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# Elasticity Analysis of Fossil Energy Sources for Sustainable Economies: A Case of Gasoline Consumption in Turkey

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**Abstract:** The current paper investigates the gasoline demand relationship in the case of Turkey, utilizing different econometric techniques and using quarterly data spanning from 2000Q1 to 2019Q1. The estimation results revealed that income and gasoline price are the main drivers of consumption. The found long-run income, price and auto stock elasticities are 0.25, −0.27 and −0.80, respectively. In addition, it is concluded that in the short-run, gasoline demand does not respond to changes in income, price and car stock. The estimation results also showed that the contribution of commercial and public car stock on gasoline demand is higher than that for private auto stock. Based on the finding of the study it is concluded that to achieve the optimal use of gasoline in line with providing high quality transport services, firstly, policies before the 2012 period can be followed. Secondly, channels such as pricing mechanism and taxation policies can be used in this framework.

**Keywords:** gasoline demand; gasoline price; Turkey; cointegration; stock of cars; elasticities

## 1. Introduction

Energy is one of the basic requirements of the social and economic development of countries. Primarily, it is used to meet the daily needs of people such as warming, lighting and transportation. On the other side, it is also considered as an important input in industrial production [1]. In other words, it makes a positive contribution to the investment amounts in the country. Therefore, it is accepted that it plays an important role in the sustainable economic development of a country [2]. Determining the level of energy demand in a country is very important. This is particularly critical for countries that have to obtain energy needs from other countries [3]. Having the relevant information about energy demand behavior allows policymakers in these countries to provide more precise decisions on energy demand and import activities.

Gasoline has a crucial role in the daily activities of people. It is mainly consumed in the transportation industry [4]. Because all private cars, vehicles and urban buses use gasoline, its price is essential for these parties. For instance, people who have private cars spend a substantial portion of their income on gasoline [5]. Therefore, any increase in the price can have an important effect on their gasoline demand behavior. In other words, it can be said that gasoline demand is very price

sensitive [6]. From the economic agents' perspective, life today can be considered as a load being carried from now into the future; a huge portion of gasoline is being consumed. In this regard, planning ways of meeting the daily need for gasoline demand plays an important role in a country's social and economic performance. Hence, it is obvious that modeling gasoline demand is an important issue for all countries.

The demand for gasoline can be affected by many different factors. First of all, it is accepted that gasoline demand is most influenced by the price [7,8]. On the other side, according to some researchers, it is also claimed that there is a strong relationship between people's income and gasoline demand [9–11]. In addition to these factors, it is also identified that there is a relationship between economic growth and gasoline consumption [12]. Moreover, the tax on gasoline by the government is also seen as an affecting issue on gasoline demand [13,14]. It indicates that when there is high tax, people can be unwilling to consume gasoline. Furthermore, market uncertainty can also affect gasoline demand negatively [4,15]. Hence, understanding the main indicators of the gasoline demand is a key issue because it has an important role in the economic performance of the country.

This study aims to model gasoline demand in Turkey. The choice of Turkey as a country case can be justified with the following reasons. The gasoline price in Turkey is quite high and there are significant taxes on gasoline consumption as well. Additionally, Turkey has a high population which has a direct effect on this consumption. Hence, analyzing the gasoline demand of this country is very important, especially for the transportation industry. Furthermore, it is thought that this situation has an important influence on the originality of this study. There are limited studies, especially recent ones, in the literature about the gasoline demand of Turkey. Hence, there is a need for an up-to-date study on this subject. Because of this issue, it is thought that this study makes an important contribution while satisfying this need. Another important contribution of this study is that it focuses on both the short and long-term relationship, using the more advanced econometric techniques to reach more appropriate results.

The remainder of this paper is designed as follows. The second part focuses on the background of gasoline consumption in Turkey. In the third part, a review of the studies on gasoline demand is conducted to understand the missing part in the literature. After that, theoretical framework, econometric methodology and data are explained. Empirical estimation results are shared in the following part. In the final parts, discussion of the results and conclusion of the study take place.

## 2. Background of Gasoline Consumption in Turkey

The automobile industry plays a crucial role in the Turkish economy. According to the report of the presidency of the Republic of Turkey, there has been a significant increase in the development of vehicle production in the last 30 years. In this framework, average vehicle production for the period 1990–1999 was 298, whereas this number radically increased to 1550 in 2018 [16]. On the other side, according to the data obtained from Organisation Internationale des Constructeurs d'Automobiles (OICA), Turkey was the leader of vehicle production in Central and Eastern Europe (CEE) in 2018. In addition, Turkey is among the first 15 countries in the World Auto Production list.

Similar to production, Turkey is also very successful in vehicle sales. The data of the Turkish Statistical Institute [17] demonstrates a 14% rise in vehicle sales from 2002 to 2017. This increase is mainly parallel with the higher purchasing power of Turkish people in this period. Another important issue in this context is that passenger car sales were much higher than commercial vehicle sales. This situation indicates that consumer preferences of Turkish drivers are shifting towards passenger cars. Parallel to this aspect, it is also identified that between 2001 and 2018, vehicle exports went up by 15% [16].

While considering these aspects, it can be understood that the automobile industry has a great importance for the Turkish economy. Therefore, it is also significant to understand gasoline demand in Turkey. Many different factors can influence gasoline demand. However, most of the researchers

expect that gasoline price is the most important driver. Thus, it is very important first to analyze gasoline prices. For this purpose, quarterly gasoline price data is illustrated in Figure 1.

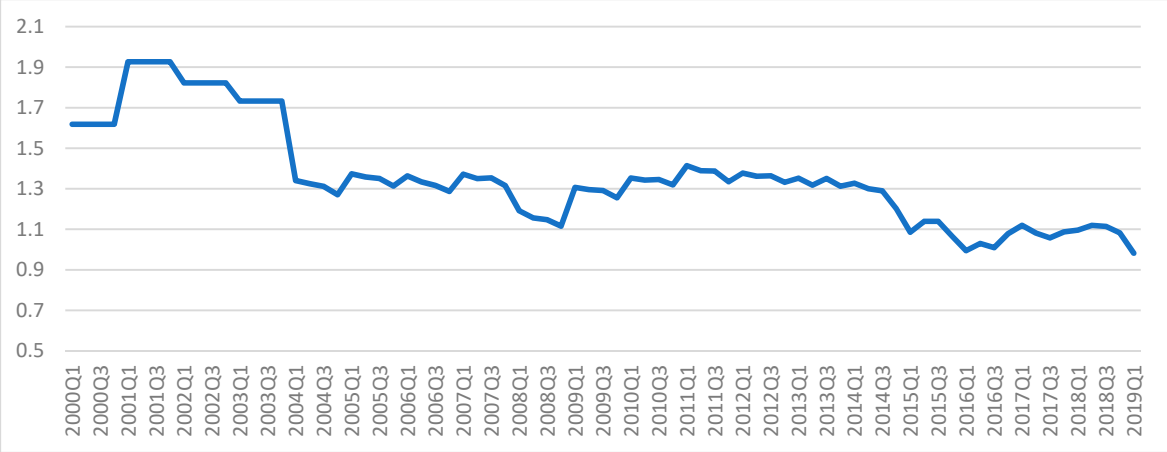


**Figure 1.** Real gasoline prices in Turkey (logarithmic form). Source: Energy Market Regulating Authority of Turkey [18].

Figure 1 indicates the logarithmic values of the quarterly real gasoline prices of Turkey between 2000 and 2018. It can be seen that after 2003, it has a decreasing trend. On the other side, during the period of the global mortgage crisis, the gasoline price increased in Turkey similar to the increasing trend in the world. After that, the gasoline price in Turkey went down again. It is possible to mention many different factors behind this increase in gasoline prices. For instance, Turkish lira depreciated significantly against the US dollar in this period. Because Turkey depends on other countries with respect to energy, any increase in the currency exchange rate can directly affect gasoline prices. It is expected that gasoline demand is influenced by this volatility in the gasoline prices. The gasoline demand of Turkey is depicted in Figure 2.

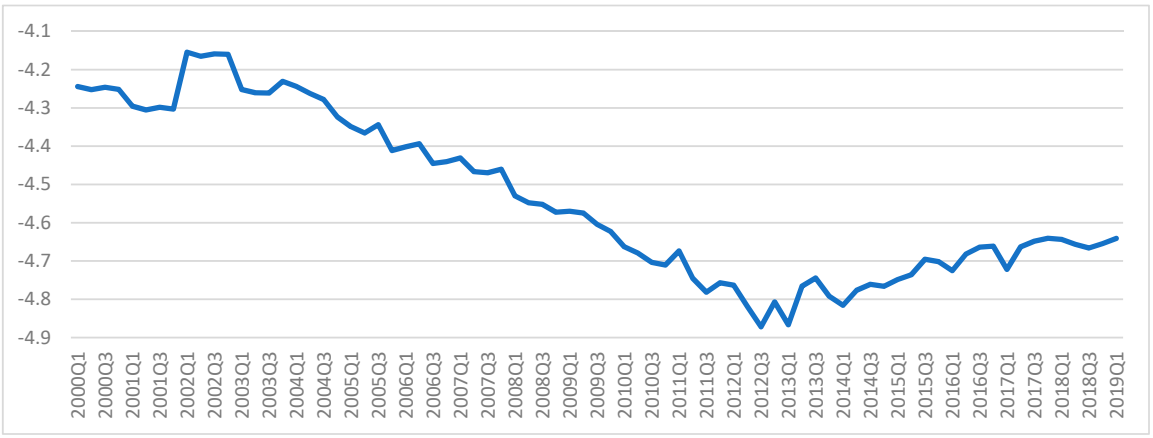


**Figure 2.** Per capita gasoline consumption in Turkey (logarithmic form). Source: The data is updated from Hasanov [19] using data from Petroleum Industry Association of Turkey [20].

It can easily be understood that gasoline consumption has a decreasing trend between the years 2003 and 2012. There are many reasons for this decrease. During the specified date range, serious investments in public transport were made in Turkey. The newly developed systems reduced the use of vehicles. This led to a decrease in gasoline consumption. On the other hand, Figure 2 shows that gasoline consumption started to increase after 2013. In this process, the price of LPG (Liquid Petroleum Gas), which is used as an alternative to gasoline in cars, has an important role to play. Based on 2018

data [20], the share of gasoline in overall transport fuel consumption is 8%, while this number is 77% for diesel. The plot of real per capita GDP is depicted in Figure 3.

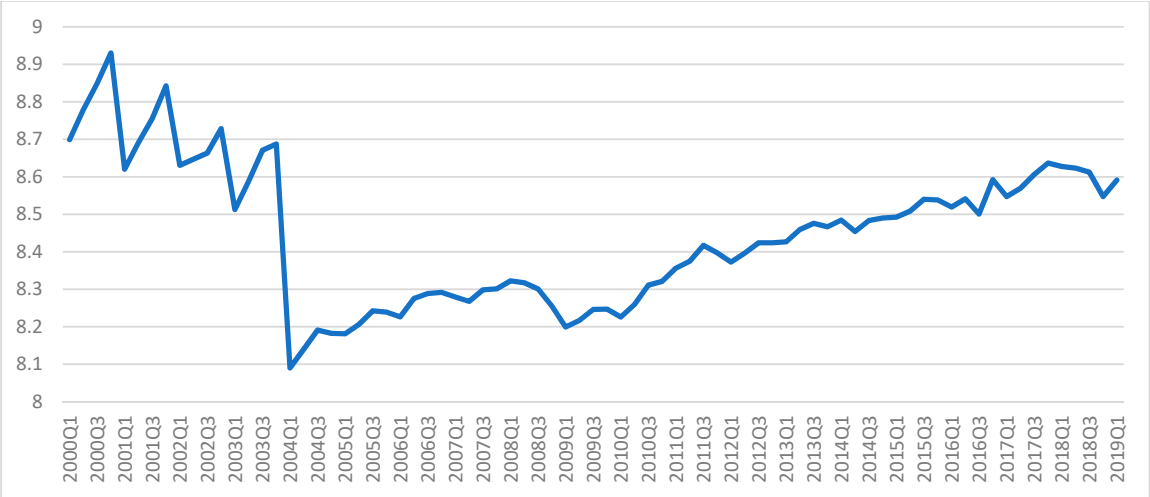


**Figure 3.** Real GDP in Turkey (logarithmic form). Source: World Bank [21].

As can be seen from Figure 3, in the period 2001–2004, there was a significant decline in Turkey's real GDP numbers. The most important reason behind this situation is the specified economic crisis in Turkey in 2001. During this period, many companies went bankrupt and many people became unemployed. It is understood that this situation affected the country's economy in a very negative way. However, Turkey's economy has been experiencing development since 2004.

## 3. Literature Review on Gasoline Demand

There are many studies in the literature to determine the factors affecting the demand for gasoline. In these studies, different factors were highlighted by the researchers. A significant group of researchers stated that gasoline demand is most influenced by the price of gasoline. For example, Park and Zhao [22] examined gasoline demand in the United States. In this context, data in the range 1976–2008 were tested. As a result, it was determined that volatility in gasoline prices had the greatest effect on gasoline demand. Similarly, Baranzini and Weber [23], Brons [24], Lin and Prince [8] and Lim and Yoo [7] examined different countries such as Korea, Switzerland and the Netherlands and emphasized the same result. In addition, Zhu et al. [25] and Algunaibet and Matar [26] are other studies that state that gasoline prices are one of the main drivers of gasoline demand.

However, in some studies, it is stated that the price of gasoline does not have a very serious effect on demand. For instance, Cheung and Thomson [27] analyzed gasoline demand in China between 1980 and 1999. As a result, it is identified that gasoline is relatively inelastic to price changes. Eltony and Al-Mutairi [28], Hughes et al. [29], Arzaghi and Squalli [30] and Atalla et al. [31] discussed this issue with different methods. These studies also reached the conclusion that gasoline demand is very inelastic to price change. Moreover, Ewing and Thompson [32] and Dash et al. [33] underlined the same conclusion in their studies.

Some studies have argued that gasoline demand is related to people's income level. Wadud et al. [34] investigated what influenced gasoline demand in the USA. In this context, surveys were conducted with a large number of people. According to the results obtained, if the income of people living in the country increases, there will be more demand for gasoline. Kanjilal and Ghosh [6] and Mensah et al. [35] conducted a study on India and Ghana and emphasized the same issue. Saelim [9], Chi [20] and Liu [11] are other researchers supporting this result. However, in some studies, it was emphasized that the relationship between people's income and gasoline demand was not very strong. For example, Havranek and Kokes [36] conducted research on OECD (Organization for Economic

Cooperation and Development) countries and found that income elasticity of gasoline demand was smaller than that found by previous studies. This has been emphasized by other researchers in the literature [37,38].

Additionally, when the studies in the literature are examined, it is accepted that exchange rate is one of the important variables affecting the demand for gasoline for some country cases. Especially after globalization, international trade has developed very much. As a result, the economies of the country became affected by the exchange rate [39,40]. Some countries import their energy needs from abroad because they do not have enough energy sources [41–44]. Therefore, the increase in exchange rates makes the gasoline purchased by these countries more expensive. Ghoddusi et al. [45] examined the issues affecting the gasoline demand in Iran. As a result, it was found that the increase in exchange rates reduced the demand for gasoline. In addition, Chou and Tseng [15] and Chen et al. [4] analyzed Taiwan and EU countries with different methodologies and underlined similar results.

Furthermore, some researchers have also argued that the tax on gasoline levied by the government is the most affecting issue on gasoline demand. In particular, countries that have to import gasoline from abroad impose certain taxes to reduce gasoline consumption in order not to increase the current account deficit. This leads to a significant reduction in gasoline demand. Kayser [46] investigated the USA case and concluded that taxes on gasoline had an important effect on the decrease of gasoline demand. Tiezzi and Verde [47], Coglianese et al. [5], Rivers and Schaufele [48] and Filippini and Heimsch [49] also examined the issues affecting gasoline demand in different countries. It was concluded that tax rate had a statistically significant effect on gasoline demand.

In addition to the aforementioned studies, some researchers have stated that the demand for gasoline is effective with the economic performance of the country. For example, Li et al. [50] attempted to identify the factors affecting gasoline demand in China. In this study, it is stated that the demand for gasoline is affected by the economic performance of the country. Ramanathan and Subramanian [51] and Ramanathan [52] conducted an analysis on Oman and India. In the related studies using VECM and cointegration methods, it was emphasized that the economic growth of the country had an effect on the demand for gasoline. Wadud [12] also tried to identify the factors in the UK and highlighted the same issue. In addition, Liddle and Lung [53] concluded that there is a causal relationship between economic growth and gasoline consumption.

Because Turkey is dependent on external countries to meet its energy needs, the subject of gasoline demand in Turkey was evaluated by many researchers in the literature. Mesutoğlu [54] estimated price elasticity of gasoline demand by employing the OLS method to monthly data over the period of 1990–1999 for Turkey. He stated that gasoline demand is inelastic (−0.41) against the price. According to Dahl [55], for gasoline demand in Turkey, the estimated average price elasticity is −0.19. Average income elasticity of gasoline demand was calculated to be 1.10. Melikoğlu [56] reported that gasoline demand in Turkey has decreased in recent years and the main reason for this condition is the high taxes the Turkish government imposed on gasoline. Alper and Torul [13] and Bor and İsmihan [14] also identified this issue in their studies. Erdogdu [57] investigated fuel demand (gasoline, diesel and LPG) in the case of Turkey by utilizing OLS. The results show that both short and long-run income elasticities of gasoline demand are statistically insignificant. Erdogdu [57] reported income elasticities of gasoline demand, although they are statistically insignificant. Otherwise, the price elasticities of gasoline demand are −0.213 and −0.481 in the short and long-run, respectively. Additionally, Erdogdu [57] found that cross-price elasticity of gasoline demand with respect to diesel and LPG are 0.64 and −1.22, respectively and statistically significant.

Hasanov [19] also examined the indicators of gasoline demand in Turkey, by employing the partial adjustment model (PAM), distributed lag (DL) and autoregressive distributed lag (ARDL) methods to the data spanning from 2003Q1 to 2014Q4. The study concludes that there is no long-run relationship among gasoline demand income and price. Hasanov [19] estimates the short-run price elasticity to be −0.427, and he concludes that gasoline demand does not respond to income in the short-run. On the other side, Yalta and Yalta [58] investigated determinants of gasoline demand in

Turkey by using the highest density region (HDR) technique. They stated that the short-run price elasticity of gasoline demand is −0.19. In addition, short-run income elasticity is 0.12, although it is statistically insignificant. On the other hand, the estimated long-run price and income elasticities of gasoline demand are −0.18 and 0.11, respectively. Moreover, Keskin [59], investigating gasoline demand behavior, reached a conclusion that there is a relationship between economic growth and gasoline consumption in the Turkey case.

As a result of the literature review, it was determined that gasoline demand was taken into consideration in many studies. For these studies, different countries and country groups were included in the scope of the study. On the other hand, it was concluded in this research that many factors such as price of gasoline, income level of people, tax on gasoline, economic performance of the country and exchange rate may affect the demand for gasoline. There is a need for an up-to-date study on this subject with different opinions. As the reviewed literature revealed, there are a limited number of gasoline demand studies in the case of Turkey. Moreover, in the best case the last date for the used time spans in the existing studies is 2014, which might not be relevant for estimating the demand relationship, considering the substantial economic changes in the Turkish economy in recent years. To summarize, there are only three recent papers by Erdogdu [57], by Hasanov [19] and by Yalta and Yalta [58] investigating the gasoline demand relationship for the Turkey case. The current paper differs from them in two main ways. First, the used sample period by the studies differs; Erdogdu [57] used quarterly data from 2006Q1 to 2010Q4, Yalta and Yalta [58] used monthly data from 2003 to 2012 and Hasanov [19] used quarterly data from 2003Q1 to 2014Q3. Hence, their findings do not take into account the recent substantial changes in the Turkish economy. Moreover, as discussed and shown in Beenstock and Willcocks [60], "the choice of observation period seems to have been unfortunate" to reveal the true relationship among the variables of interest. Second, the current study uses different econometric techniques and tools to investigate the relationships. As it is well known in the case of small sample sizes, some techniques might not be able to uncover the true parameters. In this regard, it is important to model gasoline demand using the updated data and the proper econometric techniques to reveal the gasoline demand responses to its main drivers. Moreover, none of the previous studies investigated the decomposition analyses of gasoline demand to discover the effects of different drivers on gasoline demand over the period of investigation. The decomposition analyses' findings provide useful information to reveal the sources of changes in gasoline demand.

## 4. Theoretical Framework

Referring to the literature (see for example, Baltagi and Griffin [61], among others) in the current paper per auto gasoline consumption is modelled as a function of per capita real income and real gasoline price and per capita cars. Namely, the functional specification can be expressed as below:

$$lgd_t = \alpha_0 + \alpha_1 ly_t + \alpha_2 lp_t + \alpha_3 lcars_t \; + \; \varepsilon_t \tag{1}$$

where $lgd_t$, $ly_t$ and $lp_t$ are the logarithms of gasoline demand per auto, real income per capita terms, real gasoline price and number of gasoline consuming cars per person, respectively. $\alpha_1$, $\alpha_2$ and $\alpha_3$ are corresponding elasticities to be estimated, and $\varepsilon_t$ is an error term. To see the separate impacts of private cars and commercial and public services cars on consumption, in addition to specification (1) the below specification is also utilized:

$$lgd_t = \alpha_0 + \alpha_1 ly_t + \alpha_2 lp_t + \alpha_3 lpr_t \; + \; \alpha_4 lcps_t + \varepsilon_t \tag{2}$$

where $lpr_t$ and $lcps_t$ are the logarithms of the number of gasoline consuming private cars per person and the number of gasoline consuming commercial and public cars per person, respectively.

## 5. Econometric Methodology

In this section of the study, first, the employed unit root and cointegration tests are introduced. After that, the methods used for long- and short-run estimations are described. Moreover, in the final part, decomposition analysis is presented.

### *5.1. Unit Root and Cointegration Tests*

The paper uses the Augmented Dickey Fuller (ADF) test [62] for testing the stationarity properties of the employed time series variables. The examination of long-run cointegration relationship is performed utilizing the Engle–Granger [63], Phillips–Ouliaris [64] and Trace and Max-eigenvalue [65–67] cointegration tests.

### *5.2. Long- and Short-Run Estimations*

Since the results from previous studies for the Turkey case are relatively contradicting, to investigate the details and compare results of different methods, the current study uses different estimation techniques. Namely, the Dynamic Ordinary Least Squares (DOLS) by Saikkonen [68] and Stock and Watson [69], Fully Modified Ordinary Least Squared (FMOLS) by Phillips and Hansen [70] and Canonical Cointegrating Regression (CCR) by Park [71] methods are used for investigating the long-run relationships among the variables. The short-run relationship is investigated using the General to Specific Modeling strategy following the London School of Economics approach (see for example, Hendry et al. [72] and Ericsson et al. [73], among others).

## 6. Data

The study uses quarterly data from 2000Q1 to 2018Q4. Gasoline demand is total motor gasoline consumption and measured in cubic meters per capita. The annual data from the original source is converted to quarterly data. GDP is measured by real GDP per capita (2010 US $). PRICE is gasoline price, lira per liter. Price data is expressed in real terms using CPI data (2010 = 100). The data for gasoline demand is updated from Hasanov [19], using data from the Petroleum Industry Association of Turkey (PETDER) [20]. GDP data is taken from the World Development Indicators of World Bank [21], while PRICE data is taken from the Energy Market Regulatory Authority [18]. The number of gasoline consuming cars is taken from TurkStat (Road Motor Vehicle Statistics, 2019). Descriptive statistics and correlations matrix are summarized in Table 1.

**Table 1.** Descriptive statistics and correlations matrix.

| **Mean** | | | | | **Correlation Matrix** | | | |
|---|---|---|---|---|---|---|---|---|
| *lgd* | *ly* | *lp* | *lcars* | | *lgd* | *ly* | *lp* | *lcars* |
| −2.022 | 8.451 | 1.358 | −2.514 | *lgd* | 1.000 | 0.181 | 0.697 | 0.780 |
| | | | | *ly* | 0.247 | 1.000 | 0.387 | −0.099 |
| **Standard Deviation** | | | | *lp* | 0.697 | 0.387 | 1.00 | 0.499 |
| 0.174 | 0.190 | 0.247 | 0.046 | *lcars* | 0.780 | −0.099 | 0.499 | 1.000 |

Notes: *lgd* = logarithm of gasoline demand, *ly* = logarithm of GDP, *lp* = logarithm of price, *lcars* = logarithm of car numbers.

## 7. Empirical Estimation Results

The current study investigates gasoline demand behavior in Turkey. The analysis process has two different stages. In the first step, unit-root and cointegration tests are performed. The second step is related to the long and short-run estimation results.

### *7.1. Unit-root Test Results*

First, following the methodology of time-series econometrics we tested the variables for stationarity features. We used the ADF test for unit-root for this purpose and the results are reported in Table 2.

**Table 2.** Unit-root test results.

| Variables | *lgd* | *ly* | *lp* | *lcars* |
|---|---|---|---|---|
| level | −1.434 (0.562) | −2.068 (0.554) | −2.397 (0.378) | −1.323 (0.615) |
| First difference | −9.737 (0.000) | −3.663 (0.007) | −8.752 (0.000) | −2.673 (0.084) |

Notes: *lgd* = logarithm of gasoline demand, *ly* = logarithm of GDP, *lp* = logarithm of price. The critical values for unit-root test are from Mackinnon [74]. "*p*-Values" are in parenthesis.

As the table demonstrates for all variables, the null hypothesis of non-stationarity fails to be rejected at the level form, while it is rejected at the first differenced form. Therefore, we conclude that all the variables are I(1) variables. Hence, we can proceed to the investigation of the existence of a long-run relationship.

### 7.2. Cointegration Tests' Results

Having all the variables integrated at the same order means the cointegration relationship among the variables can be tested. For this purpose, the Engle–Granger [63], Phillips–Ouliaris [64] and Trace and Max-eigenvalue [65–67] cointegration tests are used. The results of these tests are provided in Table 3.

**Table 3.** Cointegration tests' results.

| **Panel A: DOLS Based Test Results** | | | | | **Panel B: VECM Based** | | |
|---|---|---|---|---|---|---|---|
| | **Engle–Granger Tests** | | **Phillips–Ouliaris Tests** | | | **Max-Eigenvalue Statistics** | **Trace Statistics** |
| | Test Value | *p*-Value | Test Value | *p*-Value | $r = 0$ | 53.04 *** | 82.758 *** |
| *Tau-stat* | −5.668 | 0.001 | −5.647 | 0.001 | $r \leq 1$ | 15.880 | 29.710 |
| *Z-stat* | −45.048 | 0.001 | −43.303 | 0.001 | $r \leq 2$ | 11.797 | 15.495 |

Notes: in long-run estimations using DOLS, and VAR/VECM methods 4 lags chosen as max lag number. r is number of cointegrated equations under the null hypothesis; *p*-values are taken from MacKinnon [74], Haug and Michelis (1999); *** = rejection of null hypothesis at 5% significance level.

As can be seen, all the tests concluded the existence of a long-run relationship among the variables. The Max-eigenvalue and Trace tests conclude one cointegrating relationship. Therefore, combining the results of all the employed tests one can conclude the existence of a unique cointegrating relationship between the variables. Hence, one can proceed to the long-run estimations step.

### 7.3. Long and Short-Run Estimation Results

This section discusses the estimated results of long- and short-run relationships. For the long-run estimation the DOLS, FMOLS and CCR estimation techniques are employed. Using the specification discussed in the theoretical framework, the long-run relationship is estimated (We used diesel price as an independent variable, since consumers have an option to switch to diesel cars in Turkey. Estimation concluded its insignificance and it is excluded from the specification). In estimations three dummy variables are specified using Autometrics technique [75] using OxMetrics software. The specified dummies are trend dummy (t2014q1), and two step dummies (dst2001q1 and dst2013q1). As discussed in Castle and Hendry [76] and Castle et al. [77], the omission of relevant step dummies results in misspecification and parameter deteriorations. One can easily rationalize the use of these dummies having looked at the plot of the gasoline demand depicted in Figure 2.

The long-run estimates of income, price and vehicle stock elasticities (since the model with variables in logarithmic form are used, the coefficients can be interpreted as elasticities) are given in Table 4. In Table 4, Model 1 and 2 refer to the specifications (1) and (2), respectively.

**Table 4.** Long-run estimation results.

| Specifications | Model 1 | | | Model 2 | | |
|---|---|---|---|---|---|---|
| | DOLS | FMOLS | CCR | DOLS | FMOLS | CCR |
| *ly* | 0.251 *** | 0.285 *** | 0.274 *** | 0.383 *** | 0.284 *** | 0.272 *** |
| *lp* | −0.266 * | −0.337 *** | −0.316 *** | −0.394 ** | −0.342 ** | −0.325 *** |
| *lcars* | −0.801 *** | −0.999 *** | −0.926 *** | – | – | – |
| *lpr* | | – | | −0.863 *** | −0.584 * | −0.542 * |
| *lcps* | | | | −0.919 *** | −0.621 *** | −0.593 * |

Notes: ***, **, * = rejection of null hypothesis at 1%, 5% and 10% significance level, respectively.

As can be seen from Table 4, all methods produced quite similar results.

Using the error correction term from the long-run (DOLS based) relationship, the short-run estimations are performed. For the short-run estimations, the Autometrics tool [75] is utilized. The results of the short-run estimations are given in Panel A of Table 5. Panel B of Table 5 provides diagnostic tests' results for the short-run estimations. As can be seen from Panel B, the short-run specification passes all the diagnostic tests. Hence, the results are interpretable.

**Table 5.** Short-run estimation results.

| Panel A: Short-run Estimation Results | | Panel B: Diagnostic Tests' Results | | |
|---|---|---|---|---|
| | SoA | | Test Statistic | *p*-Value |
| coefficient | −0.370 | AR 1–5 | 1.600 | 0.192 |
| *p*-value | 0.000 | ARCH 1–4 | 0.510 | 0.729 |
| | | Normality | 1.925 | 0.382 |
| | | Hetero | 0.627 | 0.431 |
| | | Reset | 0.526 | 0.596 |

Notes: SoA = speed of adjustment; AR 1–5 = serial correlation test, ARCH 1–4 = Autoregressive Conditional Heteroscedasticity test, Normality = Bowman-Shenton statistic for normality, Hetero = White test for heteroscedasticity, Reset = Ramsey test for specification errors.

The estimation results show that income, price and auto stock do not have an impact on gasoline demand in the short-run. The speed of adjustment coefficient is found to be theoretically and statistically significant.

## 8. Discussion of the Empirical Outcomes

In this section, firstly, estimation results are discussed. Second, the decomposition exercises' results will be presented.

*Discussion of Empirical Estimation Results*

Since the study makes use of time-series variables, we first tested the variables for stationarity features, employing the ADF test for unit-root. The test concluded that all the variables are stationary in differenced form. Having the variables to be I(1), one can test them for the common long-run trend, hence we tested the variables for cointegration. The battery of cointegration tests are used for this purpose, and all of them concluded that the variables move together in the long-run. Our finding of a cointegration relationship between gasoline demand, income and price is in line with findings of Birol and Guerer [78], Franzen [79] and Erdogdu [57] and differs from that of Hasanov [19].

The estimation results concluded that, income, price and auto stock have a statistically significant impact on gasoline demand with the expected signs in the long-run. The estimated long-run income, price and stock elasticities of gasoline demand are 0.251, −0.266 and −0.801 (DOLS results), respectively. There are only three recent papers [19,57,58] investigating the gasoline demand relationship for the Turkey case. All other studies investigated the relationship using data, which ends in 1990 in the best case. These findings can hardly be valid, since in the recent period Turkey witnessed a dramatic change.

Erdogdu [57] did not find significant relationships in his paper, while Hasanov [19] finds only price having an impact on gasoline demand in the short-run. Although Hasanov [19] reported the short-run price elasticity to be −0.427, adding up the coefficients of the lagged price terms. Based on results from Hasanov [19], it seems that the reported version is not the final short-run specification, since it includes terms with insignificant coefficients. Yalta and Yalta [58] also found significant long-run price and income elasticities that were smaller than our findings. One explanation for the relatively higher elasticities in our case might be because of using recent data (Yalta and Yalta [58]'s data ends in 2012), which might influence the magnitudes of elasticities. In addition, none of the above three studies used auto stock as one of the gasoline demand drivers.

Considering the results of all studies in the Turkey case, our understanding of getting different/contradicting results is the use of different time spans but most importantly the use of proper econometric techniques. In this regard, we prefer the use of different econometric approaches, taking into account different possible components of the relationships.

The estimation results revealed that there is no income, price and auto stock impact in the short-run. The speed of adjustment (SoA) coefficient has expected sign and is statistically significant, indicating that short-run deviations from the long-run equilibrium require less than a year, around three quarters, to be adjusted to the long-run path.

It is also worth noting that our findings for gasoline demand elasticities are in line with the findings of previous studies for similar country cases (see for example, Dahl [55] and Havranek and Kokes [36], inter alia).

Based on the findings of empirical estimations, the elasticities can be interpreted as follows: In the long-run a 1% increase in income results, on average, in 0.25% increase in gasoline demand, while a 1% increase in price level decreases gasoline demand by 0.27%. This response is 0.80% decrease for auto stock. In the short-run gasoline demand does not respond to the changes in the drivers.

Overall, our income and price elasticities are in line with the range of values for different country groups reviewed by Dahl [55] and Havranek and Kokes [36]. Although Dahl [55] reports income and price elasticities for Turkey to be 1.10 and −0.19, as she points out, income elasticities might fall with increasing per capita income. In this regard, it is quite reasonable to expect the income elasticity to fall in line with the growth in per capita GDP in the Turkey case. The found SoA coefficient indicates that any short-run deviation from the long-run comovement will be corrected to the long-run equilibrium path in less than three quarters.

Regarding the price elasticity, Dahl [55] found higher price elasticities for countries with high gasoline prices. In this regard, the found price elasticity for the Turkey case, the highest gasoline price country, seems to be in a reasonable range, being on average −0.27.

In addition to estimating the impact of total auto stock on gasoline consumption, the separate impacts of private car stock and commercial and public auto stock are also investigated. The estimation results showed that this impact is −0.86 and −0.92 for private and commercial and public service cars, respectively. Based on these results, it can be said that private car stock contributes less to auto utilization, compared with commercial and public auto stock.

Based on the World Bank data, the number of registered cars in Turkey is 155 per 1000 inhabitants, being substantially smaller than that of the developed world, which is more than 500 [80]. In 2018 the number of sold passenger cars decreased by 33%, and the number of commercial vehicle sales dropped by 41% [16]. Drivers mainly prefer small engine cars [16] due to the engine-based tax policy. Based on 2016 statistics, 22% of the population belongs to the low- and poor-income group; this number is 87% for the middle and below category [16]. The above-mentioned facts allow us to conclude that current car purchasing capacity in Turkey is relatively low, and the car owners are mainly the ones who can afford the use and maintenance of cars. Therefore, in the short-run, car owners will not react to the income and price increases. They might change their driving preferences (and car purchasing decisions) only in the long-run. Hence, our findings of no income and price impact on gasoline demand in the short-run are plausible.

## 9. Conclusions and Policy Implications

To make relevant decisions on policies such as taxation, regulation, etc., policymakers need to be advised by two information sets: (a) the main drivers of gasoline demand, (b) the related figures on responses to the changes in those drivers.

There is a need for a more comprehensive investigation, especially in the case of gasoline importing countries. In this regard, it is worthwhile to examine the responses of gasoline demand to its main drivers in the case of one of such economies, the country with the highest gasoline prices, Turkey. Although there are a few recent studies examining gasoline demand for the Turkey case, they do not provide a detailed investigation of the gasoline demand impacts. To fill this gap, the current paper aims to model the gasoline demand responses to income and price changes. The study starts with checking the unit root features of the used time series variables. After concluding the common order of integration, the existence of a long-run relationship is tested using a battery of cointegration tests. All the used cointegration tests concluded the existence of a long-run common trend. The estimation results employing different econometric techniques produced quite similar results. The study uses cutting-edge techniques, such as Autometrics tool, to find the relevant variables and interventions. The empirical estimations revealed that the long-run income, price and auto stock elasticities of gasoline demand are 0.25, −0.27 and −0.80, respectively. In the short-run, gasoline demand does not respond to changes in income, price and auto stock. For any deviance from the long-run common trend, it takes just less than three quarters to be adjusted back.

As a result, the price of gasoline demand in the case of Turkey is understood to be inelastic. In other words, the decrease in gasoline demand is less than the increase in gasoline price. This situation indicates that it can be possible in Turkey to increase government revenues by increasing the tax rate on gasoline prices. On the other hand, when the price of gasoline increases, there is a decrease in gasoline consumption, albeit to a lesser extent. In addition, the increase in gasoline prices can increase the demand for alternative fuel types. From this point of view, it is understood that the tax increases in gasoline prices should be paid attention to in order to generate income. There is a risk that the increase in tax revenues will not be as high as expected, as consumption will decrease, albeit less. Therefore, in order to increase tax revenues, it should be ensured that gasoline prices are not raised radically.

Another important point in this process is the taxes imposed by the state to other elements. For example, if the tax on the purchase of private cars is increased, this will reduce the sales of these cars. In this case, as fewer cars are used, the demand for gasoline will also be reduced. In addition to this, improving the quality of public transport will also reduce people's use of private vehicles. This will have similar effects on gasoline demand. It can be understood from these points that if the government wants to use gasoline prices to increase tax revenues, it is necessary to take into account many different factors at the same time. Otherwise, the state's aim to increase this tax revenue will fail.

In addition to these factors, the financial and macroeconomic stability of the country plays an important role in this process. For example, if financial stability is not achieved in the country, the demand for gasoline will decrease. In this context, the change in the exchange rate is very important for countries that import private vehicles from abroad. In the case of a possible increase in the exchange rate, private instruments will become more expensive and this will naturally reduce the demand for gasoline. On the other hand, if there are macroeconomic problems such as economic downturn, high inflation and unemployment, people will be reluctant to buy private vehicles. This will negatively affect the demand for gasoline. As can be seen from these issues, financial and macroeconomic stability needs to be ensured in order to generate additional income by increasing the tax on gasoline.

The overall conclusion from the analyses is that, first, to increase the efficiency, the policies such as those before the 2012 period can be followed. Secondly, as a tool pricing mechanism, related tax policies can be used to optimize the use of gasoline. In addition, considering the small number of cars per 1000 persons, subsidies to car ownership can be applied to increase the life quality and standards. In addition, auto utilization can be optimized, increasing the car stock of vehicles possessing higher

technical characteristics. Moreover, considering different contributions of private and commercial auto stock to gasoline consumption, diverse policies can be applied depending on the set target.

The main limitation of this study is focusing only on Turkey in regards to gasoline demand. Hence, in future studies, different countries can be taken into consideration. Another limitation of the study is that different factors are not taken into consideration in the analysis due to data unavailability. Therefore, when the related data becomes available, future studies will take into account factors such as changes in the pricing of private cars, investments to improve the quality of public transport and changes in taxation in private car purchases. In this way, it will be possible to determine the effect of changes in gasoline prices on all factors.

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