examples of used vehicle markets (Duvan and Ozturkcan, 2009). After an intensive period of growth of China's national economy and the corresponding increase in living standards, the sales of used vehicles in China increased 19-fold from just 2000 to 2012. In fact, China's used vehicle market is expected to exceed 10 million vehicles annually by 2020 (Xujiao et al., 2014). In Turkey, the number of used vehicles sold in 2015 exceeded 6.4 million, which equates to approximately five times the number of new vehicle registrations (Piskin, 2017). Figure 2 illustrates the number of used vehicle registration changes in Turkey between 2010 and 2018.

Figure 2 Used vehicle registration changes in Turkey (2010–2018)



Source: TURKSTAT, Road Motor Vehicle Statistics

The number of road motor vehicles – including car, minibus, bus, small truck, truck, motorcycle and special purpose vehicles – handed over has increased as shown in Figure 2. These increase shown in Figure 2 also is parallel with the increase illustrated in Figure 1. Akci (2016) proposed a number of reasons for the increases seen in used vehicle sales in Turkey:

- *Price:* used vehicles can be purchased at significantly lower cost when compared to equivalent new vehicles;
- *Initial purchase tax:* an initial purchase tax is levied for new vehicles, whereas this does not apply for the resale of used vehicles; therefore, some consumers opt for “almost new” used vehicles as a means to avoiding this tax charge;
- *Resale value:* new vehicles face a dramatic fall in resale value immediately after the initial purchase, whereas there is no major price gap between subsequent resales of used vehicles;
- *Taxation:* the amount of annual road tax levy decreases in Turkey as the vehicle ages, with older used vehicles taxed less annually compared to new or recently new vehicles;
- *Overall economic climate:* changes seen in the general welfare level of Turkish consumers such as due to changes in domestic interest rates, currency exchange rates, or other monetary fluctuations can lead to increased or decreased demand in the Turkish used vehicle market.

From the reasons stated, it can be seen why a clear increase has been identified in the importance of the Turkish used vehicles market. However, academic research on used vehicles in Turkey has mostly focused on the price variable (see Asilkan and Irmak, 2009; Balce, 2016; Yayar and Yilmaz, 2018). In addition, the Turkish used vehicle market has also seen research conducted using artificial neural networks (see Karaatli et al., 2012) as well as through factor analysis in the Turkish literature (see Ozcalici and Ayricay, 2018).

The demographic profile of the vehicle purchaser plays a key role in the decision-making process of buyers. A research study conducted by Deloitte (2016) showed that 67% of used car buyers were aged between 26 and 35 years old, that 66% had 2–4 members in their family, and approximately 88% of used car buyers had 4-year college degree or above. Aritan and Akyuz (2015) stated that demographic segmentation is commonly used in the automotive industry, and brand preference is mainly led according to buyer demographics.

2 METHODS

The current study used household data in order to examine the consumer segmentation of used vehicle purchasers in Turkey in the context of demographic variables. The study was based on a micro dataset related to Household Budget Research that was formed from a study undertaken by TURKSTAT in 2018. The 2018 research revealed that 1 058 household heads purchased second hand vehicles. TURKSTAT conducted their survey nationwide with a significantly large sample size. However, since there was no distinction as to new or used vehicles having been purchased in the survey, it was not possible for the data to directly identify used vehicle purchases, which represented the most significant limitation of the TURKSTAT study.

In the current study, two approaches were used to describe the purchaser relationships. First, the Ordinary Least Squares (OLS) model was employed as a criterion for the purposes of evaluation, and second, quantile regression was used in order to provide a finer level of fragmentation or data granularity based on relationships within various quantiles.

In a study by Mosteller and Tukey (1977), the researchers’ stated the following explanation concerning the ordinary least squares method: “What the regression curve does is give a grand summary for the averages of the distributions corresponding to the set of x’s. We could go further and compute several regression curves corresponding to the various percentage points of the distributions and thus get a more complete picture of the set. Ordinarily this is not done, and so regression often gives a rather incomplete picture. Just as the mean gives an incomplete picture of a single distribution, so the regression curve gives a correspondingly incomplete picture for a set of distributions” (p. 266). Therefore, quantile regression techniques may be considered more successful in revealing relationships when the varying percentage values of the dependent variable are considered.

For this reason, the quantile regression approach offers several advantages. First, standard regression estimators are quite sensitive, despite the assumption of normality. Another advantage is that whilst ordinary least squares focus on the mean, quantile regressions define the entire conditional distribution of the dependent variable. Finally, a quantile regression approach avoids the restrictive assumption that error terms are distributed equally to all points of the conditional distribution (Coad and Rao, 2008).

The quantile regression, as developed by Koenker and Bassett (1978), is presented as follows:

$$y = x'\beta_q + u_q \text{ with } Quant_q(y|x) = x'\beta_q,$$

where y is the dependent variable, β_q is an unknown parameter vector association with the q^{th} quantile, u_q is an unknown error term, $Quant_q(y|x)$ denotes the q^{th} conditional quantile of y given x. In order to obtain the estimators of β_q, based on a particular value for the q^{th} quantile, the following loss function (Koenker, 2005) is applied:

$$\hat{\beta}_q = \arg min_{\beta_q}\left(\sum_{y\geq x'\beta} q|y - x'\beta| + \sum_{y<x'\beta}(1-q)\,|y - x'\beta|\right).$$

3 RESULTS

In the current study, in order to understand the behavior of consumers in Turkey who purchased used vehicles, their level of expenditure on the vehicle was considered as the dependent variable. As independent variables, the total income of the household and household size were then taken into consideration.

At the same time, the age, marital status, education level, gender, and employment status of the head of the household, which was assumed to be the decision-maker, were added to the model as independent variables. In addition, both the expenditure and income variables were included in the model using logarithms.

The status of completed education was categorically evaluated by TURKSTAT to form six categories: "primary school," "middle school," "high school," "vocational school," "university," and "postgraduate." Descriptive statistics and frequencies related to each of the variables used in the current study are presented in Table 1 and Table 2.

Table 1 Descriptive statistics of variables

Variable	Mean	Std. dev.	Min	Max
Dependent variable				
Price (log)	7.802	0.756	4.982	10.161
Independent variables				
Age	44.848	12.086	22	93
Income (log)	10.950	0.558	7.539	13.840
Household size	3.804	1.610	1	15
***N* = 1 058**				

Source: Created by the authors

Table 2 Frequencies of dummy variables

Variable	*n*	%
Primary school	449	42.45
Middle school	189	17.86
High school	220	20.79
Vocational school	61	5.77
University	125	11.81
Postgraduate	14	1.32
Male	989	93.48
Married	978	92.44
Employment status	867	81.95

Source: Created by the authors

The results of linear regression models and various levels of quantile regression are presented in Table 3. Accordingly, Table 3 first presents computations for regression models, each with only one independent variable. When these models (OLS1-OLS7) were analyzed, it can be seen that age, income, household size, and education variables all had a statistically significant effect on the vehicle purchase expenditure (i.e., the price paid), as the dependent variable. In contrast, gender, marital status, and employment status had an insignificant effect on the dependent variable. In the OLS8 model, a linear regression model was created using all of the independent variables together. For the OLS8 model, gender, disposable annual income, household size, education level, and employment status had a combined significant effect on the dependent variable. Finally, the OLS9 model was obtained as a result of excluding the independent variables that were found to be insignificant from the OLS8 model. Therefore, OLS9 is the final linear regression model, and was obtained by removing statistically insignificant independent variables from the OLS8 model on a one by one basis. According to this model, while other variables remained constant, the price (log) decreases by 0.005 when the age increases by one unit, while the increase in household size by one unit decreases the dependent variable by 0.03. However, while other independents variables remained constant, an increase of 1% in income rises spending by 0.51%. As can be seen in the OLS9 model's results, while the other independent variables remained constant, employed consumers spent less on buying used vehicles than consumers who were not employed. At the same time, spending increased in accordance with increases in the consumers' level of completed education. According to the results of the OLS9 model, education level was found to be the variable having the largest numerical effect among the independent variables, followed by working status. When other independent variables are kept constant, compared to primary school graduates, the value of the dependent variable is 0.232 units higher for secondary school graduates, 0.331 units for high school graduates, 0.329 units for university graduates, and 0.390 units for graduate graduates.

Table 3 also presents the coefficient estimates for the nine most relevant quantiles (0.05, 0.20, 0.25, 0.40, 0.50, 0.60, 0.75, 0.80, 0.99). As can be seen in Table 3, the results indicate that income has a significant and positive impact on all quantiles. Besides, Table 3 shows that educational status as well as income also have a positive effect, and that the dependent variable tends to increase due to the increase in education level in general. Finally, there were insignificant effects seen for the independent variables of gender, marital status, and household size in used vehicle expenditures.

Table 3 OLS and quantile regressions

Price (log)	*OLS1*	*OLS2*	*OLS3*	*OLS4*	*OLS5*	*OLS6*	*OLS7*	*OLS8*	*OLS9*
Age	***–0.004***							***–0.004***	***–0.005***
Income (log)		***0.570***						***0.507***	***0.510***
Household size			***–0.032***					***–0.029***	***–0.030***
Middle school				0.089				0.082	
High school				***0.354***				***0.263***	***0.232***
Vocational school				***0.548***				***0.365***	***0.331***
University				***0.701***				***0.364***	***0.329***
Postgraduate				***0.887***				***0.419***	***0.390***
Male					–0.138			–0.084	
Married						–0.069		0.075	
Employment status							0.028	***–0.138***	***–0.145***
Constant	***8.002***	***1.560***	***7.922***	***7.586***	***7.931***	***7.865***	***7.779***	***2.515***	***2.546***
R^2	0.005	0.177	0.005	0.117	0.002	0.001	0.001	0.230	0.228

Breusch-Pagan/Cook-Weisberg test for heteroscedasticity

Chi2(7) = 17.51 [Prob > chi2 = 0.014]

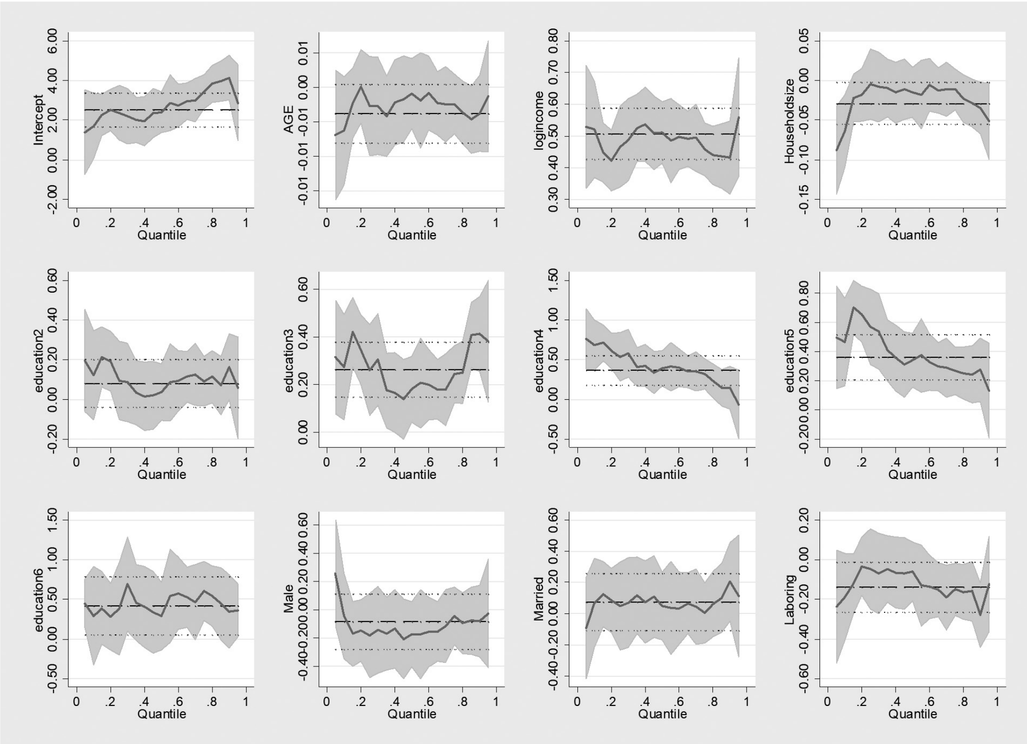
N = 1058 Jarque Bera = 9.445 [0.009]

Price (log)	**5%**	**20%**	**25%**	**40%**	**50%**	**60%**	**75%**	**80%**	**99%**
Age	–0.001	0.0001	–0.003	–0.002	–0.001	0.0004	–0.002	–0.004	0.0004
Income (log)	***0.510***	***0.423***	***0.466***	***0.537***	***0.511***	***0.531***	***0.457***	***0.440***	***0.531***
Household size	–0.015	–0.018	–0.005	–0.015	–0.015	–0.069	–0.011	–0.023	–0.069
Middle school	0.037	0.192	0.094	0.015	0.037	0.027	0.091	0.115	0.027
High school	***0.181***	***0.346***	***0.261***	***0.168***	***0.181***	0.260	***0.239***	***0.252***	0.260
Vocational school	***0.390***	***0.611***	***0.535***	***0.425***	***0.390***	–0.411	***0.321***	***0.234***	–0.411
University	***0.340***	***0.656***	***0.569***	***0.357***	***0.340***	–0.091	***0.269***	***0.252***	–0.091
Postgraduate	0.292	0.282	0.384	0.406	0.292	–0.123	***0.606***	***0.541***	–0.123
Male	–0.174	–0.145	–0.182	–0.133	–0.174	0.320	–0.042	–0.094	0.320
Married	0.050	0.085	0.048	0.075	0.050	–0.070	0.005	0.062	–0.070
Employment status	–0.060	–0.033	–0.048	–0.066	–0.060	0.043	***–0.149***	***–0.162***	0.043
Constant	***2.396***	***2.507***	***2.365***	***1.943***	***2.397***	3.368	***3.429***	***3.831***	3.368
Psd R^2	0.121	0.142	0.139	0.128	0.121	0.122	0.126	0.127	0.184

Note: Base category: primary degree, female, not married, unemployment. Emboldened and italicized numerals denote statistically significant to .05 level.
Source: Created by the authors

The Breusch Pagan/Cook-Weisberg heteroscedastic test was performed on the error terms of the OLS9 model. As can be seen in Table 3, the test statistic was 17.51 (0.014) with heteroscedasticity in the error terms of the model. The normal distribution of error terms was analyzed by way of the Jarque-Bera test and the null hypothesis was rejected (test result: 9.445 [0.009]). Therefore, using quantile regression estimators provides more meaningful results than OLS.

Figure 3 Effect of independent variables



Note: Dashed lines represent OLS estimates with 95% confidence level. Dotted lines represent 95% confidence intervals for quantile regression estimates. Solid lines represent quantile estimates with 95% confidence level. Shaded areas represent 95% confidence intervals for quantile regression estimates.
Source: Created by the authors on Stata Package Program

Figure 3 illustrates the effects of the independent variables on the dependent variable (vehicle price). In Figure 3, household size, education, gender, and quantile estimation results are shown to be outside the confidence intervals, hence using quantile estimates yields more meaningful results. It can therefore be observed that household size, age, and income level of the head of the household had significant but varying effects on the expenditure amount (vehicle price) in different tranches. On the other hand, it can be seen that the amount of expenditure was negatively affected at various levels of education (e.g., vocational school).

CONCLUSION AND DISCUSSION

The current study utilized raw data obtained from a national household budget survey that was conducted by TURKSTAT in 2018. In the study, used vehicle expenditure was employed as the dependent variable using logarithms. A series of 18 different models were calculated based on this single dependent variable. The first nine of the independent variables are least squares, whilst the other nine are quantile regressions according to different percentages. Demographic characteristics of the household head, as in total annual income and household size were used as explanatory variables in the models. In all of the models, a meaningful and positive effect of income on expenditure emerged in accordance with the economic expectation, whilst all coefficients of income met the expectations in economic terms. While it was observed that the educational status of the household head had a positive effect on the purchase of used vehicles, the expenditures of employed consumers were lower in the OLS8, OLS9, 0.75, and 0.80 quantile regression models compared to those who were unemployed. One of the surprising results of the current study was that gender and marital status were not found to be statistically significant across all of the models. When the models' results were analyzed, while age showed a significant and adverse effect in the OLS models, there was no statistically significant effect found to exist for this variable in the quantile regression models.

For developing economies like Turkey in particular, the significant role of the consumers' income and education level in the used vehicle market, as in other industries, is considered to be the most salient finding of the study. This finding correlates with the finding of Akci's (2016) study, in which the economic reasons were seen as leading factors in consumers' purchasing decisions related to used vehicles. Yayar and Yilmaz (2018) also found a relation between income level and the price of used vehicles in their study, which compared four cities within the TR83 region of Turkey (which encompasses Amasya, Çorum, Samsun, and Tokat).

The Internet has also emerged as a marketplace especially pertinent to the sale of used vehicles and for prospective buyers to gather product and market-related information (CIRP II, 2007). Online marketplaces and vehicle websites have played an effective role in matching the current market to the available consumers (Deloitte, 2016). Therefore, the used vehicle market must also be considered within the realm of general e-commerce.

In future studies, the researchers aim to discuss consumer insights and the confidence conditions of consumers within the used vehicle e-market within economies such as Turkey, where e-trade is still somewhat limited in comparison to more developed economies.

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